Organic-Inorganic Nanocomposite Monolayers and Bilayers Having Dual and Triple Shape Memory Effects

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ABSTRACT: Chemical hybrids of polyurethane-silica nanocomposites having significantly enhanced glassy and rubbery state moduli have been molecularly designed, synthesized via sol-gel reactions between the silanols of silica particle and 3-aminopropyltriethoxysilane (APTES) terminated polyurethane, and identified for the dual and triple shape memory effects with their monolayer and bi-layer, respectively.

With the addition and increasing amount of silica particles, the rubbery state modulus and glass transition temperature as well as the glassy state modulus, yield and break strengths monotonically increased while the elongation at break decreased. The monotonic increase was evidenced from the fine dispersion of silica particles in polyurethane as noted from the scanning and transmission electron microscopic images. The results were properly interpreted in terms of the dual effects of silica particles as multi-functional cross-links and reinforcing fillers, which is in accordance with the classical ideal rubber theory.

The shape fixity and shape recovery of the non-filled films were already high as 90-96% due the effective cross-linkings by APTES, and further increased by the chemical hybridizations with silica particles as 98-99% with high hysteresis resistance, regardless of the silica contents. When the two films with different transition temperatures formed bi-layer, an intermediate rubbery plateau was defined and a triple shape memory behavior with high enough shape fixity and recovery was obtained.

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