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Transmission electron microscopy investigation of the network structure of elastomers

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Elastomer is widely used in industry as it is the only material that exhibits excellent flexibility and elasticity. These attractive mechanical properties come from the thermal motion of polymer network. Therefore, many research has been done to clarify the network structure. However, one big challenge is that direct observation of the individual network structure has not been achieved yet, because of nanoscale and amorphous nature of the elastomer network. Recently, a novel techniques enabling the transmission electron microscopy (TEM) observation of individual network structures in polyelectrolyte hydrogels, which is also soft network materials like elastomers, has been developed **[1]**. The main elements of this method are staining by inorganic nanoparticles adsorption onto the electrolyte side chains and fixation of the objective network by introducing a supportive network, but this method cannot be directly applied to elastomers, which are normally not electrolytes and have a higher network density than gels. In this study, we aimed to modify this technique to applicable for elastomer network (Fig.1).

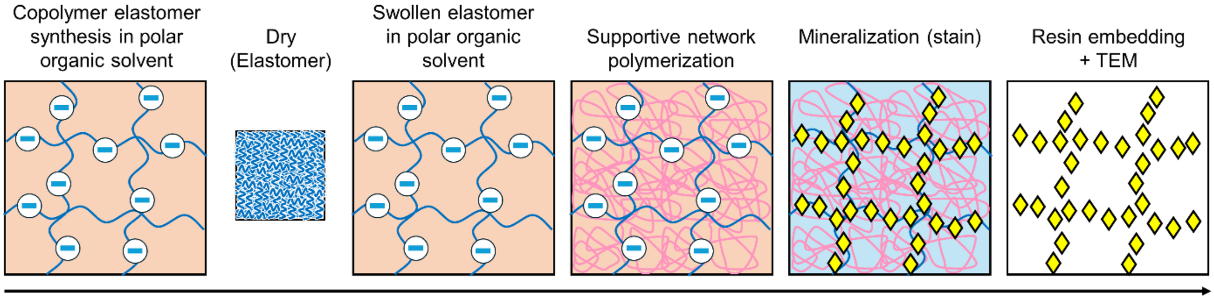

Fig.1 Schematic procedure of elastomer network visualization

We synthesized a methyl acrylate elastomer copolymerized with anionic monomer in polar organic solvent. The anionic function groups derived from the comonomers serve as staining sites and help elastomer to swell in polar organic solvent. This large swelling allowed for TEM observation without overlapping of the networks. A supportive network was then introduced to prevent structural changes that occur during staining and resin embedding. Finally, single mesh scale TEM observation of chemically crosslinked elastomer was achieved first time in the world (Fig. 2).

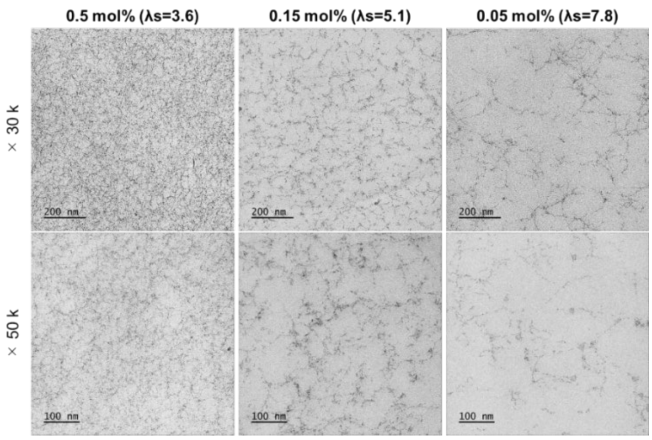

Fig.2 TEM images of various crosslinking ratio elastomers.

References: [1] Ryuji Kiyama, et al., Adv. Mater., 35, 2208902 (2023).