Editorial corner – a personal view

‘Waking sleeping beauty’: Regeneration of vulcanized rubber by triggering dynamicity of the inherent sulfur network

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Vulcanized rubber has been widely applied in modern society, which causes severe impact on environment in the meantime. This is because there are no proper disposals of the scraps, which are full of infusible and insoluble crosslinked networks. So far, methods have been developed to convert waste rubbers into small molecular weight fragments with commercial value, or granules as fillers of thermoplastics and asphalt. In some cases, the used rubber products are simply burned and buried. The bad resource management leads to significant pollution accordingly (DOI: [10.3144/expresspolymlett.2016.17](https://doi.org/10.3144/expresspolymlett.2016.17)).

When reviewing vulcanized rubber, we can find that the key technique of fabrication, i.e. vulcanization, remains nearly unchanged since the invention of Goodyear about two hundred years ago. The cross-linked networks contain tremendous disulfide and polysulfide bonds. Recent investigation indicates that metathesis of disulfide enables self-healing of polymers. In this context, so long as disulfide metathesis among different disulfide and polysulfide bonds can be triggered in sulfur crosslinked networks, the vulcanized rubber would acquire self-healability and recyclability.

In a patented invention, tiny amount of catalysts (CuCl_2 and copper(II) methacrylate) are incorporated into polybutadiene and chloroprene rubber, which are then compounded with the usual fillers and curatives following industrial formulation. The preliminary results (DOI: [10.1039/c5gc00754b](https://doi.org/10.1039/c5gc00754b) and DOI: [10.1021/acssuschemeng.6b00224](https://doi.org/10.1021/acssuschemeng.6b00224)) show that the catalysts can effectively initiate metathesis of disulfide bonds, so that the inherent sulfur crosslinks of the vulcanized

rubbers are allowed to be dynamically rearranged and reshuffled at 110~120 °C. It means that the sulfur crosslinks are as stable as the version excluding the catalysts under conventional circumstances without fear of losing stability during service at lower temperature (typically below 110 °C). More importantly, by taking advantage of the activated crosslinked networks, the vulcanized rubbers can be repeatedly self-healed, reshaped, and recycled in solid phase at 110~120 °C without environmentally unfriendly de-crosslinking. Additionally, mechanical properties of the healed and recycled materials approach to those of the original version. The catalysts do not react with the other additives in the matrix and do not accelerate aging of the rubbers.

The availability of self-healing, reshaping and reprocessing of vulcanized rubber offers new possibilities of cyclic utilization. Different circulation loops can be selected by various combinations of the smart functionalities according to actual demand. Life cycle of rubbers would thus be extended, while waste of resources is reduced.

There maybe other ‘sleeping beauties’ like the above in everyday life, which are waiting for being waked.

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