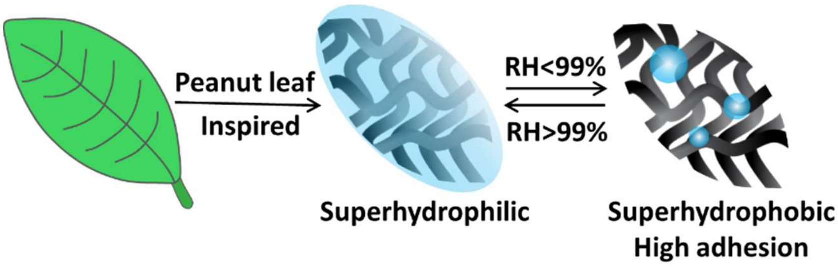
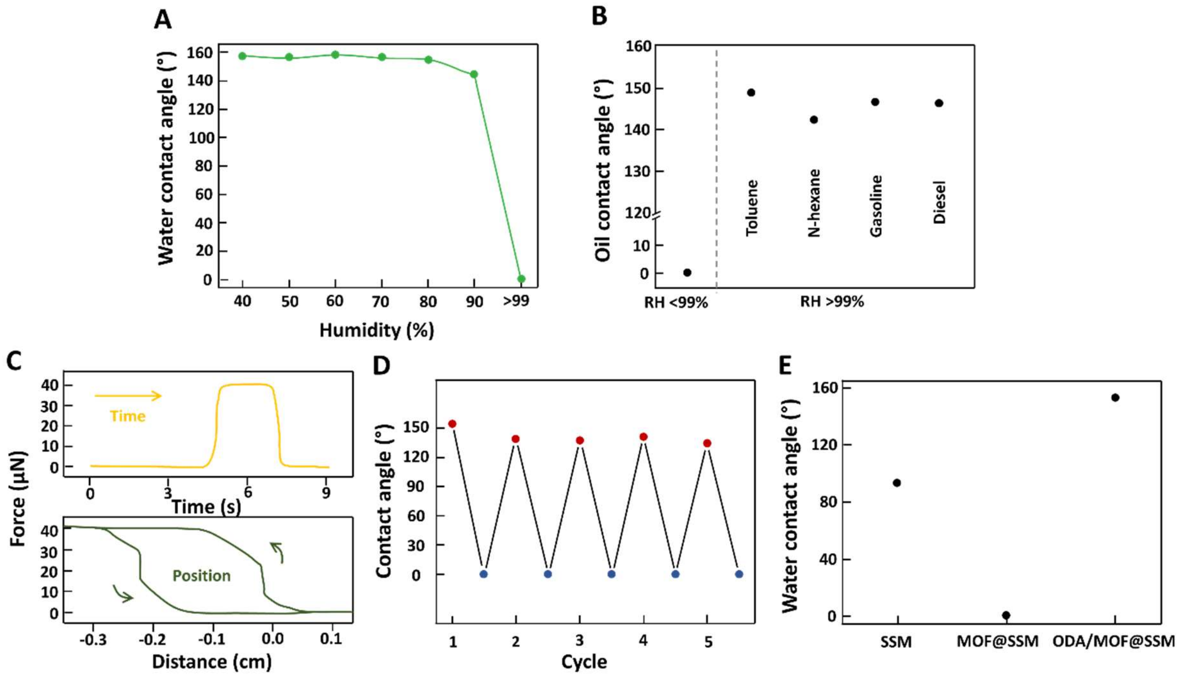
How peanut leaf can give an inspiration for materials that can do a humidity-controlled separation of diverse emulsions

Biomimetic materials using inspiration from nature have received high interest in the last years. Some fascinating examples include the nanostructures of lotus leaf, the honeycomb structure of beehives, the strength of spider silks and the water repellency of shark skin. A variety of functional materials based on nature´s inspiration have been applied for example as antiwetting coating and for liquid separation. Recently, Feng´s group has accidently found that the peanut leaf is highly humidity-responsive (HR) due to its porous nanostructures on the surface, with low or even no damage to the materials during the responsive process. Because of the special surface structure, the peanut leaf displays high hydrophobicity and high adhesion to water when the relative humidity (RH) is <99%, but presents high hydrophilicity when RH >99% (99% corresponds to saturated humidity) (**Picture 1**). Inspired by the peanut leaf, Feng´s group has developed a multifunctional material which showed binary synergy wettability under different humidities, and successfully applied this material for the controlled separation of diverse emulsions.



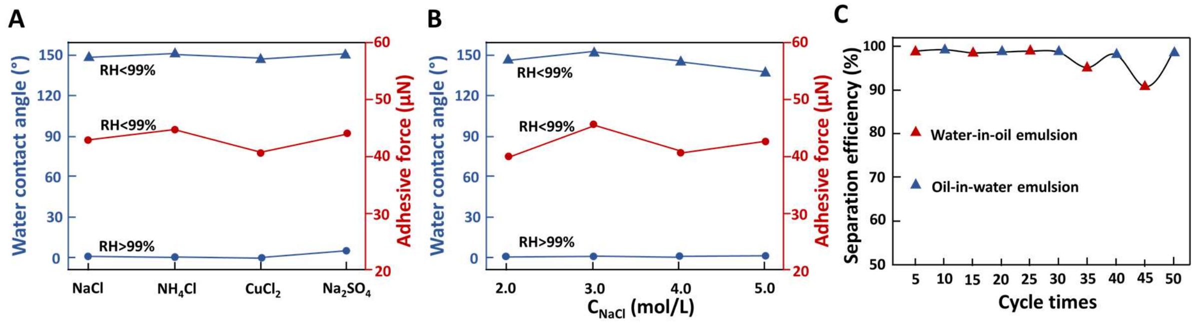
***Picture 1**. The special humidity-responsive (HR) property of peanut leaf*

In this work, a humidity-responsive MIL-100 (Fe) (MOF)/octadecylamine (ODA)-coated stainless steel mesh (SSM) (HR-MOS) was fabricated by a one-step hydrothermal reaction. To investigate the similarity between the biomimetic material and peanut leaf, they tested the wettability and the adhesive force. **Picture 2A** and **2B** show the material maintained superhydrophobicity and superoleophilicity when RH <99%, indicating that the material can be applied in the separation of water-in-oil emulsion. The material exhibited superhydrophilicity and superoleophobicity when RH was above 99%, which is suitable for oil-in-water emulsion separation. T evaluate the adhesive force, a water droplet was handled to touch and leave the material surface (**Picture 2C**). They found that the surface exhibits a high adhesive force and the droplet could steadily adhere to it, which is similar to the observations on the peanut leaf surface. Besides, the results of water contact angles (WCA) was reproducible even after five successive wettability transition processes (**Picture 2D**). To further understand the wetting behavior of the materials, the WCAs of different meshes were studied. As **Picture 2E** displays, the addition of ODA contributed greatly to the superhydrophobicity of the material because the long alkyl chain in ODA decrease the specific surface energy of the material.



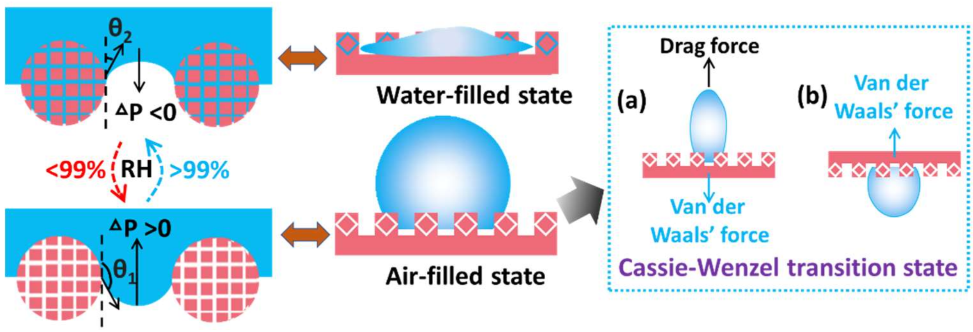
Picture 2. *WCAs (A) and Oil contact angles (OCAs) (B) on the as-prepared material surface under different humidity. (C) Adhesive force between the water droplet and the material when RH <99%; (D) Five successive HR experiments of the material when RH <99%; (E) WCAs of SSM, MOF-coated SSM, and HR-MOS*

Furthermore, even when treated with different salt solutions, the WCAs and adhesive force of the material could maintain unchanged which speaks for a high durability and the tolerance of a saline environment. Moreover, they successfully realized humidity-controlled separation of at least 12 types of emulsions consisting of different surfactants and oils with high separation efficiency after 50 times (**Picture 3C**).



Picture 3. *WCAs and adhesive force of the material after treated by different salt solutions (A) and different concentrations of NaCl (B); (C)Fifty times of alternant emulsion separations*

The authors also evaluated the mechanism behind this phenomenon (**Picture 4**). Similar to the peanut leaf, HR-MOS has two level nanostructures on the surface: the primary structure was the ordered stacked MOF with gorges which caused the high adhesive force. A water droplet first enters the primary structure and contacts with the material resulting in a Cassie-Wenzel state where the water droplet was adhered to the material due to van der Waal's force between water and the gorges. The secondary structure was the framework with various orientations in the MOF which caused the humidity-responsive properties. In the case of RH <99%, the framework was filled by air and the surface dominated by the long alkyl chains of ODA showed hydrophobicity. However, in the case of RH >99%, the water would enter the framework and form a water layer which endowed the surface with hydrophilicity.



Picture 4. *Mechanism of the humidity-responsive property and the high adhesion of the material*

Overall, the authors developed a biomimetic material with humidity-responsive wettability transition properties inspired by the peanut leaf in nature. Markedly, this is the first example to realize humidity response by mimicking natural binary synergy systems. This system exhibits great potential in different applications including humidity control, water purification, and moisture accumulation.

Aa optical contour analysis system OCA and a dynamic contact angle analyzer and tensiometer DCAT (DataPhysics Instruments GmbH, Germany) were used in this research.

For more information, please refer to the following article:

Peanut Leaf-Inspired Hybrid Metal−Organic Framework with Humidity-Responsive Wettability: toward Controllable Separation of Diverse Emulsions; Ruixiang Qu, Weifeng Zhang, Xiangyu Li, Yanan Liu, Yen Wei, Lin Feng, and Lei Jiang, *ACS Appl. Mater. Interfaces* ***2020**,* 12, 6309−6318; DOI: 10.1021/acsami.9b21118