Nano Focus

Nanoparticles used to glue hydrogels

Researchers have discovered an efficient and easy-to-use method for gluing together gels and biological tissues. Inspired by the physics of polymer adsorption, a team headed by Ludwik Leibler, involving researchers from the Laboratoire Matière Molle et Chimie (CNRS/ESPCI ParisTech) and the Laboratoire Physico-Chimie des Polymères et Milieux Dispersés (CNRS/ UPMC/ ESPCI ParisTech), has demonstrated how strong adhesion between two gels can be achieved by simply spreading a solution containing nanoparticles on their surface. The nanoparticles therefore replace the polymer adhesives that are typically used.

As described in the January 16, 2013 issue of *Nature* (DOI: 10.1038/nature12806; p. 382), the researchers synthesized two sets of hydrogel samples, a polyacrylamide and a poly(dimethylacrylamide) (PDMA). These polymers had similar cross-linking densities and degrees of swelling. They do not adhere to each other, but PDMA binds strongly to silica, while polyacrylamide does not. A drop of 15 nm silica suspension was placed on the PDMA gel surface and another PDMA piece was pressed on top to form a lap junction. Strong adhesion was observed after a few seconds of contact. In contrast, no adhesion was achieved between polyacrylamide gels treated in the same way.

The failure force measured by the lap shear test showed that the adhesion energy was weaker for more rigid gels, and that joints made of PDMA gel could be stronger than the gel itself, resulting in failure outside the bonding junction. Only when the overlap length was made comparable to the ribbon thickness did interfacial failure occur by peeling. Stronger adhesion was achieved with larger silica particles, and investigation of the adhesive properties of a wide range of particles functionalized with different surface chemistries demonstrated the generality and flexibility of the strategy. To illustrate the potential for practical applications of the nanoparticle "glues," the researchers fused two pieces of calf liver using a layer of the nanoparticle solution. After pressing the tissue pieces together for 30 seconds, the lap joint held strongly and could be manipulated with ease.

This work has many potential applications, particularly in the biomedical and veterinary fields, in surgery, and in regenerative medicine. It may, for example, be possible to use this as a straightforward method to assemble synthetic and biological hydrogels and biological tissues without any significant effect on the rigidity or permeability of the assembly.

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