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Toughening Mechanism of Double Network Hydrogels[1]

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The fundamental toughening mechanism of DN gels [1] is of great interest to researchers. Extensive experimental and theoretical studies have been performed to explain this mechanism [2-7]. Yielding and necking deformation [2] that was observed through tensile tests and rate-independent hysteresis [3] observed through cyclic loading tests have indicated that DN gels can accumulate internal damage before the suffering macroscopic fracture; after damage accumulation, the DN gels become much softer. We assume that on the microscopic level, yielding is caused by the partial breakage and fragmentation of the brittle first network and interconnection among the fragments by the polymer chains of second network [2]. Brown [4] and Tanaka [5] have proposed similar models that can qualitatively explain the anomalously high fracture energy, assuming that the DN gel is locally damaged (yielded) around the crack tip and that the energy dissipated for damage accumulation enhances the effective fracture energy. Using AFM measurements [6] and 3D color laser microscope[7], we successfully detected the existence of softened regions, of several hundreds μm in thickness, at the crack tip just below the fracture surfaces, which supports the assumption of localized damage accumulation. A linear relationship between the thickness of the softened yielding zone and the fracture energy of the gel was observed, which is in agreement with the local yielding zone explanation.

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