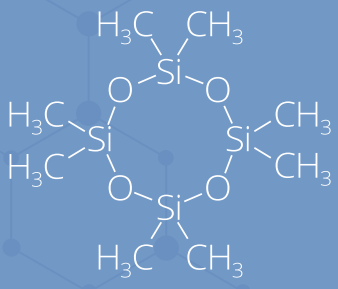
THE UNIQUE PROPERTIES OF SILOXANES

This factsheet explains what makes siloxanes unique. Want to know how siloxanes are different from carbon-based materials? Or why they behave differently in the environment? Read on to find out more, including why the current PBT assessment criteria might not be suitable for them.

WHAT ARE SILOXANES?

Siloxanes are a group of substances characterized by a chain of alternating silicon (Si) and oxygen (O) atoms. Within the group, individual siloxane substances differ in size, weight and shape. They form the backbone of silicone polymers that are used in a variety of applications such as sealants, adhesives, coatings, plastics, cosmetics, medical devices, hygiene products, food contact materials, and many other industrial applications.

Siloxane functional group

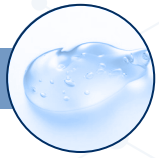


Octamethylcyclotetrasiloxane (D4)

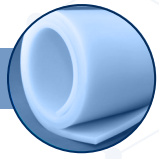
WHAT ARE SILICONE POLYMERS?

Silicones are specialty products that are used in small amounts in hundreds of applications where their special performance is needed. They are used as adhesives, they create flow, they insulate, and they have excellent mechanical/optical/thermal resistance among many other properties. Silicone polymers can have very different forms depending on how they are built, for example:

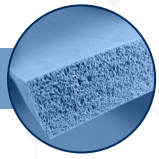
LIQUIDS/OIL — USED AS LUBRICANTS AND IN HYDRAULIC FLUIDS



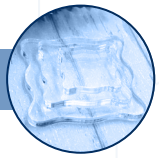
GELS — USED IN CONTACT LENSES, AND FOR SCAR REDUCTION



RUBBER — USED IN FOOD STORAGE CONTAINERS AND WITH PRODUCTS SUCH AS SILICONE SEALANTS



FOAM — USED AS SURFACTANTS AND AS FIRE PROTECTION



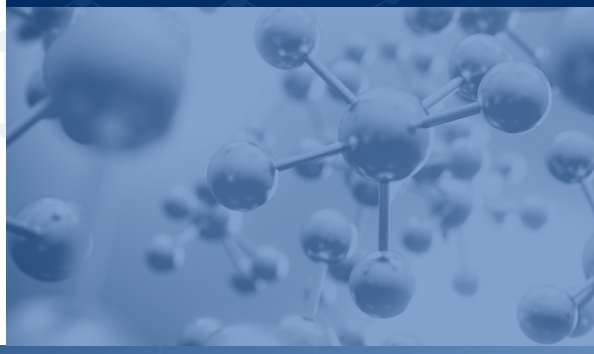
SOLIDS — USED AS LIGHTWEIGHT AUTOMOTIVE PARTS

The structure and functionality of these chemical compounds drive the specific combination of properties of **siloxanes** including:

- High propensity to repel water
- Low water solubility
- Volatility

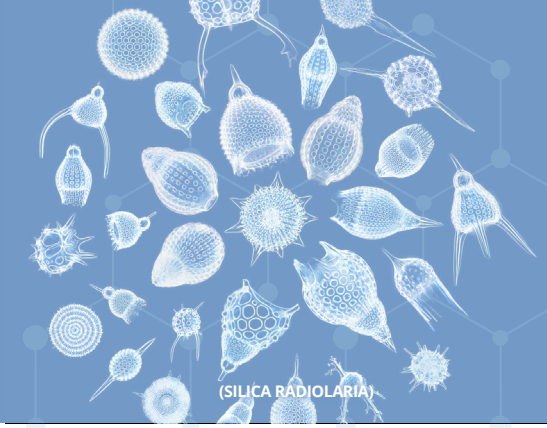
Silicone materials offer a host of useful characteristics including:

- Thermal stability (high and low temperature)
- Resistance to oxidation, ozone, UV exposure
- Good wetting, spreading, and flow
- Low electrical conductivity
- Water repellency



WHAT IS SILICON?

Silicon is a chemical element widely distributed on earth in various combinations with oxygen only (silica) or oxygen and other elements (silicates). Silicon is the second most abundant element on the earth's crust after oxygen (approximately 28% by mass) and it naturally forms long-lived, stable compounds. In many biological systems silica is an essential element of mechanical structures.



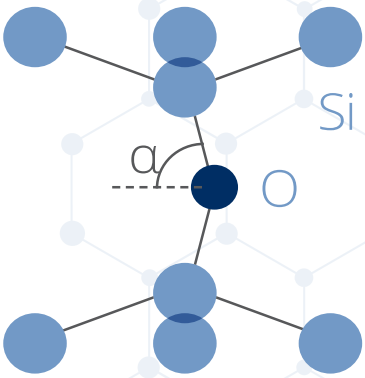
(SILICA RADIOLARIA)

SILICON CHEMISTRY IS FUNDAMENTALLY DIFFERENT FROM CARBON CHEMISTRY

As chemical elements, silicon and carbon are quite similar, though there are important differences in the way that they react and form compounds with other elements. Silicon for example forms more stable compounds with oxygen compared to carbon.

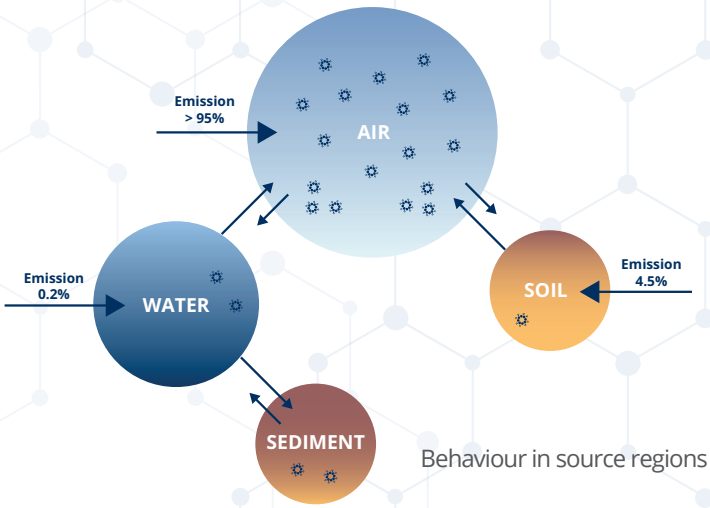
The nature of the silicon-oxygen bond gives siloxane molecules like octamethylcyclotetrasiloxane (D4) their special properties.

In addition, carbon-carbon bonds can be very strong, forming extremely stable structures such as graphite or diamond. Silicon does not form analogous structures.



THE ENVIRONMENTAL BEHAVIOUR OF SILOXANES

The unique properties of siloxanes, combined with their large size lead to differences in the way they interact with the environment such as water and organic matter in soil/sediment and lipids/fats in living organisms, when compared to similar carbon-based chemical compounds.



Behaviour in source regions

THE CHALLENGE IN ASSESSING THE BEHAVIOUR OF SILOXANES IN THE ENVIRONMENT

Because siloxanes are different from carbon based substances, other characteristics need to be taken into consideration when assessing their environmental behavior. For instance, siloxanes like octamethylcyclotetrasiloxane (D4) are highly volatile and spread differently in different media (water/fats/organic matter).

So far, the environmental behavior of siloxanes has been assessed using methodologies which were developed for non-volatile carbon based compounds with other types of properties. Therefore, scientific studies (e.g. Xu et al, 2016) conclude that these methodologies are not appropriate for estimating the behavior of siloxanes in the environment.

The criteria for identification and classification of the Persistent, Bioaccumulative and Toxic (PBT) substances under the current EU chemicals regulations have been developed on the basis of the behavior of the first chemicals that were assessed, namely carbon-based chlorinated compounds (e.g. pesticides).

The combination of fundamental intrinsic properties of siloxanes is not observed among organic compounds that are based on carbon instead of silicon.

The PBT criteria consider the accumulation of a chemical in living organisms from the surrounding environment, as well as the increased concentrations as the chemical moves up in the food chain. Siloxanes, however, are metabolised and do not accumulate up in the food chain – a fact which is not considered using the current criteria.

Because of the differences between carbon and silicon-based substances highlighted above, the environmental effects of siloxanes cannot be predicted by traditional methods that were developed for carbon-based materials. The traditional PBT criteria are, for that reason, not appropriate for assessing the risk of siloxanes on the environment.

Siloxanes are indispensable building blocks in the production of silicones. Silicones are enabling substances for many aspects of modern life: from life enhancing medical technologies, to renewable energy and energy saving solutions, to empowering the digital economy to construction and transportation.

To better understand the little-known and impressive benefits of silicones, and learn more about the value of silicones please visit silicones.eu/benefits and join us on Twitter (@SiliconesEU) and YouTube (CES-Silicones Europe).

Si / Smart. Sustainable. Surprising

About CES – Silicones Europe: We are a non-profit trade organisation representing all major producers of silicones, silanes and siloxanes in Europe. CES is a sector group of the European Chemical Industry Council (CEFIC), which is both the forum and voice of the European chemicals industry. We provide health, safety and environmental information on and are dedicated to the principles of Responsible Care. Visit silicones.eu to know more.

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References

Xu, S.; Warner, N.; Durham, J.; McNett, D. 2016. Critical review and interpretation of environmental monitoring data for cyclic methylsiloxanes: Predictions vs. empirical measurements in air and sediment. Posterbeitrag SETAC Europe 26th annual meeting 22-26 May in Nantes.