Supporting Information for

Visualizing and Quantifying Nanoscale Hydrophobicity and Chemical Distribution of Modified Polyethersulfone (PES) Membranes

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S1. Photos of polymer membranes

Figure S1. Polymer samples provided by Pall Corporation: (a) PES membrane, (b) PES membrane blended with 10% PVP, (c) PES membrane cross-linked with 8% PEG; and membrane samples provided by EMD Millipore Corporation: (d) Pristine PES membrane and PES membranes dip-coated in 2%, 3% and 4% PVP solutions; (e) Pristine PES membrane and PES membranes dip-coated in 2%, 3% and 4% PEG solutions.
S2. Adhesion force measurement with AFM

The adhesion force was obtained by recording the AFM cantilever deflection caused by the vertical movement of the AFM tip through the following three processes: firstly, the tip approaches the sample surface (noncontact region). Secondly, the tip makes contact with the surface, and is pushed against the surface (contact region). Thirdly, the cantilever deflects until a preset cantilever deflection setpoint (0.8 V) is reached. Then, the cantilever is retracted and leaves the sample at some point, resulting in the adhesion dip (retract trace). A force-distance curve is obtained from the curve of deflection (V) versus piezo position (nm). From the retrace curves the peak value of the adhesion dip was converted to the deflection of the cantilever in nanometers and the force applied to the cantilever was calculated in nanonewtons using Hook’s law: $F = K_{sp}d$, where $d$ is the cantilever deflection displacement (nm) and $K_{sp}$ is the cantilever spring constant (54.84 ± 0.02 pN/nm). The adhesion force was plotted with the water contact angles to establish a linear correlation or the standard calibration curve of adhesion force over different hydrophobicity. This calibration curve will be used to quantify the sample surface hydrophobicity at nanoscale. The adhesion force curves were collected on different locations of the PES/PVP membrane surfaces using CH$_3$-coated gold tips as illustrated in Figure S2, with the adhesion force distribution shown as the histograms on the right side. Figure S3 shows the result for PES/PEG membranes.
Figure S2. Adhesion force curve collection positions on the AFM height image (500 nm × 500 nm) (left column) and histogram (n = 210) of adhesion forces (right column) recorded on the membrane surface using AFM with a hydrophobic CH$_3$ tip. The samples are PES membranes with 0% PVP (a), 2% PVP (b), 3% PVP (c) and 4% PVP (d).
Figure S3. Adhesion force curve collection positions on the AFM height image (500 nm × 500 nm) (left column) and histogram (n = 210) of adhesion forces (right column) recorded on the membrane surface using AFM with a hydrophobic CH₃ tip. The samples are PES membranes with 0% PEG (a), 2% PEG (b), 3% PEG (c) and 4% PEG (d).
S3. Morphology of membrane surfaces by SEM and AFM

Morphology images of membrane surfaces were obtained by SEM and AFM.

Figure S4. AFM (left column) and SEM (right column) topographical images of (a-b) PES membrane; (c-d) PES/10%PVP membranes; (e-f) PES/8%PEG membranes, provided by Pall Corporation.
Figure S5. AFM topographical images and roughness values of (a) pristine PES membrane; (b) PES/2\%PVP membranes; (c) PES/3\%PVP membranes; and (d) PES/4\%PVP membranes, provided by EMD Millipore Corporation.
S4. Water contact angles of SAM surfaces and Adhesion force measurement between CH$_3$-coated gold tip and SAMs

The surface hydrophobicity is shifting from highly hydrophilic to hydrophobic when increasing the fraction of CH$_3$ groups. These contact angles measurements will be used to compare with and validate the model calculation of nanoscale “contact angles” converted from the adhesion force measurement in the following sections.

**Figure S6.** (a) Water contact angles values measured for SAMs as a function of the molar fraction of CH$_3$; (b) Histograms of adhesion forces between probes and different SAM surfaces; (c) Adhesion forces measured for SAMs as a function of the molar fraction of CH$_3$; (d) Adhesion forces versus the value of -cosθ for different SAM surfaces.
S5. AFM-IR measurement on PES/10%PVP membrane

Figure S7. FTIR (a) and AFM-IR (b) spectra range for PES membrane and PES/10%PVP membrane. (sample thickness was ca. 140 μm).

Figure S8. AFM image and AFM-IR spectrum for microtomed PES/10%PVP membranes (sample thickness was 200-500 nm).

References