Supporting Information

A Simple and Precise Estimation of Water Sliding Angle by Monitoring Image Brightness: A Case Study of the Fluid Repellency of Commercial Face Masks

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1 Proposed method to estimate the sliding angle of a hydrophobic surface

The average pixel brightness calculated from the 8-bit grayscale of each pixel indicating a completely white image at 255 or a total black at 0 is shown in Figure S 1 at late time. While the sample stage was constantly rotating to the maximum of 90 degrees, the image brightness was linearly decreasing to about 179. The brightness remained steady after about 36 s, showing the camera recording after the complete stop of the rotation. This imaging extension was likely due to the waiting period of the camera to cover a delay of the rotor. The final time ($t_F$) is defined at the complete stop of the rotation at the maximum degree. The starting point of the plateau was guessing by using the functions smooth followed by islocalmax with an option of 'FlatSelection' at 'first'. The data was split at the guessed $t_F$ into two parts. The $t_F$ was finally calculated at the intersection of these two lines showing in red and green.
Figure S1 The final time \( t_F \) at the starting point of the flat image brightness \( B \), indicating the complete stop of the rotation.

2. Sliding angle measurements of a superhydrophobic surface, an effect of water drop volume, and an angular speed optimization

The resulting sliding angles measured by using the proposed method in this work were compared with those measured by using a 16-inch T-bevel (Etoopoo, China) with the precision of ±0.5 degree and angle range of 0 – 225 degrees. The coated glass slide with a water drop was placed on the T-bevel and was manually lifted until the drop rolling off the surface. The resulting sliding angles measured by the T-bevel shown that this method could provide an initial guess of the water repellency with a precision range of about ±5 degrees due to the manual handling. The results could be corrected by using the proposed method with the optimized angular speed of 0.1 degrees per second.

Table S1 Sliding angle measured by using the drop shape image analysis monitoring the image brightness with an angular speed of 0.1 and 0.5 °/s. The result was compared to those measured by using a T-bevel.

| Coating material | Water drop volume (µL) | \( \phi = 0.1 \) °/s | \( \phi = 0.5 \) °/s | T-bevel |
|------------------|------------------------|---------------------|---------------------|---------|
| DDS-SiO₂         | 10                     | 6.2 ±0.9            | 6.3 ±1.0            | 9.1 ±0.7|
|                  | 15                     | 5.9 ±0.9            | 6.5 ±0.7            | 7.2 ±0.3|
|                  | 20                     | 4.4 ±0.6            | 4.6 ±0.4            | 6.2 ±0.4|
|                  | 25                     | 4.3 ±0.5            | 6.1 ±1.0            | 6.7 ±0.4|
|                  | 30                     | 3.7 ±0.5            | 5.4 ±1.7            | 5.8 ±1.0|
| PTFE             | 10                     | 23.0 ±1.9           | 24.2 ±2.4           | 24.6 ±0.9|
|                  | 15                     | 17.3 ±0.9           | 18.9 ±1.0           | 15.9 ±1.4|
|                  | 20                     | 12.1 ±1.5           | 13.2 ±1.3           | 10.5 ±1.2|
|                  | 25                     | 9.1 ±0.7            | 11.2 ±0.4           | 8.1 ±0.3|
|                  | 30                     | 9.0 ±0.4            | 11.0 ±0.4           | 8.9 ±0.8|
The FTIR spectra of the pristine SiO$_2$ nanoparticles and their silanization forms are shown in Figure S 2. The silanization of the SiO$_2$ nanoparticles by DDS shown C-H functional groups from -CH$_3$ in DDS. These groups increased the hydrophobicity of the particles.

![Figure S 2 FTIR spectra of SiO$_2$ nanoparticles, hydrophobic silanized SiO$_2$ nanoparticles (DDS-SiO$_2$), and the adhesive.](image)

3. Determination of fluid repellency of commercial face masks

The selected frames of a video image of SM5 are shown in Figure S 3. The consecutive images of frames number 181-182, 294-295, and 339-340 shown a slight shaking or a slide-and-stop movement of the water drop, which remained on the surface. These movements can be detected at the waveform-like peaks in the $B'$ plot. On the contrary, the proceeding from frames number 439-440 indicated the roll-off frame of the drop, which is shown in the one-sided positive peak in the $B'$ plot.

The straight rotated baseline is shown in black color on the left and the top of the image as shown in Figure S 3 (b). The boundary was extracted between the black flat glass slide placed on the left and the white background. This additional setup could improve the accuracy of the sliding angle measurement.
Figure S 3 (a, c-j) Selected frames of a video image of a water drop on a surgical mask sample (SM5). (b) The boundary line between white and black area of each video images.

The size of the cellulose fibers and the thread was determined by measuring at different locations of each samples shown in the SEM images. The fiber of the RF3 seemed flat with a larger fiber size compared to the others. However, it was knit and densely woven to a thick fabric with no visible cavity. Thus, the coating material on the RF3 surface could be easily washed out. In contrast to the RF3, the RF2 was lighter and more breathable with the thickness of 0.14 mm and the thread density of 89.1%. This made the RF2 popular among users and it could be coated to the inner material through the cavity.

Table S 2 Thread size and thread density of the raw fabric samples (RF1-RF3) analyzed from the SEM images. The fabric thickness was measured by a micrometer.

| Sample | Fabric type | Fiber size (µm) | Thread size (µm) | Thread density (%) | Fabric thickness (mm) |
|--------|-------------|----------------|------------------|--------------------|----------------------|
| RF1    | Salu        | 10.3           | 194.3            | 67.2               | 0.13                 |
| RF2    | Muslin      | 12.6           | 218.6            | 89.1               | 0.14                 |
| RF3    | Cotton      | 16.9           | 187.1            | 100.0              | 0.18                 |

The contact angle of the samples is shown in Figure S 4, which is corresponding to the sliding angle as shown in Figure 5. While the sliding angle shown a significantly different water repellency of the masks, the hydrophobicity indicated by the contact angle was indistinguishable in the range of 120 to 130 degrees for most of the samples. However, fabric masks and non-coated raw fabrics made of salu and muslin, FM1-FM2 and RF1-RF2, rapidly adsorbed a water drop with a contact angle of zero degrees, indicating a hydrophilic porous surface. In addition, the RF3 was slightly hydrophobic with a contact angle of 99 degrees, but a water drop did not roll off the surface due to the strong adhesion, indicating no water repellency. Thus, to better understand the efficiency of the face mask, the measurement of the sliding angle could provide such precise and comparable indicators to the research discussion.
**Figure S 4** Contact angle of the mask and fabric samples corresponding to the sliding angle plotted above.