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Revolutionary method for gluing gels and biological tissues

Researchers have discovered an efficient and easy-to-use method for bonding together gels and biological tissues. 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 succeeded in obtaining very strong adhesion between two gels by spreading on their surface a solution containing nanoparticles. Until now, there was no entirely satisfactory method of obtaining adhesion between two gels or two biological tissues. Published online in *Nature* on 11 December 2013, this work could pave the way for numerous medical and industrial applications.

Gels are materials that are mainly composed of a liquid, for example water, dispersed in a molecular network that gives them their solidity. Examples of gels in our everyday lives are numerous: gelatin used in desserts, redcurrant jelly, contact lenses or the absorbent part of children's nappies. Biological tissues such as skin, muscles and organs have strong similarities with gels but, until now, gluing these soft and slippery liquid-filled materials using adhesives normally composed of polymers was a seemingly impossible task.

Leibler[1] is recognized for inventing completely original materials combining real industrial interest with profound theoretical concepts. The work he carried out in collaboration with Alba Marcellan and their colleagues at the Laboratoire Matière Molle et Chimie (CNRS/ESPCI ParisTech) and the Laboratoire Physico-Chimie des Polymères et Milieux Dispersés (CNRS/ UPMC/ESPCI ParisTech) has resulted in a novel idea: gluing gels together by spreading a solution of nanoparticles on their surface.

The principle is the following: the nanoparticles of the solution bind to the molecular network of the gel, a phenomenon known as adsorption and, at the same time, the molecular network binds the particles together. In this way, the nanoparticles establish innumerable connections between the two gels. The

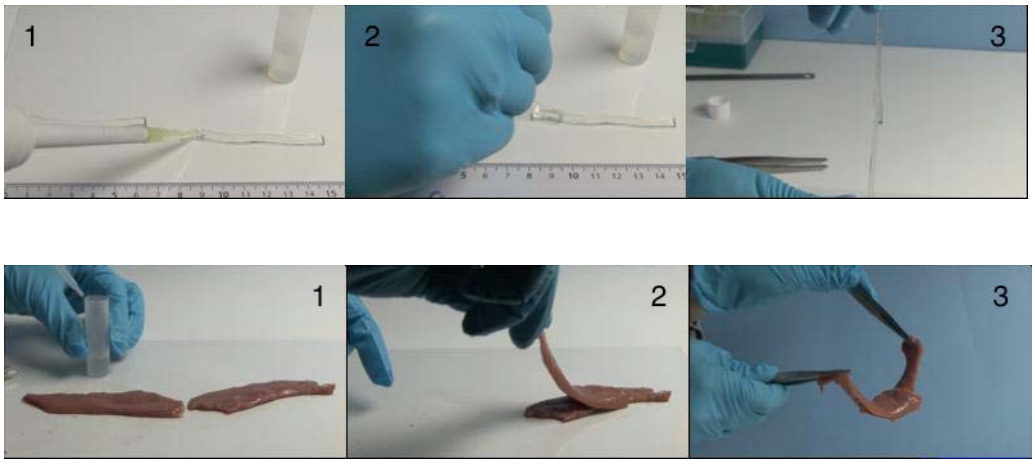
[1] Leibler was awarded the CNRS Medal of Innovation in 2013 (see press release: http://www2.cnrs.fr/presse/communique/3037.htm). With his colleagues at the Laboratoire Matière Molle et Chimie, he has developed supramolecular rubbers capable of self-healing through simple contact, after being cut to pieces. He also invented a new class of organic materials known as vitrimers. Repairable and recyclable, these materials, like glass, can be shaped as desired and in a reversible manner, while remaining insoluble, light and strong.

adhesion process only takes a few seconds. The method does not require the addition of polymers and does not involve any chemical reaction.

An aqueous solution of nanoparticles of silica, a compound that is readily available and widely used in industry, particularly as a food additive, makes it possible to glue together all types of gel, even when they do not have the same consistency or the same mechanical properties. Apart from the rapidity and simplicity of use, the adhesion provided by the nanoparticles is strong since the junction often withstands deformation better than the gel itself. In addition to offering excellent resistance to immersion in water, the adhesion is also self-repairing: two pieces that have become unstuck can be repositioned and glued back together without adding nanoparticles. Silica nanoparticles are not the only materials that display these properties. The researchers have obtained similar results using cellulose nanocrystals and carbon nanotubes.

Finally, to illustrate the potential of this discovery in the field of biological tissues, the researchers successfully glued together two pieces of calf's liver cut with a scalpel using a solution of silica nanoparticles.

This discovery opens up new applications and areas of research, particularly in the medical and veterinary fields and especially in surgery and regenerative medicine. It may for example be possible to use this method to glue together skin or organs having undergone an incision or a deep lesion. This method could moreover be of interest to the food processing and cosmetics industries as well as to manufacturers of prostheses and medical devices (bandages, patches, hydrogels, etc.).



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Use of a silica nanoparticle solution to glue two gels or two pieces of calf's liver. These three steps only take around ten seconds.

A CNRS Photothèque photo report is available on : http://bit.ly/J9SG16
To order photographs, please contact our Photothèque department by email : phototheque@cnrs-bellevue.fr

A video on the experiments carried out at the Laboratory can be viewed on : http://www.cnrs.fr/cnrs-images/leibler.htm

Bibliography

Nanoparticle solutions as adhesives for gels and biological tissues
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