DANISH MINISTRY OF THE ENVIRONMENT

Environmental Protection Agency

Siloxanes - Consumption, Toxicity and Alternatives

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Environmental Project No. 1031 2005
Miljøprojekt

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Preface

Siloxanes, the building blocks for silicone products, are widely used chemicals. The siloxanes are characterised by a high stability, physiologic inertness and good release and lubricating properties.

The stability of the siloxanes, desirable from a technical point of view, makes the siloxanes very persistent, and once released to the environment the siloxanes remain for many years.

In recent years studies indicating that some of the siloxanes may have endocrine disrupting properties, and reproductive effects have caused concern about the possible effects of the siloxanes on humans and the environment.

Until now no overview of the use of siloxanes in Denmark has been available.

The purpose of the present project initiated by The Danish Environmental Protection Agency is to assess the use of siloxanes in Denmark and identify potential sources of releases of siloxanes to the environment. Besides the toxicity of siloxanes has been reviewed, and alternatives to some of the groups of siloxanes of concern have been identified.

The project has been followed by a Steering Group consisting of:

- Frank Jensen, Danish Environmental Protection Agency (chairman);
- Annette Orloff, Danish Environmental Protection Agency;
- Carsten Lassen, COWI A/S.

The report has been prepared by Carsten Lassen, Charlotte Libak Hansen, Sonja Hagen Mikkelsen and Jakob Maag, COWI A/S.

Summary and conclusions

Siloxanes are chemical compounds with a backbone of alternating silicium (Si) and oxygen (O) atoms, each silicon atom bearing one or several organic groups. Siloxanes are building blocks for silicone products or make part of other products, such as cosmetics or paint. In colloquial language the term silicones is often used synonymously with siloxanes.

The properties of the siloxanes and the silicone products depend on the length of the Si-O backbone, the chemical groups attached to the backbone and the presence of cross-links between the backbones. Silicone products are grouped into silicone fluids, elastomers and resins. Silicone fluids are used for a wide range of applications, silicone elastomers are mainly used for sealants and rubbers, and resins are mainly used for paints. The most common siloxanes are polydimethylsiloxane (PDMS) with different modifications.

Of particular interest to this study are the relatively small compounds: Siloxanes with a cyclic structure and linear siloxanes with a small Si-O backbone with a few Si-O moieties. The most common and the most investigated as to toxicity are octamethylcyclotetrasiloxane (D4) and decamethylcyclopentasiloxane (D5). These compounds are widely used in cosmetic products and maintenance products (e.g. wax) under the name cyclomethicone - among other names. In the present report different names are used for the same compounds depending on the names typically used in the different contexts. Many of the compounds are volatile, and the users are directly exposed to the compounds when using the products, and the compounds are to a high extent released to the atmosphere or to wastewater.

Consumption of siloxanes in Denmark

The consumption of siloxanes by application area is shown in Table 1. The estimates are to a large extent based on information on the use of siloxanes in Western Europe under the assumption that the consumption pattern in Denmark of most products will resemble the general consumption pattern in Western Europe. Best estimates and an indication of the uncertainty of the best estimate are given.

The total consumption is estimated at approx. 3,100 t/year. Considering the uncertainty on applying the Western European consumption figures, the total consumption in Denmark is estimated to be within the range of 2,400-3,800 t/year.

The type of the siloxanes used is indicated in Table 1. The type can roughly indicate the potential for releases of the compounds to the atmosphere and wastewater. Volatile fluids are released to the atmosphere, whereas other fluids may end up in wastewater or released directly to surface water and soil. Elastomers and resins will mainly end up in solid waste.

The main application area is silicone sealants for construction, which account for about one third of the consumption. Besides, siloxanes are widespread, used in a vide range of products: In cosmetics and toiletries, paints, cleaning products, clothes, health-care products, etc. Often the siloxanes only account for a small part of the product, e.g. as defoaming agent.

A large number of different siloxanes are used within each application area. As an example the Danish Product Register includes 53 different siloxanes (CAS no.) registered as used in sealants and 98 different siloxanes used in paints and lacquers. About 200 siloxanes and siloxane derivatives are listed in the inventory of ingredients used in cosmetic products compiled by the European Commission (INCI 2000).

The specific siloxanes are often used in many different product types. The most widely used, polydimethylsiloxane, is in the Danish Product Register registered as being present in 159 product types. The most widely used of the cyclic siloxanes, octamethylcyclotetrasiloxane, is registered in 49 product types: Paints, cleaning agents, dyes, fillers, polishes, adhesives, etc. In most product groups the total registered amount is, however, quite small.

Table 1
Consumption of siloxanes in Denmark in 2002

Application area	Consumption Tonnes/year	Percentage	Uncertainty *	Type of siloxanes
Sealants used for construction	920	29	Low	Elastomers
Paints, inks and coatings	200	6	Medium	Resins, elastomers
Cosmetics and toiletries	240	8	Medium	Fluids, volatile fluids
Wax, polishes and cleaning agents	100	3	Medium	Fluids, volatile fluids
Mechanical fluids and heat transfer fluids	50	1.6	Medium	Fluids
Textile applications	380	12	High	Fluids, elastomers
Processing aids	470	15	Medium	Fluids
Paper coating	210	7	Medium	Fluids
Health care	110	4	High	Elastomers, fluids
Other uses of silicone elastomers	390	13	Medium	Elstomers
Other uses of silicone fluids	50	1.6	High	Fluids
Total	3,120	100		

* Uncertainty indication:
Low : the right value is most probably within a range of x ±25%
Medium: the right value is most probably more than half and less than twice the best estimate
High: the right value may be less than half or more than twice the best estimate

Releases to the environment

The main source of releases of siloxanes to the air is volatile siloxanes used in cosmetics, wax, polishes, and to a minor extent in several other applications. No information of the quantity of volatile siloxanes for these applications has been available, but the volatile siloxanes may account for a significant part of the siloxanes used for cosmetics, and it is roughly estimated that between 50 and 200 t/year is released to the air. Siloxanes disposed of to municipal solid waste incineration are deemed nearly 100% to be mineralised by the incineration, and incineration plants are not considered significant sources of siloxane releases to the atmosphere.

Non-volatile silicone fluids used in cosmetics, wax, polishes, cleaning products and for textile applications (softeners) will to a large extent end up in wastewater and be directed to wastewater treatment plants. The total release to wastewater is estimated at 200-700 t/year. By the treatment process the siloxanes mainly follow the sludge and are either spread on agricultural fields, incinerated or disposed of for landfills.

The major part of siloxanes used in silicone elastomers and resins in sealants, paints, rubbers, etc. is disposed of to incineration or to landfills with building materials. By the incineration the siloxanes are destructed.

Effects on human health and the environment

Only few siloxanes are described in the literature with regard to health effects, and it is therefore not possible to make broad conclusions and comparisons of the toxicity related to short-chained linear and cyclic siloxanes based on the present evaluation. Data are primarily found on the cyclic siloxanes D4 (octamethylcyclotetrasiloxane) and D5 (decamethylcyclopentasiloxane) and the short-linear HMDS (hexamethyldisiloxane).

These three siloxanes have a relatively low order of acute toxicity by oral, dermal and inhalatory routes and do not require classification for this effect.

They are not found to be irritating to skin or eyes and are also not found sensitizing by skin contact. Data on respiratory sensitization have not been identified.

Subacute and subchronic toxicity studies show that the liver is the main target organ for D4 which also induces liver cell enzymes. This enzyme induction contributes to the elimination of the substance from the tissues. Primary target organ for D5 exposure by inhalation is the lung. D5 has an enzyme induction profile similar to that of D4. Subacute and subchronic inhalation of HMDS affect in particular the lungs and kidneys in rats.

None of the investigated siloxanes show any signs of genotoxic effects ***in vitro*** or ***in vivo***. Preliminary results indicate that D5 has a potential carcinogenic effect.

D4 is considered to impair fertility in rats by inhalation and is classified as a substance toxic to reproduction in category 3 with the risk phrase R62 ('Possible risk of impaired fertility').

The results of a study to screen for estrogen activity indicate that D4 has very weak estrogenic and antiestrogenic activity and is a partial agonist (enhances the effect of the estrogen). It is not uncommon for compounds that are weakly estrogenic to also have antiestrogenic properties. Comparison of the estrogenic potency of D4 relative to ethinylestradiol (steroid hormone) indicates that D4 is 585,000 times less potent than ethinylestradiol in the rat stain Sprague-Dawley and 3.7 million times less potent than ethinylestradiol in the Fisher-344 rat strain. Because of the lack of effects on other endpoints designated to assess estrogenicity, the estrogenicity as mode of action for the D4 reproductive effects has been questioned. An indirect mode of action causing a delay of the LH (luteinising hormone) surge necessary for optimal timing of ovulation has been suggested as the mechanism.

Based on the reviewed information, the critical effects of the siloxanes are impaired fertility (D4) and potential carcinogenic effects (uterine tumours in females). Furthermore there seem to be some effects on various organs following repeated exposures, the liver (D4), kidney (HMDS) and lung (D5 and HMDS) being the target organs.

A possible estrogenic effect contributing to the reproductive toxicity of D4 is debated. There seems however to be some indication that this toxicity may be caused by another mechanism than estrogen activity.

Effects which based on the reviewed literature do not seem to be problematic are acute toxicity, irritant effects, sensitization and genotoxicity.

Siloxanes are in general stable compounds that are very persistent in the environment. The cyclic siloxanes and small-chain linear siloxanes are bioconcentrated (bioconcentration factors for long-chained siloxanes have not been assessed). The estimated bioconcentration factors (BCF) of the small siloxanes range from 340 for HMDS to 40,000 for a phenylated trisiloxane (phenyl trimethicone). The small phenylated siloxanes seem to have very high BCF, and model estimates indicate that these substances are the most toxic for aquatic organisms.

Alternatives to siloxanes for cosmetics and maintenance products

Traditionally when talking about substitution, the siloxanes have been on the positive side, e.g. as alternatives to PCBs. The development of alternatives to siloxanes has mainly focused on siloxanes used in cosmetics and breast implants. Until now the absence of siloxanes in cosmetics has not been a competition parameter in Denmark, but many - and in particular American producers - use the Internet for advertising "silicone-free" hair care and skin care products.

As cosmetics and maintenance products are among the most significant product groups as to consumer exposure and releases to the environment, the assessment of alternatives to siloxanes has focused on these groups.

The siloxanes have a number of properties which are not easily matched by alternatives. For soaps and leave-on products (lotions and creams for skin) the siloxanes e.g. can give the product the combination "smooth and soft feeling" on the skin combined with the sense that the product does not feel greasy on the skin after application. In particular the properties of the volatile cyclic siloxanes are difficult to substitute. The price of the alternatives ranges from the same as the price of the siloxanes to approximately the double price. The use of alternatives will in general not require changes in production equipment.

Alternatives to siloxanes in cosmetics identified by enquiries to Danish producers and suppliers are listed in Table 2.

The substitution of siloxanes has not had the particular attention of the producers of cleaning and maintenance agents. Siloxanes used in cleaning agents, waxes and polishes are in general different from the siloxanes used in cosmetics, although some of the wanted properties are the same, for example shine, spreadability and antifoaming. The identified alternatives are therefore also quite different from the alternatives developed for cosmetic products. As for alternatives to siloxanes in cosmetic products it is the general opinion in the cleaning agent trade that siloxanes have some special qualities that cannot easily be found in alternatives. These qualities are in particular as solvent, emulsifier, anti-soiling and defoaming agents.

Identified alternatives to siloxanes antifoaming agents are non-ionic mineral oils (tensides), paraffin oils, vegetable oils and block polymers consisting of polyethylenglycol and polypropylenglycol. Alternatives to amino-functional dimethylsiloxanes in polishes are lipophilic tensides. It is, however, difficult to assess to what extent the alternatives actually match the properties of the siloxanes. Advertisements for silicone-free polishes and waxes can be found, but the reason for mentioning that they are silicone-free is usually technical.

table 2
Identified alternatives to siloxanes in cosmetics from Danish producers and suppliers.

Name of alternative	CAS-no for alternative	Alternative to	Used in	Market situation	Price
Neopentylglycol heptanoate	N/A	Dimethicone	Conditioners and leave-on products	Not sold to Danish manufacturers of cosmetics yet	Approximately 100 DKK/kg, compared to app. 50 DKK/kg for dimethicone
Isodecylneopentanoate	60209-82-7	Cyclomethicone	Conditioners and leave-on products. Perhaps also shampoos and cream soaps	Not sold to Danish manufacturers of cosmetics yet	Approximately 100 DKK/kg, compared to app. 45 DKK/kg for cyclomethicone
Glycol distearate	627-83-8	Cyclomethicone and dimethicone in cream soaps. (do not have exactly the same properties)	Cream soaps	Have been used in Danish products for the last 2-3 years	Approximately half price of cyclomethicone and dimethicone (20-25 DKK per kg)
Different vegetable oil components - e.g. dicaprylyl carbonate	N/A	Dimethicone, cyclomethicone and other siloxanes. (do not have exactly the same properties)	Creams and lotions - do not have the foam reducing effect that some siloxanes have in creams and lotions	Can be found in products in Denmark	Approximately the same price level as the siloxanes
Diethylhexyl carbonate	N/A	Cyclopentasiloxan	Lotions and emulsions	The alternative is already sold to manufacturers of cosmetics, but can so far not be found in products sold in Scandinavia	Slightly less than cyclopentasiloxan
Hydrogenated polydecen*	68037-01-4	Cyclomethicone in composition with paraffin oils	Leave-on products	Have been sold in Denmark the last two years and can be found in products in Denmark	Not possible to estimate as it cannot directly substitute the siloxanes

* Is used as alternative to cyclomethicone and paraffin, but do not substitute all properties

N/A CAS No. has not been available - the substances are not included in the 1st update of the inventory of ingredients used in cosmetic products (INCI 2000)

Sammenfatning og konklusioner

Denne undersøgelse har til formål at give et overblik over anvendelsen af siloxaner i Danmark, siloxanernes miljø- og sundhedsmæssige egenskaber og hvilke alternativer, der findes til siloxaner til udvalgte formål. Undersøgelsen er igangsat af Miljøstyrelsen, fordi der de seneste år er opstået en stigende bekymring for, at visse af siloxanerne kan have nogle uønskede effekter på mennesker og i miljøet.

Siloxaner er kemiske forbindelser med en "rygrad" af skiftende silicium (Si) og ilt (O) atomer. På hvert af siliciumatomerne sidder der en eller flere organiske grupper. Siloxanerne er byggestenene i silikoneprodukter eller udgør en mindre del af andre produkter, som det fx er tilfældet i kosmetik eller maling. I dagligdags sprog anvendes navnet silikoner ofte som synonym for siloxaner.

Siloxanernes og silikoneprodukternes egenskaber er afhængig af længden af Si-O kæderne, de kemiske grupper fæstnet til kæderne og tilstedeværelsen af tværbindinger mellem kæderne. Silikoneprodukter grupperes i silikonevæsker, silikoneelastomerer og silikoneharpikser. Silikonevæsker indgår i en lang række produkter, som fx kosmetik og maling, silikone elastomerer anvendes hovedsageligt til fugemasser og silikonegummier, mens harpikser hovedsageligt anvendes til malinger. De mest almindelige siloxaner er polydimethylsiloxan med forskellige modifikationer.

Af særlig interesse for denne undersøgelse er de relativt små forbindelser: siloxaner med en cyklisk struktur og kortkædede lineære siloxaner med kun få Si-O led. De mest udbredte er octamethylcyclotetrasiloxan (D4) og decamethylcyclopentasiloxan (D5). Disse forbindelser er udbredt anvendt i kosmetikprodukter og visse plejemidler som fx voks. Mange af stofferne er flygtige, og brugerne er direkte eksponeret for stofferne, når de bruger produkterne, og en stor del af stofferne bliver udledt til luften eller med spildevand.

Forbrug af siloxaner i Denmark

Forbruget af siloxaner opdelt på anvendelsesområder er vist i tabel 1. Overslagene er i høj grad baseret på kendskab til forbruget af siloxaner i Vesteuropa under antagelse af at forbrugsmønstret i Danmark for de fleste produkter ligner det generelle forbrugsmønster i Vesteuropa. I tabellen er der for hvert anvendelsesområde angivet et bedste estimat samt en vurdering af usikkerheden på de enkelte estimater.

Det samlede forbrug er anslået til omkring 3.100 t/år. Når usikkerheden ved at basere overslagene på oplysninger om det samlede vesteuropæiske forbrug tages i betragtning, vurderes den korrekte angivelse af det samlede forbrug at befinde sig inden for intervallet 2.400-3.800 t/år.

Typen af siloxaner/silikoner er også vist i tabellen. Typen giver er grov indikation af potentialet for udledninger til luften og til spildevand. Flygtige væsker udledes til atmosfæren, mens andre væsker kan ende i spildevand eller tabes direkte til overfladevand og jord. Elastomerer og harpikser vil hovedsageligt ende i fast affald, som bortskaffes til affaldsforbrænding eller deponier.

Det største anvendelsesområde er silikonefugemasser (mængden, der angives i tabellen, er mængden af silikone i fugemasserne). Herudover anvendes siloxaner i en bred vifte af produkter: kosmetik og toiletprodukter, maling, rengøringsmidler, tøj, produkter til medicinske anvendelser, kølemidler, mm. Ofte udgør siloxanerne kun en lille del af produkterne, bl.a. som skumhindrende middel.

Der anvendes inden for hvert enkelt anvendelsesområde et stort antal forskellige siloxaner. For eksempel er der i Produktregistret registreret 53 forskellige siloxaner (CAS-numre), som anvendes i fugemasser, og 98 forskellige siloxaner, som anvendes i maling og lak. Der optræder omkring 200 siloxaner og siloxan-derivater på EUs liste over ingredienser i kosmetiske produkter (INCI 2000).

De enkelte siloxaner anvendes ofte i mange typer af produkter. Den mest udbredt anvendte siloxan, polydimethylsiloxan, er således i Produktregistret registreret anvendt til 159 produkttyper. Den mest udbredte af de cykliske siloxaner, octamethylcyclotetrasiloxan, er registreret i 49 produkttyper: Malinger, rengøringsmidler, farvestoffer, spartelmasse, pudsecreme, lime, m.m. Den samlede registrerede mængde er dog for de fleste af produkttyperne meget beskeden.

Tabel 1
Forbrug af siloxaner i Danmark i 2002

Anvendelsesområde	Forbrug tons/år	Procent af total	Usikkerhed	Type af siloxaner
Fugemasser til bygge og anlæg	920	29	Lav	Elastomerer
Maling, trykfarver og overfladebehandling	200	6	Medium	Resiner, elastomerer
Kosmetik og toiletartikler	240	8	Medium	Væsker, flygtige væsker
Voks, polish og rengøringsmidler	100	3	Medium	Væsker, flygtige væsker
Køle/skærevæsker, smørefedt, hydraulikvæsker, varmetranporterende væsker, mm.	50	1,6	Medium	Væsker
Tekstiler	380	12	Høj	Væsker, elastomerer
Proceskemikalier	470	15	Medium	Væsker
Selvklæbende mærkater	210	7	Medium	Væsker
Medicinske anvendelser, sundhedspleje, babyartikler, mm	110	4	Høj	Elastomerer, væsker
Andre anvendelser af silikone elastomerer	390	13	Medium	Elastomerer
Andre anvendelser af silikone væsker	50	1,6	Høj	Væsker
I alt	3.120	100		

* Angivelse af usikkerhed:

Lav : Den korrekte værdi er formentligt inden for et interval på x ±25%, hvor x er det bedste estimat (den værdi, der er angivet i tabellen)

Medium: Den korrekte værdi er formentlig større end halvdelen og mindre end to gange det bedste estimat.

Høj: Den korrekte værdi er kan meget vel være mindre end halvdelen end eller større end to gange det beste estimate.

Udledninger til miljøet

Den væsentligste kilde til udslip af siloxaner til luften er flygtige siloxaner, som anvendes i kosmetik, voks, polish og i mindre grad en række andre anvendelser.

Det har ikke været muligt at få præcis information om mængden af flygtige siloxaner som anvendes til disse formål. Men de flygtige siloxaner synes at udgøre en betydelig del af de siloxaner, som anvendes i kosmetikprodukter, og det anslås groft, at mellem 25 og 200 tons siloxaner hvert år udledes til luft. Siloxaner, der bortskaffes via forbrændingsanlæg regnes at blive næsten 100% destrueret ved forbrændingen, og forbrændingsanlæg betragtes ikke som væsentlige kilder til udledninger af siloxaner til luften. Ikke-flygtige silikonevæsker anvendt i kosmetik, voks, polish, rengøringsmidler og i tekstiler (blødgørere) vil i høj grad ende i spildevand og afledes til renseanlæg. De totale udledninger af siloxaner til renseanlæg anslås groft til 200-700 t/år. Ved renseprocessen vil siloxanerne hovedsageligt ende i slammet og vil med slammet spredes på landbrugsjord, forbrændes eller deponeres.

Hovedparten af siloxaner anvendt i silicone elastomerer og harpikser i fugemasser, maling, gummier, m.m. bortskaffes til affaldsforbrænding eller deponi med byggematerialer. Ved affaldsforbrændingen vil siloxanerne blive destrueret.

Sundheds- og miljøeffekter

Ved screening for sundheds- og miljøeffekter er der fokuseret på de cykliske og korte lineære siloxaner.

Kun få af siloxanerner er beskrevet i litteraturen med hensyn til sundhedseffekter, og det er derfor ikke muligt at foretage brede konklusioner og sammenligninger mellem sundhedsfarligheden af de forskellige siloxaner. De fundne data vedrører primært de cykliske forbindelser D4 (octamethylcyclotetrasiloxan) og D5 (decamethylcyclopentasiloxan) og den korte lineære siloxan HMDS (hexamethyldisiloxan).

Den akutte giftighed af de tre siloxaner er relativt lille uanset om stofferne indåndes eller indtages gennem munden eller huden, og der er ikke noget krav om klassifikation for akut giftighed. De er ikke påvist at irritere huden eller øjnene, og der er ikke fundet sensibilisering ved hudkontakt. Der er ikke fundet data om sensibilisering ved indånding.

Studier af subakut og subkronisk giftighed viser, at leveren er det organ, i hvilket der ses de væsentligste effekter af D4, som også inducerer dannelsen af levercelle enzymer. Denne enzymdannelse bidrager til at fjerne stoffet fra vævet. Det primære organ for effekter af D5 eksponering er lungerne. D5 har samme enzymdannelsesprofil som D4. Subakut og subkronisk indånding af HMDS påvirker i rotter især lungerne og nyrerne.

Ingen af de undersøgte siloxaner viser tegn på at skade arveanlæggene hverken i reagensglasforsøg (***in vitro)*** eller ved forsøg i levende organismer ***(in vivo***). Foreløbige undersøgelser viser, at D5 har et potentiale for at være kræftfremkaldende.

D4 anses at påvirke frugtbarheden af rotter ved indånding og er klassificeret som et stof der er giftigt i forhold til forplantningsevnen i kategori 3 og er tildelt risikosætningen R62, "Mulig risiko for hæmmet forplantningsevne".

Resultaterne af et studie med det formål at screene for østrogen aktivitet indikerer, at D4 har en svag østrogen og anti-østrogen aktivitet og er en delvis agonist (forøger virkningen af østrogen). Det er ikke ualmindeligt, at stoffer der har østrogen virkning også har anti-østrogene egenskaber. Sammenligning af den østrogene styrke af D4 med ethinylestradiol (et steroid hormon) indikerer, at styrken af D4 er henholdsvis 585.000 gange og 3,7 mio. gange mindre end styrken af ethinylestradiol i to forskellige rottestammer.

På grund af manglen på påviste effekter af stofferne på andre "endpoints", som anvendes til at vurdere østrogene effekter, er der stillet spørgsmålstegn ved, om effekten af D4 i forhold til forplantningen skyldes en østrogenvirkning. Det er foreslået at mekanismen er en forsinkelse af den såkaldte LH-bølge, som er nødvendig for en optimal timing af ægløsningen.

Baseret på de gennemgåede undersøgelser, er de kritiske effekter af de her omtalte siloxaner en hæmmet forplantningsevne (D4) og potentielle kræftvirkninger (svulster i livmoderen). Yderligere ser der ud til at være nogle effekter på en række organer af gentagen eksponering: leveren (D4), nyrerne (HMDS) og lungerne (D5 og HMDS).

En mulig østrogen effekt, som bidrager til D4's hæmning af forplantningsevnen er til diskussion. Der er dog en indikation på, at denne hæmning er forårsaget af andre mekanismer.

Baseret på den gennemgåede litteratur synes der ikke at være problemer hvad angår akut giftvirkning, irritationer, sensibiliseringer og skader på arveanlæggene.

Siloxanerne er generelt meget stabile forbindelser, der er svært nedbrydelige i miljøet. De cykliske siloxaner og kortkædede lineære siloxaner opkoncentreres i organismer (biokoncentreringsfaktorer er ikke undersøgt for de langkædede siloxaner). De beregnede biokoncentreringsfaktorer (BCF) af de små siloxaner varierer fra 340 for HMDS til 40.000 for phenyleret trisiloxan (phenyl trimethicone). De små phenylerede siloxaner synes at have meget høje biokoncentreringsfaktorer, og modelberegningen indikerer, at det også er disse stoffer, som er de mest giftige for organismer i vandmiljøet.

Alternativer til siloxaner i kosmetikprodukter og plejemidler

Traditionelt har siloxanerne været på positivsiden, når emnet har været substitution, fx som alternativer til PCB. Udviklingen af alternativer til siloxaner har hovedsageligt fokuseret på siloxaner anvendt i kosmetik og brystimplantater. Hidtil har det i Danmark ikke været en konkurrenceparameter, at kosmetik ikke indeholder siloxaner, men mange, især amerikanske producenter, bruger Internettet til at annoncere for silikonefri hår- og hudplejeprodukter.

Da kosmetik og plejemidler er blandt de vigtigste produktgrupper, hvad angår forbrugereksponering og udledninger af siloxaner til miljøet, har vurderingen af alternativer fokuseret på disse produktgrupper.

Siloxanerne har en række egenskaber som det ikke er nemt at erstatte med brug af alternativer. I sæber og "leave-on" produkter (bl.a. lotions og hudcremer) giver siloxanerne fx produkterne en kombination af glat og blød fornemmelse på huden samtidig med, at produkterne ikke føles fedtede på huden. Især er de flygtige siloxaners egenskaber svære at erstatte.

Prisen på alternativerne varierer fra en pris lidt lavere end siloxanernes til omtrent det dobbelte af siloxanernes pris. Brugen af alternativer vil normalt ikke kræve ændringer i produktionsudstyr.

Alternativer til siloxaner i kosmetikprodukter, fundet gennem henvendelse til danske producenter og leverandører, er vist i tabel 2.

Substitution af siloxaner har ikke tiltrukket sig særlig opmærksomhed fra producenter af rengørings- og plejemidler. Siloxaner som anvendes i rengøringsmidler, voks og polish er i almindelighed forskellige fra siloxanerne, som anvendes i kosmetikprodukter, selvom om nogle af de ønskede egenskaber er de samme fx glans, skumhindring og den egenskab at produkterne let kan fordeles på overfladen. De fundne alternativer er derfor også forskellige fra de alternativer, der er udviklet til kosmetikprodukter. Det er blandt producenter og leverandører den generelle opfattelse, at siloxanerne har visse særlige egenskaber, som det er svært at finde hos alternativerne. Disse egenskaber er især knyttet til siloxanernes brug som opløsningsmiddel, emulgeringsmiddel, skumhindrende middel og anti-smuds middel.

De fundne alternativer til siloxan antiskummidler er nonioniske mineralske olier (tensider), paraffinolier og vegetabilske olier samt blokpolymerer bestående af polyetylenglycol og polypropylenglycol. Alternativer til aminofunktionelle dimethylsiloxaner i polish er lipophile tensider. Det er dog vanskeligt at vurdere, i hvilken grad alternativernes egenskaber faktisk svarer til siloxanernes. Der kan findes en del annoncering for "silikone-fri" polish og voks, men det vil normalt være af tekniske årsager, at det fremhæves, at produkterne er silikonefri, da silikoner til visse formål er uønskede.

tabel 2
alternativer til siloxaner i kosmetikprodukter fundet hos danske producenter og leverandører

Alternativets navn	Alternativets CAS-nr.	Alternativ til	Anvendes i	Markedssituation	Pris
Neopentylglycol heptanoat	N/A	Dimethicone	Hårbalsam og "leave-on" produkter	Sælges endnu ikke til danske producenter af kosmetik	Omtrent 100 DKK/kg, sammelignet med ca. 50 DKK/kg for dimethicone
Isodecyl neopentanoat	60209-82-7	Cyclomethicone	Hårbalsam og "leave-on" produkter. Muligvis også shampooer og cremesæber	Sælges endnu ikke til danske producenter af kosmetik	Omtrent 100 DKK/kg, sammenlignet med ca. 45 DKK/kg for cyclomethicone
Glycol distearat	627-83-8	Cyclomethicone og dimethicone i cremesæber (har ikke helt same egenskaber)	Cremesæber	Har været anvendt i danske produkter i de seneste 2-3 år	Omtrent halv pris af cyclomethicone og dimethicone. (20-25 DKK pr. kg)
Forskelige vegetabilske oliekomponenter - fx. dicaprylyl carbonat	N/A	Dimethicone, cyclomethicone og andre siloxaner (har ikke helt same egenskaber)	Cremer og lotions - har dog ikke samme skumdæmpende effekt, som visse siloxaner har i disse produkter	Findes i produkter på markedet i Danmark	Omtrent samme pris som siloxanerne
Diethylhexyl carbonat	N/A	Cyclopentasiloxan	Lotions og emulsioner	Alternativerne er solgt til producenter, men kan indtil videre ikke findes I produkter solgt I Skandinavien	Lidt mindre end cyclopentasiloxan
Hydrogeneret polydecen**	68037-01-4	Cyclomethicone sammen med paraffinolie	"Leave-on" produkter	Er blevet solgt i Danmark de seneste to år og kan findes i produkter i Danmark	Ikke muligt at estimerer da alternativet ikke direkte erstatter siloxanerne

* Anvendes som alternative til cyclomethicone og paraffin, men kan ikke substituere alle siloxanens egenskaber

N/A : CAS Nr. er ikke oplyst eller fundet - stoffer er ikke fundet i den 1. opdaterede liste med ingredienser anvendt i kosmetiske produkter I EU (INCI 2000)

1 Introduction

1.1 What are siloxanes and silicones?

Siloxanes are compounds in which silicon atoms (Si) are linked via oxygen atoms (O), each silicon atom bearing one or several organic groups. According to the main rules for classification of chemicals (IUPAC) the compounds are designated siloxanes, but most often the term "silicones" are used. When talking about products and materials, "silicones" are nearly always used, and this term will be used here as well. The term "siloxanes" will be used when we talk about single compounds, or when we have a more chemical approach to the subject. In other words: Siloxanes are building blocks for silicone products.

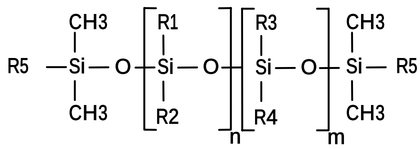
The chemical names of the compounds most often include the string "siloxane", but in particular in cosmetics and toiletries names including methicone are used instead, e.g. dimethicone derived from dimethyl silicone; synonymous with dimethylsiloxane. Another used synonym is poly(oxy(methylsilylene)). To add to the confusion about the terms, several of the compounds recorded in the Danish Product Register, listed in Annex 3, are designated "silicones and siloxanes".

The alternating silicon and oxygen atoms form a backbone structure to which different side chains are linked. The side chains may form cross links which influence the properties of the polymer.

The silicon and oxygen atoms may be linked into cyclic or linear structures, and we distinguish between ***linear siloxanes*** and ***cyclic siloxanes***.

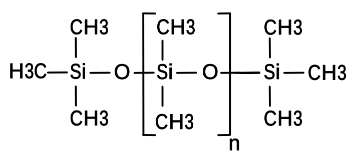
Linear siloxanes

Linear polysiloxanes are characterised by the functional side chains attached to the Si-O backbone and the endgroups terminating the structure (illustrated by R5). The side groups may be the same group or several different side groups may be attached (illustrated by R1-R4).



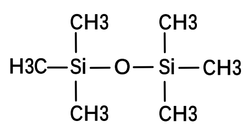
Linear polydimethyl siloxanes are the most important industrial polysiloxanes. In their most simple form they consist of methyl side-chains and methyl terminal groups, polydimethylsiloxane (PDMS).

Polydimethylsiloxane



The shorter linear polysiloxanes are, like some of the cyclic siloxanes mentioned below, volatile. The shortest, hexamethyldisiloxane, is volatile with a boiling point of 100°C, and is used in cos-

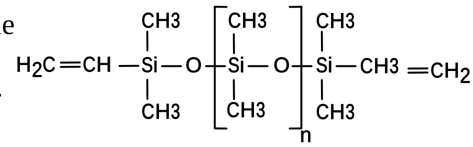
Hexamethyl disiloxane



metics among other applications.

The endgroups determine the use of the polymer. Typical endgroups are methyl, hydroxyl, vinyl or hydrogen. For example are polydimethylsiloxanes typically silicone fluids, whereas vinyl- and hydroxy-terminated polysiloxanes find major application in silicone elastomers.

Vinyl-terminated dimethylsiloxane

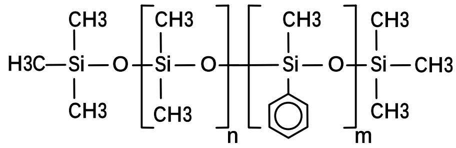


Major functional side groups are vinyl, aminopropyl, polyether, phenyl, trifluoropropyl, phenylethyl tetrachlorophenyl, and alkylene oxide. Hundreds of different compounds exist. In the Danish Product Register about 175 different compounds (CAS no.) are registered as used in products in Denmark.

The side groups determine together with the end-groups the properties of the siloxanes. Phenyl side groups provide e.g. oxidative stability.

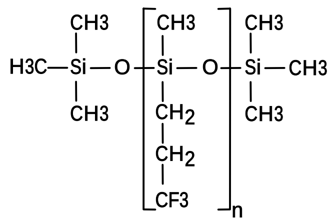
Aminopropyl and polyether side groups provide water solubility, whereas the presence of alkyl groups enhances water repellancy and lubricity.

Polyphenyldimethylsiloxane



The presence of halogens in the side chains produces very stable polymers. Very high resistance to solvents can be obtained by using trifluoropropyl side chains, whereas lubricity at high temperatures is obtained by tetrachlorophenyl side groups.

Polytrifluoropropylmethylsiloxane

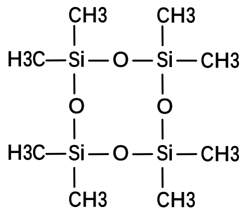


Cyclic siloxanes

Cyclic siloxanes are partly used as intermediates for the production of higher molecular weight linear siloxanes, partly used directly as fluids. In the cyclic siloxanes the Si-O backbone forms a cyclic structure with two substituents attached to each silicium atom.

The main compounds, octamethylcyclotetrasiloxane and decamethyl cyclopentasiloxane are used for a large number of applications. The two compounds are volatile, with boiling points of 176°C and 210°C respectively.

Octamethylcyclotetrasiloxane



The cyclosiloxanes are often designated with reference to the number of silicium atoms: D3 (cyclotrisiloxane), D4 (cyclotetrasiloxane), D5 (cyclopentasiloxane) and D6 (cyclohexasiloxane).

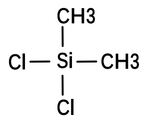
Cyclic siloxanes with other functional groups, e.g. methylphenylcyclosiloxanes, are used for fewer applications. Among other applications, cyclic methylsiloxanes are widely used in cosmetic products, in which cyclic siloxanes or mixtures of the compounds are known under the name "cyclomethicone". According to the 2000 version of the INCI list (Annex 1) cyclomethicone is synonymous with octamethyltetrasiloxane. Producers, however, use the term more widely, e.g. the UK producer Basildon Chemicals has four types of cyclomethicone, either as pure D4 or D5 or as different mixtures of D4, D5 and D6 (http://www.baschem.co.uk/downloads/cy56.pdf).

Silanes
Silanes are used as precursors in the production of siloxanes and are used as cross-linking agents for formation of silicone elastomers and resins (described later in this section).

Silanes are silicon compounds, both organic and inorganic. The siloxanes are actually one of five subgroups of silanes, but often the term "silanes" is used for designating the other groups. The other groups are those containing Si–H bonds (hydride functional silanes), Si–X (halosilanes), Si–C (organosilanes), and Si–OR (silicon esters).

Both linear and cyclic polysiloxanes are generally produced by reacting organodichlorosilanes with water (Ullmann 2003). Besides their use in production processes, organodichlorosilanes may also be present in products for polymerisation of silicones by the users.

Dichlorodimethylsilane

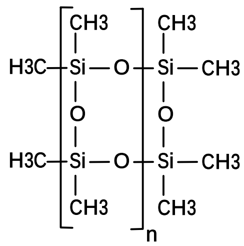


Silsesquioxanes
The silsesquioxanes are a subgroup of the siloxanes. The term silsesquioxanes denotes a polymer in which the ratio of silicon and oxygen in each moiety (sequence) is 1.5 (latin: ***sesqui***). Many commercial silicones include silsesquioxanes.

The polysilsesquioxanes are highly branched polymers and difficult to describe. In their most simple form they can be described by a ladder structure, more complex structures are designated "cage structures" and "random structures".

They are mainly used for silicon resins, in particular for paints and coatings.

Polymethyl silsesquioxane



Fluids, elastomers and resins
Silicones can be classified into three types depending on the length of the backbone, the extent of crosslinking and the type and number of organic groups attached to the silicon atoms:

- Fluids;
- Elastomers;
- Resins.

Silicone fluids
Silicones generally increase in viscosity with increasing chain length. In silicone fluids, the number of dimethylsiloxane moieties (indicated by the "n" in the chemical formulae) is up to 4000 (Ullmann 2003).

Silicone fluids are distinguished from common organic fluids by a number of unique properties (Ullmann 2003):

- Good thermal stability (150-200°C);
- Good low-temperature performance (<-70°C);
- Strong hydrophobicity;
- Excellent release properties;
- Antifriction and lubricating properties;
- Pronounced surface activity;
- Good dielectric properties;
- Very good damping behaviour;
- Good radiation resistance;
- High solubility of gases;
- Physiological inertness;
- Low temperature dependence of physical properties.

Because of these properties silicone fluids are widely applied as release agents for moulding operations, medical and cosmetic applications, polishes, coolants and dielectric fluids for electrical systems, metal processing fluids and agents for foam control.

The silicone fluid may be formulated into emulsions, dispersions, greases and compounds.

Silicone elastomers
Silicone elastomers, or silicone rubbers, are formed from fluid siloxanes by the formation of cross links between the linear polymers by use of cross-linking agents. The process is designated "curing" or "vulcanization".

In general is distinguished between four main systems:

- One component RTV (room temperature vulcanizing) elastomers;
- Two component RTV elastomers;
- HTV (high temperature vulcanizing) elastomers;
- LSR (liquid silicone rubber) elastomers.

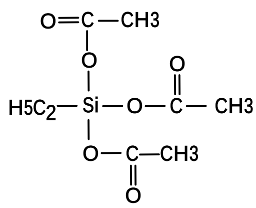
Different cross-linking agents are used depending on temperature and other conditions for the curing process. The marketed products, e.g. silicone sealants, thus both contain the siloxanes and cross-linking agents.

The principle is here illustrated by the release of compounds when one-component room-temperature-vulcanising (RTV) silicone sealants are applied. The products are widely applied by both private and professional users.

Curing of one-component RTV silicones starts when the compounds are exposed to atmospheric moisture during application. The cross-linking agents are tri- or tetrafunctional silanes containing hydrolyseable Si-O or Si-N bonds.

Depending on the used cross-linking agent different compounds are formed as cleavage product and will be released during the curing process (see Table 1.1)

Ethyltriacetoxysilane



Well known is the smell of acetic acid, when silicone sealants with ethyltriacetoxysilane as cross-linking agent are applied. The acetic acid is formed by the curing process.

Table 1.1
Crosslinking agents and cleavage products for curing of silicone elastomers (based on Ullmann 2003)

Cross-linking agent	Cleavage product
Alkoxysilanes	Alcohols
Methyl- or ethyltriacetoxysilane	Acetic acid
Tris(cyclohexylamino)methylsilane and others	Amines
Methyl(tributanone oximo)silane	Butanonoxime
Benzamide silanes	N-butylbenzamide and ethanol

Silicone elastomers are characterised by excellent electrical insulating properties, inertness, low toxicity and resistance to ozone, weathering, oil and moisture. Some grades have the ability to perform at very low temperatures, whereas others retain elastomeric properties at very high temperatures.

Unfilled silicone elastomers achieve only low mechanical strength when cured. Adequate strength is obtained by incorporating reinforcing fillers. Small-particle-size, silicas are used almost exclusively for this purpose. Because of the small particle size elastomers with high transparency can be produced.

The major application of silicone elastomers is as sealant, but they are also widely used for other applications like electrical fittings, textile coating, paints and rubbers for automotive, medical and dental purposes.

Silicone resins

Whereas silicone fluids and elastomers are based on cyclic or linear polymers, silicone resins are highly branched polymers. Compared to the fluids and elastomers, the market of silicone resins is limited.

The major market for silicone resins is surface coatings, mainly water-repellant coatings for masonry and high-performance paints. For these purposes the silicone resin is often reacted with other polymers to form copolymers. Silicone/alkyd and silicone/polyester are the most frequently used.

1.2 International market

Globally the consumption of siloxanes totals about 0.85 million tonnes (Will et al 2003). The main producer countries are the USA, Germany, Japan, France and the UK. The American producer DOW Corning Corporation is by far the largest producer of the World with production facilities in many countries. In Western Europe Wacker Group (Germany), Degussa AG (Germany) and Rhodia S.A. (France) are main producers.

The total consumption of silicones in Western Europe is according to Will et al. about 296,000 t. The breakdown by application is shown in Table 1.2. The consumption breakdown is by the authors of the report designated "somewhat tentative", but is considered to provide a general view of the market.

In this report the breakdown of the Western European consumption will be used as basis for a first rough estimate on the use of silicones in Denmark if nothing more specific is known. Denmark accounts for 1.2% of the W. European population, but for 1.4% of the total industry-related GDP (Gross Domestic Product). For the first estimate the per-capita ratio of 1.2% will be used. For most consumer products and products used in the building industry the consumption pattern of siloxanes in Denmark is most probably not very different from the common W. European market. Differently, the consumption of siloxanes in industrial processes will be very dependent on the extent to which the industrial processes, in which siloxanes are used as processing aids, take place in Denmark. The actual consumption may thus be quite different from the common W. European use pattern.

The information on the W. European market will be combined with information about siloxanes registered in the Danish Product Register and information obtained from providers and users of silicones in Denmark.

Table 1.2
Consumption of silicones in Western Europe in 2002 (Will et al. 2003)

Silicone category	Applications	Consumption	
		1000 t	%
Fluids	Processing aids	40	14
	Surfactants for PUR foam production	*25*	*8*
	Primary polymer production aids and various defoamer uses	*15*	*5*
	Textile applications	28.4	10
	Softeners	*22*	*7*
	Defoamers/antifoaming agents	*4*	*1.4*
	Water repellents	*1.2*	*0.4*
	Other	*1.2*	*0.4*
	Cosmetics, toiletries and medical/pharmaceutical preparations	25	8
	Emollients, moisturizers, hair conditioning polymers	*19*	*6*
	Medicals/pharmaceuticals	*4*	*1.4*
	Other	*2*	*0.7*
	Papercoatings and defoamers (mainly backing for self-adhesives)	17.5	6
	Thermal curing, mainly for paper backing	*12.2*	*4*
	UV curing mainly for foils backing	*3.2*	*1.1*
	EB (electron beam) curing, mainly for foils backing	*2.1*	*0.7*
	Paints, coatings and waxes	11	4
	Mechnical fluids (hydraulic fluids and lubri-cants/greases)	9	3
	Other	26	9
Subtotal		156.9	53
Elastomers	General-purpose sealants (construction)	78	26
	Special-purpose sealants and rubber	43	15
	Automotive	*11*	*4*
	Electrical fittings	*7*	*2.4*
	Medical/health	*5*	*1.7*
	Domestic appliances	*4*	*1.4*
	Consumer goods	*4*	*1.4*
	Textile coating	*3*	*1.0*
	Business machines	*2*	*0.7*
	Paints and coatings	*2*	*0.7*
	Mouldmaking	*2*	*0.7*
	Other	*3*	*1.0*
Subtotal		121	41
Resins	All applications	18	6
Grand total		295.9	100

2 Application of silicones in Denmark

2.1 Raw materials production, import and export

The statistics from Statistics Denmark (Danmarks Statistik) hold information on one commodity only for which it is explicitly stated that the commodity includes siloxanes or silicones.

Import, export and production of unprocessed silicones for the years 1998-2001 are shown in Table 2.1. The main part of unprocessed silicones is sealants packed in Denmark. As silixanes only account for a part of the sealants, the amount of silicones will be less than indicated.

Table 2.1
Import,export and production of unprocessed silicones (Statistics Denmark 1988-2002)

Year	Import tonnes	Export tonnes	Produktion in DK tonnes	Supply * tonnes
1998	2,445	875	11	1,581
1999	1,998	526.6	14	1,486
2000	1,783	483.2	11.5	1,311
2001	1,765	577.6	12.4	1,200

* supply = import + production - export

2.2 Fields of application

2.2.1 Data from the Danish Product Register

A list of siloxanes and siloxane-containing substances registered in PROBAS, the database of the Danish Product Register was retrieved. The retrieval comprises substances with chemical names including the text strings 'silox', 'silicone', 'methicon' or 'silsesquio'.

For each substance the total content of the substance in imported and exported products as well as in products produced in Denmark by application areas and branch was retrieved. The application areas registered in PROBAS are, however, not fully identical with the application areas defined in this study, and the data from PROBAS is only to some extent immediately applicable. In addition, only a part of the siloxanes in products is registered. Companies only have the obligation to submit information on the turnover of products to PROBAS, if the products contain substances classified dangerous (Bek. 439, 2002). Siloxanes are generally not classified dangerous. If the products contain dangerous substances, however, all constituents of the products are registered. The retrieval thus includes siloxanes in products in which other substances are classified dangerous.

In total 175 siloxanes or siloxanes-containing substances are registered as used in Denmark. The substances are listed in Annex 3. The total import, production and export of siloxanes registered in the Danish Product Register by application area is shown in Table 2.2. The total content of siloxanes in registered, imported products is 1,269-1,483 t in 78,000-90,500 t of products. The total content of registered products produced in Denmark is 162-1,143 t in 45,000-293,000 t of products. The data demonstrate the widespread use of siloxanes at low concentration in a very large product volume.

It should be noted that the supply calculated as import + production - export is only indicative. Siloxanes imported for production often will be registered in two different categories for import and production, respectively, e.g. imported emollients may be used for production of paints.

Table 2.2
The total import, production and export of siloxanes registered in the Danish Product Register by application area

	Import tonnes		Production tonnes		Export tonnes		Supply * tonnes		
	min	max	min	max	min	max	min	max	%
Sealant, padding materials	435	562	28	184	30	131	433	615	32
Softeners, viscosity changing agents	357	357	2	2	2	2	357	357	22
Paint, lacquers and varnishes	40	78	28	757	25	499	43	336	12
Adhesives, binding agents	63	73	15	32	4	6	74	98	5
Anti-foaming agents	85	85	0	0	0	0	85	85	5
Plastics	26	26	20	47	3	17	43	56	3
Cleaning agents, maintenance agents, etc.	43	50	4	6	1	3	47	54	3
Textile impregnation agents	50	50	0	0	0	0	50	50	3
Lubricant, cutting fluids, hydraulic fluids	34	34	2	2	0	0	35	36	2
Anti-adhesives	23	25	2	2	0	0	25	27	2
Packing, bearing linings, insulation material, etc.	10	13	47	54	38	42	20	25	1
Cosmetics, soap, etc.	0	3	0	0	0	0	0	3	0.1
Other	101	126	18	34	1	5	118	155	8
Total	1,269	1,483	168	1,121	105	707	1,331	1,897	

* Supply = import + production - export

** Calculated from the non-rounded data

The substances which are registered with the largest volumes in imported products and products produced in Denmark are shown in Table 2.3. One substance is excluded for reasons of confidentiality. For most of the substances a large number of application areas and branches are registered, and the retrieval demonstrates that many of the siloxanes are used for a large range of different applications.

Table 2.3
Content of the 20 most used siloxanes in imported and produced products as recorded in the Danish Product Register.

CAS No.	Name	Import average tonnes	Production average tonnes	No of prod.	Main application areas according to the Product Register (import)
68937-55-3	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHOXYLATED, PROPOXYLATED	312	38	133	Softeners (emollients) Adhesives (binding agents) Raw materials for synthesis
63148-53-8	SILOXANES AND SILICONES	301	3	658	Plastic construction materials
63148-62-9	POLY(DIMETHYLSILOXAN)	147	136	2385	Sealants Anti-setoff agents Paint, lacquers and varnishes Anti-foaming agents
70131-67-8	SILOXANES AND SILICONES, DI-ME, HYDROXY-TERMINATED	75	6	174	Sealants Padding materials Paint, lacquers and varnishes
68083-19-2	SILOXANES AND SILICONES, DI-ME, VINYL GROUP-TERMINATED	36	0	14	Putty
63148-57-2	SILOXANES AND SILICONES, ME HYDROGEN	52	0	67	Textile impregnation agents Filling materials
156012-96-3	SILOXANES AND SILICONES, DI-ME, 3-(4-HYDROXY-3-METHOXYPHENYL)PROPYL ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE GLYCOL MONO-ME ETHER	44	0	5	Confidential
541-02-6	CYCLOPENTASILOXANE, DECAMETHYL-	37	0	70	Confidential Car wax
9006-65-9	SILICONE OIL (DIMETHICONE)	21	195	458	Paint, lacquers and varnishes Resins for 1- and 2-comp. hardening adhesives Anti-setoff agents
556-67-2	CYCLOTETRASILOXANE, OCTAMETHYL	35	0	160	Confidential Polishing agent
68037-77-4	SILOXANES AND SILICONES, ET ME, ME 2-PHENYLPROPYL	24	1	58	Anti-foaming agents, foam-reducing agents Paint, lacquers and varnishes Surface-active agents
67762-90-7	POLY(DIMETHYLSILOXANE), REACTION PRODUCTS WITH SILICA	23	109	861	Primer Paint, lacquers and varnishes Plastic construction materials Other binding agents
128192-17-6	SILOXANES AND SILICONES DI-ME, 3-HYDROXYPROPYL ME, 3-HYDROXYPROPYL GROUP-TERMINATED, ETHOXYLATED PROPOXYLATED	19	0	31	Binding agents
68554-65-4	SILOXANES AND SILICONES, DI-ME, POLYMERS WITH ME SILSESQUIOXANES AND POLYETHYLENE- POLYPROPYLENE GLYCOL BU ETHER	12	0	147	Confidential Padding materials Paint, lacquers and varnishes
130328-16-4	SILOXANES AND SILICONES, DI-ME, POLYMERS WITH PH SILSESQUIOXANES, ME- AND METHOXY-TERMINATED, REACTION PRODUCTS WIHT ETHYLENE GLYCOL AND TRIMETHYLOLPROPANE	9	0	8	Confidential
109961-41-3	SILOXANES AND SILICONES, DI-ME, POLYMERS WITH PH SILSESQUIOXANES, HYDROXY-TERMINATED	9	0	3	Confidential
68937-54-2	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHOXYLATED	7	5	179	Confidential
67762-85-0	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE-POLYPOLENE GLYCOL ME ETHER	8	16	721	Anti-foaming agents Pigments Confidential Paint, lacquers and varnishes

CAS No.	Name	Import average tonnes	Production average tonnes	No of prod.	Main application areas according to the Product Register (import)
134180-76-0	OXIRANE, METHYL-, POLYMER WITH OXIRANE, MONO(3-(1,3,3,3-TETRAMETHYL-1-((TRIMETHYLSILYL)OXY)DISILOXANYL)PROPYL) ETHER	6	0	12	No information on main use Lacquers
69430-24-6	CYCLIC DIMETHYLSILOXANES	5	0	217	Car wax Padding materials Anti-foaming agents

Notes: Volumes refer to the total content of siloxanes in products imported to or produced in Denmark. DI-ME = Dimethyl ; ET=Ethyl ; ME= Methyl, PH=Phenyl.
No. Products = Number of registered products

2.2.2 Sealants used for construction

Silicone elastomers are widely used for sealants and rubbers. The different types of elastomers have been discussed in section 1.1.

Siloxane-based sealants can be organised into two main groups:

- One-component RTV silicones mainly used in the construction industry for sealants around windows and doors, in bathrooms, expansion joints between dissimilar materials, etc.

- Two-components RTV silicones mainly used for sealing of electronic components and sealed glazing units.

Besides the pure silicone sealants, a number of different hybrid sealants in which the siloxanes are blended with other polymers like polyurethanes, acrylics and isobutylene exist. In some of the sealants the siloxanes only account for a small part of the product.

Typical one-component RTV silicone sealants consist of the following components (Krogh 1999):

- 60-80 % siloxane;
- 5-7% cross-linking agent
- 20-30 % $CaCO_2$ filler;
- 1-6% silica filler;
- 5-20 % drying agents (siccatives);
- 0.05-0.1% organotin catalyst.

The cross-linking agents are tri- or tetrafunctional silanes containing hydrolysable Si-O or Si-N bonds. Most of the cross-linking agents react either spontaneously with the SiOH groups of the siloxane or with water. Curing of one-component RTV silicones starts when the compounds are exposed to atmospheric moisture during application. Depending on the used cross-linking agent different compounds are formed as cleavage product and will be released during the curing process (see section 1.1).

Tin catalysts are generally added to these systems to give complete curing and improve the properties.

In two-component RTV silicones, tetrafunctional alkoxysilanes are generally used as cross-linking agents in combination with tin catalysts (Ullmann 2003).

Consumption
In Western Europe 75-80% of silicones sealants are used in building and construction applications (Will et al. 2003). Based on Will et al. (2003), the total consumption of silicones for general purpose sealants in Denmark (building and construction) can be estimated at 920 t/year.

The knowledge center "Fugebranchens Samarbejds- og Oplysningsråd" does not hold any statistics on the consumption of silicone sealants in Denmark but estimates that the consumption pattern in Denmark is similar to the general Western European pattern. It is estimated by the organization that more than half of the traded elastomers are used for construction and glassing.

Imported products, recorded in the Product Register, contain in total 435-560 t silicones, whereas the content of produced products amounts to 170-1,120 t.

Siloxanes used
The Danish Product Register includes 53 different siloxanes (CAS no) registered as used in sealants. The non-confidential compounds are listed in Annex 5. The most used are polydimethyl siloxanes, vinyl group-terminated and hydroxy-terminated dimethyl siloxanes. More than half of the total volume is registered as "silicones and siloxanes" without more specific information of the siloxanes used.

For production in Denmark 0-130 t of dimethicone and 11-35 t siloxane polymers with silsesquioxanes are registered.

According to the knowledge center "Fugebranchens Samarbejds- og Oplysningsråd" silicones with acetic acid as cleavage products were formerly the most used, but they are to a large extent replaced by silicones with oxime and alcohol cleavage products.

Fate of the siloxanes
Sealants used for construction will after use most often be disposed of for incineration. Sealants adhered to non-combustive materials, e.g. applied between concrete elements or in bathrooms, may be disposed of to landfill or recycled together with the construction materials.

By the application of the sealants different volatile compounds will be released as mentioned above, whereas the release of siloxanes seems to be insignificant. Surplus sealant will mainly be disposed of to incineration.

2.2.3 Paints, inks and coatings

Siloxanes are widely used for paints and coatings.

The main application areas are:

- Coatings on masonry (silicone resins);
- High-performance paints;
- Antifouling paints;

- Defoamers, flow control agents and levelling agents in water-based paints.

Silicones are used as water repellents on mineral-based products like masonry, concrete and tiles for both interior and outdoor applications. The silicones can be applied as neat materials, in solvents or as water-based emulsions. Other silanes are used for this application area as well.

Siloxanes resins are used in high-performance paints to modify paints based on polyester, alkyd, epoxy and acrylic e.g. for anticorrosion. Silicones are used in high-temperature resistant coatings for exhaust pipes and stoves, household appliances and industrial applications.

A growing application area of silicones is antifouling paints used as alternative to TBT-containing paints. The silicone coating form a surface to which it is difficult for the fouling organisms to adhere.

Silicone liquids are widely used at low concentration in water-based paints in which the siloxanes improve the flow properties of the coating, eliminating wetting problems and thinning the coating edge.

Besides, silicones are used in small volumes in inks and dyes.

Consumption

Based on Will et al. 2003, the total consumption of silicone fluids for paint, coating and waxes can be estimated at 130 t/year. The consumption is growing by about 1.5% annually in W. Europe. Besides, water repellant coating and paints account for the major part of the consumption of silicone resins which can be estimated at 210 t/year. Roughly estimated some 300 t in total may be used for paints, inks and coatings. This figure represents the amount of siloxanes in products used in Denmark. The use of siloxanes for production of paints in Denmark has not been investigated.

According to the Product Register the total volume of siloxanes in imported products (46 product types) was 40-78 in 12,000-21,000 t of products. The total volume in produced and exported products was 7-426 t and 5-244 t respectively. Most of the products are registered as paint and lacquer without further specifications. As many water-based paints are not registered, the total volume in paints may be significantly higher.

The data from the Product Register demonstrates that the siloxanes are used in low concentration in a very large volume of products.

Siloxanes used

Paints and coatings are the main application areas for silicone resins. According to the Product Register retrieval some of the main substances used for this field are polydimethyl siloxanes with silsesquioxanes (siloxanes with a Si/O ratio of 1.5) which form highly branched polymers.

Besides the compounds with silsesquioxanes, polydimethyl siloxanes are registered as the most used siloxanes for this application area.

Silicones with side groups containing among others polyethylene and polypropylene glycol butyl ethers are used at low concentrations (<1%) in many waterborne paintings, in which the siloxanes are used as defoamers, flow control agents and levelling agents.

Fate of the siloxanes

The major part of the siloxanes will be disposed of to incineration or landfills with the products to which the paint or surface coating is adhered.

A few per cent of the siloxanes in waterborne paints may end up in the sewage system by washing of brushes and paint pots. Besides, a minor part may be diffusively released to the surrounding by maintenance of painted surfaces.

2.2.4 Cosmetics and toiletries

Silicone fluids are widely used in cosmetics and toiletries for:

- Hair care products (mainly conditioners and hair styling products, but siloxanes may also be used in shampoos and colours);
- Antiperspirants and deodorants (mainly in stick deodorants, but siloxanes may also be used in aerosols, creams, gels and roll-ons);
- Skin care products (body care, facial care and sunscreen products);
- Shaving products (pre-shave and after-shave lotion and shaving foam);
- Decorative and colour cosmetic products (eye makeup, foundations, lipsticks and powder);
- Liquid soap and shower gels.

The major use is in hair-care products and antiperspirants.

About 200 siloxanes and siloxane derivatives are listed in the inventory of ingredients used in cosmetic products compiled by the European Commission (INCI 2000) (see Annex 1). The siloxanes and derivatives function in the cosmetics as emollients, antifoaming agents, viscosity-controlling agents, antistatic agents, binders, film formers, surfactants, emulsifying agents, humectants, antioxidants and additives.

According to a leading producer of silicones the primary benefits for incorpation of different siloxanes into hair-styling products are as follows (Berthiaume 1995):

Silicone glycol copolymers:	Resin plasticizer, detackifing agent
Volatile silicones:	Reduced tack, reduced drying time, transitory shine
Dimethicone:	Softness, resin plasticizer, humidity resistance, shine
Phenyl modified silicones:	Shine, detackifying agent, humidity resistance
Aminofunctional silicones:	Conditioning, softness
Alkyl modified silicones:	Body/volume, softness
Curable fluids:	Set retention, possible conditioning
Silsesquioxane resins:	Body/volume, set retention
Siloxysilicate resins:	Body/volume, set retention

Besides their technical properties, the siloxanes are used in the products, because they are generally nonsticky, nonoily, nonirritating, do not make marks on clothing and have a relatively low toxicity.

Consumption

Based on Will et al. 2003, the total consumption of silicones for cosmetics and toiletries in Denmark can be estimated at 240 t/year. The consumption is growing by about 2% annually in both Europe and the USA.

For the American market it is specified that 60% of the silicones used for cosmetics, toiletries and pharmaceutical preparations is used in hair, skin and other personal care products, whereas 32% is used in stick antiperspirants (Will et al. 2003).

The Danish branch organization for cosmetics and toiletries, SPT, has no specific information regarding the consumption of siloxanes in cosmetic products made in Denmark. It is however believed that the total consumption of cyclomethicone, which is one of the most used siloxanes in the cosmetic industry, is approximately 5 - 6 t/year in cosmetic products produced in Denmark. The typical content of siloxanes in the products is below 2 % of the final cosmetic product, but the content can according to SPT vary between 0.5-40%, depending on the products in which the siloxanes are used.

According to one of the suppliers of silicones, the siloxanes are more widely used in cosmetic products produced by the large international companies, whereas there has been a tendency to avoid the substances in the cosmetic products made in Scandinavia.

Siloxanes used

In a Danish survey of 328 hair-styling products in 2001, 25 different siloxanes were identified as ingredients (Annex 2). Hair-styling products are used for styling of the hair and do not include shampoos and conditioners. The most common siloxanes were dimethicone copolyol (82 products out of 328), cyclomethicone (24), dimethicone (21), phenyl trimethicone (18), amodimethicone (16), cyclopentasiloxane (15), and dimethiconol (12). About half of the found silicones were at the time of the reporting of the survey not included in the INCI list.

Shampoos, conditioners and stick deodorants are the main cosmetic products in which siloxanes are used. The presence of some of the same siloxanes mentioned above in stick deodorants, shampoos and conditioners on the Danish market has been confirmed by a short survey of products carried out as part of this project.

Volatile cyclosiloxanes (mainly octamethylcyclotetrasiloxane and decamethylcyclopentasiloxane) are used in many stick deodorant and antiperspirant products. Mixtures of the compounds are in cosmetics designated 'cyclomethicones', but in some cases the term 'cyclomethicone' is also used for pure octamethylcyclotetrasiloxane (D4) or decamethylcyclopentasiloxane (D5). According to Will et al. the use has shifted from D4 towards D5 because of their supposed minor toxicity.

The Danish EPA has a database in which the content of chemicals in 766 cosmetic products on the Danish market is registered. Cyclomethicone is present in 64 of the 766 products within the product groups: suntan lotions, body lotions, hair-styling products, creams, lipsticks, children's makeup and deodorants (Pedersen 2004).

According to Will et al. 2003, polydimethylsiloxanes, either linear or cyclic are the most widely used silicones in skin-care products. According to producer web-sites (e.g. Basildon Chemicals, UK) the same siloxanes used in hair-care products may also be used for skin care.

Cosmetic products are in general not notified to the Product Register, and the database retrieval only revealed a few siloxanes used for this application area. The most common was dimethicone, polydimethyl siloxane, poly(oxy(dimethylsilylene)) and 3-hydroxypropyl methyl etoxylated dimethylsiloxanes/silicones.

According to Allan et al. (1997) 20,000 t volatile siloxanes was used in the USA for personal care applications in 1993. If it is assumed that the per capita consumption is the same in Denmark, the consumption of volatile siloxanes for this application area would be about 300 t. However, most probably it is lower.

Based on the present information it is not possible to split the total consumption on siloxanes of the different compounds, but the available information indicates a significant consumption of both volatile and non-volatile siloxanes.

Fate of the siloxanes

The non-volatile siloxanes used for this application area will mainly be discharged with wastewater and may constitute a major part of the sources of siloxanes in wastewater.

The volatile cyclosiloxanes used in cosmetic products are meant to evaporate during use and will mainly be emitted to the air. Based on American experience 92% of the volatile siloxanes should be emitted to the air (Allan et al. 1997).

2.2.5 Cleaning agents and maintenance agents

Silicone fluids are widely used in polishes and waxes for paints (e.g. car wax), rubber, plastics, silverware, leather products, etc. Silicones improve the ease of application of the wax and polish, provide water repellence and produce a quick shine.

Besides, siloxanes are used in smaller amounts in different types of cleaning agents and in softeners for laundry.

Consumption

According to the data from the Danish Product Register the total content in cleaning and maintenance products on the market amounts to approx. 47 t/year (Table 2.4). The main registered application areas are in polishes and waxes. However, only a part of the products may be registered in the Product Register, and the actual consumption may be significantly higher, e.g. as defoamers in different cleaning agents. The total amount of siloxanes as defoaming agents registered in the Product Register is 85 t, but it is not specified in which products the defoaming agents are used.

The market report by Will et al. (2003) does not specifically provide information on the W. European consumption of silicones for waxes and polishes, but paint, coatings and waxes in total are estimated at 130 t/year. If data for the U.S. market is applied on a per capita basis, the consumption with polishes and coatings would be approx. 170 t/year.

Based on the available data the consumption of siloxanes with cleaning agents and maintenance agents is roughly estimated at 100 t/year.

Table 2.4
Content of siloxanes in imported, produced and exported cleaning agents and maintenance agents according to the Danish Product Register

Application area	Siloxanes in registered products (t/year)			Average content in imported products %	Number of products
	Import average	Production average	Export average		
Polishing agents	16.7	0.3	0.0	6	72
Polishing agents for lacquers (car wax)	8.9	0.2	0.3	2	189
Polishing agents for plastic materials	6.6	1.0	0.2	7	74
Water softeners	4.7	1.4	0.0	25	34
Polishing agents for rubber materials	3.6	0.3	0.0	14	33
Cleaning/washing agents	3.2	0.6	0.4	1	83
Spot removers	0.6	0.0	0.0	5	7
Wax and other polishing preparations for floors	0.6	0.1	0.0	1	11
Other	1.8	1.7	1.0	1	147
Total	46.8	5.4	2.0	2.7	650

Siloxanes used

The Product Register holds information on 55 different compounds registered as used within this application area. The non-confidential compounds are listed in Annex 5.

According to the data from the Product Register the main compound is poly(dimethylsiloxane). This name may partly be used synonymously with many derivatives of dimethylsiloxane by the companies when notifying on the content of the products, if the exact siloxane compound is not known.

Polydimethylsiloxanes with aminofunctional groups are widely used for this application area (Will et al. 2003). The presence of aminoethyl and aminopropyl groups increases the water solubility and forms a bridge to organic substances in the product. The aminofunctional silicone fluids were developed to impart durability and detergent resistance through bonding to the paint film. Twelve different siloxanes with aminofunctional groups are registered in the Product Register for use within this application area. The total registered consumption of these compounds is approx. 10 t/year.

Volatile cyclic dimethylsiloxanes are also widely used for polishes and waxes. In a recent Danish study of car polishes, hexamethylcyclotrisiloxane was released to the air from three out of 10 investigated products, whereas decamethylcyclopentasiloxane was released from 2 products. In the Danish Product Register 33 different products including cyclic dimethylsiloxanes (CAS no. 69430-24-6) are registered. The exact chemical compounds are not indicated, but the products most probably contain a mixture of different cyclic dimethylsiloxanes. The total registered consumption of these compounds is approx. 2 t/year.

Fate of the siloxanes
The major part of the siloxanes will, either by the application or later by washing of the products on which the polish is applied, be released to wastewater or to the ground.

A minor part of the siloxanes (e.g. the cyclic dimethylsiloxanes) may be released to the air by the application.

2.2.6 Mechanical fluids and heat transfer fluids

Silicones fluids are widely applied for the following applications:

- Lubricants and grease;
- Lubricating fluids for metal processing;
- Hydraulic fluids;
- Heat transfer fluids;
- Dielectric fluids (mainly dielectric fluids for fire-resistant transformers).

The siloxanes may be formulated into grease (with filler material) or emulsions (mixed with water). For many applications the siloxanes only account for a few per cent of the products.

Silicone fluids and greases are widely used in the automotive and the aircraft industries - from hydraulic damping and brake fluids to lubricate bearings, locks, linkages, instruments, etc. Silicone fluids and greases are generally applied when high temperatures, solvents or corrosive materials would destroy petroleum-based lubricants. (Will et al. 2003)

Consumption
Based on Will et al. 2003, the total consumption of silicones for mechanical fluids can be estimated at 110 t/year. In the market report, however, this includes also antifoaming agents and water repellants for textiles.

Products within this application area are to a large extent registered in the Danish Product Register. According to the database retrieval, the total consumption of siloxanes with these products was about 35 tonnes, the main part used in lubricants. The data only indicate a minor consumption of siloxanes with metal-working fluids, but a large part of the siloxane-containing fluids for this application may not be included in the register.

Siloxanes used
For all applications mentioned in Table 2.5, poly(dimethylsiloxane) is the main substance used according to the Product Register. It is, however, doubtful to what extent this name is used synonymously with all derivatives of dimethylsiloxane in the absence of exact knowledge on the siloxanes compound, when the companies are notifying on the content of the products.

According to Will et al. (2003) phenyl methyl siloxanes and fluorosiloxanes are more widely used for these application areas than the simple dimethylsiloxane fluids.

Fate of the siloxanes
Siloxanes used for this application area are mainly disposed of as chemical waste. For some applications direct releases to soil and discharges to wastewater may occur.

Table 2.5
Siloxanes in imported, exported and produced mechanical fluids and heat transfer fluids according to the Product Register 2003

Application area	Siloxanes in registered products (t/year)			Average	Number of
	Import average	Production average	Export average	Concentration in import (%)	products
Lubricants (see also cutting oils)	15	0.4	0.07	12	34
Other grease fat and grease oils	7	0	0.05	35	12
Hydraulic fluids (hydraulic oils, transmission media, brake fluids)	6	0	0	41	8
Other lubricants	4	1.3	0.12	0.3	11
Heat transferring agents	2	0	0	88	4
Friction-reducing additives	0.18	0	0	3	8
Cutting fluids (for metal treatment) (see also lubricants)	0.08	0	0	0.0	64
Other fluids for removing metal	0.03	0	0	0.1	4
Engine oils	0.02	0	0	0.1	3
Other cutting fluids	0.01	0.02	0	0.02	5
Brake grease	..	..	..	3	2
Total	34	1.7	0.2	2	

Note: .. confidential

2.2.7 Textile applications

The main uses of silicones for textile applications are as follows:

- Softeners;
- Defoamers/antifoaming agents;
- Water repellants (liquids);
- Coatings (elastomers);
- Dry cleaning and laundry care.

The main application of the silicone fluids are as softening agent particularly in cotton and polyester/cotton substrates. They are used as emulsions or additives to other softeners.

Consumption
Based on Will et al. 2003 the total consumption of silicone fluids for the application area can be estimated at 340 t/year, broken down into 260 t in softeners, 50 t in defoamers/antifoaming agents 10 t in water repellants and 10 t other. The consumption of silicone elastomers for textile applications can - based on the same source - be estimated at 40 t/year.

In the Product Register a total of 50 t is registered in imported "textile impregnation products", whereas the content of produced and exported products were 0.3 and 0.2 t respectively. Siloxanes present in imported textiles will not be registered in the Product Register.

Siloxanes used
According to the Product Register retrieval the main compound used for textile impregnation is polymethylhydrosiloxane (methyl and hydrogen side groups). According to Will et al. 2003 primarily organo-modified silicone fluids are used as softeners in textiles.

Fate of the siloxanes
The siloxanes fluids used as softeners in the textiles will form a part of the final textile product and will to some extent be washed out by laundry ending up in the wastewater. In the technical data sheet for a new hydrophilic siloxane textile softener, DOW Corning states that traditional hydrophobic aminofunctional silicones lose their softening performance after 1-2 wash cycles (http://www.dowcorning.com/DataFiles/090007b5801286cb.pdf). It is not mentioned whether the silicones lose their softening performance because they are washed out.

It has not been possible to identify studies on the fate of siloxanes in textiles.

2.2.8 Process control and plastic additives

Siloxanes are widely used for process control and as plastic additives:

- Surfactant (surface-active agent) in the manufacturing of polyurethane (PUR) foams;

- Antifoaming agent in the manufacturing and processing of products in a range of industries (food industry, pharmaceutical industry, chemical industry, etc.);

- Plastic additive (e.g. flame retardant, smoke suppressant and for providing a smooth surface);

- Release agent for plastics extrusion and moulding operations.

Silicone used as antifoams in textile industry is included in section 2.2.7.

The main application within this area is as surfactant used for manufacturing of polyurethane foams. The silicones add stability to the liquid foaming mixture so that collapse of bubbles is retarded, and flowability is increased.

Consumption
Based on Will et al. 2003 the total consumption as surfactants for PUR production can be estimated at 290 t/year, whereas the consumption for other applications can be estimated at 180 t/year. For processing aids, however, the consumption in Denmark may deviate significantly from the general consumption pattern in Europe.

According to the trade organisation Plastindustrien i Danmark, siloxane surfactants are used for production of all PUR products. The siloxane content of the products is approximately 0.75%. In total 35,000-40,000 tonnes PUR was produced in Denmark in 1999, corresponding to 260-300 t siloxanes per year.

Based on the information above the total consumption as processing aid is estimated at 470 t of which the main part is used for PUR production.

Siloxanes used
Siloxanes used as surfactants for PUR production are usually dimethylsiloxanes copolymerised with polyesters. Fifteen compounds are registered in the Product Register as used as surfactants. The most used is "Siloxanes and silicones, di-methyl,3- hydroxypropyl methyl, ethers with polyethylene-polypolene glycol methyl ether" (CAS 67762-85-0).

Fate of the siloxanes

The siloxanes in the PUR products are estimated mainly to be disposed of with municipal solid waste for incineration. A minor part - PUR used in cars - will mainly be disposed of with the fluff from the shredding process.

2.2.9 Health-care applications

Silicones are widely used in the following healthcare applications:

- Dental impression materials (impression moulds primarily used for crown and bridge reconstruction);
- Extrusion and tubing (drainage catheters, urological applications, blood-handling equipment, etc.);
- Baby care (nipples for baby bottles and comforters, breast pumps and infant cup straws);
- Prostetics (e.g. liner and sockets);
- Control of releases of gastrointestinal gases (antiflatulant);
- Moulded parts (drainage accessories, external feeding, laboratory tubing, respiratory masks, drug delivery devices, etc.);
- Breast implants.

Consumption

Based on Will et al. 2003, the total consumption of siloxanes fluids for healthcare applications can be estimated at 50 t/year. The consumption of siloxanes elastomers can - based on the same source - be estimated at 60 t/year. The total consumption for this area is consequently estimated at 110 t/year.

The Danish Product Register will in general not include information on substances in health-care products.

Siloxanes used

Breast implants silicone gel consist mainly of dimethyl polysiloxanes, but low molecular weight siloxanes - both linear and cyclic - are included at low concentrations (IRG 1998). In the discussion of the possible health problems related to the use of silicone breast implants, diffusion of low molecular weight siloxanes plays an important role.

Simethicone (synonymous with polydimethylsiloxane) is stated to be the most commonly used antiflatulent, and acts by dispersing excess gas in the intestine (http://wiz2.pharm.wayne.edu/module/gastromed.html).

For other applications a large number of different siloxanes are applied.

Fate of the siloxanes

The fate of the siloxanes will be very different for the different applications.

As regards human exposure the use of siloxanes in breast implants, baby-care products (e.g. in nipples) and siloxanes used as antiflatulent is of particular importance.

The major part of the siloxanes will be disposed of with municipal solid waste or medical waste for incineration. A minor part, used as antiflatulent, will be released to municipal wastewater.

2.2.10 Paper coating

Silicones are used for paper coating, primaryly to coat release papers, films and foils and as a backing of pressure-sensitive adhesive labels and tapes.

Consumption

Based on Will et al. 2003 the total consumption for paper coating can be estimated at 210 t, broken down into thermal curing paper backing (140 t), UV curing for foil backing (40 t) and electron beam curing mainly for foils backing (20 t).

In the Danish Product Register a total of 9 t siloxanes were registered as surface treatment agents for paper, cardboard, etc.

Siloxanes used

In the Danish Product Register 32 different siloxanes are registered as agents for paper coating. The main siloxanes are poly(dimethylsiloxane) and poly(dimethylsiloxane), reaction products with silica.

Fate of the siloxanes

Siloxanes used in paper coating will be disposed of to municipal solid waste for incineration.

2.2.11 Other uses of silicone elastomers and resins

Other uses of silicone elastomers and resins not covered elsewhere include the following:

- Automotive applications (hard-coat coatings for protecting of polycarbonate windows, mirrors and headlamp lenses, protecting of plastic trim, electronics, airbag coatings, seat belt adhesives);
- Electrical fittings (cable accessories and insulators);
- Domestic appliances (gasketing, electronics, sealing and potting applications in household appliances like owens, irons and refrigerators) ;
- Consumer goods (diving masks and other scuba equipment, protective masks, earplugs, baking tins, consumer products packaging, showerhead membranes, soft-touch products (e.g. pencils), spatulas, etc.);
- Food/packaging (fruit labels, bakery papers, wrappers for candy, chewing gum, meat and frozen food);
- Business machines (small computer keypads);

- Mouldmaking (reproduction of complicated shapes).

Consumption
Based on Will et al. 2003 the total consumption with special purpose sealants can be estimated at 390 t/year, broken down into automotive applications (130 t), electrical fittings (80 t), domestic appliances (50 t), consumer goods inclusive of packaging (50 t), business machines (20 t) and mould-making (20 t).

Siloxanes used

A large number of different siloxanes are used for this application area.

Fate of the siloxanes

The siloxanes in other elastomers will mainly be disposed of for incineration with municipal solid waste or waste from management of electrical and electronic waste. The main part of the silicones used for automotive applications will be landfilled with waste from shredders.

2.2.12 Other uses of silicone fluids

Silicone fluids may be used for different applications not included above.

These applications include use in reprography, impregnation of water-proof insulation materials and probably other uses.

The consumption of silicone fluids for other applications is, with a sidelong glance at Will et al. 2003, roughly estimated to be of the order of magnitude of 50 t/year.

2.3 Summary

The present information on the use of siloxanes in Denmark in 2001 is summarised in Table 2.6.

The main application areas are sealants for construction (29%), processing aids (15%) and textile applications (12%).

The type can roughly indicate the potential for releases of the compounds to the atmosphere and wastewater. Volatile fluids are released to the atmosphere, whereas other fluids may end up in wastewater or released directly to surface water and soil. Elastomers and resins will mainly end up in solid waste.

Table 2.6
Consumption of siloxanes in Denmark 2002

Application area	Consumption Tonnes/year	Percentage	Uncertainty *	Type of siloxanes
Sealants used for construction	920	29	Low	Elastomers
Paints, inks and coatings	200	6	Medium	Resins, elastomers
Cosmetics and toiletries	240	8	Medium	Fluids, volatile fluids
Wax, polishes and cleaning agents	100	3	Medium	Fluids, volatile fluids
Mechanical fluids and heat transfer fluids	50	1.6	Medium	Fluids
Textile applications	380	12	High	Fluids, elastomers
Processing aids	470	15	Medium	Fluids
Paper coating	210	7	Medium	Fluids
Health care	110	4	High	Elastomers, fluids
Other uses of silicone elastomers	390	13	Medium	Elstomers
Other uses of silicone fluids	50	1.6	High	Fluids
Total	3,120	100		

* Uncertainty indication:
Low : the right value is most probably within a range of x ±25%
Medium: the right value is most probably more than half and less than twice the best estimate
High: the right value may be less than half or more than twice the best estimate

In the present study it has not been possible to obtain a detailed split of the different types of siloxanes on application areas. A study of the fate of the siloxanes in the USA may though give an indication of the fate of the siloxanes in Denmark (Allen et al. 1997). The main source of siloxanes to the air is the volatile siloxanes of which 92% is released to the air by use. Polydimethylsiloxane with modifications (silicone oils) are the main source of siloxane releases to wastewater, as about 25% of the total is discharged to wastewater treatment plants. Another 21% is "dispersed" and may end up in water bodies, on the ground, etc.

Silicone resins and elastomers mainly end up in solid waste for incineration, landfilling or recycling.

Table 2.7
Environmental loadings of industrial siloxanes for the USA in 1993 (based on Allen et al. 1997) (x 1000 t)

	Volatile methylsiloxane	Polydimethyl siloxane	Modified polydimethylsiloxane *	Polyether methylsiloxane	Silicone resins	Silicone elastomers
Wastewater treatment plants	0.65	13.59	0.74	2.69	0.00	0.00
Landfilled/incinerated/recycled	0.70	24.81	3.33	7.21	2.42	89.13
Dispersed	0.25	13.38	0.29	0.00	0.31	0.00
Soil	0.0o	0.00	0.01	0.34	0.00	0.00
Air	18.10	0.00	0.00	0.00	0.00	0.08
Total	19.71	51.78	4.37	10.24	2.73	89.21

* Modified polydimethylsiloxanes include: methyl(hydrido)siloxanes, methyl(vinyl)siloxanes, methyl(alkyl)siloxanes, methyl(phenyl)siloxanes, methyl(trifluoropropyl)siloxanes, and methyl(aminoalkyl)siloxanes. These are treated as a group, because their physico-chemical properties (which dictate their fate) are similar to PDMS and to each other.

The major release/disposal routes and risk of consumer exposure is summarised in Table 2.8 below.

The main source of releases of siloxanes to the air is volatile siloxanes used in cosmetics, wax, polishes and to a minor extent in several other applications.

No information of the quantity of volatile siloxanes for these applications has been available, but data for the USA indicates that volatile siloxanes may account for a significant part of the siloxanes used for cosmetics and it is roughly estimated that between 50 and 200 t/year is released to the air. Siloxanes disposed of for municipal solid waste incineration are deemed nearly 100% to be mineralised by the incineration, and incineration plants are not considered significant sources of siloxane releases to the atmosphere.

Non-volatile silicone fluids used in cosmetics, wax, polishes, cleaning products and for textile applications (softeners) will to a large extent end up in wastewater and be directed to wastewater treatment plants. The total release to wastewater is estimated at 200-700 t/year. By the treatment process the siloxanes mainly follow the sludge and is either spread on agricultural fields, incinerated or disposed of to landfills. According to Fendinger et al. (1997) approximately 97% of the polydimetylsiloxane will be bound to the sludge by the wastewater treatment, while the remaining 3% will be discharged to surface waters. It indicates that the main sources of discharge to surface waters in Denmark, as is the case for many heavy metals, are precipitation-dependent discharges which are discharged directly to surface water without treatment.

The major part of siloxanes used in silicone elastomers and resins in sealants, paints, rubbers, etc. is disposed of for incineration or landfills with building materials. By the incineration the siloxanes are destructed.

Table 2.8
The major release/disposal routes and risk of consumer exposure

Application area	Release/disposal route	Risk of consumer exposure
Sealants used for construction	Incineration, landfilling	Low
Paints, inks and coatings	Incineration, landfilling	Low
	Discharge to wastewater (minor)	
Cosmetics and toiletries	Emission to the air	High
	Discharge to wastewater	
Wax, polishes and cleaning agents	Discharge to wastewater	High
Mechanical fluids and heat transfer fluids	Chemical waste	Low
Textile applications	Incineration	High
	Discharge to wastewater	
Processing aids	Incineration,	Low
Paper coating	Incineration	Low
Health care	Incineration	High
Other uses of silicone elastomers	Incineration, landfilling (shredder waste)	Low
Other uses of silicone fluids	Not assessed	Not assessed

3 Health evaluation of siloxanes

3.1 Data on toxicity of siloxanes

Information about the toxicity of the siloxanes has been searched in open databases on the Internet and also as a general search based on CAS number, chemical name or just the term "siloxanes", e.g. in combination with individual terms relevant to toxicity testing and results, using different search engines and meta search engines. Contacts to a few siloxane research university environments have pointed to the same literature as identified from searching the Internet.

As a first step in the data search, a preliminary database screening was carried out for decamethyl cyclopentasiloxane (Annex 6).

The data search has included the following general databases with information on chemical substances and their toxicological effects:

- RTECS;
- TOXNET: TOXLINE, CCRIS, HSDB, IRIS, GENE-TOX, DART / ETIC;
- MEDLINE;
- ScienceDirect (Journals);
- NTP;
- ASTDR.

The screening did not reveal any data on human toxicity, and it was decided not to make similar screenings for other siloxanes, but instead make a short review based on the available original literature.

The main source of information has been the Siloxane Research Program. The program is run by The Silicones Environmental, Health and Safety Council of North America (SEHSC) which is a non-profit trade association comprised of North American silicone chemical producers and importers. The programme was started in 1993 and includes a series of studies examining acute and long-term safety of exposure to the fundamental building blocks of many silicone materials (Meeks 1999). Testing under this programme includes the following type of tests:

Fundamental research:

- Pharmacokinetics;
- Biochemical toxicology.

Descriptive toxicological studies:

- Subacute studies of up to one month of duration;
- Subchronic studies of up to three months of duration;
- Two-year chronic studies to assess carcinogenicity and chronic effects;
- Developmental studies to assess effects on foetal development;
- Two-generation reproductive and fertility studies;

- Immunotoxicity studies.

Human clinical studies:

- Determination of human response and assessment of relevance of animal studies.

Exposure assessment studies:

- Workforce;
- Consumers;
- General public.

Information was specifically searched for the CAS numbers shown in the table below.

Table 3.1 Siloxanes searched by CAS number

Chemical name	CAS no.	Synonym
Octamethyl cyclotetrasiloxane	556-67-2	D4; Part of cyclomethicone Cas. no 69430-24-6
Decamethyl cyclopentasiloxane	541-02-6	D5; Part of cyclomethicone Cas. no 69430-24-6
Hexamethyl disiloxane	107-46-0	HMDS
Octamethyl trisiloxane	107-51-7	
1,1,3,3-tetramethyl-1,3-diphenyl disiloxane	56-33-7	Phenyl dimethicone
1, 1, 5, 5, 5- hexamethyl- 3- phenyl- 3-[(trimethylsilyl)oxy] trisiloxane	2116-84-9	Phenyl trimethicone

Information has primarily been identified for D4, D5 and HMDS which besides polydimethylsiloxane (PDMS) is part of the Siloxane Research Program. For the other three siloxanes which are not part of the program, little or no information has been found. This is also the situation as regards more general information on toxicity related to small linear siloxanes and cyclic siloxanes.

A few studies are focussing on estrogenic and anti-estrogenic properties of D4 and HMDS, but in general data on endocrine disruption end points are scarce.

3.2 Toxicity of siloxanes

Although siloxanes are used in many products including consumer products and have been so for many years, there is relatively little information available about their toxicity apart from the information provided by the Siloxane Research Program. However, siloxanes have generally been regarded as safe in consumer products, but new uses, e.g. in breast implants and focus on reproductive toxicity and possible endocrine disrupting effects have focussed attention on this group of substances.

Of the six siloxanes mentioned in Table 3.1 only D4 is on Annex I to the Substance Directive (67/548/EEC) with a health classification as toxic to reproduction in category 3. The German justification for classification of D4 with regard to carcinogenic, mutagenic and reprotoxic effects is included in the reference list.

D4 is on the list of potential PBT and vPvB (very persistent and very bioaccumulative) substances selected on the basis of screening criteria in the EU (DEPA 2003).

In the following a short review of the findings in literature about the substances are presented. An overview of the studies and their results are presented in Annex 7.

3.2.1 Toxicokinetics

A number of studies in rats using unlabelled or 14C labelled D4 show that the level of absorption following inhalation of this substance is low and independent of gender and dose. The substance is distributed to most tissues and the highest concentrations were found in fat and the lowest in the reproductive tissues. Parent D4 is eliminated via the lungs and metabolised D4 via urine and faeces. The elimination profile from tissues except from fat and lung resembles that from blood and follows a two-compartment model (EPA DCN 86970000024 1996).

The elimination half-life for D4 has been shown to vary from 68 hours in plasma to approximately 150 hours in skin. Higher values are seen in testes. Blood clearance in human volunteers was non-linear and more rapid than by rats, whereas the elimination from the lungs resembled that from rats (BAuA 2001).

D4 has unusual distribution properties that have become apparent after examination of the time course data for blood and tissues using a quantitative physiological model (PBPK). Despite the very high lipophilicity, D4 does not show prolonged retention because of high pulmonary and hepatic clearance coupled with induction of metabolising enzymes at high exposure concentrations (Andersen et al. 2001). This avoids accumulation of free D4.

Pharmacokinetics of D4 administered to rats by inhalation and dermal route are similar and differs from the intravenous and oral route (Sarangapani et al. 2003).

Percutaneous absorption of neat D4 in humans following topical application between 1 and 24 hours has been shown at levels of 0.57 – 1.09% (EPA DCN 86980000153 1998 and EPA DCN 8601000003 2000).

In in vitro studies with percutaneous absorption following 24 hours exposure to 14C-D5 the absorption was found to be 0.8 – 1.08% (EPA DCN 86960000593 1996 and EPA DCN 86970000009 1996).

In rats administered HMDS orally and intravenously no parent HMDS was found in the urine. Metabolites from this linear siloxane appear to be structurally different from those obtained for cyclic siloxane except for the commonly present Me(2)Si(OH)(2).

3.2.2 Acute toxicity

In general the acute toxicity of siloxanes is considered low. LD_{50} following oral administration of D4 in rats is reported to be more than 4,500 mg/kg and more that 5,000 mg/kg for HMDS. LC_{50} in rats exposed to D4 was >12.17 mg/l and >48 mg/l when exposed to HMDS (European Commission 2000). LC_{50} in rats exposed to HMDS for four hours was 15,956 ppm (EPA DCN 86970000724 1997).

LD_{50} following dermal application of D4 was >2400 mg/kg bw. Several studies with dermal application of HMDS have shown greater LD_{50} values, but mortality was observed at 10000 mg/kg bw. Toxic effects at 10000 mg/kg included gross pathological findings (lung, kidney, bladder, heart), while clinical findings (altered activity, ataxia, gasping and eschar formation) occurred in small numbers of rabbits. In contrast to rabbits, rats did not produce mortality or signs of toxicity at the dose tested (European Commission 2000).

3.2.3 Irritation and sensitization

D4 and HMDS have been tested on rabbit eyes without signs of irritation. The substances are also found non-irritant on rabbit skin. For both substances one study exists that describes the substances as slightly irritating. There are no further details from these studies (European Commission 2000).

D4 was not sensitizing in guinea pig maximisation test and also not sensitizing in 50 human subjects exposed to repeated insult patch test (European Commission 2000). HMDS has also been tested in guinea pig maximisation test without positive result (European Commission 2000).

3.2.4 Subacute / subchronic / chronic toxicity

D4 administered by oral gavage to rats over 28 days did not cause any immune suppression at doses between 10 and 300 mg/kg (EPA DCN 86980000072 1997). Human volunteers did not show any immunotoxic or proinflammatory/adjuvant effects following ingestion of 12 mg D4 in corn oil for 7 or 14 days (EPA DCN 86990000015 1998). The same result was obtained after inhalation of 10 ppm for one hour and re-exposure after three months (Loony et al. 1998).

Investigation of subacute oral toxicity in rats administered between 25 and 1600 mg/kg per gavage over two week with five applications per week caused increased relative liver weights in female animals at 100 mg/kg and male animals at 400 mg/kg. Absolute liver weight was also increased in female rats at 400 mg/kg. Decreased body weight was seen at the highest concentration in both male and female animals (BAuA 2001).

Rats exposed to D4 at 70 and 700 ppm by inhalation for 28 days, 5 days per week and 6 hours per day in different studies show rapid but reversible increase in liver size, induction of several metabolising enzymes, primarily CYP2B1 and induction of hepatic cytochrome P450 enzymes. D4 appears to be a phenobarbital-like inducer of hepatic microsomal enzymes in Fisher-344 rats (EPA DCN 86970000723 1996; EPA DCN 86970000725 1997; McKim et al. 1998).

Other studies with D4 in Fisher-344 rats exposed by inhalation over 3 months, 5 days per week and 6 hours per day, showed slight reduction in body weight and food intake at the 10.87 mg/kg dose group, slight dose-related increase in absolute and relative lever weight in female rats at 10.87 mg/kg and slight reduction in thymus and ovarian weight in female rats in the two highest dose groups, 5.91 and 10.87 mg/kg. Ovarian atrophy and vaginal mucification was also seen at the highest dose group (EPA DCN 8690000155 1995; EPA DCN 8690000153 1995).

Rats exposed to D5 by inhalation for 28 days, 7 days per week and 6 hours per day at concentrations between 10 and 160 ppm showed no adverse effects on body weight, food consumption or urinalysis. Minor transient changes in haematological serum chemistry and organ weight and a transient increase in liver to body weight and thymus to body weight at 160 ppm. NOEL (histopathological changes) was determined at 10 ppm, NOEL (systemic toxicity) was determined at 75 ppm and NOEL (immunosuppression) was determined at 160 ppm (EPA DCN 86970000385 1996).

Subchronic toxicity studies in rats exposed over three months at doses up to 224 ppm show that the lung is the primary target organ following D5 inhalation (Burns et al. 1998).

Rats exposed to inhalation of HMDS for one month in concentrations between 0.9 and 59.2 mg/l showed moderate increase in focal inflammatory lesions in the lungs in the highest dose group, increase in incidence and severity of renal tubule regeneration in male rats exposed to 12.7 and 59.2 mg/kg, hyaline droplet accumulation, protein casts and granular casts were present in kidneys in several males in the highest 59.2 mg/kg dose group. Other signs of toxicity included minimal hepatocellular hypertrophy in males of the two highest dose groups and a slight increase in pigment accumulation in bile ducts in the high dose group males (EPA DCN 869000048 1997).

Exposure of rats for three months to HMDS in concentrations between 0.33 and 33.3 mg/kg showed also similar histological lesions in the kidneys of males in the three highest dose groups; 4.0, 10.0 and 33.3 mg/kg. NOEL was determined at 1.3 mg/kg for male rats and 33.0 mg/kg for female rats (EPA DCN 86980000182 1998; Cassidy 2001).

Multifocal, subpleural, subacute to subchronic interstitial inflammation were seen in lungs of all groups of rats exposed for three months to inhalation of concentrations between 0.9 and 13.64 mg/kg HMDS. After the recovery period an increase of these finding were still seen in the high dose group (EPA DCN 86980000048 1997).

3.2.5 Genetic toxicity

Both D4 and HMDS have been tested in a number of in vitro studies including Ames test in different strains (with and without metabolic activation), DNA damage and repair test in E. Coli, cytogentic assay in Chinese Hamster Ovary cells, chromosome aberration assay and sister chromatide exchange assay in mouse lymphoma cells, all with and without activation with negative result. In vivo tests have included cytogenetic assay in rat (HMDS) and dominant lethal assay in rat (D4). Both tests were negative (European Commission, 2000). An in vivo chromosome aberration test in rats exposed to 700 ppm D4 was also negative (Vergnes et al. 2000).

The results gave no indication of a genotoxic potential - neither for D4 nor HMDS.

3.2.6 Carcinogenicity

Very little information is available on carcinogenicity of siloxanes. The only information identified is a report from Dow Corning received by EPA with preliminary results from a two-year chronic toxicity and carcinogenicity study in rats exposed to vapour concentrations of 0, 10, 40 or 160 ppm of D5 for 6 hours per day, 5 days per week, for 24 months. The preliminary results show that female rats in the highest dose group had a statistically significant increase of uterine tumours. These findings may indicate that there is a potential carcinogenic hazard associated with D5 (EPA. 2003). Final results are expected in the Spring of 2004.

Other relevant information is related to silicone in breast implants, where IARCH has evaluated that there is ***evidence suggesting lack of carcinogenicity*** in humans of breast implants, made of silicone, for female breast carcinoma (IARC 1999).

3.2.7 Reproductive toxicity

Tests to examine reproductive toxicity for siloxanes are primarily available to D4 which is also classified in the EU as Toxic for Reproduction. Cat. 3; R62 (Possible risk of impaired fertility). D4 has been evaluated based on information on toxic effects on the parent animals, toxicity to fertility and developmental toxicity/teratogenicity.

Various effects have been observed in both male and female parent animals in both studies to examine reproductive toxicity and other relevant studies. These effects have included decreased body weight, haematological and clinical-chemical effects, increased liver weight, cellular and subcellular changes, induction of liver enzymes, reduced organ weights (adrenals and thymus), ovarian atrophy and mucification of the vagina. The last two effects are indications of changes in the oestrus cycle. However, the results from the different tests have not shown a consistent picture with regard to the listed effects (BAuA, 2001).

Data on impairment of fertility are related to a reduction of the number of mean corpora lutea and implantation sites and increased post-implantation losses. The effects are phase specific indicating that D4 influences the hormonal cycle. It is suggested that this effect on the ovary is indirect and that the mode of action is related to neuroendocrine mechanisms in rodents which are quite different than those in humans. The rodent estrous cycle is generally four days long but in humans it is much longer (i.e. 28 days). It is this brevity of the estrous cycle that requires the precise control of the neuroendocrine events, the sensory inputs, and the sexual behaviours (Centre Europeen des Silicones 1999).

Studies to investigate developmental toxicity of D4 have not shown significant teratogenic effects (BAuA 2001).

A single generation study in rats exposed to inhalation is available for D5 showing no significant toxicological findings and no effects on reproductive parameters (EPA DCN 86970000006 1996).

3.2.8 Endocrine disruption

Very little information is available on endpoints which are considered relevant to endocrine disruption.

In a uterotrophic assay in immature rats receiving oral doses of D4 and HMDS for 4 days, D4 exhibited weakly estrogenic effects (dose-related increase in uterine weight and epithelial cell height) in both SP and F-344 rats. The substance also showed weak antiestrogenic properties by partially blocking EE (ethinylestradiol) induced uterine weight increases (competitive inhibition of estrogen receptor binding or D4 acting as a partial estrogen agonist). Estrogenic and antiestrogenic effects of D4 were several orders of magnitude less potent than EE, and many times less potent than the weak phytoestrogen CE (EPA DCN 86990000059 1999).

In the same assay HMDS showed no measurable effect on uterine weight when tested as an agonist. When co-administered together with EE, HMDS produced a slight, but statistically significant reduction in absolute uterine weight. The biological relevance of this could not be assessed in the present study (EPA DCN 86990000059 1999).

3.3 Conclusion

Only few siloxanes are described in the literature with regard to health effects, and it is therefore not possible to make broad conclusions and comparisons of the toxicity related to short chained linear and cyclic siloxanes based on this evaluation. Data is primarily found on the cyclic siloxanes D4 and D5 and the small linear HMDS.

The three siloxanes have a relatively low order of acute toxicity by oral, dermal and inhalatory routes and do not require classification for this effect.

They are not shown to be irritating to skin or eyes and are also not found sensitizing by skin contact. Data on respiratory sensitization have not been identified.

Subacute and subchronic toxicity studies show that the liver is the main target organ for D4 which also induces hepatocellular enzymes. This enzyme induction contributes to the elimination of the substance from the tissues. Primary target organ for D5 exposure by inhalation is the lung. D5 has a similar enzyme induction profile as D4. Subacute and subchronic inhalation of HMDS affects in particular the lungs and kidneys in rats.

None of the investigated siloxanes show any signs of genotoxic effects ***in vitro*** or ***in vivo***. Preliminary results indicate that D5 has a potential carcinogenic effect.

D4 is considered to impair fertility in rats by inhalation and is classified as a substance toxic to reproduction in category 3 with the risk phrase R62 ('Possible risk of impaired fertility').

The results of a study to screen for estrogen activity indicate that D4 has very weak estrogenic and antiestrogenic activity and is a partial agonist (enhances the effect of the estrogen). It is not uncommon for compounds that are weakly estrogenic to also have antiestrogenic properties. Comparison of the estrogenic potency of D4 relative to ethinylestradiol (steroid hormone) indicates that D4 is 585,000 times less potent than ethinylestradiol in the rat stain Sprague-Dawley and 3.7 million times less potent than ethinylestradiol in the Fisher-344 rat strain. Because of lack of effects on other endpoints designated to assess estrogenicity, the estrogenicity as mode of action for the D4 reproductive effects has been questioned. An indirect mode of action causing a delay of the LH (luteinising hormone) surge necessary for optimal timing of ovulation has been suggested as the mechanism.

Based on the reviewed information, the critical effects of the siloxanes are impaired fertility (D4) and potential carcinogenic effects (uterine tumours in females) (D5). Furthermore there seem to be some effects on various organs following repeated exposures, the liver (D4), kidney (HMDS) and lung (D5 and HMDS) being the target organs.

A possible estrogenic effect contributing to the reproductive toxicity of D4 is discussed. There seems however to be some indication that this toxicity may be caused by another mechanism than estrogen activity.

Effects which based on the reviewed literature do not seem to be problematic are acute toxicity, irritant effects, sensitization and genotoxicity.

4 Environmental fate and effects

It is beyond the scope of this project to prepare a comprehensive review of environmental effects of the siloxanes, but some data on persistence, bioaccumulation and toxicity are summarised below.

4.1 Initial screening for decamethylcyclopentasiloxane (D5)

Information about environmental properties and toxicity of decamethylcyclopentasiloxane (D5) was initially retrieved from the databases Aquire, CambridgeSoft Corporation database, HSDB database, IUCLID-CD, PHYSPROP DEMO-database, SPIN database, DART Special (RTECS) and ToxLine. The screening result for decamethylcyclopentasiloxane is shown in Annex 6. No information on environmental toxicity was found and it was decided not to go further on with similar database screenings for the other substances.

4.2 PBT profiler screening

In order to make a first comparison between the substances as to persistence, bioaccumulation and toxicity, the substances were screened using the PBT profiler developed by U.S. EPA (U.S. EPA 2003).

The profiler uses a procedure to predict persistence, bioaccumulation, and toxicity of organic chemicals on the basis of the chemical structure and physical parameters of the substances combined with experimental parameters for substance with a similar structure, using a QSAR approach. For more information see U.S. EPA (2003).

The results for six members of the siloxane family (Table 4.1) predict the highest bioconcentration factors for the two phenyl siloxanes, one order of magnitudes higher than the values for the cyclic siloxanes and two orders of magnitudes higher than the values for the small linear methyl siloxanes. The predicted toxicity is as well significantly higher (lowest ChV values - see description in table notes) for the phenyl siloxanes. The predicted half-life is nearly the same for all substances.

Using U.S. EPA's criteria, the screening indicates that all substances are of high concern as to environmental toxicity, and that the phenyl siloxanes are considered very bioaccumulative.

Table 4.1

PBT profiler results for selected siloxanes (based on U.S. EPA 2003)

Chemical name	CAS no.	Synonymous	LOG K_{ow}	BCF Bioconcentra-tion-factor	Fish ChV * (mg/l)	Half-life water/ sediment (days)
Octamethylcyclotetrasi-loxane	556-67-2	Part of cyclomethicone Cas. no 69430-24-6	5.1	1,700	0.058	38 / 340
Decamethylcyclopentasi-loxane	541-02-6	Part of cyclomethicone Cas. no 69430-24-6	5.2	2,000	0.021	38 / 340
Hexadimethyldisiloxane	107-46-0		4.2	340	0.062	15 / 140
Octamethyltrisiloxane	107-51-7		4.8	990	0.028	38 / 340
1,1,3,3-tetramethyl-1,3-diphenyl disiloxane	56-33-7	Phenyl dimethicone	7.2	35,000	0.00082	38 / 340
1, 1, 5, 5, 5- hexamethyl- 3-phenyl- 3- [(trimethylsi-lyl)oxy] trisiloxane	2116-84-9	Phenyl trimethicone	7.2	40,000	0.0012	38 / 340

CvH: Chronic Value (ChV) is the same as the chronic NEC (No effect concentration). US EPA uses the following criteria for Fish ChV (mg/l):
> 10 mg/l: Low Concern
0.1 - 10 mg/l: Moderate Concern
< 0.1 mg/l: High Concern

4.3 Aquatic toxicity data for octamethylcyclosiloxane and PDMS

The environmental fate and effects of volatile methylsiloxanes (mainly cyclosiloxanes) and polydimethylsiloxane (PDMS) have been reviewed by Hobson et al. (1997) and Fendinger et al. (1997), respectively.

A summary of aquatic toxicity data for octamethylcyclosiloxane is shown in Table 4.2 whereas toxicity data for PDMS is shown in Table 4.3.

Table 4.2
Summary of octamethylcyclosiloxane aquatic toxicity data (Hobson et al. 1997)

Species	Test type(time)	NOEC (µg/L)	L(E)C50 or LOEC (µg/L)
Rainbow trout	Acute (14 d)	4.4 µg/L	LC50 = 10 µg/L
Sheepshead minnow	Acute (14 d)	6.3 µg/L *	LC50 > 6.3 µg/L *
Daphnia magma	Acute (48 h)	15 µg/L *	EC 50 > 15 µg/L *
Mysid shrimp	Acute (96 h)	9.1 µg/L *	LC50 > 9.1 µg/L *
Rainbow trout	Chronic (90 d)	4.4 µg/L *	-
Daphnia magma	Chronic (21 d)	7.9 µg/L *	LOEC = 15 µg/L

* This concentration is the mean value measured in the highest exposure level.

Table 4.3
Soil and sediment testing results used for PDMS risk screening (Fendinger et al. 1997)

Organism	Test conditions	NOEC (mg/kg)	End points
Terrestrial			
Eisenia foetida	PDMS dosed in high organic soil	1100 *	Number and viability of cocoons, survival and growth of adult and off-spring
Folsomia candida	PDMS dosed in OECD standard soil matrix	250 **	Survival, reproduction
Aquatic/Sediments			
Chironomus tentans	PDMS dosed into high, medium and low organic content sediments	350-560 * with no evidence of bioaccumulation	Survival, growth
Daphnia magna	Daphnia magma were cultured over sediment amended with PDMS	572*	Growth, survival, number of offspring, mortality
Hyalella azteca	PDMS dosed in pond sediment	2200 *	Survival
Ampelisca abdita	PDMS dosed in marine sediment	2300 ***	Survival

* Indicates highest dose tested with no effects observed in test.

** Indicates nominal concentration.

*** Indicates acute test.

5 Alternatives

The use of some types of siloxanes is regarded potentially to cause problems to the aquatic environment and human health. The investigation on alternatives has therefore focussed on product groups where the risk of exposure to humans and releases to the aquatic environment is regarded to be present.

The investigation has focused on the following product groups:

- Cosmetics;
- Cleaning agents, waxes and polishes.

The information in this chapter is based on telephone interviews with manufacturers and suppliers of both siloxanes and alternatives to siloxanes.

In the following chapter the names of the compounds when they are used in cosmetic products (INCI names) will be used. Dimethicone is synonymous with linear polydimethylsiloxane, cyclopentasiloxane with decamethylcyclopentasiloxane and cyclomethicone with cyclic siloxanes, either pure or in mixtures.

5.1 Alternatives to siloxanes in cosmetic products

The investigation has primarily focused on the siloxanes cyclomethicone and dimethicone, which are commonly used in the cosmetics industry. Cyclomethicone is volatile and is furthermore suspected to cause different types of health and environmental problems.

As mentioned in section 2.2.4 the siloxanes have many applications in the different types of cosmetic products, and the siloxanes have very specific properties depending on the composition of the compounds. Because of this it is not possible to find just one alternative for e.g. cyclomethicone, as cyclomethicone can have many different applications and compositions depending on the product in which the substance is used.

The alternatives for siloxanes must therefore be very specific, as they have to comply with the special characteristics that the given siloxane has in the given product.

The use of alternatives to siloxanes in cosmetic products is still modest. The Danish suppliers of both siloxanes and alternatives to siloxanes have so far not experienced great demand for alternatives, but most of the contacted suppliers expect an increased demand for alternatives in the coming years. The suppliers have consequently started to develop alternatives to especially cyclomethicone and dimethicone.

It has so far been a difficulty that some of the properties of siloxanes are lacking in the developed alternatives. For soaps and leave-on products (lotions and creams for skin) the siloxanes can give the product the combination 'smooth and soft feeling' on the skin combined with the effect that the product does not feel greasy on the skin after application. These properties are obtained because the used siloxanes are volatile and can give extra softness. It has so far been difficult to find alternatives that can match these properties, and especially cyclomethicone is difficult to substitute. Dimethicone is in general easier to substitute, because the same properties can often be obtained with different types of vegetable oils. A test of one of the alternatives in Table 5.1 has shown that the developed alternative can give almost the same properties as cyclomethicone in the tested cosmetic emulsion. Emulsions are regarded to be one of the most problematic products to substitute cyclomethicone from.

The functional silicone oils, which for example can be a mix of cyclomethicone and dimethicone, are even more problematic to substitute, as the mixture of the different siloxanes is made to obtain some very specific properties. Polyether-modified silicones and other types of functional silicones will give the same problem, and alternatives have so far not been regarded.

The typical content of siloxanes in the products is below 2% of the final cosmetic product, but the content can according to SPT (The Danish trade organization for cosmetics and toiletries) vary between 0.5-40%, depending on the products in which the siloxanes are used.

Table 5.1 shows identified alternatives to siloxanes used in cosmetic products.

5.1.1 Neopentylglycol heptanoate

Neopentylglycol heptanoate is an alternative to dimethicone in different cosmetic products like conditioners and leave-on products. Neopentylglycol heptanoate has the same good spreadability as dimethicone and can like dimethicone be used as solvent for other substances and emulsifiers. The substance has just been introduced in Denmark, and customers have according to the supplier shown great interest in the alternative, but the substance cannot be found in Danish cosmetic products yet.

The price of neopentylglycol heptanoate is approximately the double of the price for dimethicone, as 1 kg of dimethicone costs approximately 50 DKK per kg, while the alternative costs approximately 100 DKK per kg. The use of neopentylglycol heptanoate should according to the supplier not result in changes in the production equipment. It would though be necessary to change the packaging, due to changes in the declaration.

5.1.2 Isodecyl neopentanoate

Isodecyl neopentanoate is an alternative to cyclomethicone. It can be used in leave-on products, conditioners and perhaps also in shampoos and cream soaps. Isodecyl neopentanoate has high spreadability like cyclomethicone and gives a soft feeling like cyclomethicone. It can be used as solvent and emulsifier. The alternative is new on the Danish market and has not been sold to Danish customers yet, but customers have shown great interest in the product.

Isodecyl neopentanoate is quite expensive compared to cyclomethicone. Cyclomethicone costs approximately 45 DKK/kg, while the price of isodecyl neopentanoate is expected to be approximately 100 DKK/kg. The use of the isodecyl neopentanoate should according to the supplier not result in changes in the production equipment. It would though be necessary to change the packaging, due to the changes in the declaration.

Table 5.1
Identified alternatives to siloxanes from Danish producers and suppliers

Name of alternative	CAS no. of alternative	Alternative to	Used in	Market situation	Price
Neopentylglycol heptanoate	N/A	Dimethicone	Conditioners and leave-on products	Not sold to Danish manufacturers of cosmetics yet	Approximately 100 DKK/kg, compared to app. 50 DKK/kg for dimethicone
Isodecylneopentanoate	60209-82-7	Cyclomethicone	Conditioners and leave-on products. Perhaps also shampoos and cream soaps	Not sold to Danish manufacturers of cosmetics yet	Approximately 100 DKK/kg, compared to app. 45 DKK/kg for cyclomethicone
Glycol distearate	627-83-8	Cyclomethicone and dimethicone in cream soaps (do not have exactly the same properties)	Cream soaps	Have been used in Danish products for the last 2-3 years	Approximately half the price of cyclomethicone and dimethicone (20-25 DKK/kg)
Different vegetable oil components - e.g. dicaprylyl carbonate	N/A	Dimethicone, cyclomethicone and other siloxanes (do not have exactly the same properties)	Creams and lotions - do not have the foam-reducing effect that some siloxanes have in creams and lotions	Can be found in products in Denmark	Approximately the same price level as the siloxanes
Diethylhexyl carbonate	N/A	Cyclopentasiloxane	Lotions and emulsions	The alternative is already sold to manufacturers of cosmetics, but can so far not be found in products sold in Scandinavia	Slightly less than cyclopentasiloxane
Hydrogenated polydecen	68037-01-4	Cyclomethicone in composition with paraffin oils	Leave-on products	Have been sold in Denmark the last two years and can be found in products in Denmark	Not possible to estimate as it cannot directly substitute the siloxanes

N/A CAS No. has not been available - the substances are not included in the 1st update of the inventory of ingredients used in cosmetic products (INCI 2000)

5.1.3 Glycol distearate

Glycol distearate is an alternative to siloxanes in different types of soaps. Glycol distearate gives the product a "milk-like" appearance and contains wax that gives shine and smooth feeling to cream soaps, shower gels and shampoos. Glycol distearate can typically not directly substitute all properties of dimethicone, cyclomethicone or other types of siloxanes, which often can give a more distinct feeling of softness etc., but it has similar qualities. Glycol distearate has been used in cream soaps sold in Denmark for the last 2 - 3 years, and the use of glycol distearate is increasing.

A compound containing glycol distearate costs approximately 20 - 25 DKK/kg, but the compound only contains 20-40% of glycol distearate - the rest are other additives used in soaps. Glycol distearate is therefore economically competitive compared to the siloxanes. The use of glycol distearate instead of siloxanes will according to the supplier not cause changes in the production equipment. It would though be necessary to change the packaging, due to changes in the declaration.

5.1.4 Dicaprylyl carbonate (vegetable oil components)

Different vegetable oil components can be used in creams and lotions instead of siloxanes. One particular example of these oils is dicaprylyl carbonate. Dicaprylyl carbonate cannot directly substitute the properties of siloxanes used in creams and lotions, as the alternative does not have the foam reducing effect that the siloxanes have. But except from this dicaprylyl carbonate can be used instead of cyclomethicone, dimethicone and other siloxanes and can add softness and spreadability to the products. The product is in use in products sold in Denmark.

The price of dicaprylyl carbonate is approximately the same as for the different types of siloxanes, perhaps a bit more expensive than cyclomethicone and dimethicone. It should be possible to use the same production facilities. It would though be necessary to change the packaging, due to changes in the declaration.

5.1.5 Diethylhexyl carbonate

Diethylhexyl carbonate is an extremely spreadable and low-viscous ester oil, which can substitute cyclopentasiloxane in lotions and emulsions. A cream product based on diethylhexyl carbonate has been tested together with a cream product based on cyclopentasiloxane. The test, where 6 people in a sensory panel tested the two creams, showed that the cream based on cyclopentasiloxane was perceived by all panellists, because it feels better with respect to spreadability and soft feeling than the cream based on diethyl carbonate. If an additive was added to the cream with diethylhexyl carbonate, three of the panellists did not find any difference between the two creams, while the three remaining still found that the cream with cyclopentasiloxane was a bit lighter. The conclusion of the test is that it is possible to make a product based on diethylhexylcarbonate that has almost the same qualities as the product based on cyclopentasiloxane.

The diethylhexyl carbonate has so far not been used in products sold in Scandinavia. The price of the alternative is approximately 35 - 40 DKK/kg while cyclopentasiloxane is more expensive, approximately 55 - 65 DKK/kg. The use of the diethylhexyl carbonate will not result in changes in the production equipment, but will of course involve new packaging due to new declarations of the product.

5.1.6 Hydrogenated polydecen

Hydrogenated polydecen is an alternative to different basis mineral oil or paraffin oils. If a product contains both paraffin oils and cyclomethicone, hydrogenated polydecen can, however, usually substitute both substances, as hydrogenated polydecen can give some of the soft feeling on the skin and can easily be absorbed in the skin without greasing. Hydrogenated polydecen will therefore to some extent match the properties of cyclomethicone. It can, however, not give the extra soft feeling that the siloxanes can add to a cosmetic leave-on product.

The product has been sold in Denmark for the last two years and can be found in several products in Denmark. The price of hydrogenated polydecen cannot be compared to cyclomethicone due to fact that it is not a direct alternative to cyclomethicone.

5.1.7 Summary and general experience

The investigation of alternatives to siloxanes in cosmetic products has shown that some alternatives have been developed and are used in Denmark, but the alternatives can at present typically not substitute the properties of siloxanes 100 %. The producers of cosmetic products must therefore often dispense with some of the properties of the siloxanes. Cyclomethicone and dimethicone in emulsions and creams are especially difficult to substitute, as the alternatives typically do not have a foam-reducing effect in the products. One alternative used in a cream has, however, been tested to have the same qualities as a cream with cyclopentasiloxane.

The suppliers of alternatives are experiencing great interest in alternatives to siloxanes, partly because of the environmental and health aspects, partly due to the options for evading different patents.

Many international producers use the Internet to advertise for hair and skin care products that are "silicone-free", but it seems that this is so far not a competition parameter for Danish producers.

Most of the alternatives are competitive with the siloxanes as regards price, however for some of the alternatives the price is twice the price of the siloxanes. A few of the alternatives are more expensive than the siloxanes. It is the general opinion that the use of alternatives to siloxanes does not cause changes in the production equipment, and the costs of substitution will therefore primarily be the extra costs for buying an alternative substance. Costs of new packaging are not regarded to be significant, as the substitution in most cases can be implemented when it suits into the production. As earlier mentioned the Danish industrial organization for cosmetics and toiletries, SPT, assesses the consumption of cyclomethicone used in Danish production to be approximately 5-6 tonnes per year. If the price of the most expensive alternative is used to predict an estimate of the costs of substitution of this amount of cyclomethicone, the price of the substitution will be approximately 200,000-300,000 DKK for the 5-6 tonnes. The 5-6 tonnes are however only a small part of the total consumption of siloxanes with cosmetics in Denmark (approximately 240 tons/year), as cyclomethicone is only one out of several siloxanes, and most cosmetic products are imported and not produced in Denmark.

5.2 Alternatives to siloxanes in cleaning agents and polishes

The siloxanes used in cleaning agents, waxes and polishes are in general not the same as the siloxanes used in cosmetics, although some of the wanted properties are the same, for example shine, spreadability and antifoaming. The identified alternatives are therefore also quite different from the alternatives developed for cosmetic products.

As for alternatives to siloxanes in cosmetic products it is the general opinion in the cleaning agent trade that silicones have some special properties that cannot easily be found in alternatives. These properties are especially as solvent, emulsifier and anti-soiling agent. Especially the use of the siloxane as defoaming agent is in many products difficult to substitute.

Siloxanes are used for polish, primarily because they give extremely high shine and strong adherence to the materials, especially glass, metal and plastic.

The siloxane content in cleaning agents is for most products less than 1% of the product which is further diluted in use. For polish products the siloxane content can be up to 5%, perhaps 10 % in some products.

The use of siloxanes and alternatives to siloxanes in cleaning agents and polishes has been investigated through contact with manufacturers and suppliers. The 6 main suppliers of siloxanes and chemicals to the cleaning agent trade and 10 of the Danish main manufacturers of cleaning agents and polishes have been contacted. It has however been difficult to identify alternatives to siloxanes, because substitution of siloxanes has not had special focus in the cleaning agent trade. Some alternatives have been used for several years, but have not been developed in the aim of substituting siloxanes, and it is a question to what extent they actually have similar properties.

Substances that are insoluble in water and with long carbon chains are in general suitable as alternatives to siloxanes in cleaning and maintenance agents. The longer carbon chains the substance have the more effective defoaming effect is obtained.

It is the general impression that there are fewer different types of alternatives to silicones in cleaning and maintenance products than in cosmetic products. If a search is made on the Internet for 'silicone-free' antifoaming agents, wax or polishes several products can be found, indicating that the use of alternatives is quite widespread. The reason for using the 'silicone-free' products is, however, most often technical.

The alternatives have been developed both due to the general interest in environment-friendly products in the trade for cleaning and maintenance agents, but also because the use of siloxanes can be problematic in some products. Silicones are for example often avoided in car waxes and other polish products for cars, because the use of silicones is disadvantageous if the car should later be re-painted.

Table 5.2 shows the types of alternatives to siloxanes in cleaning and maintenance agents identified through contact to Danish suppliers and manufacturers.

Table 5.2
Identified alternatives to siloxanes from Danish producers and suppliers

Name of alternative	Alternative to	Used in	Market situation	Price
Mineral oils (tensides), non-ionic	Polydimethylsiloxanes	Antifoam agents in cleaning products, washing powder, polishes	Is used in Danish products	Approximately same price level for mineral oils used in antifoam agents as dimethylsiloxane. The used siloxanes cost app. 30- 200 DKK per kg
Paraffin oils and vegetable oils	Polydimethylsiloxanes	Antifoam agents in cleaning products	Is used in Danish products	Normally cheaper than dimethylsiloxanes
Lipophilic tensides	Amino functional dimethylsiloxanes	Polishes	-	-
Block polymers consisting of polyethylenglycol and polypropylenglycol	Polydimethylsiloxanes	Antifoaming agents in cleaning products and polishes	Is used in Danish products	Normally a bit more expensive than dimethylsiloxanes

5.2.1 Mineral oils (tensides)

Many of the suppliers and manufacturers of maintenance products point at nonionic mineral oils or tensides as the main alternative to polydimethylsiloxanes in antifoaming agents. The mineral oils can be used in both polish products and antifoaming agents. Odourless kerosene is mentioned as a possible alternative to antifoaming.

The mineral oils typically do not have all the properties of polydimethylsiloxan. It can especially be difficult to obtain the same smooth surface for polishes. As antifoaming agents, the mineral oils are not always suitable for cleaning agents used in cold water, for example in floor cleaning machines.

The price level of the mineral oils is approximately the same as that of siloxanes, and in some cases they are cheaper, but as the siloxanes or alternatives only constitute few per cent of the product or even less than one per cent, the costs for using an alternative instead of a siloxane is regarded to be minimal.

5.2.2 Paraffin oils and vegetable oils

Paraffin oils and vegetable oils may like mineral oils be used as alternatives to polydimethylsiloxanes. Paraffin oils and vegetable oils are not very frequently used as alternatives to siloxanes in cleaning agents and polish products, but these types of oils can be used, as they have the defoaming properties.

The price of the paraffin oils and vegetable oil is in general lower than that of siloxanes.

5.2.3 Lipophilic tensides

Lipophilic tensides can be used as alternative to aminofunctional polydimethylsiloxanes used in polishes. The attractive shine and easy-cleaning surface that is obtained by using siloxanes can however not always be obtained to the same degree by using lipophilic tensides instead of siloxanes.

5.2.4 Block polymers

Block polymers consisting of polyethylenglycol and polypropylenglycol are a very applicable alternative to siloxanes in cleaning agents and polish products. The block polymer can be supplied with an extra alkyl chain by which the substance gets a lower surface tension that makes it possible to use the block polymer as antifoaming agent.

Block polymers are some of the most used alternatives to siloxanes in cleaning and maintenance agents, but are still less widespread used than the siloxanes. Block polymers are in general more expensive than the siloxanes that can be used in this type of products.

5.2.5 Summary

It has been difficult to identify alternatives to siloxanes, because substitution of siloxanes has not had particular focus in the cleaning agent trade. Some alternatives have been used for several years, but have not been developed in the aim of substituting siloxanes, and it is a question to what extent they actually have similar properties. Siloxanes are mainly used as antifoaming agent and to provide shine and spreadability to polishes. The antifoaming properties can be provided by a number of alternatives at approximately the same price as the siloxanes, but often the properties of the alternatives cannot fully match the properties of the siloxanes.

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Annex 1
Siloxanes listed in the INCI database

Inventory of ingredients used in cosmetic products, published in Section I of the Annex to Commission Decision 96/335/EC. 1st Update EU Inventory - 09/06/2000. http://europa.eu.int/comm/food/fs/sc/sccp/out123cm_en.pdf

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
ACRYLATES/DIMETHIONE COPOLY-MER			Polydimethylsiloxane, copolymer with one or more monomers of acrylic acid, methacrylic acid or one of their simple esters	anticaking / binding / film forming	1/04/1998
AMINO BISPROPYL DIMETHICONE			1,1'-iminobis(3-(tris(trimethylsiloxy)silyl)propane	emulsifying / hair conditioning	1/09/1998
AMINO BISPROPYL DIMETHICONE	243842-22-0			emulsifying / hair conditioning	23/01/2000
AMMONIUM DIMETHICONE CO-POLYOL SULFATE	130381-11-2		Dimethylsiloxane, polymer, mono((15-hydroxy-1,3-dimethyl-1-(3-(2-(2-(2-(fulfooxy)ethoxy)ethoxy)ethoxy)propyl)-3- ((trimethylsi-lyl)oxy)-2,7,10,13-tetraoxa-1,3-disilapentadec-1-yl)oxy)-terminated, ammonium salts	surfactant / hair conditioning / skin	1/09/1998
AMODIMETHICONE	71750-80-6		Dimethylsiloxane, polymer, (((3-((2-aminoethyl)amino)propyl)-dimethoxysilyl)oxy)-terminated	antistatic / hair conditioning	1/09/1998
AMODIMETHICONE HYDROXY STE-ARATE			3-(2-Aminoethylamino)propylsiloxane, polymer with dimethylsi-loxane, 12-hydroxyoctadecanoates	hair conditioning	1/04/1998
AMODIMETHICONE/DIMETHICONE COPOLYOL			3-(2-Aminoethylamino)propylsiloxane, polymer with dimethylsi-loxane, ethoxylated, propoxylated	antistatic / emollient	1/12/1999
BEHENOXY DIMETHICONE	193892-43-2		Poly(oxy(dimethylsilylene)),.alpha.-docosyl-.omega.-(docosyloxy)-	emollient	1/09/1998
BISPHENYLHEXAMETHICONE	18758-91-3		Tetrasiloxane, 1,1,1,7,7,7-hexamethyl-3,5-diphenyl-3,5-bis[(trimethylxilyl)oxy]-	antifoaming / emollient	1/06/1996
C24-28 ALKYL METHICONE	158061-44-0		Siloxanes and silicones, C24-28-alkyl methyl	emollient	15/04/2000
C30-45 ALKYL DIMETHICONE			Poly[oxy(dimethylsilylene)],.alpha.-(C30-45)-alkyldimethylsilyl-,.omega.-(C30-45)-alkyloxy	skin conditioning	1/04/1998
C30-45 ALKYL METHICONE	246864-88-0		Siloxanes and silicones, C30-45-alkyl methyl	emollient	15/04/2000
CETEARYL DIMETHICONE/VINYL DI-METHICONE CROSSPOLYMER	243137-50-0		Siloxanes and silicones, dimethyl, methyl vinyl, polymers with mono-(C16-18-alkoxy)-terminated dimethyl siloxanes	film forming / hair conditioning / skin	8/01/2000
CETEARYL METHICONE	227200-32-0		Poly{oxy[(C16-18)-alkylmethylsilylene]}, trimethylsilyl terminated	skin conditioning	2/01/2000
CETYL CAPRYLATE	29710-31-4	249-794-2	Hexadecyl octanoate	emollient	1/06/1996
CETYL DIMETHICONE	191044-49-2		Siloxanes and silicones, hexadecyl methyl, dimethyl	emollient	27/04/2000

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
CETYL DIMETHICONE COPOLYOL	251320-26-0		Siloxanes and silicones, hexadecyl methyl, dimethyl, polymers with ethoxylated propoxylated dimethyl siloxanes	emulsifying	27/04/2000
CETYL TRIETHYLAMMONIUM DI-METHICONE COPOLYOL PHTHALATE			Dimethylpolysiloxane, ethoxylated, propoxylated, 2- carboxyben-zoate esters, hexadecyltrimethylammonium salts	hair conditioning	1/04/1998
CYCLOETHOXYMETHICONE			Methylethoxysiloxane cyclic polymer	emollient / skin conditioning / solve	1/09/1998
CYCLOHEXASILOXANE	540-97-6	208-762-8	Dodecamethylcyclohexasiloxane	hair conditioning / emollient / solvent	2/12/1999
CYCLOMETHICONE	556-67-2	209-136-7	Octamethylcyclotetrasiloxane	antistatic / emollient / humectant / s	1/09/1998
CYCLOPENTASILOXANE	541-02-6	208-764-9	Decamethylcyclopentasiloxane	hair conditioning / emollient / solvent	2/12/1999
CYCLOTETRASILOXANE	556-67-2	209-136-7	Octamethylcyclotetrasiloxane	hair conditioning / emollient / solvent	2/12/1999
CYCLOTRISILOXANE	541-05-9		Hexamethylcyclotrisiloxane	hair conditioning / emollient / solvent	8/05/2000
DIAMMONIUM DIMETHICONE CO-POLYOL SULFOSUCCINATE				surfactant / cleansing / hair conditioner	1/01/1998
DIISOSTEAROYL TRIMETHYLOLPRO-PANE SILOXY SILICATE				skin conditioning	1/01/1998
DILAUROYL TRIMETHYLOLPROPANE SILOXY SILICATE				skin conditioning	1/01/1998
DILINOLEAMIDOPROPYL DIMETH-YLAMINE DIMETHICONE COPOLYOL PHOSPHATE	138698-34-7			surfactant / hair conditioning	1/01/1998
DIMETHICONE	9006-65-9 / 631		Dimethicone	antifoaming / emollient	1/06/1996
DIMETHICONE BISAMINOHYDROXY-PROPYL COPOLYOL	244058-69-3		Siloxanes and silicones, dimethyl, 3-(3-amino-2-hydroxypropoxy)propyl group terminated, ethoxylated propoxy-lated	hair conditioning / skin conditioning	3/01/2000
DIMETHICONE COPOLYOL	64365-23-7		Siloxanes and silicones, di-me, hydroxy-terminated, ethoxylated propoxylated	antistatic / emollient / antifoaming	1/01/1998
DIMETHICONE COPOLYOL ACETATE				humectant / skin conditioning / emollient	1/01/1998
DIMETHICONE COPOLYOL ADIPATE				humectant / skin conditioning / emollient	1/01/1998
DIMETHICONE COPOLYOL ALMON-DATE				emollient / skin conditioning	1/01/1998
DIMETHICONE COPOLYOL AVOCADO-ATE				emollient / skin conditioning	1/01/1998
DIMETHICONE COPOLYOL BEESWAX				emollient	1/06/1996
DIMETHICONE COPOLYOL BEHENATE				humectant / emollient	1/01/1998
DIMETHICONE COPOLYOL BENZOATE			Ester of dimethylsiloxane-glycol copolymer and benzoic acid	skin conditioning	1/04/1998
DIMETHICONE COPOLYOL BISHY-DROXYETHYLAMINE	244058-65-9		Siloxanes and silicones, 3-[3-[bis(2-hydroxyethyl)amino]-2-hydroxypropoxy]propy methyl, dimethyl, 3-hydroxypropoxy methyl, ethoxylated propoxylated	hair conditioning	3/01/2000
DIMETHICONE COPOLYOL BOR-AGEATE			Ester of dimethylsiloxane-glycol copolymer and the fatty acid de-rived from Borago officinalis seed oil	hair conditioning / skin conditioning	1/04/1998

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
DIMETHICONE COPOLYOL BUTYL ETHER				humectant / moisturising	1/01/1998
DIMETHICONE COPOLYOL COCOA BUTTERATE				emollient	1/06/1996
DIMETHICONE COPOLYOL CROSSPOLYMER			Crosspolymer of dimethylsiloxane-glycol copolymer crosslinked with a polyethylene glycol diallyl ether	viscosity controlling	1/04/1998
DIMETHICONE COPOLYOL DHUPA BUTTERATE			Ester of dimethylsiloxane-glycol copolymer and the fatty acids derived from Dhupa butter	hair conditioning / skin conditioning	1/04/1998
DIMETHICONE COPOLYOL HY-DROXYSTEARATE				humectant / emollient	1/01/1998
DIMETHICONE COPOLYOL ISOSTE-ARATE				humectant / emollient	1/01/1998
DIMETHICONE COPOLYOL KOKUM BUTTERATE			Ester of dimethylsiloxane-glycol copolymer and the fatty acids derived from Kokum butter	hair conditioning / skin conditioning	1/04/1998
DIMETHICONE COPOLYOL LAURATE				humectant / emollient	1/01/1998
DIMETHICONE COPOLYOL MANGO BUTTERATE			Ester of dimethylsiloxane-glycol copolymer and the fatty acids derived from Mango butter	hair conditioning / skin conditioning	1/04/1998
DIMETHICONE COPOLYOL METHYL ETHER	68951-97-3			humectant / moisturising	1/01/1998
DIMETHICONE COPOLYOL MOHWA BUTTERATE			Ester of dimethylsiloxane-glycol copolymer and the fatty acids derived from Mohwa butter	hair conditioning / skin conditioning	1/04/1998
DIMETHICONE COPOLYOL OCTYLDO-DECYL CITRATE			Mixed ester of citric acid and dimethylsiloxane-glycol copolymer and 2-octyl-1-dodecanol	skin conditioning / emollient	1/04/1998
DIMETHICONE COPOLYOL OLIVATE				emollient	1/06/1996
DIMETHICONE COPOLYOL PHOS-PHATE				humectant / emulsifying	1/01/1998
DIMETHICONE COPOLYOL PHTHA-LATE				emollient / skin conditioning	1/01/1998
DIMETHICONE COPOLYOL SAL BUT-TERATE			Ester of dimethylsiloxane-glycol copolymer and the fatty acids derived from Sal butter	hair conditioning / skin conditioning	1/04/1998
DIMETHICONE COPOLYOL SHEA BUT-TERATE				emollient / skin conditioning	1/01/1998
DIMETHICONE COPOLYOL STEARATE				humectant / skin conditioning / emollient	1/01/1998
DIMETHICONE COPOLYOLAMINE	133779-14-3			humectant / hair conditioning	1/01/1998
DIMETHICONE HYDROXYPROPYL TRI-MONIUM CHLORIDE	133779-10-9		Silicones and siloxanes, dimethyl, 3-[2-hydroxy-3-(trimethylammonio)propoxy]propyl methyl, chlorides	antistatic / hair conditioning	3/01/2000
DIMETHICONE PROPYL PG-BETAINE				antistatic / surfactant / hair conditioning	1/01/1998
DIMETHICONE PROPYLETHYLENEDI-AMI NE BEHENATE	132207-30-8			emollient / skin conditioning	1/01/1998
DIMETHICONE SILYLATE				humectant / skin conditioning	1/01/1998

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
DIMETHICONE/MERCAPTOPROPYL METHICONE COPOLYMER				film forming / skin conditioning	1/01/1998
DIMETHICONE/PHENYL VINYL DI-METHICONE CROSSPOLYMER	243137-51-1		Siloxanes and silicones, dimethyl, polymers with [(dimethyl-phenylsilyl)oxy]- and [(ethenyldimethylsilyl)oxy]-terminated di-methyl siloxanes	viscosity controlling	3/01/2000
DIMETHICONE/SODIUM PGPROPYL-DIMETHICONE THIOSULFATE CO-POLYMER				film forming / skin conditioning	1/01/1998
DIMETHICONE/VINYL DIMETHICONE CROSSPOLYMER	243137-53-3		Siloxanes and silicones, dimethyl, polymers with mono[(ethenyldimethylsilyl)oxy]-terminated dimethyl siloxanes	viscosity controlling	3/01/2000
DIMETHICONOL	31692-79-2		Poly[oxy(dimethylsilylane)], .alpha.-hydro-.omega.-hydroxy-	antifoaming / emollient / moisturising	1/01/1998
DIMETHICONOL BEESWAX	227200-35-3		Reaction product of beeswax and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydroxy	skin conditioning	3/01/2000
DIMETHICONOL BEHENATE	227200-34-2		Reaction product of docosanoic acid and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydroxy	skin conditioning / emollient	3/01/2000
DIMETHICONOL BORAGEATE	226994-45-2		Reaction product of the fatty acids derived from Borago officinalis seed oil and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydroxy	skin conditioning / emollient	3/01/2000
DIMETHICONOL DHUPA BUTTERATE	243981-39-7		Silicones and siloxanes, dimethyl, hydroxy-terminated, esters with Vateria indica fatty acids	skin conditioning / emollient	3/01/2000
DIMETHICONOL FLUOROALCOHOL DILINOLEIC ACID				skin conditioning	7/01/1998
DIMETHICONOL HYDROXYSTEARATE				emollient	1/06/1996
DIMETHICONOL ILLIPE BUTTERATE			Reaction product of the fatty acids derived from Illipe (Bassia latifolia) butter and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydroxy	skin conditioning / emollient	1/04/1998
DIMETHICONOL ISOSTEARATE				emollient	1/06/1996
DIMETHICONOL KOKUM BUTTERATE	226994-48-5		Reaction product of the fatty acids derived from Kokum butter and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydroxy	skin conditioning / emollient	3/01/2000
DIMETHICONOL LACTATE	227200-33-1		Siloxanes and silicones, dimethyl, hydroxy-terminated, 2-hydroxypropanoates	hair conditioning / skin conditioning	3/01/2000
DIMETHICONOL MOHWA BUTTERATE	225233-88-5		Silicones and siloxanes, dimethyl, hydroxy teminated, esterswith mowrah (mohwa)-oil fatty acids	skin conditioning / emollient	2/02/2000
DIMETHICONOL SAL BUTTERATE			Reaction product of the fatty acids derived from Sal butter and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydroxy	skin conditioning / emollient	1/04/1998
DIMETHICONOL STEARATE				emollient	1/06/1996
DIMETHICONOL/IPDICOPOLYMER	193281-67-3		Poly[oxy(dimethylsilylene)], .alpha.-hydro-.omega.-hydroxypolymer with 5-isocyanato-1-(isocyanatomethyl)-1,3,3-trimethylcyclohexane	film forming	1/04/1998
DIMETHICONOL/SILSESQUIOXANE COPOLYMER	68554-67-6		Siloxanes and silicones, di-Me, polymers with Me silsesquioxanes, hydroxy-terminated	hair conditioning / skin conditioning	1/04/1998

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
DIMETHICONOL/STEARYL METHICONE/PHENYL TRIMETHICONE COPOLYMER			Polymer formed from poly[oxy(methylstearyl)silylene, .alpha.-trimethylsilyloxy, .omega.-trimethylsilyl, poly[oxy(phenyltrimethylsilyloxy) silylene,.alpha.-trimethylsilyloxy,.omega.-trimethylsilyl, and poly[oxy(dimethylsilylene),.alpha.-hydro,.omega.-hydro	stabilising / skin conditioning	1/04/1998
DIMETHOXYSILYL ETHYLENEDIAMINOPRO PYL DIMETHICONE	71750-80-6			emulsifying / hair conditioning	1/01/1998
DIMETHYLAMINOPROPYLAMIDO PCA DIMETHICONE	179005-02-8		Polymer formed from poly[oxy(dimethyl)silylene and poly{oxy[(3-{4-[({3-[dimethylamino]-propyl}-amino)carbonyl]2-oxo-1-pyrrolidinyl}propyl)methyl]}, .alpha.-trimethylsilyloxy, .omega.-trimethylsilyl	hair conditioning / skin conditioning	1/04/1998
DIMETHYLSILANOL HYALURONATE	128952-18-1		Hyaluronic acid, dimethylsilylene ester	humectant / moisturising	1/09/1998
DIPHENYL DIMETHICONE				emulsifying / skin conditioning / emollient	1/01/1998
DISODIUM DIMETHICONE COPOLYOL SULFOSUCCINATE				surfactant / skin conditioning	1/01/1998
DROMETRIZOLE TRISILOXANE	155633-54-8		Phenol, 2-(2H-benzotriazol-2-yl)-4-methyl-6-[2-methyl-3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]disiloxanyl]-	uv absorber	1/04/1998
ETHYLHEXYL DIMETHICONE ETHOXY GLUCOSIDE				surfactant / emulsifying	1/04/1998
FLUORO C2-8 ALKYLDIMETHICONE				emulsifying	1/06/1996
HEXADECYL METHICONE				emollient / viscosity controlling / ski	1/01/1998
HEXAMETHYLDISILOXANE	107-46-0	203-492-7	Hexamethyldisiloxane.	antifoaming / emollient / antistatic /	1/01/1998
HEXYL METHICONE	56746-86-2		Poly[oxy(hexylmethylsilylene)],.alpha.-trimethylsilyl),.omega.-[(trimethylsilyl)oxy]-.	skin conditioning / emollient	3/01/2000
HYDROLYZED SOY PROTEIN/DIMETHICONE COPOLYOL ACETATE			Polydimethylsiloxane, copolymer with polyoxyethylene andpoly-oxypropylene, acetylated, reaction products hydrolyzed soy protein	hair conditioning	1/04/1998
HYDROLYZED WHEAT PROTEIN/DIMETHICONE COPOLYOL ACETATE			Polydimethylsiloxane, copolymer with polyoxyethylene and poly-oxypropylene, acetylated, readion products hydrolyzed wheat protein	hair conditioning	1/04/1998
HYDROLYZED WHEAT PROTEIN/DIMETHICONE COPOLYOL PHOSPHATE COPOLYMER				humectant / skin conditioning / film forming agent	1/01/1998
LAURYLMETHICONE COPOLYOL				emollient / emulsifying	1/06/1996
LINOLEAMIDOPROPYL PG-DIMONIUM CHLORIDE PHOSPHATE DIMETHICONE	243662-49-9		Propanaminium, 2,3-dihydroxy-N,N-dimethyl-N-[3-(1-oxo-9,12-octadecadienylamino)propyl]-3-phosphate triester, trichloride, reaction products with polydimethylsiloxane	hair conditioning	2/02/2000
METHICONE	9004-73-3		Poly[oxy(methylsilylene)]	antistatic / emollient / skin condition	1/01/1998
METHYLSILANOL ACETYLMETHIONATE	105883-43-0		L-methionine, N-acetyl-, dihydroxymethylsilyl ester	antistatic / skin conditioning / air c	1/01/1998
METHYLSILANOL ACETYLTYROSINE	105883-45-2		L-tyrosine, N-acetyl-o-(dihydroxymethylsilyl)-	antistatic / skin conditioning	1/01/1998
METHYLSILANOL ASCORBATE	187991-39-5		L-Ascorbic acid, 6-O-(dihydroxymethylsilyl)	antioxidant	1/09/1998

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
METHYLSILANOL CARBOXYMETHYL THEOPHYLLINE	105883-42-9		7H-purine-7-acetic acid, 1,2,3,6-tetrahydro-1,3-dimethyl-2,6-dioxo-, dihydroxymethylsilyl ester	skin conditioning	1/01/1998
METHYLSILANOL CARBOXYMETHYL THEOPHYLLINE ALGINATE			reaction product of methyl-silanol carboxymethyl theophylline and alginic acid	skin conditioning	1/09/1998
METHYLSILANOL ELASTINATE	133101-79-8		elastins, esters with hydroxy-terminated hydroxy Me siloxanes	antistatic / skin conditioning	1/09/1998
METHYLSILANOL GLYCYRRHIZINATE			Alpha-d-glucopyranosiduronic acid, (3beta,20beta)-20-carboxy-11-oxo-30-norolean-12-en-3-yl 2-o-beta-d-glucopyranosyl- ,dihydroxymethylsilyl ester	skin conditioning	1/01/1998
METHYLSILANOL HYDROXYPROLINE	105883-44-1		L-proline, 5-hydroxy-, dihydroxymethylsilyl	ester antistatic / skin conditioning	1/01/1998
METHYLSILANOL HYDROXYPROLINE ASPARTATE				antistatic / skin conditioning	1/01/1998
METHYLSILANOL MANNURONATE	128973-71-7		Siloxanes and Silicones, alpha-D-mannopyranuronoyl-oxy Me,hydroxy-terminated	antistatic / skin conditioning	1/09/1998
METHYLSILANOL PCA	105883-41-8		L-proline, 5-oxo-, dihydroxymethylsilyl ester	humectant / skin conditioning	1/01/1998
METHYLSILANOL PEG-7 GLYCERYL COCOATE	106040-46-4		Fatty acids, coco, 3-esters with polyethylene glycol dihydroxymeth-ylsilyl 2,3-dihydroxypropyl ether	emulsifying / skin conditioning	1/01/1998
METHYLSILANOL SPIRULINATE	188012-54-6		Proteins, Spirulina, reaction products with methylsilanetriol	skin conditioning	1/09/1998
METHYLSILANOL TRIPEG-8 GLYCERYL COCOATE	128973-72-8		Fatty acids, coco, ester with .alpha., .alpha.',.alpha."-(methylsilylidyne)tris (.omega.-(2,3-ihydroxypropoxy)poly(oxy-1,2-ethanediyl))	emulsifying / skin conditioning	1/09/1998
MYRISTAMIDOPROPYL DIMETHYLA-MINE DIMETHICONE COPOLYOL PHOSPHATE	137145-36-9			surfactant	1/06/1996
OCTAMETHYLTRISILOXANE	107-51-7	203-497-4	Octamethyltrisiloxane.	skin conditioning	1/01/1998
PCA DIMETHICONE	179005-03-9		3-(4-Carboxy-2-oxo-1-pyrrolidinyl)propyl methyl siloxane, polymer with dimethylsiloxane, trimethylsilyl- terminated	hair conditioning / skin conditioning	1/04/1998
PHENETHYL DIMETHICONE	67762-82-7		2-Phenylethyl methyl siloxane, polymer with dimethylsiloxane, trimethylsilyl- terminated	emollient	1/04/1998
PHENETHYL DISILOXANE			Disiloxane, 1,1,2,2,2-pentamethyl-1-(2-phenylethyl)-	antifoaming	1/06/1996
PHENYL DIMETHICONE	56-33-7	200-265-4	1,1,3,3-tetramethyl-1,3-diphenyldisiloxane.	emollient	1/06/1996
PHENYL METHICONE	63148-58-3			emollient	1/06/1996
PHENYL TRIMETHICONE	2116-84-9	218-320-6	1,1,5,5,5-hexamethyl-3-phenyl-3-[(trimethylsilyl)oxy]trisiloxane.	antifoaming / antistatic / emollient	1/06/1996
POLYSILICONE-1				humectant	1/06/1996
POLYSILICONE-10			Polydimethylsiloxane, methyltrimethylsilyloxy-3-hydroxypropoxysilyl terminated, ethoxylated, diester with perfluo-roalky hydrogen dilinoleate	antifoaming / hair conditioning	1/04/1998
POLYSILICONE-11	226992-90-1		Cyclosiloxanes, dimethyl, polymers with dimethyl, methyl hydro-gen siloxanes and vinyl-group terminated dimethylsiloxanes	film forming	6/01/2000
POLYSILICONE-2				humectant	1/06/1996

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
POLYSILICONE-3				emollient	1/06/1996
POLYSILICONE-4				emollient	1/06/1996
POLYSILICONE-5				emollient	1/06/1996
POLYSILICONE-6	146632-09-9			film forming	1/06/1996
POLYSILICONE-7	146632-08-8			antifoaming / antistatic	1/06/1996
POLYSILICONE-8			3-Thiopropyl methyl siloxane, polymer with dimethylsiloxane, Sester with polymer of 2-propenoic acid and methyl 2-methyl-2-propenoate	antifoaming / hair conditioning	1/04/1998
POLYSILICONE-9	165445-18-1		Silicones and siloxanes, 3-aminopropyl methyl, dimethyl, reaction products with 2-ethyl-4,5-dihydrooxazole homopolymer, ethyl sulfates	hair fixing	6/01/2000
POTASSIUM DIMETHICONE COPOLYOL PANTHENYL PHOSPHATE				humectant	1/06/1996
POTASSIUM DIMETHICONE COPOLYOL PHOSPHATE				humectant	1/06/1996
PVP/DIMETHICONYLACRYLATE/POLYCARBAMYL/POLYGLYCOL ESTER				binding / film forming / skin conditioning	1/01/1998
QUATERNIUM-86	245090-44-2		Protein hydrolizates, wheat, reaction products with acetyl chloride and ethoxylated propoxylated dimethyl siloxanes, 2-chloroethanol-quaternized	antistatic / hair conditioning	6/01/2000
SILANEDIOL SALICYLATE			2-Hydroxybenzoic acid, dihydroxysilyl ester	emollient	1/04/1998
SILANETRIOL ARGINATE	190270-68-9		L-arginine, dihydroxymethylsilyl ester	emollient	2/12/1999
SILANETRIOL GLUTAMATE	190270-72-5		L-glutamic acid, 5-(dihydroxymethylsilyl) ester	emollient	2/12/1999
SILANETRIOL LYSINATE	190270-74-7		L-lysine, dihydroxymethylsilyl ester	emollient	2/12/1999
SILANETRIOL TREHALOSE ETHER	190270-70-3		.alpha.-D-Glucopyranoside, .alpha.-D-Glucopyranosyl 2-O-(dihydroxymethylsilyl)-	emollient	2/12/1999
SILICA DIMETHYL SILYLATE	68611-44-9	271-893-4	Silane, dichlorodimethyl-, reaction products with silica.	antifoaming / emollient / viscosity c	1/01/1998
SILICA SILYLATE				antifoaming / emollient / viscosity c	1/01/1998
SILICONE QUATERNIUM-1				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-11	226992-88-7		Siloxanes and silicones, dimethyl, 3-hydroxypropyl methyl,ethers with polyethylene glycol mono[[dodecylbis(2-hydroxyethyl)ammonio]acetate], chlorides	antistatic / hair conditioning	6/01/2000
SILICONE QUATERNIUM-12	142657-60-1		Siloxanes and silicones, dimethyl, 3-hydroxypropyl methyl,ethers with polyethylene glycol mono[[(3-cocoamidopropyl) dimeth-ylammonio]acetate], chlorides	antistatic / hair conditioning	6/01/2000
SILICONE QUATERNIUM-13	227200-29-5		Siloxanes and silicones, 3-(3-carboxy-1-oxopropoxy) methyl, di-methyl, 3-hydroxypropyl methyl, esters with (2R)-2,4-dihydroxy-N-(3-hydroxypropyl)-3,3-dimethylbutanamide, ethers with polyethyl-ene glycol mono[[dimethyl[3-[(1- oxotetrade-cyl)amino]propyl]ammonio]acetate], chlorides	antistatic / hair conditioning	6/01/2000

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
SILICONE QUATERNIUM-2				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-3				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-4				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-5				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-6				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-7				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-8				antistatic / hair conditioning	1/01/1998
SILICONE QUATERNIUM-9				antistatic / hair conditioning	1/01/1998
SILOXANETRIOL ALGINATE			Alginic acid, esters with siloxanetriol	skin conditioning	1/04/1998
SILOXANETRIOL PHYTATE	190454-04-7		Siloxanes and silicones, hydroxy Me, hydroxy-terminated, esters with myo-inositol exakis(dihydrogen phosphate)	skin conditioning	2/12/1999
SIMETHICONE	8050-81-5			emollient / hair conditioning / antifoam	1/01/1998
SODIUM LACTATE METHYLSILANOL			2-[(dihydroxymethylsilyl)oxy] propionic acid, mono sodium salt	skin conditioning	1/09/1998
SODIUM PG-PROPYL THIOSULFATE DIMETHICONE				humectant / hair conditioning	1/01/1998
SORBITYL SILANEDIOL	221346-75-4		D-glucitol, 1,3-O-(dimethylsilylene)-	emollient	8/01/2000
STEARALKONIUM DIMETHICONE CO-POLYOL PHTHALATE			Siloxanes and silicones, di-Me, ethers with ethyleneglycol, propyl-ene glycol copolymer mono(hydrogen phthalate), N,Ndimethyl-N-octadecylbenzenemethanaminium salts	hair conditioning	8/01/2000
STEARAMIDOPROPYL DIMETHICONE	227200-31-9		Siloxanes and silicones, dimethyl, methyl 3-[(1-oxooctadecyl)amino]propyl	anticorrosive / film forming	8/01/2000
STEAROXY DIMETHICONE	68554-53-0		Siloxanes and silicones, di-me, (octadecyloxy)-terminated	emollient / skin conditioning	1/01/1998
STEAROXYMETHICONE/DIMETHICONE COPOLYMER				emollient / skin conditioning	1/01/1998
STEARYL DIMETHICONE	67762-83-8		Siloxanes and silicones, di-me, me stearyl	emollient / skin conditioning	1/01/1998
STEARYL METHICONE				emollient / skin conditioning / skin p	1/01/1998
STEARYL/AMINOPROPYL METHICONE COPOLYMER	110720-64-4			emollient	1/06/1996
TEA-DIMETHICONE COPOLYOL PHOS-PHATE			Siloxanes and silicones, di-Me, ethers with ethylene glycol /propylene glycol copolymer mono(dihydrogenphosphate),triethanolamine salts	humectant / surfactant	1/04/1998
TETRABUTOXYPROPYL TRISILOXANE				emollient	1/06/1996
TETRAMETHYL TETRAPHENYL TRISI-LOXANE	3982-82-9	223-620-5	1,3,3,5-tetramethyl-1,1,5,5-tetraphenyltrisiloxane.	emollient	1/06/1996
TRIFLUOROMETHYL C1-4 ALKYL DI-METHICONE				humectant / hair conditioning / skin	1/01/1998
TRIMETHYL PENTAPHENYL TRISILOX-ANE				emollient	1/06/1996

INCI name	CAS No	EINECS/ ELINCS No	Chem/IUPAC Name	Function	Last modifications
TRIMETHYLSILOXYSILICATE				antifoaming / emollient / skin conditioning	1/01/1998
TRIMETHYLSILYLAMODIMETHICONE				antistatic / emollient / skin conditioning	1/01/1998
TRIPHENYL TRIMETHICONE				emollient / skin conditioning	1/01/1998
TRIS(TRIBUTOXYSILOXY) METHYLSI-LANE	67060-84-8		Trisiloxane, 1,1,1,5,5,5-hexabutoxy-3-methyl-[(tributoxysilyl)oxy]-	emollient	1/06/1996
VINYLDIMETHICONE				viscosity controlling	1/06/1996

Emollients: Substances which are added to cosmetic products to soften and smoothen the skin.

Humectants: Substances which are added to cosmetic products to hold and retain moisture.

Antistatic agents: Substances which are added to cosmetic products to reduce static electricity by neutralising electrical charge on a surface.

Annex 2
Siloxanes in hair styling products on the Danish market

The table below lists siloxanes identified in a Danish survey of chemicals in hair styling products. In total 585 different chemicals were identified in 328 products, among these 25 siloxanes (Poulsen et al. 2002).

The table shows the number of products in which the compounds were found and the average ranking of the substance in the declaration of contents of the products. The ranking is an indication of the relative concentration of the substances in the products. A low number (high ranking) indicates that the compound is a main ingredient, whereas a high number (low ranking) indicates that the substance is an additive.

Declared name	CAS No.	Chemical name according to the INCI list *	Function according to the INCI list *	No. of products	Average ranking
ACRYLATES / DIMETHICONE COPOLYMER				3	6.0
AMODIMETHICONE			antistatic agents	16	9.5
AMODIMETHICONE CETRIUM CHLORIDE				1	7.0
CYCLOMETHICONE	69430-24-6	Octamethylcyclotetrasiloxane / decamethylcyclopentasiloxane	antistatic agents / emollients / humectants / solvents / viscosity controlling agents	24	6.3
CYCLOMETHICONE DIMETHICONOL				1	3.0
CYCLOPENTASILOXANE	541-02-6 (found)			15	5.9
DIMETHICONAL				1	19.0
DIMETHICONE	9006-65-9 63148-62-9	Dimethicone	antifoaming agents / emollients	21	5.4
DIMETHICONE BISAMINO HYDROXYPROPYL COPOLYOL / ALGAE / ALOE BARBADENSIS / CHAMOMILE / HENNA / JOJOBA / ROSEMARY / DIMETHICONE COPOLYOL				2	6.5
DIMETHICONE BISAMINO HYDROXYPROPYL COPOLYOL / GLUTAMINE / TYROSINE / LEUCINE / CYSTEINE / GLYSINE / COMFREY / PLANTAIN / HYDROLYZED WHEAT PROTEIN / DIMETHICONE COPOLYOL				1	8.0
DIMETHICONE BISAMINO HYDROXYPROPYL COPOLYOL / WHITE GINGER / DIMETHICONE COPOLYOL				4	7.5
DIMETHICONE COPOLYOL	64365-23-7	Siloxanes and silicones, di-me, hydroxy-terminated, ethoxylated propoxylated	antistatic agents / emollients	82	7.5
DIMETHICONE COPOLYOL ACETATE			humectants	1	7.0
DIMETHICONE PROPYL PG-BETAINE			antistatic agents / surfactants	4	6.5

Declared name	CAS No.	Chemical name according to the INCI list *	Function according to the INCI list *	No. of products	Average ranking
DIMETHICONOL	31692-79-2	Poly[oxy(dimethylsilylane)], a-hydro-?-hydroxy-	antifoaming agents / emollients	12	7.0
DIPHENYL DIMETHICONE			emulsifying agents	1	7.0
PEG / PPG 25 / 25 DIMETHICONE / ACRYLATES CO-POLYMER				1	2.0
PEG / PPG-14 / 4 DIMETHICONE					6.0
PHENYL TRIMETHICONE	2116-84-9	1, 1, 5, 5, 5-hexamethyl-3-phenyl-3-[(trimethylsilyl)oxy]trisiloxane	antifoaming agents/ antistatic agents / emollients	18	5.3
POLYSILICONE-11				1	5.0
POLYSILICONE-8				5	4.6
POLYSILOXAN				1	4.0
SIMENTHICON				1	16.0
SIMETHICONE	8050-81-5		emollients	1	16.0
TRIMETHYLSILYLAMODIMETHICONE			antistatic agents / emollients	1	15.0

* Chemicals with no indication of function were not included in the INCI list at the time the study was reported.

Source:

Poulsen, P., A. A. Jensen & L. Hoffmann. 2002. ***Kortlægning af kemiske stoffer i hårstylingsprodukter.*** Kortlægning no. 18/2002. Danish EPA, Copenhagen. http://www.mst.dk/kemi/02052600.htm

Annex 3
Siloxanes in the Danish Product Register

The compounds are ranked according to max. import.

Volumes refer to the total content of siloxanes in products imported, exported or produced in Denmark. The same volumes may actually be registered both as import and production if the compound is imported in some semi-manufactures

DI-ME = Dimethyl ; ET=Ethyl ; ME= Methyl; PH=Phenyl.

		Tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CAS No.	Name (used in the Product Register)	min	max	min	max	min	max	prod	comp
68937-55-3	SILOXANER OG SILICONER, DI-ME, 3-HYDROXYPROPYL ME, ETHOXYLERET, PROPOXYLERET	311.787	312.503	25.897	50.673	6.2½23	18.225	133	38
63148-53-8	SILOXANES AND SILICONES	300.933	301.567	0.000	6.539	0.333	3.873	658	51
63148-62-9	POLY(DIMETHYLSILOXAN)	129.918	164.681	18.667	252.998	7.284	151.320	2385	340
70131-67-8	SILOXANES AND SILICONES, DI-ME, HYDROXY-TERMINATED	51.069	97.961	4.623	8.019	5.816	9.615	174	77
68083-19-2	SILOXANES AND SILICONES, DI-ME, VINYL GROUP-TERMINATED	0.133	71.909	0.000	0.000	0.000	0.000	14	8
	CONFIDENTIAL	60.840	60.840	0.000	0.000	12.168	12.168	2	1
63148-57-2	SILOXANES AND SILICONES, ME HYDROGEN	52.478	52.485	0.000	0.020	0.000	0.004	67	34
156012-96-3	SILOXANES AND SILICONES, DI-ME, 3-(4-HYDROXY-3-METHOXYPHENYL)PROPYL ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE GLYCOL MONO-ME ETHER	44.225	44.663	0.000	½0.000	0.000	0.000	5	4
541-02-6	CYCLOPENTASILOXANE, DECAMETHYL-	36.792	36.990	0.026	0.028	0.118	0.120	70	34
9006-65-9	SILIKONEOLIE	6.489	35.345	5.538	384.147	0.614	229.142	458	89
107-51-7	OCTAMETHYLCYCLOTETRASILOXAN	34.768	34.944	0.065	0.094	0.022	0.041	160	62
68037-77-4	SILOXANES AND SILICONES, ET ME, ME 2-PHENYLPROPYL	23.910	24.872	0.085	2.833	0.025	1.198	58	20
67762-90-7	POLY(DIMETHYLSILOXAN), REAKTIONSPRODUKTER MED SILICA	22.207	23.719	0.745	217.039	1.034	171.511	861	166
128192-17-6	SILOXANES AND SILICONES DI-ME, 3-HYDROXYPROPYL ME, 3-HYDROXYPROPYL GROUP-TERMINATED, ETHOXYLATED PROPOXYLATED	19.051	19.101	0.001	0.022	0.000	0.011	31	15
68554-65-4	SILOXANES AND SILICONES, DI-ME, POLYMERS WITH ME SILSESQUIOXANES AND POLYETHYLENE- POLYPROPYLENE GLYCOL BU ETHER	12.057	12.341	0.004	0.660	0.060	0.133	147	39
130328-16-4	SILOXANES AND SILICONES, DI-ME, POLYMERS WITH PH SILSESQUIOXANES, ME- AND METHOXY-TERMINATED, REACTION PRODUCTS WIHT ETHYLENE GLYCOL AND TRIMETHYLOLPROPANE	7.972	9.932	0.000	0.000	0.891	0.891	8	7
109961-41-3	SILOXANES AND SILICONES, DI-ME, POLYMERS WITH PH SILSESQUIOXANES, HYDROXY-TERMANATED	9.044	9.049	0.000	0.000	0.000	0.000	3	3

CAS No.	Name (used in the Product Register)	Tonnes siloxanes						No. of	No. of
		Import		Production		Export			
		min	max	min	max	min	max	prod	comp
68937-54-2	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHOXYLATED	4.578	8.614	3.184	7.330	0.281	2.968	179	38
67762-85-0	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE-POLYPOLENE GLYCOL ME ETHER	7.770	8.059	8.088	24.235	0.542	10.405	721	102
134180-76-0	OXIRANE, METHYL-, POLYMER WITH OXI-RANE, MONO(3-(1,3,3,3-TETRAMETHYL-1-((TRIMETHYLSI-LYL)OXY)DISILOXANYL)PROPYL) ETHER	5.516	5.693	0.000	0.000	0.000	0.000	12	10
69430-24-6	CYCLISKE DIMETHYLSILOXANER	4.135	4.900	0.049	0.154	0.038	0.135	217	72
68554-68-7	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES, POLY-ETHYLENE-POLYPROPYLENE GLYCOL AND POLYETHYLENE-POLYPROPYLENE GLYCOL MONO-BU ETHER	4.624	4.734	69.421	98.303	48.682	67.322	17	9
75718-16-0	SILOXANES AND SILICONES, 3-((2-AMINOETHYL)AMINO)PROPYL ME, DI-ME, HYDROXY-TERMINATED	4.611	4.611	0.000	0.000	0.000	0.000	4	3
	CONFIDENTIAL	4.510	4.510	0.000	0.000	0.000	0.000	2	1
64365-23-7	SILOXANES AND SILICONES, DI-ME, ETH-OXYLATED-PROPOXYLATED	1.141	4.427	0.976	3.118	0.571	4.165	246	53
68037-62-7	SILOXANES AND SILICONES, DI-ME, ME HYDROGEN, REACTION PRODUCTS WITH POLYETHYLENE GLYCOL MONOACETATE ALLYL ETHER AND POLYETHYLENE-POLYPROPYLENE GLYCOL MONOACETATE ALLYL ETHER	4.167	4.194	0.000	0.000	0.000	0.000	4	2
71750-79-3	SILOXANES AND SILICONES, 3-((2-AMINOETHYL)AMINO)PROPYL ME, DI-ME	3.878	3.952	0.000	0.000	0.000	0.000	8	4
9016-00-6	POLY(OXY(DIMETHYLSILYLENE))	3.025	3.484	0.249	0.249	0.148	0.148	123	38
71750-80-6	SILOXANES AND SILICONES, DI-ME, (((3-((2-AMINOETHYL)-AMINO)PROPYL)DIMETNOXYSILYL)OXY)-TERMINATED	3.375	3.375	0.000	0.000	0.000	0.000	9	7
67923-07-3	SILOXANES AND SILICONES, DI-ME, (((3-((2-AMINO-ETHYL)AMINO)PROPYL)SILYLIDYNE)TRIS(OXY))TRIS-, METHOXY-TERMINATED	3.021	3.248	0.095	0.095	0.011	0.011	131	53
162567-81-9	SILOXANES AND SILICONES, ME HYDRO-GEN, REAKCTION PRODUCTS WITH 1-OCTENE AND POLYPROPYLENE GLYCOL MONO-BU ETHER	0.974	3.060	0.087	0.340	0.122	0.211	108	38
63148-55-0	SILOXANES AND SILICONES, DI-ME, HY-DROXY-TERMINATED, ETHOXYLATED	2.823	3.002	0.086	0.706	0.036	0.564	34	8
67762-96-3	DIMETHYLSILOX-ANER/DIMETHYLSILICONER, POLYMERER MED POLYPROPYLENGLYKOL BUTYLETHER	2.593	2.992	0.042	0.115	0.000	0.000	126	57
	CONFIDENTIAL	2.767	2.767	0.000	0.000	0.000	0.000	1	1
67923-08-4	SILOXANES AND SILICONES, DI- ME,(((3-((2-AMINO-ETHYL)AMINO)PROPYL)SILYLIDYNE)TRIS(OXY))TRIS-	0.869	2.525	0.615	0.620	0.255	0.256	4	3
	CONFIDENTIAL	2.350	2.350	0.000	0.000	0.000	0.000	1	1
68554-64-3	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES AND POLYPROPYLENE GLYCOL BU ETHER	0.861	2.016	0.313	0.374	0.164	0.187	146	33
	CONFIDENTIAL	0.005	1.765	0.000	0.000	0.000	0.000	2	2
999990-11-3	SILOXANES AND SILICONES, DI-ME, ME H, REACTION PRODUCT WITHPOLY(OXY-1,2-ETHANEDIYL), .ALFA.-METHYL-.OMEGA-(2-PROPENYLOXY)-AND POLY(OXY(METHYL-1,2-ETHANEDIYL)), .ALFA-(2-PROPENYL)-.OMEGA.-HYDROXY-, ACETYLATED	1.730	1.754	0.192	0.296	0.180	0.199	44	13

CAS No.	Name (used in the Product Register)	Tonnes siloxanes						No. of	No. of
		Import		Production		Export			
		min	max	min	max	min	max	prod	comp
	CONFIDENTIAL	1.500	1.700	0.000	0.000	0.000	0.000	1	1
70900-21-9	POLY(DIMETHYLSILOXAN), HYDROGEN-TERMINERET	1.620	1.633	0.213	0.489	0.002	0.073	47	32
63148-56-1	SILOXANES AND SILICONES, ME 3,3,3-TRIFLUOROPROPYL	1.566	1.566	0.009	0.018	0.010	0.015	251	36
	CONFIDENTIAL	1.544	1.544	0.000	0.000	0.000	0.000	2	1
68037-64-9	SILOXANES AND SILICONES DI-ME, ME HYDROGEN, REACTION PRODUCTS WITH POLYETHYLENE-POLYPROPYLENE GLYCOL MONOACETATE ALLYL ETHER	0.825	1.302	0.040	28.550	0.013	17.533	474	37
67762-87-2	SILOXANES AND SILICONES DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE-POLYPROPYLENE GLYCOL MONO-BU ETHER	1.127	1.129	0.160	0.160	0.064	0.064	10	4
	CONFIDENTIAL	1.000	1.000	0.000	0.000	1.000	1.000	1	1
999984-79-1	ISOPHTHALSYRE/(OCTADECADIENOIC ACID)/P-TERT-BUTYLBENZOESY-RE/PENTAERYTHRITOL/(SILOXANES AND SILICONES DI-ME, DI-PH, HYDROXY-TERMINA-TED)/SOJABØNNEOLIEFEDTSYRER/TALLOLIEFEDTSYRER POLYMER	0.998	0.998	0.000	0.000	0.000	0.000	8	2
	CONFIDENTIAL	0.000	0.932	0.000	0.000	0.000	0.000	2	2
143372-54-7	SILOXANES AND SILICONES, (3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-HEPTADECAFLUORODECYL)OXY ME, HY-DROXY ME, ME OCTYL, ETHERS WITH POLYETHYLENEGLYCOL MONO-MET ETHER	0.928	0.931	0.333	0.401	0.095	0.097	60	11
73138-87-1	DIHYDROXYPOLYDIMETHYLSILOXAN	0.874	0.874	0.000	0.000	0.000	0.000	5	6
	CONFIDENTIAL	0.610	0.760	0.000	0.000	0.000	0.000	3	1
110028-34-7	SILOXANES AND SILICONES, DI-ME, HY-DROXY-TERMINATED, POLYMERS WITH ACRYLIC ACID, MALEIC ANHYDRIDE AND PENTAERYTHRITOL	0.366	0.710	0.000	0.000	0.053	0.053	4	2
71750-81-7	SILOXANES AND SILICONES, DI-ME, MONO(((3-((-AMINO-ETHYL)AMINO)PROPYL)DIMETHYOXYSILYL)OXY)-TERMINATED	0.566	0.570	0.018	0.093	0.012	0.027	19	15
68583-49-3	CYCLOTETRASILOXANE, OCTAMETHYL-, REACTION PRODUCTS WITH SILICA	0.046	0.541	0.002	0.011	0.002	0.009	50	24
68957-04-0	SILOXANES AND SILICONES, DI-ME, METHOXY PH, POLYMERS WITH PH SIL-SESQUIOXANES, METHOXY-TERMINATED	0.527	0.527	0.000	0.000	0.000	0.000	7	2
68440-90-4	METHYLOCTYLPOLYSILOXAN	0.518	0.519	0.531	0.531	0.264	0.264	37	7
68554-67-6	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES, HY-DROXY-TERMINATED	0.252	0.455	0.110	0.110	0.000	0.000	4	3
68554-66-5	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES, ETH-OXY-TERMINATED	0.359	0.451	0.000	0.000	0.000	0.000	11	9
68554-54-1	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH 3-((2-AMINOETHYL)AMINE) PROPYL SILSESQUIOXANES, HYDROXY-TERMINATED	0.350	0.413	0.108	0.108	0.022	0.022	11	10
73138-88-2	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH PH SILSESQUIOXANES	0.304	0.393	18.579	18.605	17.712	17.729	15	7
70914-12-4	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE GLYCOL ACETATE	0.332	0.359	0.267	0.531	0.132	0.264	19	12

		Tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CAS No.	Name (used in the Product Register)	min	max	min	max	min	max	prod	comp
73398-65-9	POLY(DIMETHYLSILOXAN), ACRYLOY-LOXYMETHYL-TERMINERET	0.211	0.348	0.000	0.000	0.000	0.000	13	7
	CONFIDENTIAL	0.342	0.342	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.325	0.325	0.000	0.000	0.302	0.302	3	1
9011-19-2	POLY(OXY(DIMETHYLSILYLENE)), .ALPHA.-HYDRO-.OMEGA.-HYDROXY-, POLYMER WITH .ALPHA.-HYDRO-.OMEGA.-HYDROXYPOLY(OXY(METHYL(2-PHENYLETHYL)SILYLENE))	0.322	0.323	0.000	0.000	0.000	0.000	4	3
	CONFIDENTIAL	0.000	0.295	0.000	0.000	0.000	0.000	1	1
162567-97-7	SILOXANES AND SILICONES, DI-ME, ME HYDROGEN, REACTION PRODUCTS WITH POLYETHYLENE GLYCOL MONO-ME ETHER AND POLYPROPYLENE GLYCOL MONO-BU ETHER	0.142	0.279	0.000	0.002	0.013	0.014	33	18
157479-55-5	siloxanes and silicones, di-Me, 3-hydroxypropyl group-terminated, ethers with polyethylene-polypropylene glycol mono-Me ether	0.254	0.278	0.000	28.961	0.000	17.798	291	4
63148-58-3	METHYLPHENYLSILOXAN	0.252	0.270	0.055	0.061	0.011	0.011	28	22
	CONFIDENTIAL	0.265	0.265	0.000	0.000	0.000	0.000	2	1
107-51-7	OCTAMETHYLTRISILOXAN	0.241	0.242	0.135	0.599	0.126	0.509	14	4
	CONFIDENTIAL	0.241	0.241	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.238	0.238	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.237	0.000	0.000	0.000	0.067	2	2
102782-92-3	SILOXANES AND SILICONES, 3-((AMINOETHYL)AMINO)PROPYL ME, DI-ME, METHOXY-TERMINATED	0.236	0.236	0.000	0.000	0.000	0.000	4	3
	CONFIDENTIAL	0.231	0.231	0.000	0.000	0.000	0.000	1	1
68037-74-1	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES	0.187	0.187	0.138	0.138	0.000	0.000	5	5
	CONFIDENTIAL	0.091	0.146	0.000	0.000	0.000	0.000	3	1
	CONFIDENTIAL	0.134	0.141	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.116	0.138	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.137	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.137	0.000	0.000	0.000	0.000	1	1
87244-72-2	SILOXANES AND SILICONES POLYOXYAL-KYLENE-	0.136	0.136	0.875	2.519	0.000	0.056	8	3
2157-42-8	SILICIC ACID, (H6SI2O7), HEXAETHYL ESTER	0.127	0.127	0.000	0.000	0.000	0.000	8	6
	CONFIDENTIAL	0.127	0.127	0.000	0.000	0.000	0.000	2	2
162567-89-7	SILOXANES AND SILICONES, DI-ME, ME HYDROGEN, REACTION PRODUCTS WITH ACETIC ANHYDRIDE, POLYETHYLENE GLY-COL ALLYL ME ETHER AND POLYPROPYLE-NEGLYCOL MONOALLYL ETHER	0.110	0.112	0.033	0.033	0.013	0.013	9	6
	CONFIDENTIAL	0.000	0.104	0.000	0.000	0.000	0.000	2	2
115361-68-7	siloxanes and silicones, di-Me, Me 3,3,3-trifluoropropyl	0.100	0.100	0.001	0.001	0.000	0.001	8	2
68938-54-5	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE GLYCOL ME ETHER	0.097	0.097	0.000	0.000	0.000	0.000	6	3
68607-69-2	SILOXANES AND SILICONES 3-(ACETYLOXY)PROPYL ME, DI-ME	0.026	0.091	0.000	0.000	0.000	0.000	16	4
94469-32-6	SILOXANES AND SILICONES, POLYETHER-	0.089	0.089	0.000	0.000	0.000	0.000	7	5
	CONFIDENTIAL	0.064	0.088	0.000	0.000	0.000	0.000	1	1
162567-80-8	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL GROUP-TERMINATED, REACTION PRODUCTS WITH 2-OXEPANONE, ACETATES	0.085	0.085	0.001	0.001	0.000	0.000	17	5

CAS No.	Name (used in the Product Register)	Tonnes siloxanes Import min	Import max	Production min	Production max	Export min	Export max	No. of prod	No. of comp
107-46-0	HEXAMETHYLDISILOXAN	0.082	0.083	0.003	0.033	0.003	0.030	37	15
	CONFIDENTIAL	0.082	0.082	0.000	0.000	0.014	0.014	1	1
999988-86-2	(2-HYDROXYETHYL)ACRYLAT/DISILOXANE, 1,1,3,3-TETRAMETHYL-/ISOPHORONDIISOCYANAT/POLY(OXY-1,2-ETHANEDIYL), .ALPHA.-2-PROPENYL-,OMEGA.-HYDROXY-/SILOXAN OG SILICONE, DIMETHYL, REAKTIONSPRODUKT MED POLYETHYLEN GLYCOL MONOLKRYL ETHER OG 1,1,2,3-DETRAMETHYLDISILO	0.068	0.080	0.000	0.000	0.000	0.000	5	2
	CONFIDENTIAL	0.073	0.073	0.000	0.000	0.000	0.000	1	1
104133-09-7	HEXAMETHYLDISILOXAN/TETRAETHYLSILICAT POLYMER	0.044	0.069	0.014	0.014	0.000	0.000	19	14
104780-70-3	SILOXANES AND SILICONES, DI-ME, ME 3-(1,1,2,2-TETRAFLUOROETHOXY)PROPYL, ME 3,3,4,4,5,5,6,6,7,7,8,8,8-TRIDECAFLUOROOCTYL	0.059	0.061	0.013	0.016	0.012	0.013	67	16
	CONFIDENTIAL	0.000	0.060	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.000	0.060	0.000	0.000	0.000	0.000	1	1
999987-56-3	1-DODECEN/ISOBUTYLVINYLETHER/(SILOXANES AND SILICONES, ME HYDROGEN) POLYMER	0.051	0.052	0.266	0.266	0.120	0.120	9	7
	CONFIDENTIAL	0.051	0.051	0.000	0.000	0.000	0.000	1	1
999990-86-2	1-OCTEN/POLYOXYETHYLEN ALLYL METHYL ETHER/SILOXANES AND SILICONES, ME HYDROGENPOLYMER	0.047	0.051	0.000	0.000	0.000	0.000	6	4
	CONFIDENTIAL	0.050	0.050	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.050	0.050	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.049	0.049	0.000	0.000	0.000	0.000	1	1
68037-81-0	SILOXANES AND SILICONES, DI-PH, ME PH, POLYMERS WITH ME PH SILSESQUIOXANES	0.044	0.044	0.000	0.000	0.000	0.000	3	3
68037-59-2	SILOXANES AND SILICONES, DI-ME, ME HYDROGEN	0.038	0.038	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.037	0.037	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.031	0.031	0.000	0.000	0.000	0.000	3	2
540-97-6	CYCLOHEXASILOXANE, DODECAMETHYL-	0.015	0.030	0.000	0.003	0.000	0.002	17	11
	CONFIDENTIAL	0.029	0.029	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.028	0.028	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.020	0.027	0.000	0.000	0.000	0.000	2	1
	CONFIDENTIAL	0.026	0.026	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.025	0.000	0.000	0.000	0.020	1	1
	CONFIDENTIAL	0.023	0.023	0.000	0.000	0.000	0.000	1	1
68440-66-4	SILOXANES AND SILICONES, DI-ME, 3-HYDRROXYPROPYL ME, ETHERSWITH POLYPROPYLENEGLYCOL BU ETHER	0.022	0.023	0.018	0.018	0.015	0.015	19	9
68552-43-2	fatty acids, soya, polymers with hydroxy-terminated Me Ph siloxanes, pentearythrtol and phthalic anhydride	0.022	0.022	0.000	0.000	0.000	0.000	5	2
162567-83-1	siloxanes and silicones, Me hydrogen, reaction products with methylstyrene and 1-octene	0.017	0.022	0.000	0.000	0.000	0.000	7	2
104780-71-4	SILOXANES AND SILICONES DI-ME, ((2-OCTYLDODECYL)OXY)-TERMINATED	0.019	0.020	0.000	0.000	0.000	0.000	15	12
	CONFIDENTIAL	0.018	0.018	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.018	0.018	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.016	0.016	0.000	0.000	0.000	0.000	1	1

		Tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CAS No.	Name (used in the Product Register)	min	max	min	max	min	max	prod	comp
	CONFIDENTIAL	0.015	0.015	0.000	0.000	0.000	0.000	1	1
63148-52-7	SILOXANES AND SILICONES, DI-ME ME PH	0.012	0.012	0.232	0.248	0.211	0.225	6	4
	CONFIDENTIAL	0.000	0.010	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.010	0.010	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.008	0.000	0.000	0.000	0.000	1	1
27306-78-1	POLY(OXY-1,2-ETHANEDIYL), .ALPHA.-METHYL-.OMEGA.-(3-(1,3,3,3-TETRAMETHYL-1-((TRIMETHYLSI-LYL)OXY)DISILOXANYL)PROPOXY)-	0.005	0.008	0.000	0.000	0.000	0.000	7	5
68440-64-2	SILOXANES AND SILICONES, DI-ME, DI-PH, POLYMERS WITH ME PH SILSESQUIOX-ANES	0.000	0.008	0.075	0.075	0.000	0.000	3	2
	CONFIDENTIAL	0.006	0.008	0.000	0.000	0.000	0.000	1	1
115340-95-9	siloxanes and silicones, dimethyl, methyl 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl	0.007	0.007	0.028	0.028	0.020	0.020	10	2
3555-47-3	TRISILOXANE, 1,1,1,5,5,5-HEXAMETHYL-3,3-BIS((TRIMETHYLSILYL)OXY)-	0.007	0.007	0.000	0.000	0.003	0.003	6	6
104199-38-4	HEXAMETHYLDISI-LOXAN/TETRAETHYLSILICAT/TETRAMETHYL-1,3-DIVINYLDISILOXAN POLYMER	0.006	0.006	0.001	0.001	0.000	0.000	4	4
68951-93-9	SILOXANES AND SILICONES DI-ME, DI-PH, HYDROXY-TERMINATED	0.002	0.005	0.000	0.000	0.000	0.000	3	2
	CONFIDENTIAL	0.004	0.005	0.000	0.000	0.000	0.000	2	1
	CONFIDENTIAL	0.005	0.005	0.000	0.000	0.005	0.005	1	1
69430-45-1	POLY(DIMETHYLSILOXAN), REAKTIONS-PRODUKTER MED ETHOXYLERET ALLYLAL-KOHOL OG 1,1,3,3-TETRAMETHYLDISILOXAN	0.000	0.004	0.000	0.000	0.000	0.000	5	2
146905-77-3	siloxanes and silicones, 3-[3-[(carboxymethyl)dimethylammonio]-2-hydroxypropoxy)]propyl Me, di-Me, hydroxides, inner salts	0.004	0.004	0.000	0.000	0.000	0.000	3	3
8050-81-5	SIMETHICONE	0.002	0.003	0.000	0.000	0.000	0.000	5	5
	CONFIDENTIAL	0.003	0.003	0.000	0.000	0.000	0.000	1	1
18001-60-0	DISILOXANE, 1,1,3,3-TETRAETHOXY-1,3-DIMETHYL-	0.002	0.002	0.000	0.000	0.000	0.000	3	2
	CONFIDENTIAL	0.002	0.002	0.000	0.000	0.000	0.000	1	1
4521-94-2	SILICIC ACID, (H8SI3O10), OCTAETHYL ESTER	0.002	0.002	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.001	0.001	1	1
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.000	0.001	0.000	0.000	0.000	0.000	1	1
63148-61-8	SILOXANES AND SILICONES, DI-ET	0.001	0.001	0.000	0.000	0.000	0.000	1	1
13331-84-5	SILICIC ACID(H10SI4O13), DECAETHYL ES-TER	0.001	0.001	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	1	1
141-62-8	DECAMETHYLTETRASILOXAN	0.001	0.001	0.000	0.000	0.000	0.000	10	3
999983-93-6	NATRIUMSILICAT (US-PEC.)/POLY(DIMETHYLSILOXAN)/SILOXANES ANDSILICONES, DI-ME, HYDROXY-TERMINATED POLYMER	0.000	0.000	0.006	0.006	0.005	0.005	9	5
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	3	2
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	2	2

CAS No.	Name (used in the Product Register)	Tonnes siloxanes						No. of	No. of
		Import		Production		Export		prod	comp
		min	max	min	max	min	max		
18727-73-6	DECAETHOXYCYCLOPENTANSILOXAN	0.000	0.000	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.000	0.000	0.007	0.000	0.005	22	2
	CONFIDENTIAL	0.000	0.000	0.000	0.243	0.000	0.210	2	2
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	2
17995-36-7	OCTAETHOXYCYCLOTETRASILOXAN	0.000	0.000	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	2	1
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
541-05-9	CYCLOTRISILOXANE, HEXAMETHYL-	0.000	0.000	0.000	0.000	0.000	0.000	9	5
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.000	0.919	0.919	0.549	0.549	16	2
	CONFIDENTIAL	0.000	0.000	0.002	0.002	0.000	0.000	1	1
	Total	1215.233	1425.921	162.229	1142.806	106.401	741.978		

Annex 4
Siloxanes in sealants

Product Register T12 codes: U0540, U0510, U0530, U0520, H1548.

The compounds are ranked according to max. import.

DI-ME = Dimethyl ; ET=Ethyl ; ME= Methyl.

		tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CAS No.	Name(used in the Product Register)	min	max	min	max	min	max	prod	comp
63148-53-8	SILOXANES AND SILICONES	300.060	300.062	0.000	07	00	03	25	18
68083-19-2	SILOXANES AND SILICONES, DI-ME, VINYL GROUP-TERMINATED	0.035	71.642	0.000	00	00	00	3	2
70131-67-8	SILOXANES AND SILICONES, DI-ME, HY-DROXY-TERMINATED	33.810	65.769	0.947	0.952	00	0.348	34	20
	CONFIDENTIAL	60.840	60.840	0.000	00	12.168	12.168	2	1
63148-62-9	POLY(DIMETHYLSILOXAN)	18.262	36.961	0.468	0.530	0.219	0.505	76	47
	CONFIDENTIAL	4.510	4.510	0.000	00	00	00	2	1
67762-90-7	POLY(DIMETHYLSILOXAN), REAKTIONSPRODUKTER MED SILICA	2.728	3.079	0.387	0.959	0.442	0.950	114	66
	CONFIDENTIAL	2.767	2.767	0.000	00	00	00	1	1
63148-57-2	SILOXANES AND SILICONES, ME HYDRO-GEN	2.753	2.753	0.000	02	00	00	13	11
69430-24-6	CYCLISKE DIMETHYLSILOXANER	2.093	2.640	0.000	00	02	08	17	10
68554-65-4	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES AND POLYETHYLENE- POLYPROPYLENE GLYCOL BU ETHER	2.017	2.068	0.000	00	0.012	0.012	21	13
	CONFIDENTIAL	0.000	1.760	0.000	00	00	00	1	1
	CONFIDENTIAL	1.000	1.000	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.932	0.000	00	00	00	2	2
9006-65-9	SILIKONEOLIE	0.111	0.806	0.000	130.737	00	84.291	21	20
67762-87-2	SILOXANES AND SILICONES DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE-POLYPROPYLENE GLYCOL MONO-BU ETHER	0.796	0.796	0.000	00	0.064	0.064	10	4
68554-64-3	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES AND POLYPROPYLENE GLYCOL BU ETHER	0.574	0.594	0.000	00	0.024	0.024	11	8
73138-87-1	DIHYDROXYPOLYDIMETHYLSILOXAN	0.577	0.577	0.000	00	00	00	3	3
	CONFIDENTIAL	0.500	0.500	0.000	07	00	06	2	2
70900-21-9	POLY(DIMETHYLSILOXAN), HYDROGEN-TERMINERET	0.323	0.323	0.000	00	00	00	3	3
	CONFIDENTIAL	0.320	0.320	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.295	0.000	00	00	00	1	1
	CONFIDENTIAL	0.165	0.165	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.137	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.137	0.000	00	00	00	1	1
67762-85-0	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE-POLYPOLENE GLYCOL ME ETHER	0.111	0.111	0.077	0.077	0.166	0.166	11	10

		tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CAS No.	Name(used in the Product Register)	min	max	min	max	min	max	prod	comp
68037-54-7	CYCLOSILOXANES, ME PH	0.000	0.104	0.000	00	00	00	2	2
70914-12-4	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE GLYCOL ACETATE	0.089	0.089	0.000	00	00	00	3	2
	CONFIDENTIAL	0.082	0.082	0.000	00	0.014	0.014	1	1
	CONFIDENTIAL	0.079	0.079	0.000	00	00	00	1	1
	CONFIDENTIAL	0.050	0.050	0.000	00	00	00	1	1
556-67-2	OCTAMETHYLCYCLOTETRASILOXAN	0.045	0.046	0.000	00	00	00	7	5
541-02-6	CYCLOPENTASILOXANE, DECAMETHYL-	0.042	0.042	0.000	00	00	00	7	5
63148-58-3	METHYLPHENYLSILOXAN	0.041	0.041	0.000	00	00	00	3	2
67762-96-3	DIMETHYLSILOX-ANER/DIMETHYLSILICONER, POLYMERER MED POLYPROPYLENGLYKOL BUTYLETHER	0.022	0.025	0.000	00	00	00	6	6
67923-07-3	SILOXANES AND SILICONES, DI-ME, (((3-((2-AMINO-ETHYL)AMINO)PROPYL)SILYLIDYNE)TRIS(OXY))TRIS-, METHOXY-TERMINATED	0.010	0.019	0.026	0.026	00	00	4	4
68554-68-7	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES, POLY-ETHYLENE-POLYPROPYLENE GLYCOL AND POLYETHYLENE-POLYPROPYLENE GLYCOL MONO-BU ETHER	0.006	0.011	25.555	50.046	16.474	32.263	7	5
	CONFIDENTIAL	0.008	0.008	0.000	00	00	00	1	1
999987-56-3	1-DODE-CEN/ISOBUTYLVINYLETHER/(SILOXANES AND SILICONES, ME HYDROGEN) POLY-MER	0.006	0.006	0.089	0.089	05	05	4	4
68583-49-3	CYCLOTETRASILOXANE, OCTAMETHYL-, REACTION PRODUCTS WITH SILICA	0.003	0.004	0.000	00	00	00	4	4
	CONFIDENTIAL	0.002	0.002	0.001	01	00	00	2	2
	CONFIDENTIAL	0.002	0.002	0.000	00	00	00	2	1
	CONFIDENTIAL	0.001	0.001	0.000	00	00	00	1	1
162567-81-9	SILOXANES AND SILICONES, ME HYDRO-GEN, REAKCTION PRODUCTS WITH 1-OCTENE AND POLYPROPYLENE GLYCOL MONO-BU ETHER	0.001	0.001	0.000	00	00	00	6	6
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
104780-71-4	SILOXANES AND SILICONES DI-ME, ((2-OCTYLDODECYL)OXY)-TERMINATED	0.000	0.000	0.000	00	00	00	3	3
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	2	2
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	2	1
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	2	1
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
104780-70-3	SILOXANES AND SILICONES, DI-ME, ME 3-(1,1,2,2-TETRAFLUOROETHOXY)PROPYL, ME 3,3,4,4,5,5,6,6,7,7,8,8,8-TRIDECAFLUOROOCTYL	0.000	0.000	0.000	00	00	00	4	3
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.000	0.000	00	00	00	1	1
	CONFIDENTIAL	0.000	0.000	0.000	07	00	06	1	1
	CONFIDENTIAL	0.000	0.000	0.597	0.597	0.171	0.171	1	1
	CONFIDENTIAL	0.000	0.000	0.075	0.075	00	00	2	1
	CONFIDENTIAL	0.000	0.000	0.138	0.138	00	00	2	2

CAS No.	Name(used in the Product Register)	tonnes siloxanes							
		Import		Production		Export		No. of	No. of
		min	max	min	max	min	max	prod	comp
	CONFIDENTIAL	0.000	0.000	0.003	03	03	03	1	1
	CONFIDENTIAL	0.000	0.000	0.003	03	03	03	1	1
		434.842	562.154	28.366	184.255	29.767	131.012	468	326

Annex 5
Siloxanes in cleaning and maintenance products

Product register T12 codes: A4000, A4010, A4020, D0500, K3000, P1000, P1005, P1010, P1015, P1020, P1040, P1045, P1050, P1099, R1000, R1015, R1016, R1018, R1025, R1035, R1037, R1040, R1045, R1050, R1060, R1080, R1097, R1099, S0510, S0520, S2500+2550.

The compounds are ranked according to max. import.

DI-ME = Dimethyl ; ET=Ethyl ; ME= Methyl.

		tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CASNo.	Name (used in the Product Register)	min	max	min	max	min	max	prod	comp
63148-62-9	POLY(DIMETHYLSILOXAN)	29.233	34.151	3.916	5.178	0.972	1.727	297	188
	CONFIDENTIAL	3.300	3.300	0.000	0.000	0.000	0.000	1	1
71750-79-3	SILOXANES AND SILICONES, 3-((2-AMINOETHYL)AMINO)PROPYL ME, DI-ME	2.761	2.834	0.000	0.000	0.000	0.000	4	2
9006-65-9	SILIKONEOLIE	1.223	2.354	0.008	0.528	0.000	0.515	23	20
69430-24-6	CYCLISKE DIMETHYLSILOXANER	1.933	1.962	0.006	0.010	0.001	0.002	33	24
9016-00-6	POLY(OXY(DIMETHYLSILYLENE))	1.253	1.490	0.000	0.000	0.020	0.020	27	22
67923-07-3	SILOXANES AND SILICONES, DI-ME, (((3-((2-AMINO-ETHYL)AMINO)PROPYL)SILYLIDYNE)TRIS(OXY))TRIS-, METHOXY-TERMINATED	1.260	1.399	0.003	0.003	0.004	0.004	35	30
71750-81-7	SILOXANES AND SILICONES, DI-ME, MONO(((3-((-AMINO-ETHYL)AMINO)PROPYL)DIMETHYOXYSILYL)OXY)-TERMINATED	0.640	0.644	0.018	0.093	0.012	0.027	19	16
68037-56-9	SILOXANES AND SILICONES, 3-((2-AMINOETHYL)AMINO)PROPYL METHOXY, DI-ME, POLYMERS WITH 3-((2-AMINOETHYL)AMINO)PROPYL SILSESQUI-OXANES	0.460	0.540	0.000	0.000	0.000	0.000	3	2
70131-67-8	SILOXANES AND SILICONES, DI-ME, HY-DROXY-TERMINATED	0.448	0.460	0.015	0.015	0.003	0.003	29	20
	CONFIDENTIAL	0.330	0.330	0.120	0.125	0.090	0.091	2	2
541-02-6	CYCLOPENTASILOXANE, DECAMETHYL-	0.181	0.215	0.015	0.015	0.109	0.109	12	12
68554-54-1	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH 3-((2-AMINOETHYL)AMINE) PROPYL SILSESQUIOXANES, HYDROXY-TERMINATED	0.077	0.148	0.108	0.108	0.022	0.022	12	11
107-46-0	HEXAMETHYLDISILOXAN	0.127	0.127	0.000	0.000	0.000	0.000	4	4
68037-62-7	SILOXANES AND SILICONES, DI-ME, ME HYDROGEN, REACTION PRODUCTS WITH POLYETHYLENE GLYCOL MONOACETATE ALLYL ETHER AND POLYETHYLENE-POLYPROPYLENE GLYCOL MONOACETATE ALLYL ETHER	0.100	0.127	0.000	0.000	0.000	0.000	3	2
	CONFIDENTIAL	0.056	0.056	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.046	0.046	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.037	0.037	0.000	0.000	0.000	0.000	2	1
	CONFIDENTIAL	0.037	0.037	0.000	0.000	0.000	0.000	2	1

CASNo.	Name (used in the Product Register)	tonnes siloxanes Import min	Import max	Production min	Production max	Export min	Export max	No. of prod	No. of comp
134737-05-6	SILOXANES AND SILICONES, DI-ME, 3-(3-((3-COCOAMIDOPRO-PYL)DIMETHYLAMMONIUO)-2-HYDROXYPROPOXY)PROPYLGROUP-TERMINATED, ACETATES (SALTS)	0.031	0.031	0.000	0.000	0.000	0.000	3	2
115606-51-4	SILOXANES AND SILICONES 3-AMINOPROPYL ME, DI-ME, ME 3-((1-OCOOCTADECYL)AMINO)PROPYL	0.000	0.030	0.000	0.000	0.000	0.000	3	3
540-97-6	CYCLOHEXASILOXANE, DODECAMETHYL-	0.014	0.030	0.000	0.000	0.000	0.000	7	6
70900-21-9	POLY(DIMETHYLSILOXAN), HYDROGEN-TERMINERET	0.023	0.026	0.028	0.028	0.002	0.004	9	9
556-67-2	OCTAMETHYLCYCLOTETRASILOXAN	0.021	0.024	0.050	0.050	0.010	0.010	27	26
	CONFIDENTIAL	0.023	0.023	0.000	0.000	0.000	0.000	1	1
68552-43-2	fatty acids, soya, polymers with hydroxy-terminated Me Ph siloxanes, pentearythrtol and phthalic anhydride	0.022	0.022	0.000	0.000	0.000	0.000	5	2
	CONFIDENTIAL	0.021	0.021	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.018	0.018	0.000	0.000	0.000	0.000	1	1
63148-53-8	SILOXANES AND SILICONES	0.016	0.016	0.000	0.002	0.013	0.015	5	5
	CONFIDENTIAL	0.014	0.014	0.000	0.000	0.000	0.000	2	1
104133-09-7	HEXAMETHYLDISI-LOXAN/TETRAETHYLSILICAT POLYMER	0.010	0.010	0.000	0.000	0.000	0.000	8	7
	CONFIDENTIAL	0.010	0.010	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.010	0.010	0.000	0.000	0.000	0.000	1	1
68037-64-9	SILOXANES AND SILICONES DI-ME, ME HYDROGEN, REACTION PRODUCTS WITH POLYETHYLENE-POLYPROPYLENE GLYCOL MONOACETATE ALLYL ETHER	0.009	0.009	0.000	0.065	0.000	0.064	8	8
134180-76-0	OXIRANE, METHYL-, POLYMER WITH OXI-RANE, MONO(3-(1,3,3,3-TETRAMETHYL-1-((TRIMETHYLSI-LYL)OXY)DISILOXANYL)PROPYL) ETHER	0.009	0.009	0.000	0.000	0.000	0.000	4	4
27306-78-1	POLY(OXY-1,2-ETHANEDIYL), .ALPHA.-METHYL-.OMEGA.-(3-(1,3,3,3-TETRAMETHYL-1-((TRIMETHYLSI-LYL)OXY)DISILOXANYL)PROPOXY)-	0.004	0.008	0.000	0.000	0.000	0.000	4	4
68937-54-2	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHOXYLATED	0.006	0.007	0.065	0.065	0.013	0.013	7	7
67762-85-0	SILOXANES AND SILICONES, DI-ME, 3-HYDROXYPROPYL ME, ETHERS WITH POLYETHYLENE-POLYPOLENE GLYCOL ME ETHER	0.006	0.006	0.083	0.083	0.042	0.042	9	5
67762-90-7	POLY(DIMETHYLSILOXAN), REAKTIONSPRODUKTER MED SILICA	0.003	0.006	0.003	0.003	0.000	0.000	26	16
	CONFIDENTIAL	0.005	0.005	0.000	0.000	0.000	0.000	1	1
68037-59-2	SILOXANES AND SILICONES, DI-ME, ME HYDROGEN	0.004	0.004	0.000	0.000	0.000	0.000	3	3
68937-55-3	SILOXANER OG SILICONER, DI-ME, 3-HYDROXYPROPYL ME, ETHOXYLERET, PROPOXYLERET	0.002	0.004	0.008	0.008	0.002	0.002	4	4
	CONFIDENTIAL	0.003	0.003	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.002	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.001	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.000	0.001	0.000	0.000	0.000	0.000	1	1
68554-64-3	SILOXANES AND SILICONES, DI-ME, POLY-MERS WITH ME SILSESQUIOXANES AND POLYPROPYLENE GLYCOL BU ETHER	0.000	0.000	0.002	0.002	0.000	0.000	5	5
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
104780-71-4	SILOXANES AND SILICONES DI-ME, ((2-OCTYLDODECYL)OXY)-TERMINATED	0.000	0.000	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	2	2
	CONFIDENTIAL	0.000	0.000	0.000	0.066	0.000	0.065	1	1

		tonnes siloxanes							
		Import		Production		Export		No. of	No. of
CASNo.	Name (used in the Product Register)	min	max	min	max	min	max	prod	comp
64365-23-7	SILOXANES AND SILICONES, DI-ME, ETH-OXYLATED-PROPOXYLATED	0.000	0.000	0.000	0.000	0.000	0.000	3	3
	CONFIDENTIAL	0.000	0.000	0.000	0.000	0.000	0.000	1	1
	CONFIDENTIAL	0.001	0.001	0.000	0.000	0.000	0.000	1	1
	Total	43.790	50.610	4.447	6.447	1.316	2.735		

Annex 6
Contacted companies and organisations

Allison A/S, Bramming
Arma Tube A/S, Herning
AWL KEMI APS, Helsingør
BASF, København
Bayer, Kongens Lyngby
Bionord A/S, København Ø
Blumøller A/S, Odense C
Brancheforeningen SPT, Kongens Lyngby
Brenntag Nordic, Glostrup
Brøste, Kgs. Lyngby
Brøste, Kongens Lyngby
Casco A/S, Fredensborg
Cleantabs A/S, Hammel
Colgate-Palmolive, Glostrup
Dana Lim, Køge
Derma Pharm as, Spentrup
Diatom A/S, Hvidovre
Dow Europe GmbH, Kongens Lyngby
Ecolab, Valby
Foreningen for Danmarks Farve- og Lakindustri, København K
Fosroc, Rødding
Fugebranchens Samarbejds- og Oplysningsråd, Hørsholm
Goldschmidt Scandinavia A/S (Degussa), Farum
Johnson Diversey, Nivå
Knud E. Dan, Greve
Marsing & Co. Ltd. A/S, Greve
Mercantas A/S, Birkerød
Nordisk Parfumerifabrik, Randers
Novadan, Kolding
Persano Cosmetics A/S, Græsted
Plastindustrien, København
SIKA, Lynge
Tribo Tec, Kvistgård
VTK, Vejle

Annex 7
Database screening for decamethyl cyclopenta-siloxane

Decamethyl cyclopentasiloxane

CAS number: 541-02-6

Data compilation, environmental and health screening

Summary

Health and Environment:

No relevant information on health was found.

The substance decamethyl cyclopentasiloxane is only slightly soluble in water and has a high affinity for organic phases (log P_{ow} 5.2). Based on the physical/chemical properties Decamethyl cyclopentasiloxane is estimated to bioaccumulate, and biodegradation is not expected. Data on environmental toxicity were not found.

Identification of the substance

CAS No.	541-02-6 (CambridgeSoft Corp 2003)
EINECS	No. 208-764-9 (Spin2000.net 2003)
EINECS Name	Decamethylcyclopentasiloxane (HSDB 2003)
Synonyms	Dimethylsiloxane pentamer (HSDB 2003), Cyclopenta-siloxane, decamethyl- (Spin2000.net 2003)
Molecular Formula	C_{10}-H_{30}-O_5-Si_5 (HSDB 2003)
Structural Formula	
Known Uses	Paint, laquers and varnishing. Fuel additives. Surface treatment (Spin2000.net 2003)

IUCLID	No data found
EU	

Physico-chemical Characteristics

Physical Form	Oily Liquid (HSDB 2003)
Molecular Weight (g/mole)	378.80 (HSDB 2003)
Melting Point/range (°C)	- 38˚ C (HSDB 2003)
Boiling Point/range (°C)	210˚ C (HSDB 2003)
Decomposition Temperature (°C)	No relevant data found
Vapour Pressure (mm Hg at °C)	0.2 mm Hg at 25˚ C (HSDB 2003)
Density	0.9593 at 20˚ C (HSDB 2003)
Vapour Density (air=1)	No relevant data found
Solubility (water)	0.017 mg/l at 25˚ C (PhysProp 2003)
Partition Coefficient (log P_{ow}):	5.20 (HSDB 2003)
pK_a	No relevant data found
Flammability	Flashpoint 77˚ C (CambridgeSoft 2003)
Explosivity	No relevant data found
Oxidising Properties	No relevant data found

Toxicological Data

Observation in Humans	None Found

Acute Toxicity

Oral	No relevant data found
Dermal	No relevant data found

Inhalation	No relevant data found
Other Routes	No relevant data found
Skin Irritation	No relevant data found
Eye Irritation	No relevant data found
Irritation of Respiratory Tract	No relevant data found
Skin Sensitization	No relevant data found
Sensitization by Inhalation	No relevant data found

Subchronic and Chronic Toxicity

Observation in humans	No relevant data found
Oral	No relevant data found
Inhalation	No relevant data found
Dermal	No relevant data found

Genotoxicity and Carcinogenicity

Mutagenicity	No relevant data found
Gene Mutation	No relevant data found
Chromosome Abnormalities	No relevant data found
Other Genotoxic Effects	No relevant data found
Cancer Review	No relevant data found

Reproductive Toxicity, Embryotoxicity and Teratogenicity

Reproductive Toxicity	No relevant data found
Teratogenicity	No relevant data found
Other Toxicity Studies	No relevant data found
Toxicokinetics	No relevant data found

Ecotoxicity Data

Algae	No relevant data found
Crustacean	No relevant data found
Fish	No relevant data found
Bacteria	No relevant data found

Environmental Fate

BCF	Estimated 5300 (HSDB 2003)
Aerobic biodegradation	Expected to be persistent (HSDB 2003)
Anaerobic biodegradation	Expected to be persistent (HSDB 2003)
Metabolic pathway	No relevant data found
Mobility	Estimated immobile (HSDB 2003)

Conclusion

Health and Environment	No relevant information on health was found and no conclusion can be drawn. Based on the physical/chemical properties Decamethyl cyclopentasiloxane is estimated to bioaccumulate and biodegradation is not expected. Data on environmental toxicity were not found. The substance has to be further investigated e.g. on substance group level before a conclusion can be made.

List of references:

CambridgeSoft 2003. CambridgeSoft Corporation database (available at www.chemfinder.com)

HSDB 2003. HSDB database (available through toxnet.nlm.nih.gov)

PhysProp 2003. PHYSPROP DEMO-database (available at esc.syrres.com/interkow/physdemo)

Spin2000.net 2003. SPIN database (available at www.spin2000.net)

References used for screening:

1. Aquire (available at www.epa.gov/ecotox)
2. CambridgeSoft Corporation database (available at www.chemfinder.com)
3. HSDB database (available through toxnet.nlm.nih.gov)
4. IUCLID-CD (1996)
5. PHYSPROP DEMO-database (available at esc.syrres.com/interkow/physdemo)
6. SPIN database (available at www.spin2000.net)
7. DART Special (RTECS) (available through toxnet.nlm.nih.gov)
8. ToxLine (available through toxnet.nlm.nih.gov)

Annex 8
Human toxicity test results for siloxanes

Abbreviations are described in the notes to the table. References are listed in the main report.

CAS no	Synonym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
Octamethyltetracyclosiloxane									
556-67-2	D4	toxicokinetics, pharmacokinetics of 14C-D4	inhalation, nose only	rat (♀,♂), Fisher 344, 50 ♀,♂/group	7 and 700 ppm	14 days, single, 6 hours/day (unlabelled D4); single 6 hour (14C-D4)	level of absorption low and independent of gender and dose distribution to most tissues elimination via expired volatiles (parent) or metabolized via urine and faeces rate of elimination of radioactivity in tissues was the same as from plasma except of fat small dose-related effect on elimination on ♀ rats (more expired at the high dose compared to lower doses) suggesting saturation of metabolism at high doses	not relevant	86970000024 1996
556-67-2	D4	toxicokinetics, pharmacokinetics of 14C-D4	inhalation, nose only	rat (♀), Fisher 344	7 and 700 ppm	14 daily exposures to unlabelled D4 and a single exposure to 14C-D4 (day 15) at7 and 700 ppm	absorption and distribution mimicked single exposure results rate of elimination of radioactivity in tissues was the same as from plasma except of fat and lung small dose-related effect on elimination route on ♀,♂ rats (larger quantities eliminated via lung, decreased quantities eliminated via faeces, urinary excretion constant at high compared to low dose) suggesting compensation of saturation effects through induction after repeated exposure	no data	86970000875 1997
556-67-2	D4	kinetics	inhalation, nose only, vapour	rat (♀), Fisher-344 (F-344) and Sprague-Dawley (SP)	700 ppm	single 6 hour exposure	F-344 rats retained significantly higher amount of radioactivity (8.3+0.44%) than SD (5.9+0.26%) excretion of radioactivity was similar in both strains in urine, faeces and expired volatiles different concentration of radioactivity in fat over time F rats showed a higher amount of radioactivity present as metabolites as compared to D4 kinetic difference suggest important biochemical differences leading to a decreased metabolism of D4 in female SP rats	not relevant	86010000010 2000

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2	D4	kinetics, effect on immunologi-cal parameters, blood chemistry and pul-monary factors	inhalation, mouthpiece and nasal exposure	human	10 ppm	one hour	mean deposition was 12% peak plasma concentration was 78 ng/ml rapid elimination from plasma after exposure termination (25 ng/ml; 6 hr and 4 ng/ml; 24 hr) no effect on blood chemistry no immunotoxic or proinflammatory/adjuvant effects	not relevant	86980000017 1997
556-67-2	D4	kinetics, ^{13}C-D4	dermal	human (3♀,3♂)	1.4 g (♂), 1 g (♀)	1, 2, 4, 6 and 24 hours	D4 levels significantly elevated above baseline in blood and plasma at 1, 2, 4 and 6 hrs and in exhaled air at all time points female subjects had significantly higher blood and plasma levels compared to male subjects	not relevant	86010000007 2000
556-67-2	D4	kinetics, pilot study to determine if in-ducing agents alter the metabolic profile of a single dose ^{14}C-D4	oral gavage, i.p. and i.v.	rat (♀)	pre-treatment: PB: 80 mg/kg i.p.; 3-MC: 30 mg/kg i.p. ^{14}C-D4: 70 mg/kg i.v. or oral gavage	pre-treatment: once per day for 4 consecu-tive days; single admin-istra-tion of ^{14}C-D4 the next day	Phenobarbital but not 3-MC pre-treatment increases the amount and rate of urinary excretion PB pre-treatment did not change urinary metabolic of D4 profíle evidence that PB-inducible enzymes are involved in metabo-lism of D4 in rats	not relevant	86980000037 1997
556-67-2	D4	non-regulated study: identification of metabolites in urine (^{14}C-D4)	intravenously	rat (♀,♂), Fisher 344	not stated	no data	ring opening and demethylation occurs (oxidation and hy-drolysis) major metabolites constituting 75 - 85% of the total radioac-tivity were dimethylsilanediol, methylsilanetriol minor metabolites were tetramethyldisiloxane-1,3-diol [Me(2)Si(OH)-O-Si(OH)Me(2)], hexamethyltrisiloxane-1,5-diol [Me(2)Si(OH)-OSiMe(2)-OSi(OH)Me(2)], trimethyldisilox-ane-1,3,3-triol [MeSi(OH)(2)-O-Si(OH)Me(2)], dimethyldisi-loxane-1,1,3,3-tetrol [MeSi(OH)(2)-O-Si(OH)(2)Me], and di-methyldisiloxane-1,1,1,3,3-pentol [Si(OH)(3)-O-Si(OH)(2)Me]. no parent D4 present in urine	no data	86980000032 86980000072 1997

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2	D4	evaluation of D4 as inhibitor of human cytochrome P450 enzymes	in vitro	human liver microsomes from 7 individuals	0.32 - 2.9 µM	no data	non competitive inhibitor of rat CYP2B1/2 (estimated Ki=0.11 mM) non competitive inhibitor of human CYP2B6 (estimated Ki=3.6 mM) competitive inhibitor of human CYP1A2 (estimated Ki=12 mM) non competitive inhibitor of human CYP2D6 and CYP3A4/5 (estimated Ki=14 and 11 mM) either competitive or non competitive inhibitor of CYP2C19 (estimated Ki=6.4 or 11 mM) little or no capacity to inhibit rat CYP1A2 and human CYP2A6, CYP2C9 and CYP4A9/11 activity activator of human CYP2E1 little or no capacity to to function as metabolism-dependent inhibitor of any of the P450 enzymes examined (except rat CYP1A1/2 and human CYP3A4/5	not relevant	86990000017 1998
556-67-2	D4	*in vitro* dermal absorption, Flow-Through Diffusion Cell System	*in vitro* percutaneous	human skin	neat D4 and formulated D4 (anti-perspirant)	24 hours	0.50% of neat D4 absorbed (91.6% recovered from analysed sample) 0.49% of formulated D4 (103.2% recovered from analysed sample)	not relevant	86980000163 1998
556-67-2	D4	absorption potential	oral gavage	rat (♀,♂), Fisher 344	300 mg/kg 14C-D4	single exposure	carrier has an impact on absorption peak levels of radioactivity delayed relative to parent D4 by 24 hr most of the radioactivity in blood could be attributed to metabolites most of D4 absorbed from corn oil and neat D4 was metabolised and excreted via urine	not relevant	86980000184 1998
556-67-2	D4	physiologically based pharmacokinetic modelling (PBPK)	inhalation	human	10 ppm 14C-D4	one hour during altering periods of rest and exercise	hepatic extraction calculated from model parameters was 0.65 to 0.8 (clearance nearly flow-limited) decreased retension of inhaled D4 during periods of exercise was explained by altered ventilation/perfusion characteristics and a rapid approach to steady-state conditions high lipophilicity coupled with high hepatic and exhalation clearance increased confidence in the utility of the model for predicting human tissue concentrations of D4 and metabolites during inhalation exposures	not relevant	Ready MB et al, 2003
556-67-2	D4	physiologically based pharmacokinetic modelling (PBPK)	inhalation, dermal, oral, i.v.	rat	no data	no data	pharmacokinetics of D4 delivered by inhalation or dermal routes is similar, and is different from the i.v. or oral delivery route	not relevant	Sarangapani R et al 2003

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2	D4	pharmacokinetics	inhalation via mouthpiece	human, 12 volun-teers	10 ppm	one hour	no changes in lung function rapid non-linear blood clearance mass transfer coefficient for D4 was 5.7×10^{-5} cm/s from lung air to blood	no data	Utel MJ et al 1998
556-67-2	D4	pharmacokinetics, PBPK modelling	inhalation	rat (♀,♂), Fisher 344	7, 70 and 700 ppm	single expo-sure	Despite its very high lipophilicity, D4 does not show pro-longed retention because of high hepatic and exhalation clearance.	no data	Andersen ME et al 2001
556-67-2	D4	pharmacokinetics, pilot study	inhalation, nose only	rat (♂),Fisher 344	700 ppm, ^{14}C-D4	6 hours	radioactivity concentration highest in the lung tissue max. conc. of radioactivity in blood, plasma or tissues ob-served at end of exposure period rate of elimination of radioactivity from tissues the same as for plasma except for perirenal fat and lung elimination routes: expired volatiles, renal or faecal excretion	no data	86960000517 1996
556-67-2	D4	percutaneous ab-sorption, human skin / nude mouse model	percutaneous	human skin	neat and formu-lated D4	24 hours	absorption of neat D4 was determined to be 1.09%	not relevant	86010000003 2000
556-67-2	D4	percutaneous absorption, ^{14}C-D4, semi occlusive	percutaneous	rat (♀), Fisher-344	topical application at 10, 4.8, and 2 mg/cm^2	1, 6 and 24 hours	average percentage of applied dose being absorbed was be-tween 0.57 and 0.95% for all doses and all time points significant decrease in per cent absorbed over time washing exposed skin after 24 hrs decreased exposure	not relevant	86010000009 2000
556-67-2	D4	immunotoxicity	oral gavage	rat (♀,♂), Fisher, 10 (♀,♂) / group	10, 30, 100, and 300 mg/kg	28 days	no alterations in NK cell activity, macrophage function, lym-phocyte subpopulation no alterations in humoral activity (♂) dose-dependent increase in AFC-response (♀) slight but dose-dependent increase in erythroid elements (♀,♂) dose-dependent increase in liver weight and dose-dependent decrease in thymus weight (mostly ♀) systemic adsorption dependent on vehicle D4 at doses between 10 and 300 mg/kg does not cause im-mune suppression (♀,♂)	no data	86980000072 1997
556-67-2	D4	non-regulated study; immunotoxicity	oral	human	12 mg	two weeks	no effects on studied immunological parameters or blood chemistry	no data	86990000015 1998
556-67-2	D4	immunotoxicity	inhalation via mouthpiece	human	10 ppm	one hour, reexposure after 3 months	no immunotoxic or proinflammatory effects of respiratory exposure were observed	no data	Looney RJ et al 1997

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2	D4	dose-response study	inhalation, whole body	rat (♀), Fisher 344	1, 7, 30, 70, 150, 300, 500, 700 and 900 ppm	6 hours/day; 5 days	dose-dependent increase in liver size and induction of PROD activity achieving a max response between 300 and 900 ppm hepatic conc. of D4 may reach levels saturating CYP2B1/2 activity induction of CYP2B1/2 enzymes is an early and sensitive biochemical response to D4 exposure in rat max can be achieved following 5 days repeated inhalation of approx. 500 ppm D4 D4 is a Phenobarbital-like inducer of rat hepatic cytochrome P450 enzymes	no data	86990000029 1999
556-67-2	D4	subacute toxicity, pilot study on effects on liver size and hepatic enzyme induction	inhalation, whole body	rat (♀,♂), Fisher	70 and 700 ppm	28 days, 6 hours/day; 5 days/week	dose and time dependent liver enlargement in ♀ rats, maxi-mum by day 7 induction of several metabolizing enzymes, primarily CYP2B1 D4 induces hepatic cytochrome P450 enzymes biochemical response similar to phenobarbital	no data	86970000723 1996
556-67-2	D4	subacute toxicity, effects on liver size and hepatic enzyme induction	inhalation, whole body	rat (♀,♂), Fisher 344	70 and 700 ppm	28 days, 6 hours/day; 5 days/week	rapid but revesible increase in liver size induction of several metabolizing enzymes, primarily CYP2B1 D4 induces hepatic cytochrome P450 enzymes biochemical response similar to phenobarbital	no data	86970000725 1997
556-67-2	D4	subacute toxicity; induction of rat he-patic microsomal cytochrome P450, UDP-glucoronosyltrans-ferase, and epoxid hydrolase	inhalation, whole body	rat (♀,♂), Fisher 344	70 and 700 ppm	28 days, 6 hours/day; 5 days/week	D4 induces CYP enzymes and epoxide hydrolase in a manner similar to Phenobarbital - i.e. D4 is a PB-like inducer of he-patic microsomal enzymes in the Fisher 344 rat.	no data	McKim JM et al 1997
556-67-2	D4	subchronic toxicity	inhalation	albino rat (♀,♂), Fisher 344, 4 groups, 10 ♀/10 ♂ / group	≤1000 ppm, repeated dose (2.78, 5.13, 8.62 and 14.21 mg/l)	20 days (♂), 21 days (♀), 6 hours/day; 5 days/week	reduced food consumption reduced body weight and body weight gain thymic atrophy vaginal mucification reduction in corpora lutea score	no data	86950000155 1995
556-67-2	D4	subchronic toxicity, range finding study for chronic study	inhalation, nose only	albino rat (♀,♂), Fisher 344, 4 groups, Gr.2, 3, 4: 20 ♀/20 ♂ / group; Gr.5: 30 ♀/30 ♂ / group	≤990 ppm, re-peated dose (0.42, 1.48, 5.91 and 10.87 mg/l)	3 months, 6 hours/day; 5 days/week	slight reduction in body weight and food intake at 990 ppm. slight dose related increase in abs. and rel. liver weight (♀ most sensitive) slight reduction in thymus and ovarian weight in ♀ at the highest 2 doses ovarian atrophy and vaginal mucification in ♀ at 990 ppm	no data	86950000153 1995

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2	D4	subchronic toxicity and splenic antibody cell response	inhalation, whole body	rat (♀,♂), Fisher	7, 20, 60, 180 and 540 ppm	28 days, 6 hours/day; 5 days/week	statictically significant increase in liver weight and liver to body weight (♂ at 540 ppm; ♀ at 20-540 ppm) no alterations in immune system AFC response	no data	86980000040 1997
556-67-2	D4	genetic toxicity, Ames test	in vitro	salmonella typhimurium strains TA98, TA100, TA1535, TA1537, and TA1538	maximum dose = 5 mg/plate with or without S9	no data	no mutagenicity was detected in salmonella thyphimurium (negative)	no data	Vergnes JS et al 2000
556-67-2	D4	genetic toxicity, SCE assay	in vitro	chinese hamster ovary cells (CHO)	≤0.003 mg/ml with and without S9	no data	no significant dose-related increases in chromosomal aberra-tion frequencies (negative)	no data	Vergnes JS et al 2000
556-67-2	D4	genetic toxicity, chromosome ab-berations	inhalation, whole body	rat (♀,♂), Spra-gue-Dawley	700 ppm	5 days, 6 hours/day	No significant, treatment-related increases in chromosomal aberrations were detected (negative)	no data	Vergnes JS et al 2000
556-67-2	D4	single generation study (range-finding study for 2 gen. study)	inhalation	rat (♀,♂), Spra-gue-Dawley; 2 groups, 20 F_0 ♀/20 F_0 ♂ / group	70 and 700 ppm	28 days, 6 hours/day	treatment related reduction in mean body weight (♀,♂) shortly after exposure initiation and late in gestation (♀) statistically significant reduction in mean live litter size at 700 ppm accompanied by a decreased number of uterine implan-tations	no data	86960000398 1995
556-67-2	D4	reproductive toxicity, range-finding (test reproducibility of EPA, 3)	inhalation, whole body	rat (♀,♂), Spra-gue-Dawley; 2 groups, 22 F_0 ♀/22 F_0 ♂ / group	700 ppm	≥28 days, 6 hours/day	treatment related reduction in mean body weight (♀,♂) shortly after exposure initiation and late in gestation (♀) statistically significant reduction in mean live litter size at 700 ppm accompanied by a decreased number of corpora lutea and uterine implantations	no data	86970000023 1995
556-67-2	D4	reproductive toxicity, range-finding	inhalation, whole body	rat (♀), Sprague Dawley, 22 ♀ / group	70, 300, 500, and 700 ppm	6 hours/day for 70 at least days prior to mating	maternal toxicity in F_0 females at 300, 500 and 700 ppm statistically significant reduction in mean live litter size and implantation site at 700 ppm	no data	86970000847 1997
556-67-2	D4	reproductive toxicity, range-finding study	inhalation, whole body vapour	rat (♂), Sprague-Dawley. 22 / group	70, 300, 500, and 700 ppm	6 hours daily for 70 days prior to mat-ing	increased liver and thyroid weights at 700 ppm slight statistically insignificant reductions in pup survival (% per litter) at 700 ppm on PND 0 and during PND 0-4 interval decrease in mean pup body weights on PND 1 and PND 4 at 700 ppm relative to control	no data	86980000049 1997
556-67-2	D4	reproductive toxicity, range-finding study	inhalation, whole body vapour	rat (♂), Sprague-Dawley. 40 / group	500 and 700 ppm	6 hours daily for 70 days prior to mat-ing	toxicity demonstrated in F0 males at 700 ppm by clinical signs and reduces mean body weight gain and food con-sumption during the first week no adverse effects on F_1 pups at 500 and 700 ppm	500 ppm (F_0 toxicity) 700 ppm (F_1)	86980000061 1997

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2	D4	reproductive toxicity	inhalation, whole body vapour	rat (♀), Sprague-Dawley, 4 groups, 24 / group	70, 300, 500, and 700 ppm	multiple exposure regimens during different phases of the reproduction cycle	effects on intrauterine survival following exposure from 3 days prior to mating until gestation day 3 were similar to effects following exposure from 28 days prior to mating until gestation day 19 no effects on intrauterine survival when exposure was terminated 3 days prior to mating indicating reversibility of these effects	not relevant	86980000153 1997
556-67-2	D4	reproductive toxicity	inhalation, whole body	rat (♀)	700 ppm	6 hr/day, multiple or single day exposure	pre-mating phase: reduced pregnancy rate, effects on mean body weight gain, reduced food consumption and/or reduced no. of mean corpora lutea and implantation sites, increased no. of small implantation sites and reduced mean uterine weight for different treatment regimes post-mating phase: toxicity only expressed in a single group by reduced mean body weight gain and food consumption	no data	86990000058 1999
556-67-2	D4	interim risk assessment of D4 reproductive effects - combination of reproductive toxicity studies with estimates of D4 intake in humans	inhalation, whole body	rat (♀ or ♂), Sprague-Dawley, 24 / group	70, 300, 500, or 700 ppm	6 hours/day, 7 days/week; 70 days prior to mating and continuing through PND 20	estimated ADI's for a hypothetical woman using several products and working in a silicone product manufacturing were 0.158 or 0.145 mg/kg/day for dermal and inhalation exposure ADI's for persons exposed to D4 in food were highest for children one year of age or younger: approx. 0.002 mg/kg/day Margins of Safety or Exposure (MOE) > 100 Vast majority of MOE's > 10,000 for workers, consumers, and the general public exposed to background levels of D4 MOE's considered acceptable to support the safety of D4 for use in its intended applications	NOAEL (reproductive effects): 300 ppm	86990000029 1999
556-67-2	D4	uterotrophic assay; estrogenic and anti-estrogenic activity	oral	immature rat (♀), Fisher and Sprague-Dawley, 6 groups, 12 ♀/group, 12 control groups (estrogenic effect: EE, DES-DP and CE; antiestrogenic effect: D4 +EE))	D4: 250, 500 and 1000 mg/kg/day; EE: 1, 3, 10 and 30 µg/kg/day; DES-DP: 0.5, 1.5, 5, and 15 µg/kg/day; CE: 10, 35, 75 and 175 mg/kg/day; D4+EE: 500 mg/kg/day (D4)+1, 3, 10 and 30 µg/kg/day (EE)	4 consecu-tive days beginning on PND 18 (SP) or 21 (F-344), single dose once per day	weakly estrogenic (dose-related increase in uterine weight and epithelial cell height) in both SP and F-344 rats weak antiestrogenic properties by partially blocking EE induced uterine weight increases (competitive inhibition of estrogen receptor binding or D4 acting as a partial estrogen agonist) estrogenic and antiestrogenic effects of D4 were several orders of magnitude less potent than EE, and many times less potent than the weak phytoestrogen CE	NOAEL (increased uterine weight: 100 mg/kg/day)	84000000002 1999/2001
556-67-2	D4	estrogenicity	in vitro	human MCF-7 cell system	exp. 1 and 2: 10µM D4 or 0.3 nM estradiol exp. 3: 0.1 - 10 µM D4 or 0.3 nM estradiol	exp. 1 and 2:24 or 48 hours	D4 appears to have estrogenic potential at 0.1 - 10 µM seen as early as 15 min post exposure reaching maximal induction at 6-24 hours results suggest that D4 can elicit an estrogenic effect that is dose-dependent with no significant anti-estrogenic activity	no data	86010000004 2000
Decamethylcyclopentasiloxane									

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
541-02-6	D5	pharmacokinetics: metabolites of 14C-D5 and 14C-HMDS in urine	oral and intra-venous	rat (♀,♂), Fisher 344	no data	no data	major metabolites: Me(2)Si(OH)(2), HOMe(2)SiCH(2)OH, HOCH(2)Me(2)SiOSiMe(2)CH(2)OH, HOMe(2)SiOSiMe(2)CH(2)-OH, HOCH(2)Me(2)SiOSiMe(3), and Me(3)SiOH no parent D5 was present in urine	not relevant	Drug metabo-lism and dispo-sition, 2003
541-02-6 (evt. ud)	D5	evaluation of D5 as a potential inhibitor of human cytochrome P450 enzymes	in vitro	human liver mi-crosomes from 7 individuals	0.04 - 3.5 µM	incubation 0 - 15 min	D5 appears to be a weak competitive inhibitor of human CYP3A4/5 D5 appears to be a strong reversible metabolism-dependent inhibitor of human CYP3A4/5 D5 has little or no capacity to function as a metabolism-dependent inhibitor of several subfamilies of rat and human cytochrome P450 enzymes.	no data	86010000008 2000
541-02-6	D5	dermatotoxicology	in vitro	percutaneous absorption, 14C-D5, rat skin, non occlusion	6.4 mg/cm^2 14C-D5	24 hours	percentage of radioactivity found in the skin was 1.08% (♂) and 1.46% (♀) respectively similar penetration profile for ♀ and ♂	not relevant	86960000593 1996
541-02-6	D5	dermatotoxicology	in vitro	percutaneous absorption, 14C-D5, rat skin, non occlusion	no data	24 hours	approx. 85% volatilized from skin surface dose site contained 0.35% of administered dose less than 1% of 14C recovered in urine and carcass total absorbed was 0.8% with a total recovery of approx. 89%	not relevant	86970000009 1996
541-02-6	D5	subacute toxicity	inhalation, whole body	rat (♀,♂), Fisher 344, 4 groups, 15 ♀ / 15 ♂ / group	10, 25, 75 and 160 ppm	28 days, 6 hours/day; 7 days/week	no adverse effects on body weight, food consumption or urinalysis no alteration of humoral immunity minor transient changes in haematological serum chemistry and organ weight increase in liver to body weight (♀,♂) at 160 ppm, but not after recovery increase in thymus to body weight (♂) at 160 ppm, but not after recovery	NOEL (histo-pathological changes): 10 ppm; NOEL (systemic toxicity: 75 ppm, NOEL (immunosup-pression): 160 ppm	86970000385 1996
541-02-6	D5	subacute toxicity	inhalation	albino rat (♀,♂), Fisher 344, 4 groups, 10 ♀ / 10 ♂) / group	0.44, 0.65, 1.50, and 2.27 mg/l	20 days (♂), 21 days (♀), 6 hours/day; 5 days/week	no D5 related effects	250 ppm	86950000174 1995

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
541-02-6	D5	subacute toxicity, liver enlargement	inhalation, whole body	rat (♀), Fisher 344	160 ppm	28 days, 6 hours/day; 7 days/week	similar enzyme induction profile as D4 but lower magnitude (less effective) induction of hepatic phase I and II metabolising enzymes (nearly identical to that following exposure to 70 and 700 ppm D4 and to Phenobarbital) liver enlargement (liver to body weight change) only slightly less than after exposure to 700 ppm D4 and considerably greater than following exposure to 70 ppm D4 although enzyme induction and proliferation of the smooth ER may contribute to cellular hypertrophy other mechanisms are also involved	no data	86980000020 1997
541-02-6	D5	subchronic toxicity	inhalation, nose only	rat (♀,♂), Fisher 344	0 (30 ♀,♂) 26 (20 ♀,♂), 46 (20 ♀,♂), 86 (20 ♀,♂) and 224 (30 ♀,♂) ppm Recovery gr. : 0 (10 ♀,♂) and 224 (10 ♀,♂) ppm	three months, 6 hrs/day, 5 days/week	primary target organ following D5 inhalation is the lung nose-only D5 vapour inhalation provides minimal changes in the lung similar in incidence and severity to spontaneously occurring changes in control animals no histopathological finding in the liver	no data	Burns LA et al 1997
541-02-6	D5	subchronic toxicity	inhalation	albino rat (♀,♂), Fisher 344, 4 groups, 20 ♀ / 20 ♂) / group, 30 in the high dose group	0.44, 0.75, 1.33, and 3.53 mg/l	13 weeks, 6 hours/day; 5 days/week	minor reduction in body weight gain possible mild effect on the liver (elevated gamma-glutamyltransferase activitet) slight increase in absolute and relative liver weight (♀) at 250 ppm no histopathological findings	no data	86950000154 1995
541-02-6	D5	reproductive toxicity, two-generation	inhalation, whole body	rat (♀,♂),Sprague-Dawley, 30 ♀ / 30 ♂ / group	30, 70 and 160 ppm	6 hours/day; at least 70 days prior to mating	no parental toxicity observed in F_0 and F_1 no effects on reproductive performance (F_0 and F_1) no neonatal toxicity (F_1 and F_2) no F_2 developmental neurotoxicity	NOAEL (parental tox., reproductive tox., neonata tox., and developmental neurotox.: 160 ppm	86990000032 1999
541-02-6	D5	reproductive toxicity, single generation, range-finding study	inhalation, whole body	rat (♀,♂), Sprague-Dawley, 2 groups of F0, 22 ♀ / 22 ♂ / group	26 and 132 ppm	min. 28 days, 6 hours/day	total litter loss in 2 dams at 132 ppm (significance uncertain) no effects on reproductive parameters no significant toxicological findings	no data	86970000006 1996
541-02-6	D5	chronic toxicity and carcinogenicity (not finalised)	inhalation	rat (♀,♂), Fisher 344, 60 ♀ / 60 ♂ / group	10, 40 and 160 ppm	two years, 6 hrs/day, 5 days/week	the preliminary results show that female rats exposed to the highest concentration of D5 exhibited a statistically significant increase of uterine tumours. these preliminary findings may indicate that there is a potential carcinogenic hazard associated with D5	no data	EPA, August 2003
Hexamethyldisiloxane									

CAS no	Synonym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
107-46-0	HMDS	metabolites of 14C-D5 and 14C-HMDS in urine	oral and intravenous	rat (♀,♂), Fisher 344	no data	no data	major metabolites: Me(2)Si(OH)(2), MeSi(OH)(3), MeSi(OH)(2)OSi(OH)(3), MeSi(OH)(2)OSi(OH)(2)Me, MeSi(OH)(2)OSi(OH)Me(2), Me(2)Si(OH)OSi(OH)Me(2), Me(2)Si(OH)OSiMe(2)OSi(OH)Me(2), nonamethylcyclopentasiloxanol, and hydroxymethylnonamethylcyclopentasiloxane no parent HMDS was present in urine metabolites of the linear siloxane are structurally different from that obtained for cyclic siloxane except for the commonly present Me(2)Si(OH)(2).	not relevant	Drug metabolism and disposition, 2003
107-46-0	HMDS	acute toxicity	inhalation, whole body	albino rat (♀,♂), Fisher 344, 3 groups, 5♂ and 5♀ / group	1,067; 14,050 and 16,659 ppm (mean values)	4 hours, obs. 14 days	LC50 = 15,956 ppm	10,067 ppm	86970000724 1997
107-46-0	HMDS	subacute toxicity	inhalation, nose only	albino rat (♀,♂), Fisher 344, 5 groups, 10♂ and 10♀ / group	Gr.1: 0 mg/l, Gr.2: 0.9 ± 0.2 mg/l; Gr.3: 3.4 ± 0.4 mg/l; Gr 4.: 12.7 ± 0.8 mg/l and Gr.5: 59.2 ± 8.6 mg/l	one month, 6 hrs/day, 5 days/week	the incidence and severity of focal inflammatory lesions in the lungs was moderately increased in Gr. 5 animals (♀,♂) increase in incidence and severity of renal tubule regeneration in male rats of Gr. 4 and 5. hyaline droplet accumulation, protein casts and granular casts were present in kidneys in several gr. 5 males minimal hepatocellular hypertrophy was evident in males of Gr. 4 and 5 and one female in Gr.5 and a slight increase in pigment accumulation in bile ducts in Gr.5 males	no data	86980000041 2001
107-46-0	HMDS	subchronic toxicity	inhalation, whole body	rat (♀,♂), Fisher 344, 6 groups, 20♂ and 20♀ / group	Gr.1: 0 mg/l, Gr.2: 0.33 mg/l; Gr.3: 1.3 mg/l; Gr 4.: 4.0 mg/l, Gr.5: 10.0 mg/l and Gr6: 33.3 mg/l	13 weeks, 6 hrs/day, 5 days/week	test related effects in kidneys of males at 4.0, 10.0 and 33.3 mg/l (at 4.0 mg/l, increased incidence and severity of tubular regeneration; at 10 and 33.3 mg/l increased incidence and severity of tubular regeneration with tubular hyaline casts	NOAEL= 1.3 mg/l (♂) and 33.0 mg/l (♀)	86980000182 1998
107-46-0	HMDS	subchronic toxicity	inhalation, whole body	rat (♀,♂), Fisher 344, 6 groups, 20 ♀ / 20 ♂ / group	50, 200, 600, 1500, and 5000 ppm (nominal)	13 weeks, 6 hours/day; 5 days/week	no treatment-related signs of clinical toxicity or mortality, statistically significant effects upon body weight gain or food consumption, ophthalmoscopic changes, gross macroscopic necropsy findings, or organ weight changes were noted histological lesions in the kidney apparently consistent with male rat-specific alpha-2-urinary globulin nephropathy were observed in male rats exposed to 593, 1,509, and 5,012 ppm of HMDS, accompanied by slightly increased plasma urea and creatinine concentrations	not stated	Cassidy SL et al 2001

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
107-46-0	HMDS	subchronic toxicity	inhalation, nose only	albino rat (♀,♂), Fisher 344, 5 groups, 30♂ and 30♀ / group or 20♂ and 20♀ / group	Gr.1: 0 mg/l, Gr.2: 0.14 ± 0.02 mg/l; Gr.3: 0.73 ± 0.2 mg/l; Gr 4: 3.42 ± 0.49 mg/l and Gr.5: 13.64 ± 1.47 mg/l	three months, 6 hrs/day, 5 days/week	no treatment related deaths, clinical signs, effect on body weight, food consumption, or hematology or clinical bio-chemistry parameters multifocal, subpleural, subacute to subchronic interstitial inflammation in lungs of all groups. After the recovery period an increase of these finding were still seen in Gr.5 slightly increased incidence and severity of testicular tubular atrophy in Gr.5 males slightly increased incidence of proteinaceous casts and se-verity of tubular regeneration in the kidneys in Gr.5 males	no data	86980000048 1997
107-46-0	HMDS	reproductive toxicity, one generation	inhalation	rat (♀,♂), Crl:CD®(SD)IGS BR, 4 groups, 24♂ and 24♀ / group	Gr.1: 0 ppm, Gr.2: 100 ppm Gr.3: 1030 ppm and Gr 4: 5000 ppm	6 hrs/day, 28 consecutive days prior to mating	all F0 animals survived transient effect on body weight gain and food consumption at 5000 ppm slight but not statistically significant effect on postnatal pup survival for the 500 ppm group	not stated	86010000010 2000
107-46-0	HMDS	uterotrophic assay; estrogenic and anti-estrogenic activity	oral	immature rat (♀), Sprague-Dawley	HMDS: 600 and 1200 mg/kg/day; EE: 3 µg/kg/day; HMDS+EE: 1200 mg/kg/day + 3 µg/kg/day (EE)	4 consecu-tive days begin-ning on PND 18 (SP), single dose once per day	no measurable effect on uterine weight when tested as an agonist when co-administered together with EE HMDS produced a slight, but statistically significant reduction in absolute uter-ine weight	not stated	84000000002 2001
Combined									
540-05-9, 556-67-2, 541-02-6, 540-97-6, and 107-50-6, or LMWS	D3, D4, D5, D6, and D7 or LMWS	kinetics, distribution	subcutaneous	mice (♀), CD-1	Gr.1: 250 mg LMW cyclosiloxane mix-ture; Gr.2: DMPS-V	single expo-sure	low molecular weight silicones persist in the organs of mice for at least one year after a single s.c. injection every organ examined (10 different) accumulated silicones individual cyclosiloxanes show different retention in tissues D5 and D6 appear to persist longer than D4 high levels of cyclosiloxanes in ovaries and moderately high in uterus	not relevant	Subbarao VK et al

CAS no	Syno-nym	Test	Exposure route	Species / model	Conc.	Exposure period	Result/Effects	NOAEL / LOAEL	EPA DCN/Ref.
556-67-2, 541-02-6, 107-46-0	D4, D5, D6	exposure assessment, interim, establishment of average daily dose (ADD)	inhalation, dermal, oral	human, workers, consumers, general public	three year analysis of potential exposure	Various exposures	women are typically exposed to a greater diversity of personal care products individuals who are exposed from several sources seem to get the highest exposure female siloxane workers who use siloxane products high in D4 content and resides in the vicinity of a plant using these materials could experience a total base case ADD exposure for most other persons is smaller ADD: 0.71 (D4), 0.23 (D5), and 0.09 (D6) mg/kg/day occ. exposure, female workers: 0.5252 mg/kg/day consumers: 0.4784 mg/kg/day general public: 0.0217 mg/kg/day (residents in vicinity of a silicone plant)	not relevent	1998

Mucification: A change produced in the vaginal mucosa of spayed experimental animals following stimulation with oestrogen; characterised by the formation of tall columnar cells secreting mucus.
PND = postnatal day
NK cells = natural killer cells
AFC = Antibody Forming Cells
KI = K(i) = Inhibition constant
PROD = pentoxyresorufin *O*-dealkylase
EE = ethinylestradiol
ER = endoplasmatic reticulum
PB= Phenobarbital
3-MC = 3-methylchlolanthrene
PBPK model = physiologically-based pharmacokinetic model
LMW = Low Molecular Weight
LMWS = Low Molecular Weight Siloxanes
DMPS-V = Low molecular weight linear siloxane mixture