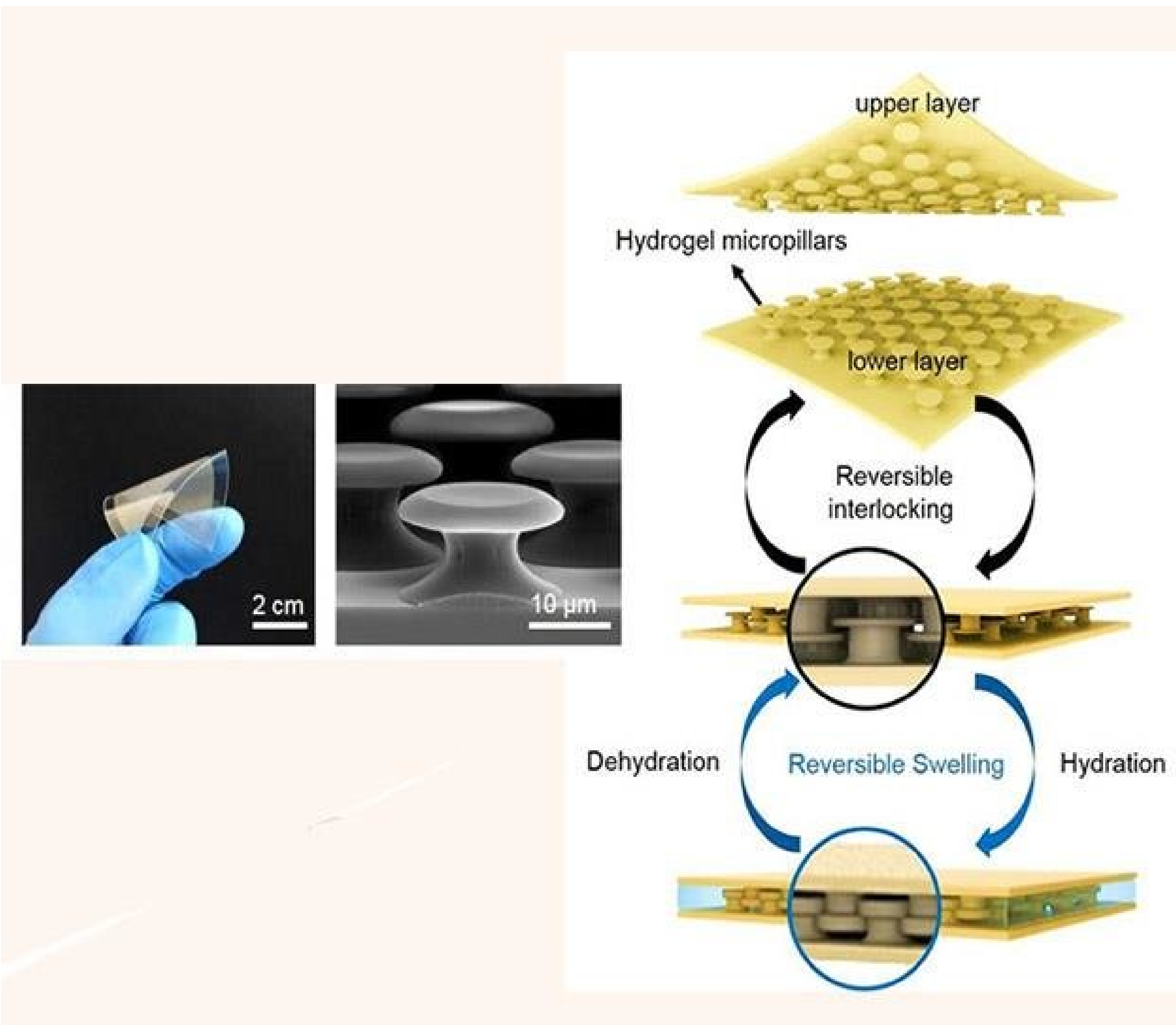
Researchers develop new class of underwater adhesives

January 17 2018



Photograph of the fabricated flexible interlocking adhesive (left) and a SEM image (center) of the PEGDMA microhook arrays of the adhesive. Shown on right is the conceptual illustration of the reversible interlocking of the PEGDMA microhook arrays via the hydration-induced shape reconfiguration of the array for high adhesion under wet conditions. Credit: UNIST

A Korean research team affiliated with UNIST has presented a new type of underwater adhesive that is tougher than the natural biological glues that mussels normally use to adhere to rocks, ships and larger sea creatures. This has attracted much attention as a technology to surpass the limits of conventional chemical-based adhesives that lose adhesion when exposed to moisture or when reused.

The research was led by Professor Hoon-Eui Jeong in the School of Mechanical Aerospace and Nuclear Engineering and his research team at UNIST. The findings of this study have been selected as the front cover of the December 2017 issue of *ACS Macro Letters*.

Stable adhesion between surfaces under wet conditions has many practical applications, particularly in the bioengineering and medical fields, where most surfaces are wet. However, limitations in complicated surface treatment and expensive protocols restrain the extensive use of these natural protein adhesives. Furthermore, the adhesives are typically permanent, and therefore have limitations for application as a reversible and reusable adhesive.

Professor Jeong solved such issues using the simple hydrogel microstructures alone. In the study, the research team presented a wet-responsive, shape-reconfigurable, and flexible hydrogel adhesive that exhibits strong adhesion under wet environments based on reversible interlocking between reconfigurable microhook arrays.

The microhooks of the adhesive were designed to exhibit a unique structural configuration with protruding heads. The adhesion between the interlocked microhook arrays is greatly enhanced under wet conditions because of the hydration-triggered shape reconfiguration of the hydrogel microstructures. Furthermore, this water-responsive shape change is reversible, and the microstructure can recover its original shape and size upon water removal by drying.

"These adhesives take the form of thin flexible films with bio-inspired, mushroom-shaped micropillars uniformly spread on the surface of microstructure," says Hyun-Ha Park in the Ph.D. program of Mechanical Engineering, the first author of the study. "When the interlocked arrays are exposed to water, a notable volume expansion of a corresponding shape transformation of the hydrogel microhooks occurred by the swelling of the hydrogel, resulting in significantly increased wet adhesion both in the shear and normal directions."

The research team notes, "In contrast to other wet binding systems, the current interlocking mechanism does not involve any complicated surface treatment or chemical moieties, thus allowing for a simple yet efficient route to strong and reversible wet adhesion in a cost-effective manner."

"The surface of the conventional chemical adhesives softens or dissolves when exposed to moisture or water, which can lead to a significant decrease in adhesive bond strength or loss of adhesion over time," says Professor Jeong. "In contrast to other wet binding systems, the current interlocking mechanism does not involve any complicated surface treatment or chemical moieties, thus allowing for a simple yet efficient route to strong and reversible wet adhesion in a cost-effective manner."

"This wet-responsive and reversible hydrogel interlocking adhesive can serve as a robust and versatile wet adhesive for a broad range of applications which require stable and strong adhesion under diverse wet conditions," Professor Jeong adds.

More information: Hyun-Ha Park et al, Flexible and Shape-Reconfigurable Hydrogel Interlocking Adhesives for High Adhesion in Wet Environments Based on Anisotropic Swelling of Hydrogel Microstructures, *ACS Macro Letters* (2017). DOI: 10.1021/acsmacrolett.7b00829

Provided by Ulsan National Institute of Science and Technology