Silicone rubber

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Jump to: navigation, search

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Silicone rubber is a polymer that has a "backbone" of silicon-oxygen linkages, the same bond that is found in quartz, glass and sand. Normally, heat is required to vulcanise (set) the silicone rubber; this is normally carried out in a two stage process at the point of manufacture into the desired shape, and then in a prolonged post-cure process. It can also be injection molded.

Contents

History

The first silicone elastomers were developed in the search for better insulating materials for electric motors and generators. Resin-impregnated glass fibers were the state-of-the-art materials at the time. The glass was very heat resistant, but the phenolic resins would not withstand the higher temperatures that were being encountered in new smaller electric motors. Chemists at Corning Glass and General Electric were investigating heat-resistant materials for use as resinous binders when they synthesized the first silicone polymers, demonstrated that they worked well and found a route to produce polydimethylsiloxane commercially.

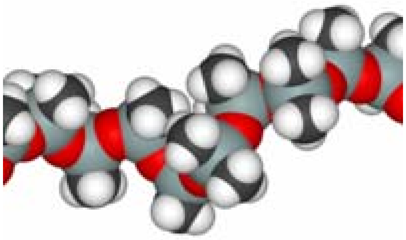
Corning Glass formed a joint venture with Dow Chemical in 1943 to produce this new class of materials. As the unique properties of the new silicone products were studied in more detail, their potential for broader usage was envisioned, and GE opened its own plant to produce silicones in 1947. Wacker Chemie also started production of silicones in Europe in 1947.

Properties

Silicone rubber offers good resistance to extreme temperatures, being able to operate normally from -55° C to +300° C. At the extreme temperatures, the tensile strength, elongation, tear strength and compression set can be far superior to conventional rubbers although still low relative to other materials. Organic rubber has a carbon to carbon backbone which can leave them susceptible to ozone, UV, heat and other ageing factors that silicone rubber can withstand well. This makes it one of the elastomers of choice in many extreme environments.

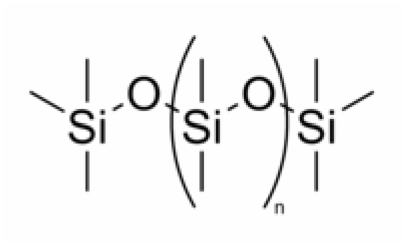
Compared to other organic rubbers, however, silicone rubber has a very low tensile strength. For this reason, care is needed in designing products to withstand even low imposed loads. Silicone rubber is a highly inert material and does not react with most chemicals. Due to its inertness, it is used in many medical applications and in medical implants. However, typical medical products like breast implants and catheters have failed because of poor design.

Structure



silicone rubber chain

Polysiloxanes differ from other polymers in that their backbones consist of Si-O-Si units unlike many other polymers that contain carbon backbones. One interesting characteristic is an extremely low glass transition temperature of about -127°C (Fitzpatrick 1999:428). Polysiloxane is very flexible due to large bond angles and bond lengths when compared to those found in more basic polymers such as polyethylene. For example, a C-C backbone unit has a bond length of 1.54 Å and a bond angle of 112°, where as the siloxane backbone unit Si-O has a bond length of 1.63 Å and a bond angle of 130°.



repeat unit of silicone rubber

The siloxane backbone differs greatly from the basic polyethylene backbone, yielding a much more flexible polymer. Because the bond lengths are longer, they can move further and change conformation easily, making for a flexible material. Another advantage of polysiloxanes is in their stability. Silicon is in the same group (IV) on the periodic table as carbon, but the properties of these elements are quite different. Silicon has the same oxidation state as carbon, but has the ability to use 3d orbitals for bonding by expanding its valence shell. Si-Si bonds have far less energy than C-C bonds and so are more stable, though in practice Si-Si-bonds are very hard to create.

Mechanical properties	
Hardness, shore A	40 - 90
Tensile strength	11 N/mm²
Elongation at break	490%

Maximum temperature	+200° C
Minimum temperature	-40° C

(Polymax 2005)

Special grades

There are also many special grades and forms of silicone rubber, including: Steam resistant, metal detectable, electrically conductive, chemical/oil/acid/gas resistant, low smoke emitting, and flame-retardant. A variety of fillers can be used in silicone rubber, although most are non-reinforcing and lower the tensile strength.

Applications

Once milled and coloured, silicone rubber can be extruded into tubes, strips, solid cord or custom profiles according the size restrictions of the manufacturer. Cord can be joined to make "O" Rings and extruded profiles can be joined to make seals. Silicone rubber can be moulded into custom shapes and designs.

Becoming more and more common at the consumer level, silicone rubber products can be found in every room of a typical home. From automotive applications; to a large variety of cooking, baking, and food storage products; to apparel, undergarments, sportswear, and footwear; to electronics; to home repair and hardware, and a host of unseen applications.

Non-dyed silicone rubber tape with an iron-oxide additive (making the tape a red-orange colour) is used extensively in aviation and aerospace wiring applications as a splice or wrapping tape due to its non-flammable nature. The iron-oxide additive adds high thermal conductivity but does not change the high electrical insulation property of the silicone rubber. This type of tape self-fuses or amalgamates without any added adhesive.

See also

- Elastomers
- Forensic engineering

- Forensic polymer engineering
- Polymer

References

- Brydson, John, *Plastics Materials* Butterworth, 9th Ed (1999).
- Lewis, PR, Reynolds, K and Gagg, C *Forensic Materials Engineering:Case studies*, CRC Press (2004)

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- Article
- Discussion
- Edit this page
- History

Personal tools

- Log in / create account

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- Main page
- Contents
- Featured content
- Current events
- Random article

Interaction

- About Wikipedia
- Community portal
- Recent changes
- Contact Wikipedia
- Donate to Wikipedia
- Help

Toolbox

- What links here

- Related changes
- Upload file
- Special pages
- Printable version
- Permanent link
- Cite this page

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