

Controlling Dynamic Interfacial Self-Assembly in Functional Materials

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We are interested in the development of controlled polymer architectures, hybrid nanoparticle-soft matter assemblies and the integration of dynamic supramolecular systems at interfaces. Current research projects in the group include the application of macrocyclic host-guest chemistry using cucurbit[n]urils (CB[n]) in the development of novel microcapsules, supramolecular hydrogels, drug-delivery systems based on dynamic hydrogels, adhesion between a variety of surfaces, the conservation and restoration of important historical artefacts through the exploitation of supramolecular polymer chemistry and sensing and catalysis using self-assembled nanophotonic systems.

Modification of solution viscosity using multivalent polymers has been accomplished through dynamic cross-linking in water using CB[8]. These hydrogels, with extremely high water content (up to 99.75% water by weight), have also been prepared by utilising renewable cellulose derivatives and other polysaccharides. Their rapid formation and shear-induced flow properties make them perfectly suited for use as injectable hydrogels for delivery of therapeutics.¹

Polymer-inorganic composite materials can be readily prepared based on the CB[8] coupling of multivalent nanoparticles to functional copolymers. These CB[8] mediated composites exhibit dynamic self-assembly and are capable of responding to stimuli (photochemical, chemical, and thermal) allowing for external control and imbedded function within materials. We recently reported the formation of a supramolecular polymeric colloidal hydrogel mediated by CB[8] interactions.² The hybrid material comprises 98 wt% water and can be drawn into uniform 'supramolecular fibers' of arbitrary length at room temperature. These ductile fibers exhibit a unique combination of stiffness and high damping capacity (60-70%), the latter of which exceeds that of biological silks. These hybrid supramolecular composites open a window into fiber technology through low-energy manufacturing.³

In another example, we reported a new class of dual network gels formed through in situ polymerization, which incorporated both dynamic and covalent crosslinks exhibiting remarkable toughness, energy dissipation and self-recovery, behaving like an "artificial muscle".⁴ The hydrogel network exhibits extreme stretchability (>100x), remarkable toughness (> 2000 J/m²) and strength (fracture stress ~1.8 MPa), fast room temperature self-healing, with promising applications such as wearable electronics, super-tough interfacial adhesion, as well structural biomaterials.⁵

References

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