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Recovering Value from Used Automobile Tires: Dissolution

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PURPOSE OF THE ABSTRACT

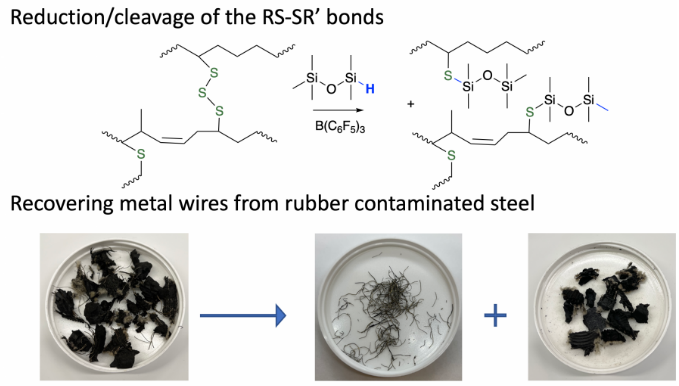
At the end of life, most automobile tires still have ~85% of their original mass and are, in the best circumstances, converted to very low value materials, burned as fuel or, in many jurisdictions, landfilled. Tires are arguably the worst example of single use synthetic polymers.

It is possible under mild conditions to completely dissolve 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 the small silicone HMe2SiOSiMe2H, produced excess to needs in the silicone industry, in the presence of B(C6F5)3. The resulting silylated oils -RSSiO- are converted back to thiols by silicon transfer to oxygen, e.g., to isopropanol. The polymers are readily filtered from fillers (carbon black, silica, fiber, steel) and catalysts leaving a sulfur rich polymer that can be recrosslinked to give new rubber. The process is currently not commercially viable due to the need for high quantities of an expensive catalyst (10%).

We report that complete dissolution of the tire is unnecessary. High quality products can result from implementation of much lower degrees of chemical degradation. The reductive reaction on rubber-contaminated steel ? recovered during tire shredding - showed that less that 0.1% catalyst was required and, more importantly, the reacting solution was readily reused for up to 5 reaction cycles. The steel during cleaning was removed magnetically, and the unreacted rubber by filtration or centrifugation. That is, higher efficiency results from focusing reactions at the steel and rubber interfaces; it is not necessary to completely degrade the rubber (Figure 1).

Similar outcomes were observed with used automotive crumb rubber, which is available in different sizes and external morphology, depending on whether grinding or cryogenic grinding were used. Reduction on the crumb surface, again using much lower catalyst concentrations, led to surface siliconization. The samples could be directly used as reinforcing agents for silicone elastomers (Figure 2). Samples loaded with ~50 wt% elastomer showed exceptional tear resistance and had Shore D hardness of ~50. Alternatively, once the silicone was washed from the crumb surface, the residual thiols could be used to directly graft crumbs to each other by oxidation, or annealed with alkene functional polymers. The resulting rubbers had essentially the same physical properties of the original tire. In retrospect, this should not be surprising since most of the body of the material is the high quality tire material that acted as a starting material. The simple process leads to high value materials from what was, essentially, waste single use rubber.

FIGURES



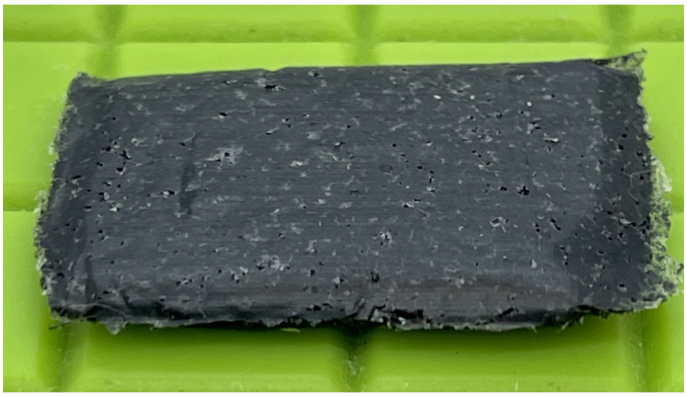


FIGURE 1

The reductive silylation applied to scrap tire to clean metal, and to rubber crumb that can be converted back to high quality elastomers.

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FIGURE 2

50 wt% recycled crumb rubber in commercial silicone.

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KEYWORDS

Waste tires | Rubber | Recycling | Silicone

BIBLIOGRAPHY

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