Synthesis and Mechanics of Anisotropic Double Network Elastomers

Ludovic FEIGE*, Costantino CRETON

Sciences et Ingénierie de la Matière Molle (SIMM), ESPCI, Paris

Double network elastomers are novel materials inspired by Gong's hydrogels [1]. They are made of two or more interpenetrated elastomeric networks where the first one is in minority and has a high crosslink density with respect to the other ones. As a result, these materials exhibit an enhancement both in toughness and stiffness that is attributed to a dissipation mechanism based on fracture of covalent bonds in the first network [2].

Until now, double network elastomers were prepared by swelling the first network in the monomer of the second network and subsequently polymerizing the second network. This results in an isotropically pre-stretched first network embedded in a soft and extensible matrix of second network. Interestingly, previous work demonstrated that this pre-stretching is the key parameter that controls the mechanical response of the system.

In the present work, we synthesized anisotropic networks by pre-stretching the first network manually in only one direction, and then swelled the material into monomer and polymerized the second network. By using a synthetic strategy inspired by existing dual-cure mechanisms in the field of epoxy resins [3], we performed the crosslinking of the first network in two steps, thus freezing the pre-stretching of the first network in one direction. Resulting double networks exhibit moderate anisotropy with a strain-hardening occurring at lower strains in the pre-stretched direction. Ongoing work involve the study of the details of this strain-hardening and the determination of its precise origin as well as the study of the fracture properties of this new class of materials.

[1] Gong, J.P.; Katsuyama, Y.; Kurokawa, T.; Osada, Y., Advanced Materials 2003, 15, 1155-1158.
[2] Ducrot, E.; Chen, Y.; Bulters, M.; Sijbesma, R. P.; Creton, C., Science 2014, 344, 186-189.
[3] Park, C-H.; Lee, S-W., Park; J-W.; Kim, H-J., Reactive and Functional Polymers 2013, 73, 641-646.