Molecular design of tough hydrogels with sacrificial bonds mechanism

Jian Ping Gong
WPI-ICReDD, Faculty of Advanced Life Science, Global Station for Soft Matter GI-CoRE, Hokkaido University
Sapporo 001-0021, Japan
gong@sci.hokudai.ac.jp

Invention of the tough double network hydrogels (DN gels), consisting of interpenetrated rigid/brittle network and soft/stretchable network, shows that the effective energy dissipation by the breaking of the covalent bond of the brittle network prevents catastrophic crack propagation upon deformation, and thus, gives the extraordinarily high toughness of the material[1]. Such sacrificial bond effect has been successfully applied to develop tough double network hydrogels of diverse chemistry and also to double and triple network elastomer materials. Thus, sacrificial bond concept is proved to be a general approach for developing tough soft materials.

As the internal rupture of DN gels is due to the irreversible breaking of the covalent bonds of the brittle network, the conventional DN gels deteriorate gradually after repeated deformation. To address this problem, many recent works have replaced the covalent bonds with non-covalent bonds to allow the sacrificial bonds to be reformed.

In this talk, novel hydrogels with reversible sacrificial bonds developed in author's group are reviewed and their excellent mechanical behaviors such as high toughness, self-healing [2,3], adhesion to biological tissues[4], and fast underwater adhesion are demonstrated[5]. Furthermore, this principle is extended to develop tough composites using tough hydrogels as energy dissipative soft matrix[6]. Recent development of self-growing hydrogels will also be introduced [7].

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