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Designing reliable silicone elastomers for high temperature applications

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Abstract

Reliability and **durability** are strict requirements for silicone elastomers employed in high-temperature applications, if long-time device performance is desired. **Improving the thermal stability** of silicone elastomers is a major challenge, addressed by both the scientific and the industrial community. Nevertheless, traditional methods such as adding heat-resistant fillers[1] or chemical modifications[2] still suffer from considerable shortcomings. Here, it is demonstrated that the thermal degradation behaviour of silicone elastomers is affected strongly by network reactant stoichiometry.[3] **Comparative thermal degradation studies** were performed on **silicone elastomers synthetized with different stoichiometric ratios** - and thereby different fractions of elastic, dangling, and sol structures (Fig. 1).

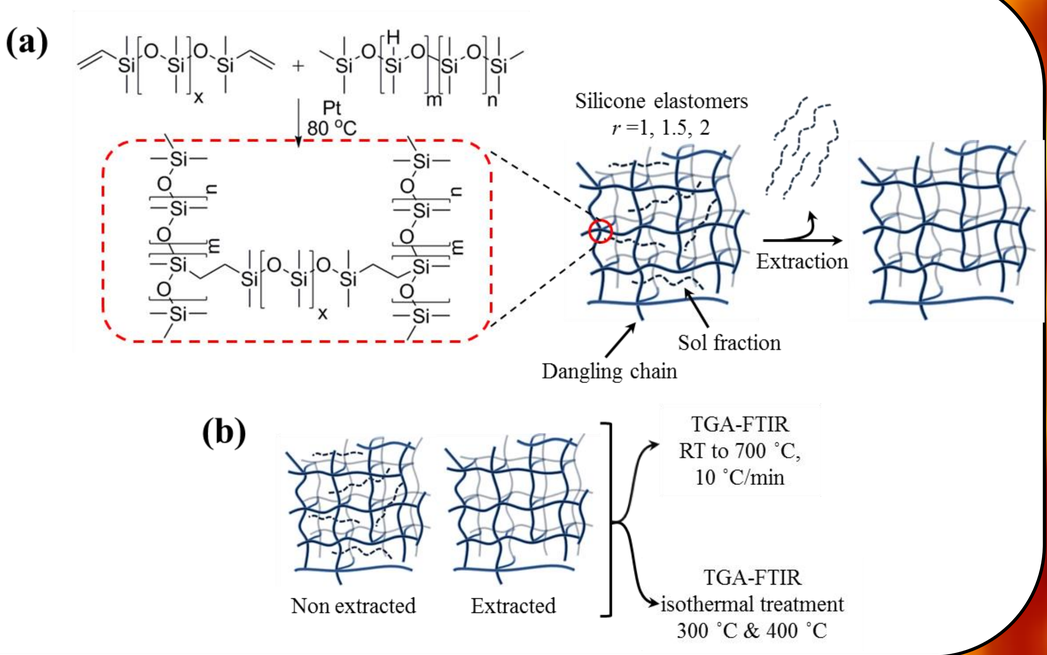


Fig. 1. (a) Hydrosilylation reaction scheme used to synthesize the silicone elastomers with different stoichiometric ratios. (b) The experimental procedure scheme was designed to investigate the thermal degradation behaviour of the silicone elastomers, before and after removal of the sol fraction by extraction.

General thermal degradation behaviour of the silicone elastomers

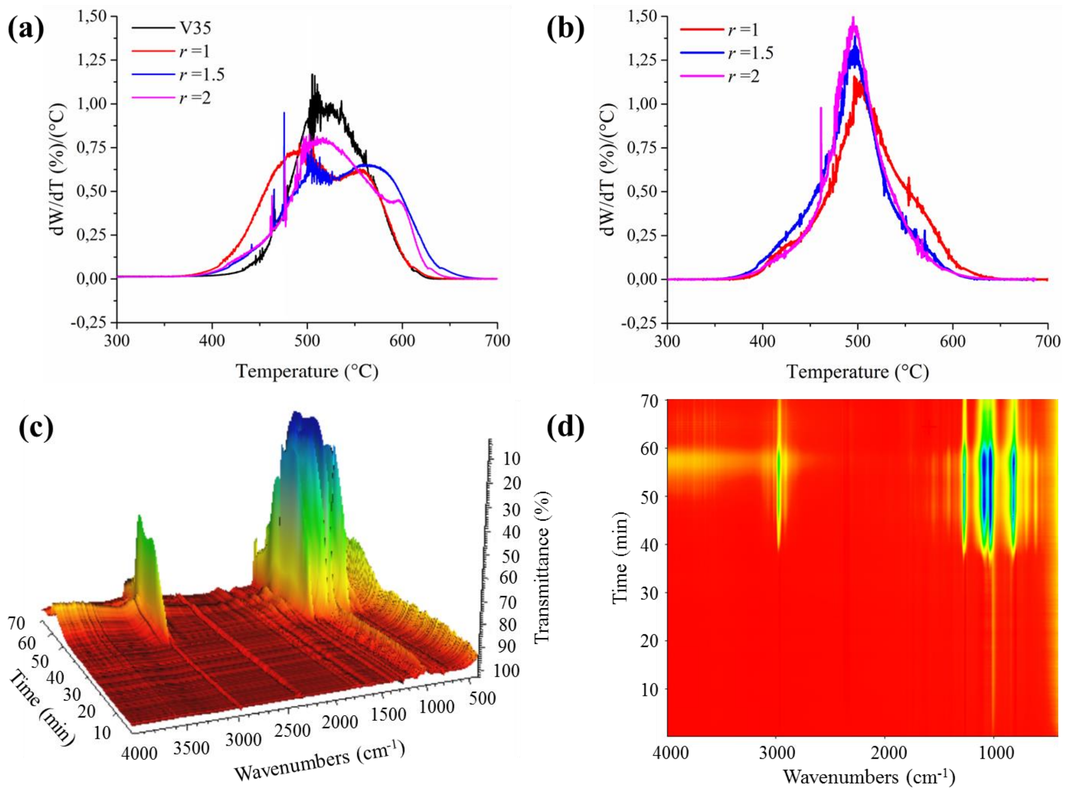


Fig. 2. First derivative of the weight loss curves as a function of the temperature of linear vinyl PDMS (V35) and silicone elastomers, before (a) and after (b) solvent extraction. 3D (c) and 2D (d) TG-FTIR spectra of pyrolysis products of the extracted silicone elastomer r=1 recorded during TG analysis.

Isothermal treatment of the silicone elastomers

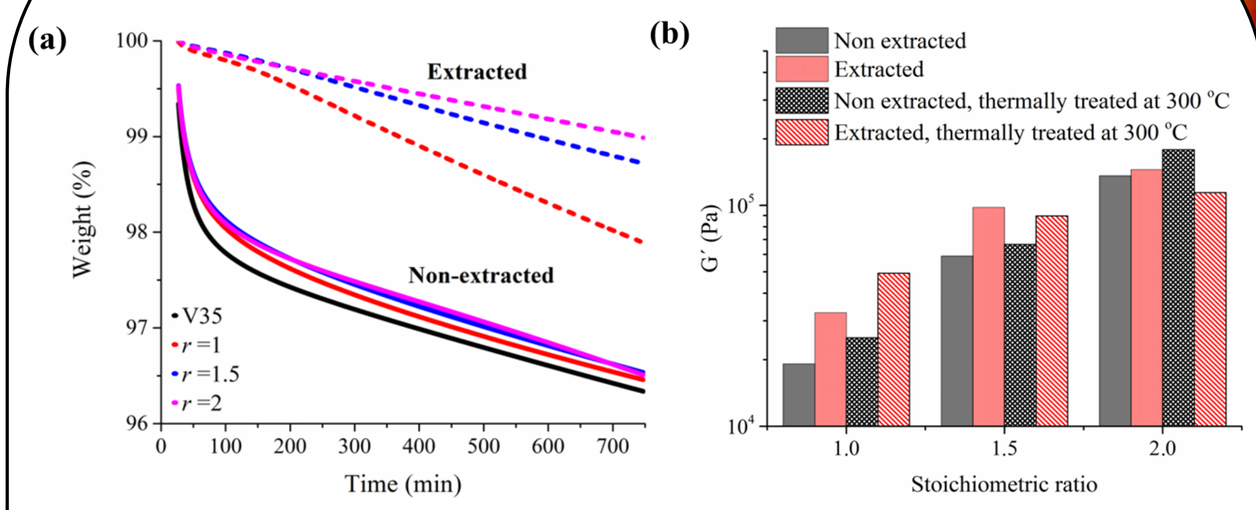


Fig. 3. (a) Weight loss curves of linear polymer V35, non-extracted, and extracted silicone elastomers during the isothermal treatment **at 300˚C**. (b) Storage moduli G´ (recorded at 1 Hz) of the silicone elastomers, before and after extraction, and before and after isothermal treatment at 300˚C.

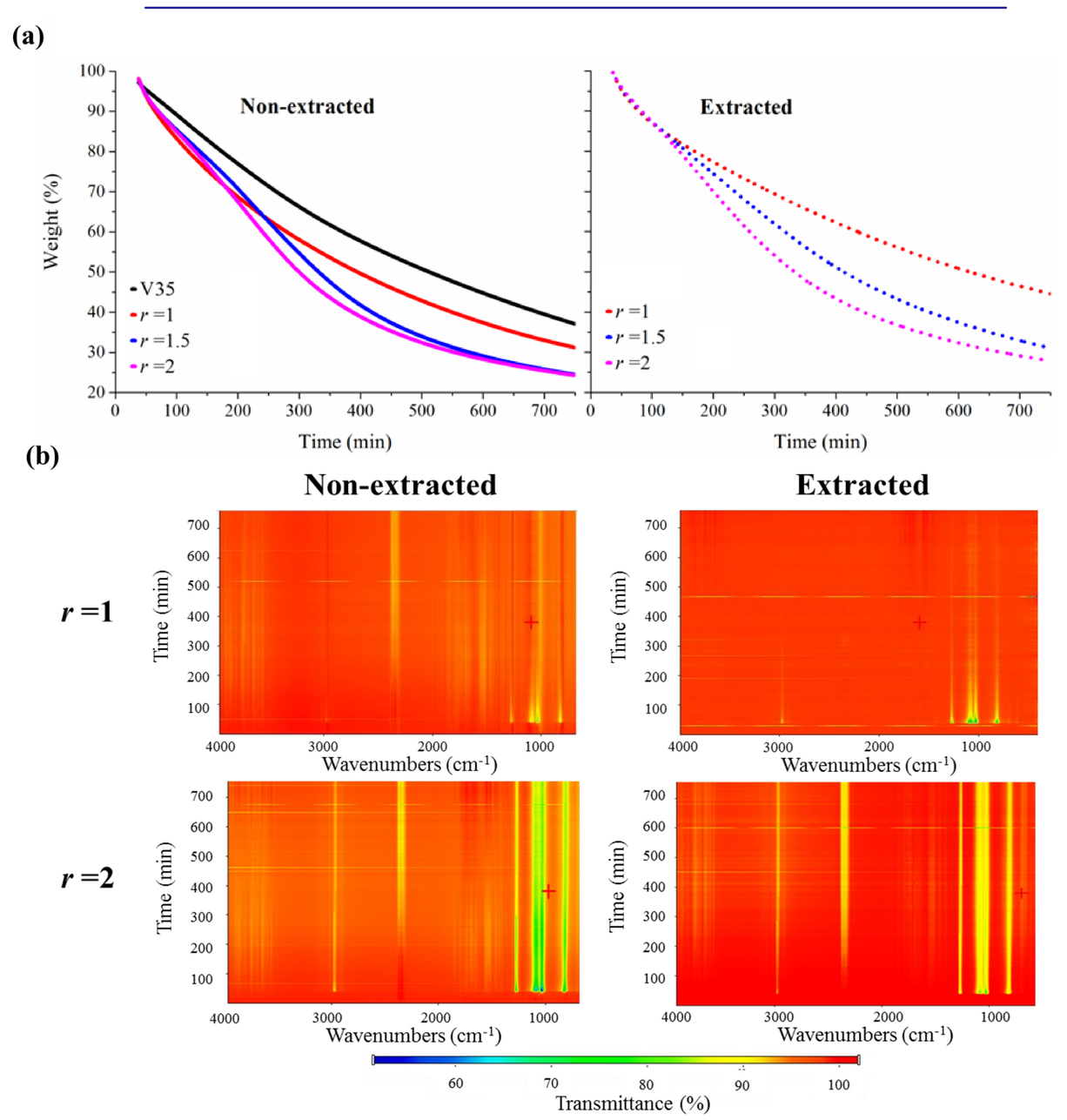
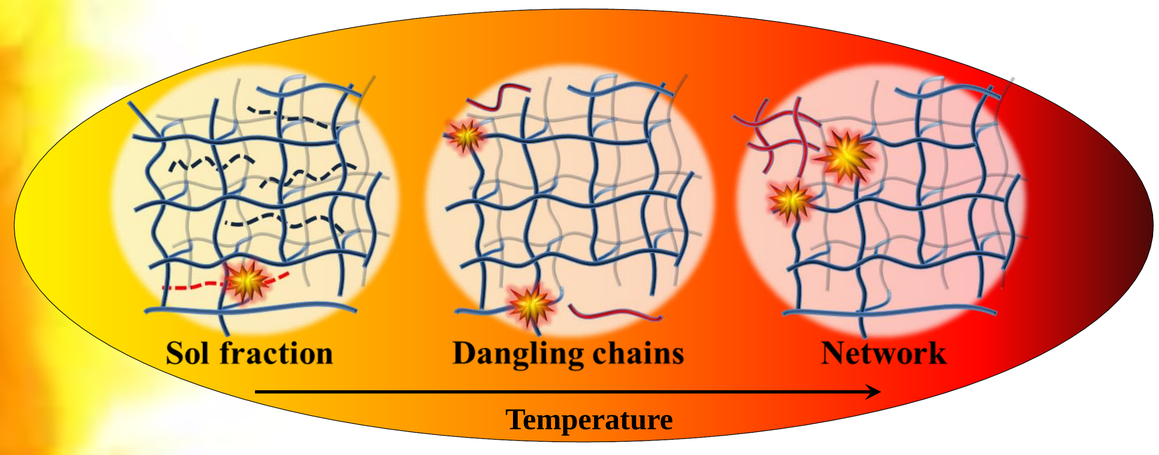


Fig. 4. (a) Weight loss curves of V35 and non-extracted and extracted silicone elastomers during isothermal treatment **at 400˚C**. (b) TG-FTIR: 2D plots of the volatiles released during 12 hours thermal treatment at 400 ˚C.

Conclusions



- It is possible to enhance the thermal stability of silicone elastomers simply by **optimizing the stoichiometric ratio** used to synthesise the network.
- **Removal of the sol fraction** leads to an increase in the thermal stability.
- Silicone elastomers degrade thermally following a **hierarchical trend**, depending on the degree of PDMS chain mobility.
- **At 300˚C**, thermal degradation involves the **sol fraction**, but after removing it by extraction, the thermal stability of the elastomers increases in line with increasing crosslinking density, since thermal degradation mainly affects the **dangling chains**.
- **At 400˚C**, enhanced thermal stability and reduced volatilization can be achieved by synthetizing silicone elastomers with **low crosslinking density**.

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[2] Y. Liu, Y. Shi, D. Zhang, J. Li, G. Huang, *Polymer* (Guildf). 54 (**2013**) 6140–6149.
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