A New Feedstock for Silicone Elastomers: Used Automobile Tires

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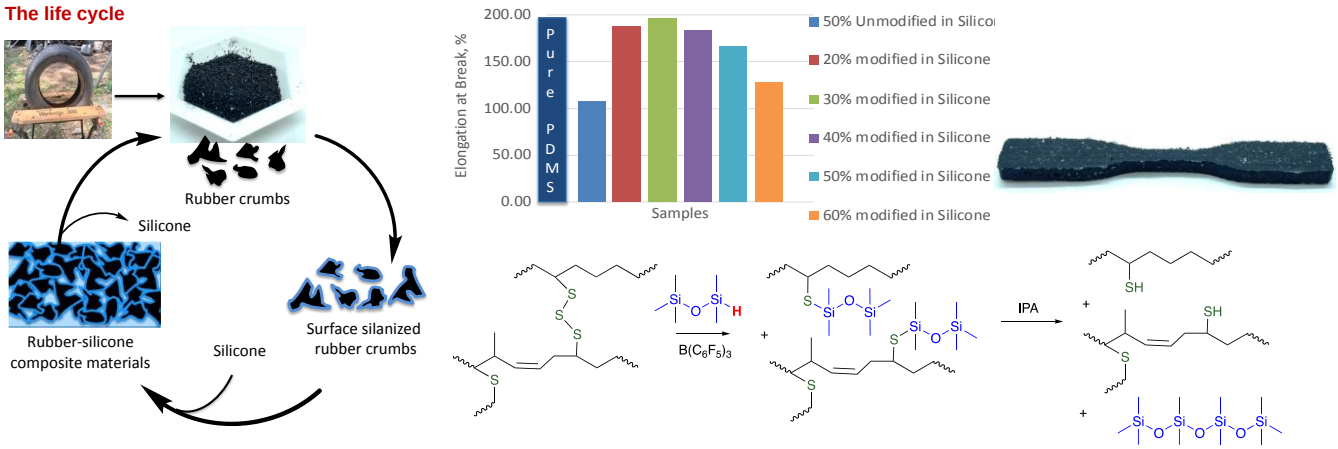
In order to tackle the simultaneous crises on climate change and pollution, society must quicky move to truly circular economies. A key strategy to implement a circular economy requires effective processes that transform waste from one process into valuable raw materials for the same or different processes.

Tires are arguably the worst example of single use synthetic polymers in linear economies. At the end of life, most automobile tires still have ~85% of their original mass and are, in the best circumstances, converted to very low value materials, burned as fuel or, in many jurisdictions, landfilled. It is possible under mild conditions to completely decrosslink the rubber in tires under mild conditions (100 °C, toluene, 30 min).[1] Reduction/cleavage of the RS-SR' bonds that crosslink the rubber can be induced using silicones containing HSi-groups, including $HMe_2SiOSiMe_2H$, in the presence of $B(C_6F_5)_3$. The resulting silyl thioether oils – RSSiO~ – are converted back to thiols by silicon transfer to oxygen, e.g., to isopropanol. The polymer oils are readily filtered from fillers (carbon black, silica, fiber, steel) and catalysts leaving a sulfur rich polymer that can be re-crosslinked oxidatively to give new rubbers.

The process is currently not commercially viable due to the need for high quantities of the expensive boron catalyst (10%). We report, however, that complete dissolution of the tire is unnecessary. High quality products can result from implementation of much lower degrees of chemical degradation, by 'doing less chemistry.' Chemical reduction can be directed only to the surface of readily available, inexpensive automotive crumb rubber, using much lower catalyst concentrations, leading to surface siliconization. The siliconized crumb could be directly used as reinforcing agents for silicone elastomers. Samples loaded with ~50wt% elastomer showed exceptional tear resistance and had Shore D hardness of ~50. The resulting rubber-silicone composite materials had essentially the similar tensile strength as the parent silicone elastomers. This simple process leads to high value materials from what was, essentially, waste single use rubber by controlling the entrained sulfur. A further benefit: the composite is readily recycled to silicone oil and siliconized crumb.



References

[1] (a) Zheng, S.; Liao, M.; Chen, Y.; Brook, M. A., Dissolving used rubber tires. *Green Chemistry* **2020**, *22* (1), 94-102. (b) Sijia Zheng, Michael A. Brook, *Macromol. Rapid Commun.* **2021,** *42,* 2000375.