Technology Offer

Bioinspired Liquid-Superrepellent Fibrillar Dry Adhesives

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Since 2000 bioinspired fibrillar dry adhesives have been studied intensively culminating in commercial products already available on the market. Currently known fibrillar adhesives are fully wetted by oils, leading to significantly decreased adhesion and friction performance. Therefore, a high demand exists for reversible dry fibrillar adhesives that can repel oil-like liquids and adhere strongly to surfaces wetted by them.

To meet the aforementioned challenges, an extraordinary fibrillar dry adhesive made of elastomeric soft materials, such as PDMS, and combining strong reversible dry adhesion with superrepellency towards all liquids, has been developed in the group of Prof. Metin Sitti at MPI Stuttgart. The developed fibrillar adhesive is a breakthrough in the bioinspired adhesives

Background

Since 2000 bioinspired fibrillar dry adhesives have been studied intensively culminating in commercial products already available on the market.

While the basic principles of fibrillar, reversible dry adhesives have been understood well, there are still engineering barriers and challenges to overcome; especially low cost and high volume production, and suitability for a wider range of real-world applications including manufacturing industry, robotics, sports, portable and wearable electronics, and medical devices, where low surface tension liquids such as oils are present on surfaces. Currently known fibrillar adhesives are fully wetted by oils, leading to significantly decreased adhesion and friction performance.

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This unique adhesive surface allows pushing away liquids, including oils, at the contact interface so that short-range van der Waals forces dominate, resulting in strong adhesion similar to dry conditions. Owing to the extreme liquid repellency, our new fibrillar adhesives also prevent liquids from collapsing between the fibrils, which is typically a catastrophic, irreversible failure mode for fibrillar dry adhesives.

Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de

To achieve these exceptional properties, arrays of microscale fibrils with re-entrant, mushroom-like tip geometries are produced with high accuracy using two-photon lithography (laser 3D printing), and subsequently replicated in PDMS using micromolding techniques. The fibril dimensions and center-to-center distance are chosen in a way that favors robust liquid repellency while maintaining strong adhesion.

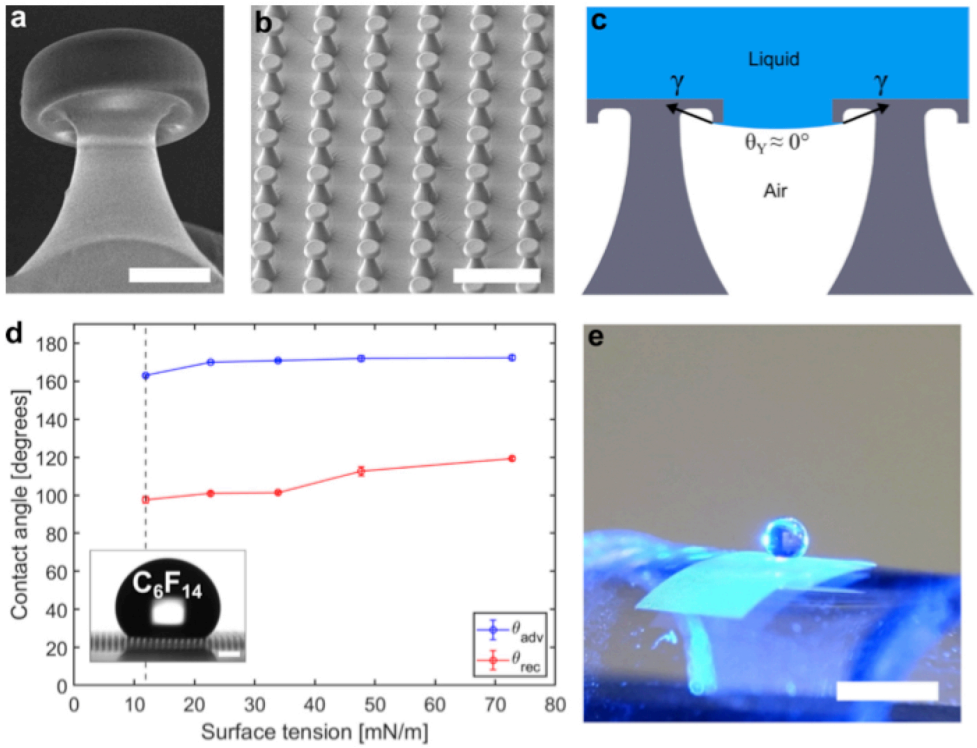

Fig. 1: (a), (b) Liquid repellency of double re-entrant PDMS microfibrils. **(c)** Liquid on top of the fibrils supported by vertical components of surface tension. **(d)** Advancing (blue) and receding (red) contact angles of perfluorohexane (γ = 11.91 mN/m), methanol (γ = 22.7 mN/m), dipropylene glycol (γ = 33.90 mN/m), ethylene glycol (γ = 47.7 mN/m) and water (γ = 72.8 mN/m) on the PDMS fibril array. The inset shows a droplet of perfluorohexane in the Cassie state on the PDMS fibril array (scale bar: 200 µm). **(e)** A droplet of methanol on a bent PDMS fibril array (scale bar: 2 mm).

Advantages

- Unique elastomeric dry adhesive based on double re-entrant fibril tip geometry combining strong reversible dry adhesion and superrepellency towards all liquids regardless of surface tension
- First fully soft liquid-superrepellent surface that is not mechanically brittle, durable against physical contact, and highly deformable, flexible, scratch-resistant and stretchable
- Use: applications where wet conditions have so far rendered conventional fibrillar dry adhesives infeasible, including medical devices, wearable electronics and robotic handling of wet objects.

Patent Information

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Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de

Max-Planck-Innovation

Contact

Gökçe Özyurt

Patent- & License Manager
Elektroingenieur (M.Sc. Wirtschaft)

Telefon: 089 / 29 09 19-18
E-Mail: oezyurt@max-planck-innovation.de

Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de