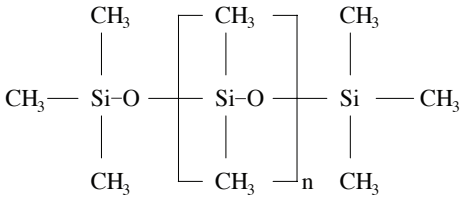
Environmental Information

An Overview of Polydimethylsiloxane (PDMS) Fluids in the Environment

Summary of Use:

Most polydimethylsiloxane fluids are non-volatile polymeric organosilicon materials consisting of $(CH_3)_2SiO$ structural units.



typically, n > 4*

Various PDMS fluids ranging from low to high viscosity are used in a wide range of industrial applications, such as manufacturing textiles, paper, and leather goods[1]. In these industries, PDMS fluids are highly efficient process aids, able to provide desirable properties at very low concentrations. They often serve as antifoams, softeners, or water repellents.

In consumer applications, PDMS fluids can be found in personal-, household- and automotive care products.[1] They are used as softeners in skin care products, conditioners in hair care, additives in polish formulations, waterproofers and as a component of other surface treatments. Some PDMS materials are also sold as end products (usually in the industrial market), such as transformer dielectric fluids and heat transfer liquids.

Environmental Entry:

Due to the wide range of applications for PDMS fluids, they can enter the environment in a variety of ways. Since they are non-volatile, they do not evaporate into the atmosphere. In household products, very small amounts of PDMS fluids may be washed from the surfaces to which they've been applied and eventually into the soil or a wastewater treatment plant (WWTP).

For example, personal care products such as shampoos and conditioners are rinsed away after use, and the PDMS they contain is carried with wastewater to the treatment site. This could be a private septic system or municipal plant. When PDMS fluids are used in industrial applications such as process aids or surface treatments, small quantities can also be found in process wastewater that is carried to the treatment plant. Of the total PDMS production volume worldwide, about 17% is used in "down-the-drain" applications. End-use industrial products such as transformer fluids are used in contained applications. These are suitable for recycling and are therefore unlikely to enter the environment except in cases of accidental release.

Environmental Fate and Effects:

The fate of PDMS is partly a function of where it enters the environment. A number of studies have shown that PDMS will degrade into lower molecular weight compounds, primarily $Me_2Si(OH)_2$, when in contact with soils.[2-6] Testing under a variety of representative conditions has confirmed the observation in a wide range of different soils,[4] indicating that the phenomenon is widespread in nature.

Significant degradation to lower molecular weight compounds has been noted after a only few weeks' soil contact. The actual rate and extent of degradation vary as a function of soil moisture content[4] and clay type.[7] These lower molecular weight degradation products have been shown to further oxidize in the environment, both biologically [8,9] and abiotically,[10-12] to form naturally occurring substances: silica, carbon dioxide and water.

No effects from PDMS (or its degradation products) have been observed on seed germination, plant growth/survival or the plant biomass.[13] In addition, research has shown no adverse effects from PDMS on terrestrial life forms such as insects[14] or birds,[15] even under highly exaggerated conditions of exposure. Research includes studies on survivability and growth,[14, 15] as well as egg-laying, egg quality, hatchability, and chick vitality.[15]

PDMS fluids pose no known hazard to the environment; they are not classified as hazardous wastes. If PDMS fluids should enter the aquatic environment, they attach to particulate matter and are removed from the water column by the natural cleansing process of sedimentation. PDMS fluids do not partition back into the water column,[16] and have no detectable Biological Oxygen Demand (BOD).[17]

Bioconcentration is not a significant concern with PDMS. Their molecular size renders them too large to pass through biological membranes in fish[18] or other organisms.[14, 19] Specific testing has shown that PDMS is not toxic and does not bioaccumulate in sediment-dwelling organisms[19] or various terrestrial species, including earthworms.[14] Because of the lack of any inherent toxicity, PDMS is not relevant for European product labeling.

In wastewater: Household (on-site) septic systems and municipal treatment plants are both designed to facilitate the natural degradation of waste by microscopic organisms. Biomass (or "sludge") is generated by this degradation, and must eventually be discarded. In a municipal system, treated sludge is typically incinerated, landfilled or used as fertilizer. In the United States, where on-site septic systems are common, the tank is usually pumped out periodically and the biomass is taken to a WWTP.

PDMS fluids from personal care and household products enter these treatment systems as tiny dispersed droplets in wastewater. Because the water solubility of these silicone fluids is essentially nil,[20] they attach to suspended materials in wastewater systems and become a minor part of the sludge. Wastewater treatment monitoring and simulation studies have confirmed that PDMS fluids that enter treatment facilities will be almost completely absent from the treated effffluent.[21, 22]

PDMS does not inhibit the microbial activity by which wastewater is treated. Test levels far exceeding those expected in the environment have shown no effect on the activated sludge process, other than the expected benefits of foam control.[21] PDMS loadings had no effect on the operating parameters (pH, suspended solids, sludge volume index, and specific oxygen uptake) or physiological activity of the microflora in the model activated sludge units. Sludge digestion operating parameters (suspended solids, gas generation, pH) were also unaffected by loadings of up to 100 mg/kg of PDMS.[21]

* Materials with n=4 or less are referred to as VMS (volatile methylsiloxane)

The ultimate fate of sludge-bound PDMS depends on the sludge disposal technique. If the sludge is incinerated, the silicone content converts to amorphous silica, which presents no further environmental consequence when the ash is landfilled. When treated sludge is used as fertilizer, very small levels of PDMS may be introduced to the soil environment, where it is subject to soil-catalyzed degradation.[2-7] Similar soil-catalyzed degradation may also occur if sludge-bound PDMS is landfilled. Overall, PDMS has shown no significant environmental effects.[15]

Dow Corning is committed to developing products and processes that exhibit the highest sense of environmental responsibility. As our research continues, we update our communications on a regular basis to share our findings with regulatory agencies, customers, employees, industry associations and the public. The company maintains an extensive facility in the U.S. dedicated to health and environmental sciences, and was a significant contributor to a handbook on the environmental aspects of organosilicon materials, which is now in publication.[23]

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