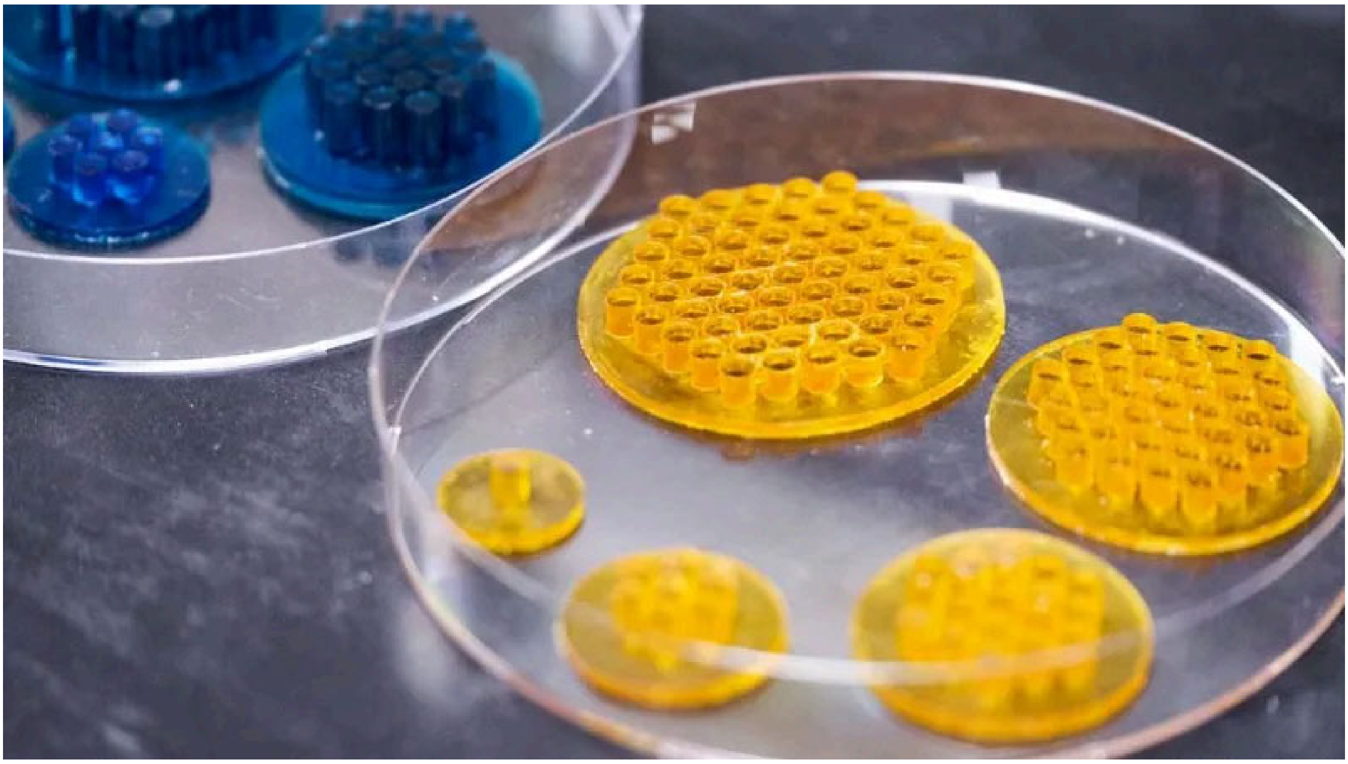
Reusable adhesive could let people 'climb walls like Spider-Man'

News

Humans could be imbued with the climbing ability of Spider-Man following the development of a reusable adhesive derived from shape-memory polymers.



The NTU team designed shape-memory polymers, which are smart materials that can 'remember' their previous forms, in the form of hair-like fibrils which they found in their testing to provide maximum adhesive strength - *NTU Singapore*

This is the claim of a team of scientists at Nanyang Technological University, Singapore (NTU Singapore), who said the reusable adhesive is over ten times stronger than the adhesive grip of a gecko's foot and could lead to reusable superglue and grippers capable of holding heavy weights across rough and smooth surfaces.

Led by Professor K Jimmy Hsia, the NTU research team found a way to maximise the adhesion of the smart adhesives by using shape-memory polymers, which stick and detach easily when heat is applied to them. The team's findings are detailed in *National Science Review*.

In a statement, Professor Hsia said: "This research is based on a fundamental understanding of the mechanisms of adhesion forces on rough surfaces. It can help us develop very strong, yet easily detachable, adhesives adaptable to rough surfaces. The technology will be very useful in adhesive grippers and climbing robots and might one day let humans climb walls like a real-life Spider-Man."

Shape-memory polymers return to their original shape after they have been deformed by applying external stimuli such switchable adhesives that can adapt to various surfaces.

In their testing, the researchers used E44 epoxy, a stiff and glass-like plastic at room temperature. Upon heating, the material turns into a soft rubber-like state that can conform and lock onto microscopic nooks and crevices. As it cools, it becomes glassy, creating extra-strong adhesive bonds due to a shape-locking effect.

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When the material is reheated, it reverts to its rubbery state so it can be detached from the surface it was clinging to. The researchers found that the most effective adhesion came from designing the shape-memory polymer into an array of hair-like fibrils between 0.5mm and 3mm in radius.

In their experiments, the researchers found that one fibril with a 19.6 mm2 cross-section could support loads up to 1.56kg. Every additional fibril allows for more weight to be supported; a palm-sized array of 37 fibrils weighing about 30g can hold 60kg.

The paper’s first author, NTU Research Fellow Dr Linghu Changhong, said: “Our smart adhesive exemplifies how shape-memory polymers can maintain and even enhance adhesion as surface roughness increases. This overcomes the ‘adhesion paradox’, which scientists have been puzzling over, where there is a decrease in adhesion strength on rough surfaces despite having more surface area for molecules to adhere to. Our tests showed that adhesion strength of the polymer increases along with surface roughness when in a solid state and decreases when in the rubbery state.”

Detaching the shape-memory polymer while it is attached to a surface in a glass state takes less than a minute of heating using a hair dryer to bring temperatures up to 60°C. For attachment, it takes about three minutes for the material to cool down thoroughly and lock into place.

The temperature at which the polymer changes states can be controlled by adjusting the ratios of the components used to form the polymer. This allows the polymer to be used in extreme environments, such as hot weather conditions. In their testing, the researchers set the temperature at which the polymer detaches to 60°C.

Reusable adhesive fibrils

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