Chemical Recycling of Silicones

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The exceptional mechanical and thermal properties of silicones as well as their low toxicity make them the materials of choice for numerous applications in fields as diverse as energy and insulation or health, cosmetics and the food industry. The raw material is quartz (crystalline silica) from which pure silicon metal is obtained via metallurgy to then form chlorosilanes that can be hydrolyzed/polymerized into silicones.

In a circular economy context, the chemical recycling of silicones to recover the monomers essential for their industrial synthesis is particularly relevant. It saves about 70% of the energy needed to manufacture virgin material by avoiding the metallurgy step from native quartz. This leads to a minimal carbon footprint from the chemical recycling of silicones.

We have recently develop two original catalytic recycling processes for depolymerizing silicones (see Figure 1). The first one uses a ligand-potassium silanolate complex in a very effective catalytic process allowing chemical recycling of silicones into cyclic monomers from many substrates including silicone wastes.[1] The process, which requires only a small amount of catalyst (typically 0.1 mol% or a few mass ppm), operates over a wide temperature range (60°C-170°C) to efficiently produce the mixture of cyclosiloxanes (D3/D4/D5, efficiency up to 99%). The effectiveness of the catalyst has been demonstrated over five consecutive recycling cycles. Additionally the same catalyst can be advantageously used to re-polymerize the monomers by Ring Opening Polymerization into silicones.

The second developed chemical recycling process of silicones goes further upstream in the silicone production chain allowing for the depolymerization of a tremendous variety of silicone substrates (oils, gums, resins and even cross-linked elastomers and actual silicone wastes) into chlorosilane monomers.[2] It requires a metalloid source of chlorine and a small amount of a metallic catalyst and operates at low temperature (< 60°C). Depending on substrates, almost quantitative yields in $SiMe_2Cl_2$, $SiMe_3Cl$ and/or $SiRMeCl_2$ have been obtained.

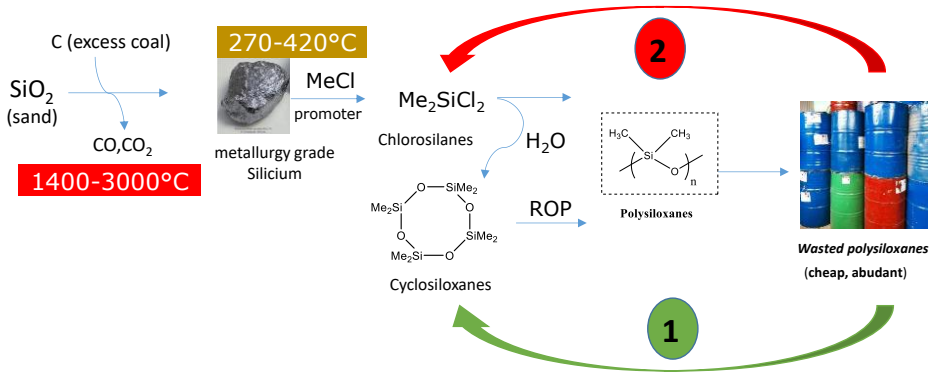

Figure 1. The two loops of silicones chemical recycling.

References

[1] N. D. Vu, A. Boulegue-Mondiere, N. Durand, J. Raynaud, V. Monteil, *Green Chem.*, **2023**, *25, 3869-3877.*
[2] N. D. Vu, A. Boulegue-Mondiere, N. Durand, J. Raynaud, V. Monteil, **2023**, *Under Review*.