Supporting Information

Mechanical Durability of Low Ice Adhesion

Polydimethylsiloxane Surfaces

Pablo F. Ibáñez-Ibáñez, Francisco Javier Montes Ruiz-Cabello, Miguel A. Cabrerizo-Vilchez,
Miguel A. Rodríguez-Valverde*

Laboratory of Surface and Interface Physics, Department of Applied Physics, University of
Granada, Avenida de Fuentenueva; ES-18071 Granada, Spain

*Corresponding author. E-mail address: marodri@ugr.es; Telephone: +34-958243229

1. Schematic diagrams of the tests

Figure S1. Ice detachment test. Tensile mode is reproduced when the applied force is
perpendicular to the surface. Shear mode is when the applied force is tangential to the surface.
2. Importance of axisymmetric droplets

It is widely accepted that to measure meaningful contact angles (on non-tilted substrates) from a single side view, sessile drops must be axisymmetric. This happens when the drops are larger than the scale of surface features, which should be randomly distributed \(^1\)–\(^4\). In the case of patterned surfaces, the drops might be non-axisymmetric. This is the case for the worn surfaces (see Figure S3). Surface presenting stripped patterns have different ACA, RCA and SA depending on the direction of measurement. This has been the basis of recent approaches to create surfaces with anisotropic wetting properties \(^5\)–\(^7\). On these patterned surfaces, we acquired the drop profiles on the direction perpendicular to the patten, which maximizes CAH, as mentioned in main text.

Figure S2. Left: Taber 5750 Linear Abraser, and abrasion test being performed on a PDMS sample. Right: erosion test being performed on a control sample.
Figure S3. Example of non-axisymmetric water drop placed on the surface PDMS 1:1 damaged with the Taber Linear Abraser for 4000 cycles (P320, 20.5 kPa). The camera was positioned on the right of the image, so the contact line moved perpendicular to the stripes, which are horizontal in this picture.

3. Linearity of weight loss with number of cycles

Thickness loss of the PDMS coatings scales linearly with the abrasion cycles (Figure S4). From the linear regression we may calculate the coating thickness loss each 1000 cycles. For the surface PDMS 1:10, the coating loss was $9.6 \pm 0.2 \, \mu m$ per 1000 cycles. For the surface 1:1 it was $16.0 \pm 0.6 \, \mu m$ per 1000 cycles. And for surface 1:2 50% it was $24 \pm 3 \, \mu m$ per 1000 cycles.

4. Abrasion of rigid coatings

For comparison, we evaluated the weight (thickness) loss under abrasion of hard (aluminum 6061) and ductile (paraffine wax) rigid materials. After 4000 cycles with P320 and 600 cycles with P60, the thickness of aluminum only lost about 30 and 12 $\mu m$, respectively. After the same abrasion, paraffine wax lost about 220 and 230 $\mu m$ respectively. We found, as expected, that aluminum is resistant while paraffin is weaker, even its material was clearly detached. The sandpaper used with the paraffin was replaced every 200 cycles because it was fully covered with paraffin after the abrasion. Indeed, more paraffin would be detached if the sandpaper were more frequently replaced. Unlike paraffin, the PDMS surfaces were long lasting. Moreover, the surface
PDMS 1:10 presented a durability similar to aluminum. This way, the elastic surfaces were unexpectedly resistant, due to precisely their adaptive deformability.

**Figure S4.** Thickness loss for the PDMS surfaces abraded with grit P320 in linear scale. Continuous lines represent the linear fits to the equation \( y = a + b \cdot x \). The value of R squared coefficient is greater than 0.99, except for the surface PDMS 1:2 50% \( (R^2 = 0.95) \).

**5. Particularities of the erosion test**

As mentioned in Section 3.3 (main text), the thickness loss for the erosion test did not scale linearly with the number of cycles (see Figure 8). Indeed, 50 cycles with the homemade setup were equivalent to 1.5 L of sand, while 2 cycles with the ASTM D968 were equivalent to 6 L of sand, but however, the 6 L of sand just slightly increased the weight loss. To understand why this happened, it is important to know how sand interacted with the surfaces. After a single sand erosion cycle, the surfaces are completely covered with sand (see Figure S5). This happened for the three types of surfaces, but the sand attachment was greater for the softer surfaces. The sand stuck to the surface might act as a protective layer against subsequent particle impacts. For that reason, we cleaned the surfaces with a brush between cycles. We noticed that when performing several cycles (cleaning with the brush between cycles, but without water), the sand did not stick more to the surfaces. This might be due to the dust accumulation, mitigating the surface-sand contact. The
sand stopped attaching relatively quickly for surface 1:10 and 1:1, but for surface 1:2 50% it took about 25 cycles. This revealed a higher interaction of sand with the surface PDMS 1:2 50%.

Figure S5. Top-view of a PDMS surface completely covered with sand after a falling-sand test.

The surface cleaning after an erosion cycle was a difficult task. Consequently, we hypothesize that the wear produced on the surfaces was partly originated by the cleaning process with the brush, rather than the own wear test. Thus, the impacting sand would only cause part of the damage. To elucidate whether this hypothesis is correct, we will focus on the roughness parameters presented in Figure S6. The surface PMDS 1:10 maintained its roughness parameters, within a narrow range, after the wear test, the surface PDMS 1:1 increased the roughness (Rₐ and Rₕ) up to 200-300 nm, and the roughness of the surface PDMS 1:2 50% increased up to about 2 µm. This increasing roughness is in good agreement with the calculated thickness loss. However, we also measured the surface roughness after the overall erosion although outside the sand impact zone. We found that the roughness also increased in this zone up to about 200 nm for the surface PDMS 1:1 and to about 1.2 µm for the surface PMDS 1:2 50%. However, this non-attacked zone should not have increased its roughness, because the particles impacting on that zone are bounced from the direct impact area, so they should produce a negligible damage. Our explanation for the apparent erosion in that zone is that it was produced by the later cleaning process, instead of the rebounded sand particles. Thus, we might consider the cleaning by using the brush as a part of the wear test. This would explain why there is a small weight loss for the two cycles (6 L of sand) performed with the
D968, since there was no wear produced by brush cleaning between cycles (the wear zone was dirty but free of sand particles after the first cycle).

Figure S6. Roughness parameters of the PDMS surfaces in terms of the number of erosion cycles produced with both, the homemade and ASTM D968 tests. The two cycles with the D968 setup were performed on the surface previously worn for 50 cycles. Label “out erosion” refers to roughness measured far from the direct impact zone.

As we hypothesized that a considerable part of the wear was done out of the nominal wear zone, we recalculated the thickness loss by using the total area of the samples instead of the wear area. These results are also show in Figure 8. With this estimation, the thickness loss for the surface 1:10 is negligible (-0.2 ± 0.5 µm), for surface 1:1 is lower than 5 µm (3.8 ± 0.5 µm), and lower than 30 µm (26.9 ± 0.6 µm) for surface 1:2 50%. To confirm the validity of these new values, we estimated the coating thickness (by using a confocal microscope) in the nominal wear zone and in the surface corners (areas far from the actual wear zone). The difference between corners and wear zone were 2.2 ± 2.1 µm for the surface PDMS 1:10, 5.9 ± 2.1 µm for surface PDMS 1:1, and 23.7 ± 2.1 µm for surface PDMS 1:2 50%. This difference between the central part (where sand felt) and the corners disagreed with the mean thickness loss, although the corners were the zones with the least damage. If wear occurs only on the impact zone, the thickness differences estimated with the microscope should be similar to the calculated ones. However, there is a better agreement if
we used the full surface area. This way, we can consider that the wear happened on the entire surface although it obviously was more severe on the sand impact zone, as confirmed by the roughness measurements.

6. **Dirt accumulation after erosion test**

   In addition to sand grains, some tiny particles accumulated on the PDMS surfaces after several cycles of sand erosion. This dirt accumulation is more noticeable on the surface PDMS 1:2 50% (Figure S7). After cleaning with water, scarce dirt remained on the surfaces.

![Figure S7. Top-view of the surface PDMS 1:2 50% after two cycles (6 L of sand) with the ASTM D968 protocol.](image)

7. **Abrasion under high pressure**

   The surfaces PDMS 1:10 and 1:1 supported 1000 cycles without significant damage (similar to damage produced with 20.5 kPa) even at 330 kPa. However, the surface PDMS 1:2 50% supported 100 cycles at 110.5 kPa without noticeable damage, but then a crack appeared, and the coating was destroyed after 120 cycles (see Figure S8). Under 330 kPa, the surface PDMS 1:2 50% was destroyed before 5 cycles.
Figure S8. The surface PDMS 1:2 50% abraded with 110.5 kPa. The abrader tip was Taber H-18 with 6.35 mm in diameter. The zone previously damaged at 20.5 kPa is also visible.

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