

Eco-Profiles of Silicones

A report by Prof. Ian Boustead

Executive Summary

November 2002



Introduction

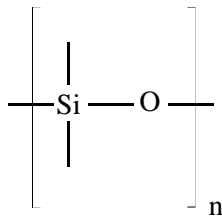
The concept of sustainable development proposed by the United Nations has been a powerful driving force to focus global attention on the need to integrate environmental stewardship with economic development.

Member companies of the Centre Européen des Silicones (CES) recognise the importance for industry of understanding the environmental impact of its products during production, use, recovery and disposal. This has become an important element in our continuous striving for improvement and our commitment to Responsible Care®.

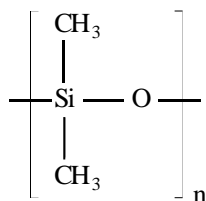
CES has therefore undertaken an examination of some of the products manufactured by its members using the best data available and covering as wide a cross section of operators as possible.

Silicones

Silicones are a family of polymers based on silicon. The most usual repeat unit is the siloxane group of the form:



One of the most widely used linear siloxanes is polydimethylsiloxane, which has the form:

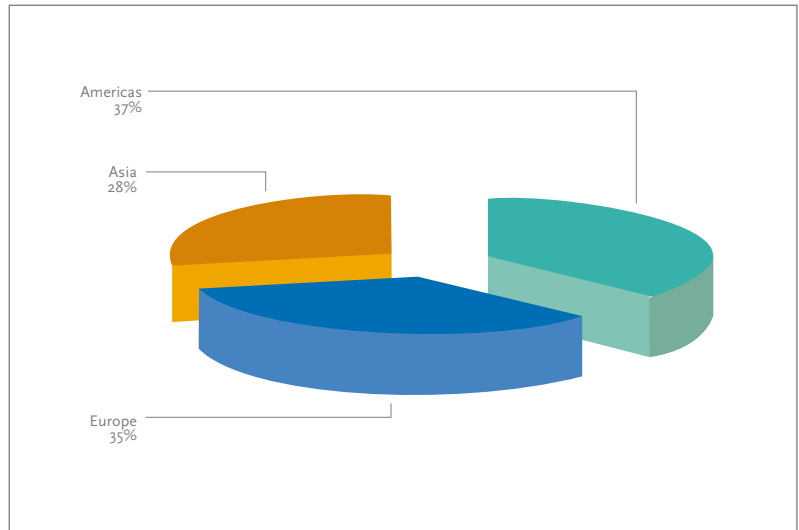


By adjusting the precise chemical structure and chain length of the polysiloxane, it is possible to produce silicone polymers with almost any desired property ranging from rigid solids to low viscosity liquids. Commercially available silicone fluids for example are the capped

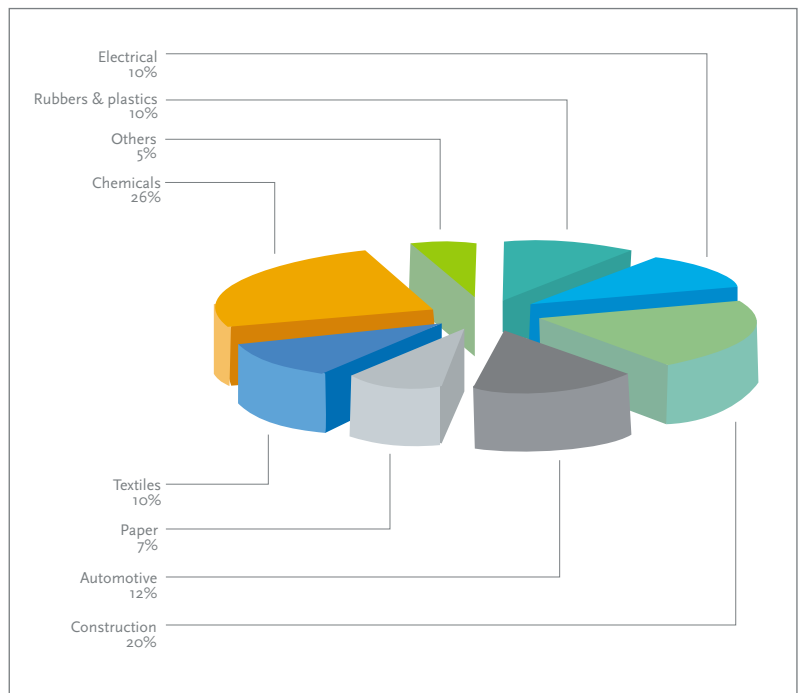
species of silicone polymers and sealants are room-temperature vulcanising rubber materials containing silicon polymers and an appropriate amount of inorganic fillers.

The market for silicones

Total global production of final silicone products in 2001 was almost 700 thousand tonnes. The use pattern by region is:



And the use pattern by application is:



Eco-profiles for environmental improvement

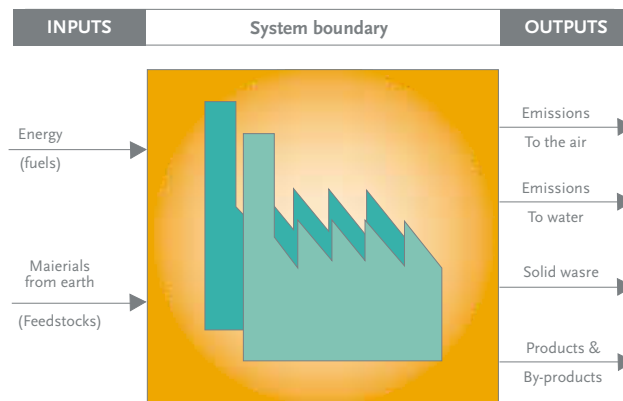
Eco-profiles for silicones are a 'cradle-to-factory-gate' summation of the consumption of energy and raw materials and of the solid, liquid and gaseous emissions during their manufacture when the starting materials are raw materials

in the earth. These eco-profiles are of immediate use for environmental improvements within individual companies.

In addition, the silicone eco-profiles are intended for use by downstream industry, consultants and others who wish to evaluate the environmental performance of products using silicones. By providing infor-

mation based on real current industrial practice, it aims to provide valid industrial data superior to all partial assessments and to the 'guesswork' available from third parties. The level of detail as well as the transparency of the report makes the data even more valuable to the evaluation of the environmental implications of the use of silicones.

"CRADLE-TO-FACTORY-GATE" STUDY: ECOPROFILE



Gross energy results

In this summary report, the results referring to the cumulative, gross energy requirements – traditionally the details of greatest interest – are given. These energies are calculated as the average for a 12-month period during 2000 for each producer weighted by the output from the plant. The results refer to the production of some 500,000 tonnes of polydimethylsiloxane produced in 7 production facilities based in France, Germany, Japan, the United Kingdom and the United States.

These data are thought to be representative of the industry as a whole. Data are also presented for the production of silicone fluids and silicone sealants.

It is important to recognise that elemental silicon contributes almost half of the gross energy needed to produce polydimethylsiloxane. Current advances in the production technology for elemental silicon, however, may lead to a 10% reduction in this contribution in the near future.

Gross energy required to produce 1 kg of silicon and silicone products.

Product	Fuel production ¹ (MJ)	Fuel use ² (MJ)	Transport (MJ)	Feedstock ³ (MJ)	Total (MJ)
Elemental silicon	38.44	103.45	1.33	32.29	175.52
Polydimethylsiloxane	29.10	84.74	0.91	33.59	148.35
Silicone fluid	30.29	86.24	0.95	32.53	150.01
Silicone sealant ⁴	23.29	57.56	0.69	17.51	99.05

1. Consumed by the fuel and energy producing industries; e.g. for the generation of electricity.
2. Consumed in chemical production processes.
3. Contained in the organic materials sources used to produce silicone products.
4. The energy for sealants is significantly lower than that for the siloxane or the fluid because sealants incorporate a significant proportion of fillers.

Outlook

To extend the "cradle-to-factory-gate" study to specific products, it is essential to select the correct raw materials and to combine their data in the correct ratio to produce a full "cradle-to-grave" life cycle. Only when this is done is it possible to carry out meaningful comparisons. Eco-profiles, such as those initiated by CES, are essential building blocks in the construction of complete life cycles.

It is important to note that it is meaningless to compare 1 kg of one material with 1 kg of a different material. Comparisons between different materials can only be made by looking at the complete life cycles of the materials and when they are used in applications that perform identical functions.

Methodology & data sources

CES has followed the general methodology established by APME (Association of Plastics Manufacturers in Europe) and carried out by Dr Ian Boustead .

Data on the production of silicone products were supplied by Dow Corning, GE Silicones, Rhodia Silicones, Shin-Etsu Silicones and Wacker. The work was carried out on behalf of the Global Silicones Council (GSC).

Centre Européen des Silicones

Centre Européen des Silicones - CES - is a non profit-making trade organisation representing all major producers of silicones in Europe. It provides information on silicones from a health, safety and environmental perspective. Please visit our website for further information www.silicones-europe.com

CES is a sector group of Cefic – the European Chemical Industry Council.

Further details about this study can be obtained from:

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Dépôt légal D/3158/9



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