## Abstract

Cross-linking is the foremost step in the manufacturing process of any polymer or rubber product, which increases the elastic modulus of rubbers by forming a three-dimensional network structure. The outstanding properties of these conventionally cross-linked elastomeric compounds are very difficult to reprocess because of the permanent cross-linked network structure with the restricted long-range motion of polymeric chain molecules. Consequently, the reprocessing or recycling and reusing of conventionally cross-linked elastomeric compounds are crucial research interests. Due to this, we have developed an investigation into a "cradle to grave" approach. The cross-linked elastomer does not degrade after recycling using this method, nor does it require any extra chemical processing steps. For example, thermos-reversible supramolecular cross-linking reactions (covalent and non-covalent interactions) such as Diels Alder reactions, disulfide metathesis reactions, imine bond formation, boronate ester bond formation, metal-ligand interactions, host-guest interactions, hydrophobic interactions, H-bonds, $\pi - \pi$ stacking interactions and ionic interactions, etc. Adding such dynamic supramolecular interactions into the elastomeric matrix enhances the mechanical properties and self-healing ability with commercial applications. Herein, we developed a coordination network of carboxylated nitrile rubber (XNBR), cross-linked by metal-ligand interactions of transition metal complexes between the various metal salts and ligand molecules. Such metal-ligand cross-linked compounds exhibited better tensile strength, extreme stretchability, recyclability and outstanding self-healing ability at appropriate temperatures and times. We have discussed a dual ionic network structure formation via zinc oxide and naturally occurring amino acids (L-lysine and L-tryptophan), which exhibit superior physical properties to the conventional cross-linking system. Also, we investigated a network of carboxylated nitrile rubber cross-linked by biologically derived coordination complexes (metal-cysteine complex) with good room temperature healing ability, high tensile strength, extreme stretchability, and recyclability. These coordination complexes are used as a cross-linking agent for ionic elastomers, which add new possibilities for developing self-healing elastomers.



*Keywords:* Metal-ligand interactions, XNBR rubber, Physical cross-linking, Self-healing, Amino acids, Mechanical properties