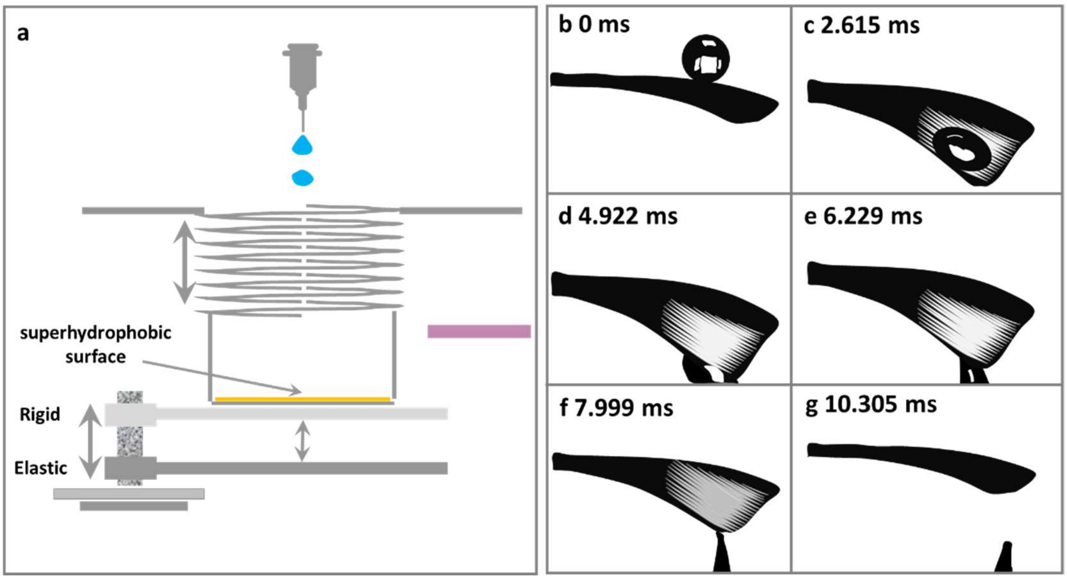
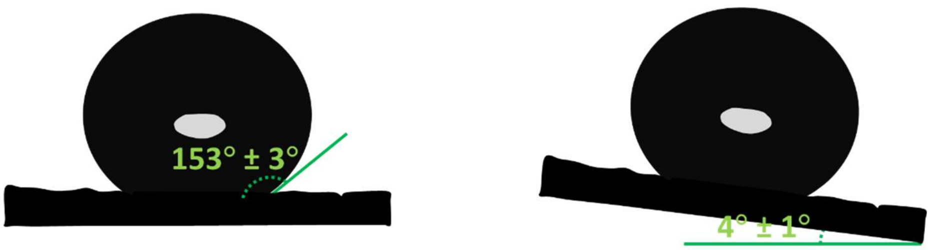
Why kingfishers can fly in the rain without becoming wet. A study of dynamic wetting behavior.

Bird feathers display excellent water repellency due to optimized structural parameters and resistance to water penetration. In this context it was found that hummingbirds could almost completely avoid moisture adhered to their body. Also kingfisher feathers show some exquisite properties and studies revealed that their high feather elasticity can transfer elastic potential into reversible bending when hit by water drops. The feather tip is then accelerated four times faster than a rigid feather would be making it particularly difficult for water to adhere. Until now these effects of vertical linear elasticity on droplet wetting dynamics have not been understood well. Recently, Zhang and team have evaluated the difference between the impact dynamics of water on elastic feathers (elasticity formed by natural bending) and that of rigid feathers (fixed on a rigid substrate) in order to reveal the mechanism how birds can fly in the rain without getting wet and to guide the design of water-repellent surfaces in the daily life,

In order to study the dynamic wetting effects on kingfisher feathers the droplet impact was simulated in a testing setup as described in **Picture 1**. Two models were tested including a rigid and an elastic feather movement to realize comparative experiments. To reduce viscoelastic dissipation and anisotropic wetting, a 200-mesh copper net with superhydrophobic surface (contact angle 153° ± 3°, sliding angle 4° ± 1°) was applied in this device (**Picture 2**).

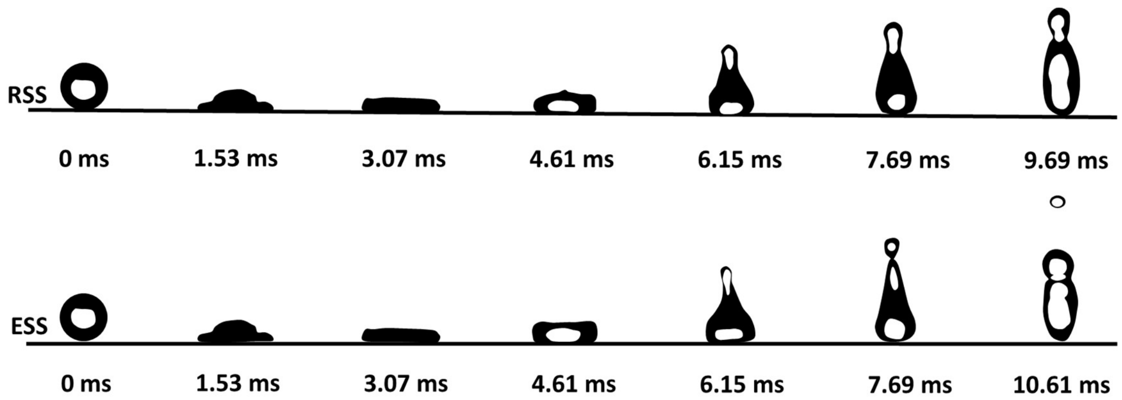


Picture 1: *(a) Scheme of the switchable substrate system; (b-g)Droplet impact on the tip of a kingfisher feather. Upon interaction with a droplet (D_0 = 2.056 ± 0.00 1 mm, W_e = 20), the droplet was first fragmented and bounced off, and finally the feather returned to its original state without any residual water*



Picture 2: *The water contact angle (CA) on the superhydrophobic copper net is 153 °± 3 °, the sliding angle (SA) is 4 °± 1 °*

Next, they demonstrated that the dynamic behaviors of droplets (diameter D_0 = 2.056 ± 0.001 mm, Weber number W_e = 17) impacting on the rigid and elastic superhydrophobic substrates (RSS, ESS) differed (**Picture 3**). For RSS, the droplet remained intact all the time until lift-off within 9.69 ms; for ESS, the droplet exhibited almost the same spreading process within 3.07 ms, however, the morphology of the droplet completely differed from that on RSS after 6.15 ms and a secondary droplet detached from the top of the droplet due to capillary instability in the case of W_e = 17. It can be reasoned that the hydrophobicity of the surface enhanced the water repellency, and the elasticity of the ESS caused the efficient and early rearrangement of the droplet during the interaction with ESS, thus resulting in the redistribution of droplet mass and dramatically reducing the contact time (decreased by 1.2-8.4%). Notably, various Weber numbers would also affect the dynamic behaviors of water droplets impinging on RSS and ESS. These findings could be used to proposed a corresponding parameterized kinematics equation, and establish a simplified elastic dissipation model to better explain the positive effect of the elasticity of kingfisher feather on water-repellency under heavy rains.



Picture 3: *Two dynamic processes of droplet impact on rigid superhydrophobic substrate (RSS) and elastic superhydrophobic substrate (ESS)*

Overall, inspired by kingfisher feathers, the authors experimentally and theoretically confirmed that the elastic of a superhydrophobic surface can enhance its water repellency. This work generated new insights and strategies to design water repellent surfaces in the industry and helps to understand the reason why kingfishers can fly in the rain without getting wet.

An optical contour analysis system OCA (DataPhysics Instruments GmbH, Germany) was used in this research.

For more information, please refer to the following article:

Non-wet kingfisher flying in the rain: The water-repellent mechanism of elastic feathers; Chengchun Zhang, Yihua Zheng, Zhengyang Wu, Jing Wang, Chun Shen, Yan Liu, Luquan Ren; *Journal of Colloid and Interface Science,* **2019,** 541, 56–64; DOI: 10.1016/j.jcis.2019.01.070