Electronic Supplementary Material (ESI) for Soft Matter.

Supporting Information

Nature-Inspired Lubricant-Infused Surface for Sustainable Drag Reduction

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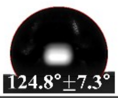
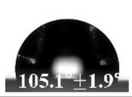
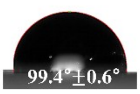
	Pristine	Fluorianted	Liquid-infused	Sliding angle for dry surfaces	Sliding angle of lubricated surfaces
Bare PVA	 60.8°±3.4°	 117.9°±2.3°	 101.8°±3.4°	> 90°	6.34°±2.0°
Sanded PVA	 66.5°±2.7°	 124.8°±7.3°	 105.1°±1.9°	> 90°	5.89°±1.9°
Re-entrant cavity PVA	 99.4°±0.6°	 121.4°±6.8°	 107.4°±3.7°	> 90°	7.7°±1.1°

Table S1. Comparison of contact and sliding angles of water droplets (10 μL) on various surfaces.

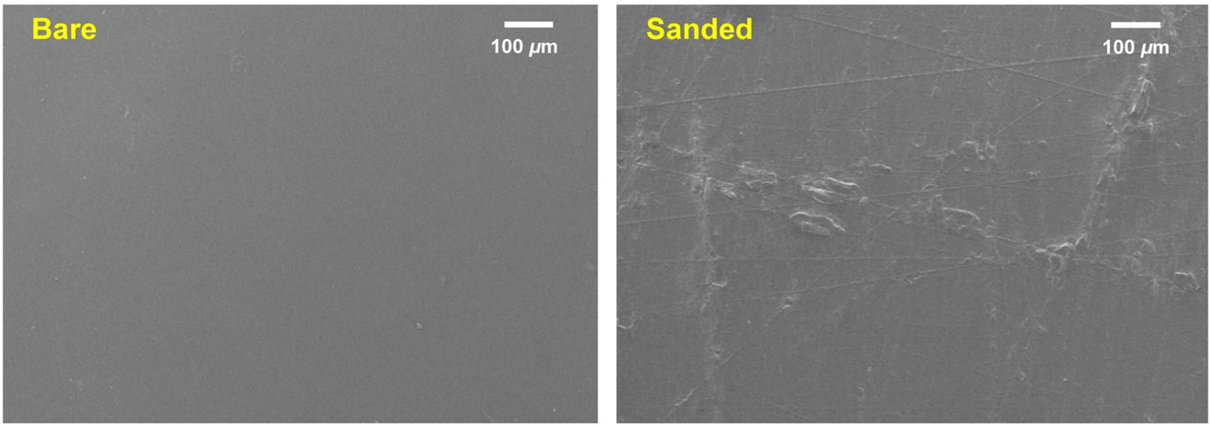


Fig. S1. SEM images of bare PVA surface (left) and sanded PVA surface (right).

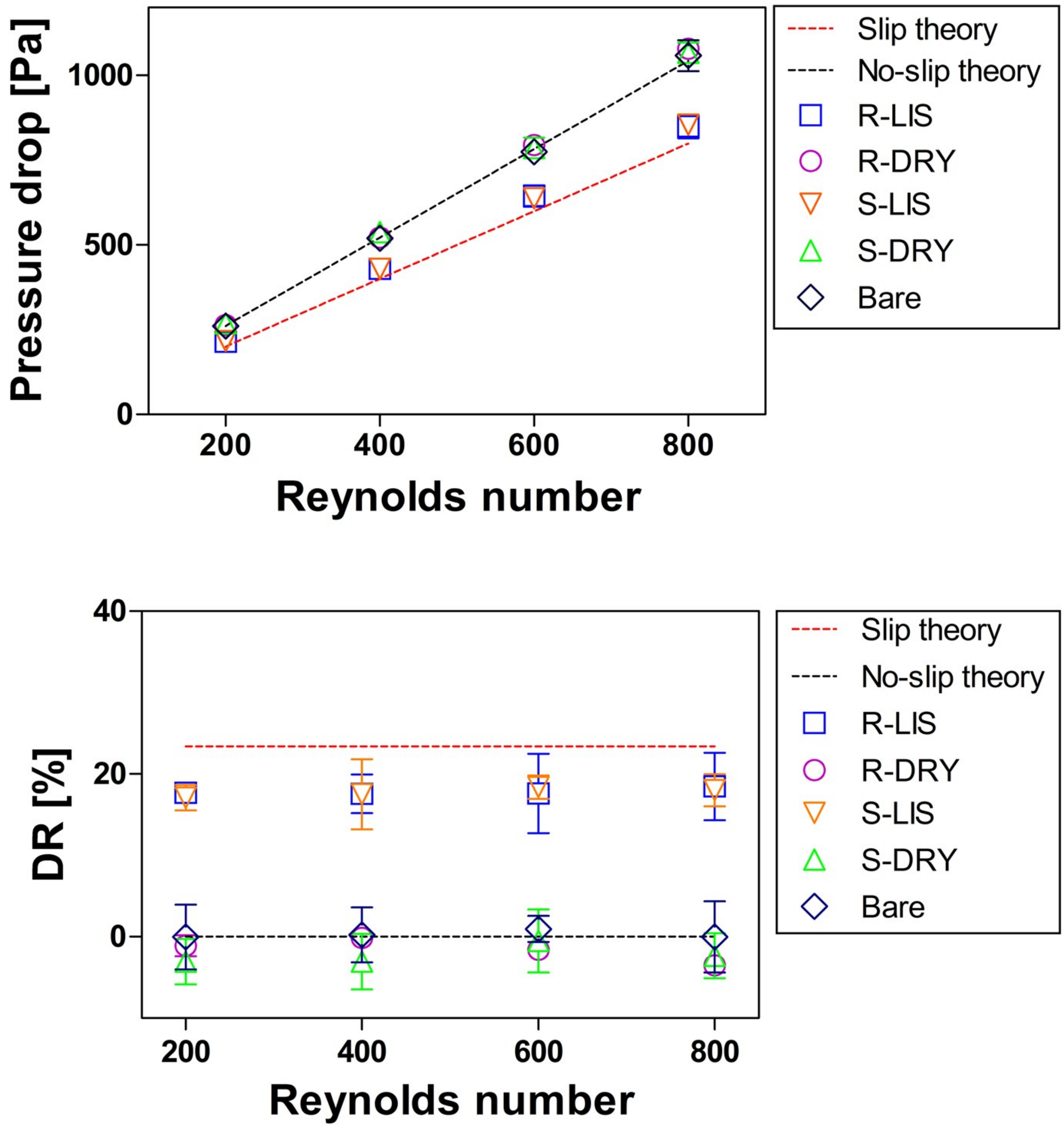


Fig. S2. Variations of measured pressure drop (top) and calculated drag reduction rate (bottom) for the dry biomimetic surface (R-DRY), biomimetic LIS (R-LIS), dry sanded surface (S-DRY), sanded LIS (S-LIS), and bare PVA surface (Bare) according to Reynolds number.

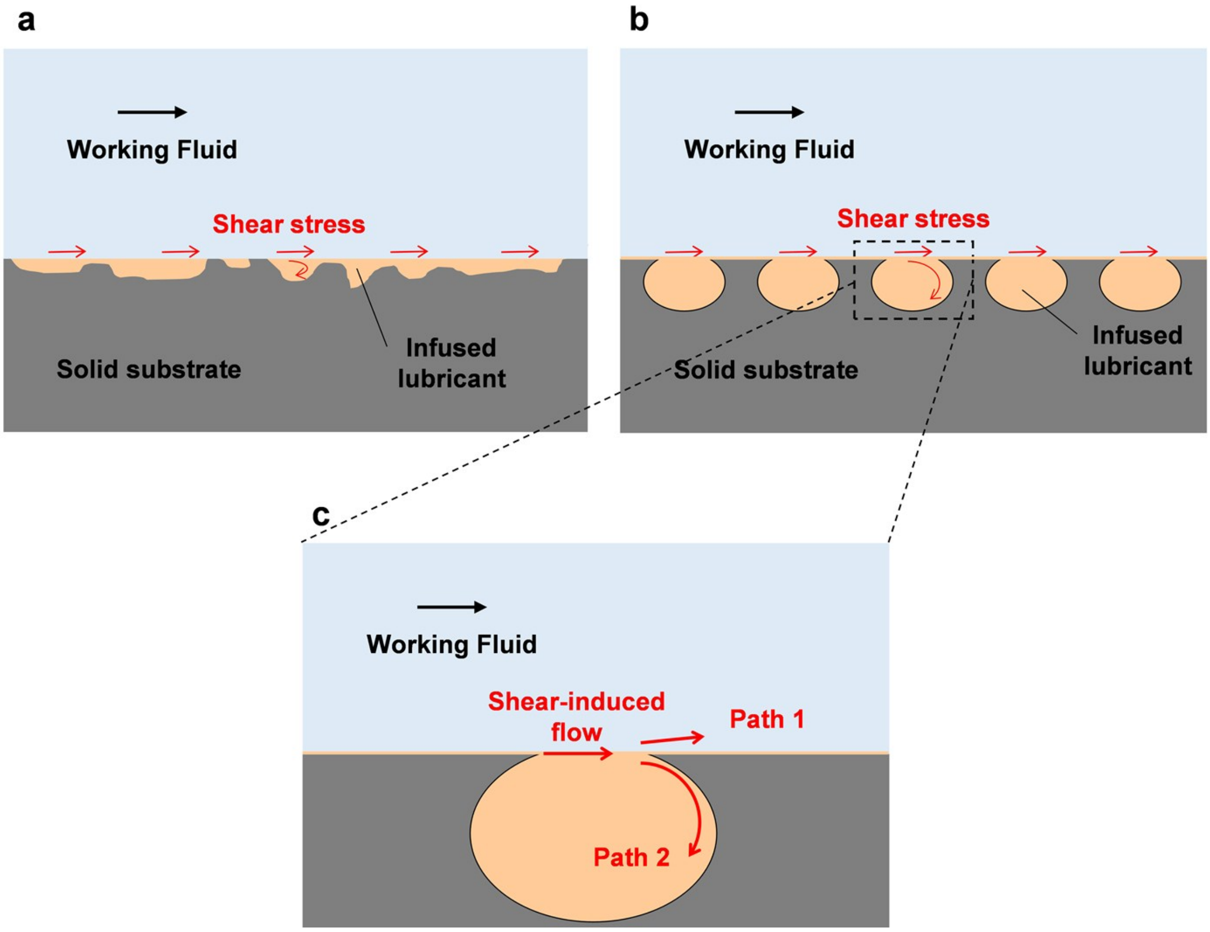


Fig. S3. Schematics of the physical mechanism of lubricant retention in the biomimetic LIS.

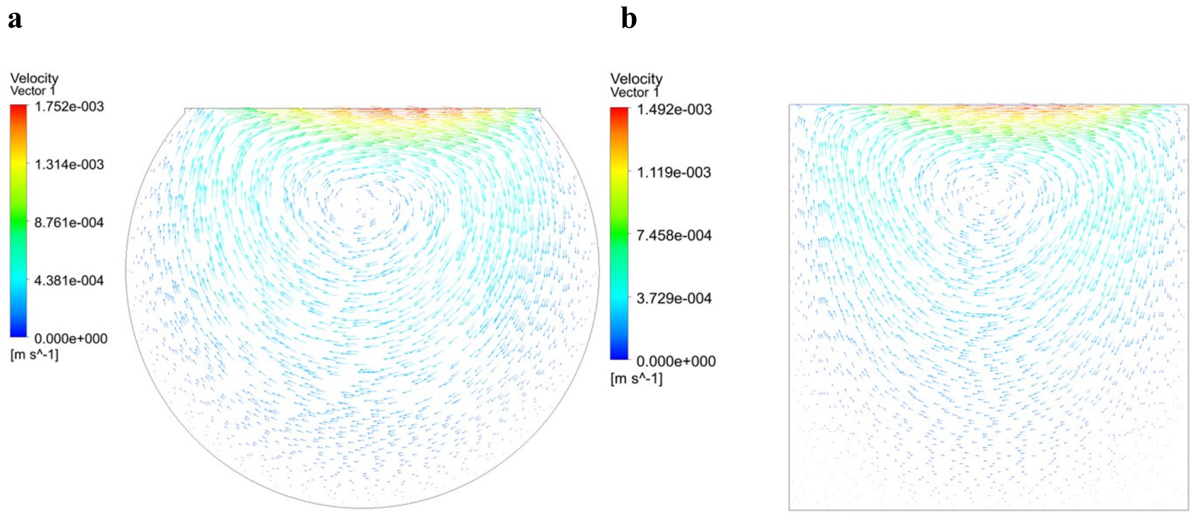


Fig. S4. Velocity fields of lubricant in the re-entrant cavity (a) and square cavity (b) with the same dimension (100 μm) of upper lid

Supplementary note

In order to fabricate a thermodynamically stable LIS, appropriate combinations of working fluid, lubricant, and solid substrate should be selected. That is, the working fluid and lubricant should be immiscible and the lubricant should not spread over and cloak the droplet of working fluid[1-2]. Otherwise, the cloaking problem can induce a severe loss of infused lubricant under external flow. The criterion for cloaking can be expressed with respect to spreading coefficient, $S_{lw(a)} = \Upsilon_{wa} - (\Upsilon_{la} + \Upsilon_{lw})$, where l, w, a and Υ denotes lubricant, working fluid, air and interfacial tension between the two phases, respectively. When $S_{lw(a)} > 0$, the lubricant spreads over the working fluid and cloaking problem occurs, while $S_{lw(a)} < 0$ implies the non-cloaking condition which is a desired configuration for stable LIS. Chemical affinity of the solid substrate is also an important factor. For a stable LIS, the solid substrate should be preferentially wetted by the infused lubricant rather than working fluid. This criterion is determined by the sign of spreading coefficient, $S_{ls(w)} = \Upsilon_{ws} - (\Upsilon_{ls} + \Upsilon_{lw})$, where s denotes solid substrate phase[1, 3]. $S_{ls(w)} < 0$ implies that the infused lubricant do not spread over the substrate when surrounded by working fluid, whereas $S_{ls(w)} > 0$ implies the opposite case. For negative spreading coefficient configuration, however, by adopting proper topography on the surface of solid substrate, stable lubricant layer formation is possible when $\theta_{ls(a)}$ & $\theta_{ls(w)} < \theta_{cr}$. Here $\theta_{ls(a)}$ and $\theta_{ls(w)}$ mean contact angle of the lubricant on the smooth substrate surface surrounded by air and working fluid, respectively. And θ_{cr} is a critical angle satisfying the equation:

$$\cos\theta_{cr} = \frac{1-\varphi}{r-\varphi} \tag{1}$$

where r stands for the ratio of total surface area to projected area of the substrate surface and φ stands for solid fraction of the projected area of substrate surface[1, 3].

References

1 J. D. Smith, R. Dhiman, S. Anand, E. Reza-Garduno, R. E. Cohen, G. H. McKinley and K. K. Varanasi, *Soft Matter*, 2013, **9**, 1772-1780.

2 S. Sett, X. Yan, G. Barac, L. W. Bolton, V. Milikovic, *ACS Appl. Mater. Interfaces*, 2017, **9**, 36400-36408.

3 L. Rapoport, B. R. Solomon and K. K. Varanasi, *ACS Appl. Mater. Interfaces*, 2019, **11**, 16123-16129.