Life Cycle Assessment of RTV-1 Silicone Sealants

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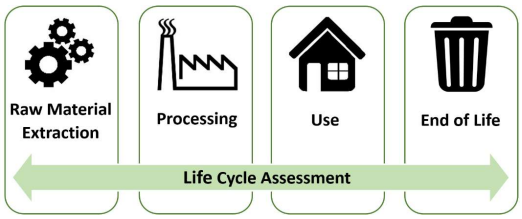
Introduction

Climate change, limited resources and environmental pollution are motivations for sustainable end-of-life management. The growth in polymer use has contributed to environmental problems, but the impact can be reduced through improved procedures, renewable materials and recycling technologies.[1]
To provide a scientific measure of a products actual environmental impact and sustainability of new technologies, the life cycle assessment (LCA) method is commonly used. Thereby, all related material and emission streams are measured, mapped and evaluated regarding different impact categories.[2]
Here, we present for the first time a comprehensive cradle-to-grave LCA for room-temperature vulcanizing (RTV) silicone sealants, as one of the most commonly used adhesives.[3]



Life cycle stages from „Cradle to Grave"

Methodology

This LCA study was based on ISO 14040 and ISO 14044 guidelines:

Goal and Scope

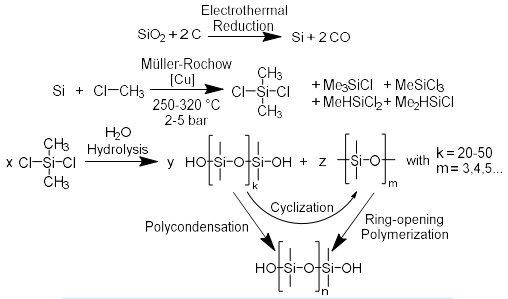
The objective was the identification of mayor carbon emission drivers and waste stream utilization potential of RTV-1 silicones. System boundaries were set as cradle to grave and 1 kg of commercial RTV-1 window sealant set as functional unit. End-of-life scenarios compare linear waste disposal, thermal recycling and advanced recycling techniques.

Life cycle inventory

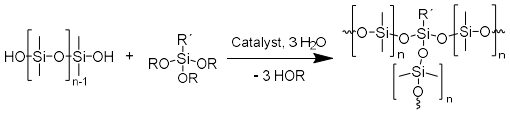
In this study, data was obtained from the industry, literature and patents as a source of background data and databases such as EcoInvent and Environmental Footprint (EF). Flows related to packaging production and transport are not considered. Inventory values for processing, use phase and end-of-life are calculated based on locations in Germany.

Life cycle assessment

The system was modelled using OpenLCA software. Normalization, weighting and assessment of all related flows was performed utilizing EF 3.0 impact assessment method (mid-point indication).



Industrial synthesis of PDMS[3,4]



RTV-1 crosslinking mechanism[3]

Current Emission Drivers

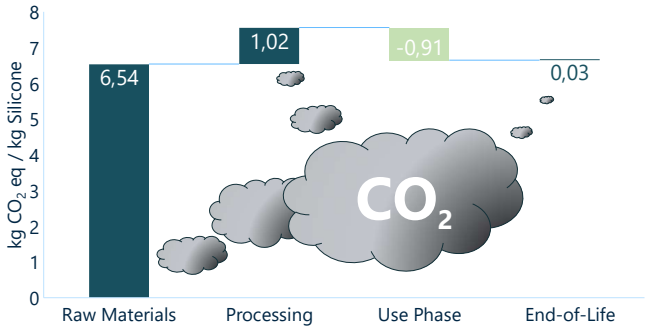


Fig.1: Net CO_2 equivalents of each life cycle stage. Causal allocation used for calculation. Use phase refers to window sealant and end-of-life to municipal waste management.

Raw Materials

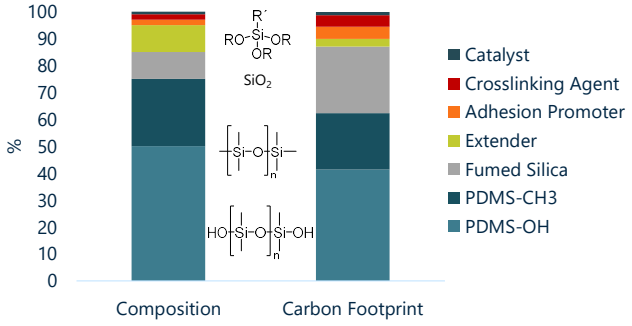


Fig.2: Composition of industry average formulation for RTV-1 silicone sealants and percentual contribution to the overall CO_2 emissions of raw materials.

End-of-Life Opportunities

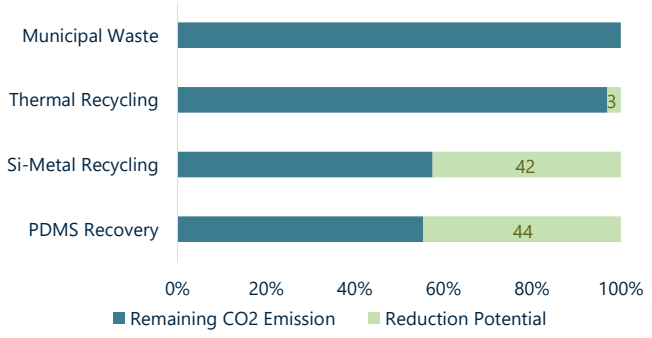


Fig.3: Comparison of thermal recycling, Si-metal recycling and PDMS recovery relative to current linear end-of-life treatment, calculated as CO_2 emission equivalent reduction ratio.

Conclusion

- **6,67 kg CO_2** emissions per kg RTV-1 silicone sealant
- **>60% of CO_2** emissions caused by PDMS and silicon metal production

+ Potential for recycling technologies to save up to **44% of CO_2** emissions
+ Waste streams as source for new silicone products

References

1. A. Eisen, M. Bussa, H. Röder, International Journal of Cleaner Production, 2020, 277, 124277. 2. L. Rigamonti, E. Mancini, International Journal of Life Cycle Assessment, 2021, 26 (10), 1937. 3. F. de Buyl, International Journal of Adhesion and Adhesives, 2001, 21 (5), 411. 4. E.G. Rochow, W.F. Gilliam, Polymeric methyl silicon oxides, J. Am. Chem. Soc. 63 (1941) 798–800.

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