

Supporting Information

A Polydimethylsiloxane (PDMS) Sponge for the Selective Absorption of Oil from Water

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General information

Fabrication of the PDMS sponge

Different sizes of sugar particles (i.e., granulated, sanding, and black sugar particles) were prepared to develop various kinds of sugar templates. The powdered sugar particles were kneaded by adding water and then cast onto various molds to shape the sugar template for the PDMS sponges. Thereafter, the molds were carefully peeled away (see Supporting Information, Figure S1). The final sugar templates taken from the mold were placed into a Petri dish in which a mixture of PDMS prepolymer (Sylgard 184, Dow Corning) and a thermal curing agent was poured in a ratio of 10:1 by weight. While the Petri dish was degassed in a vacuum chamber for 4 hours, the mixture infiltrated into the sugar templates due to capillary forces. The sugar templates with the absorbed mixture were then cured at 120 °C for 12 minutes. After the curing process, the sugar templates were dissolved and washed away by soaking them in an ultrasonic cleaner at 40 °C before air drying. Finally, after the removal of the sugar templates, three-dimensional eco-friendly interconnected microporous PDMS sponges were formed.

Characterization of the PDMS sponge properties

The morphology and structure of the PDMS sponge were characterized using field-emission scanning electron microscopy (FETI, Sirion) and an optical microscope (Eclipse L200). The elastic modulus was measured with an Instron 4206 instrument. A commercially available dye (Oil red O, Aldrich) was used to better discern the oil in the water.

We measured the absorption capacity of the PDMS sponges for various organic solvents and oils with different densities, including N,N-dimethylmethane ($0.944 \text{ g}\cdot\text{cm}^{-3}$), dichloromethane ($1.33 \text{ g}\cdot\text{cm}^{-3}$), acetone ($0.78 \text{ g}\cdot\text{cm}^{-3}$), toluene ($0.87 \text{ g}\cdot\text{cm}^{-3}$), 1,2-dichlorobenzene ($1.3 \text{ g}\cdot\text{cm}^{-3}$), chloroform ($1.48 \text{ g}\cdot\text{cm}^{-3}$), methanol ($0.79 \text{ g}\cdot\text{cm}^{-3}$), ethanol ($0.79 \text{ g}\cdot\text{cm}^{-3}$), silicone oil ($0.76 \text{ g}\cdot\text{cm}^{-3}$), motor oil ($0.88 \text{ g}\cdot\text{cm}^{-3}$), and transformer oil ($0.89 \text{ g}\cdot\text{cm}^{-3}$). For these measurements, pristine PDMS sponges were cut into cubic shapes and placed inside the solvents and oils for 10 seconds. Absorption occurred within a relatively short amount of time and typically reached the saturation point within a few seconds after the immersion of the PDMS sponge into the liquids. The weight of the PDMS sponges before and after the absorption was recorded to calculate the absorption capacity. The weight measurements were performed quickly to avoid the evaporation of the absorbed solvents and oils.

Fabrication of the PDMS sponge by hand-made sugar templates

The powdered sugar particles were kneaded by adding water and then cast onto various molds to shape the template for the PDMS sponge. Thereafter, the molds were carefully peeled away (Figure S1). Then, we replicated the PDMS sponge from the sugar template by the lock-and-key casting method.

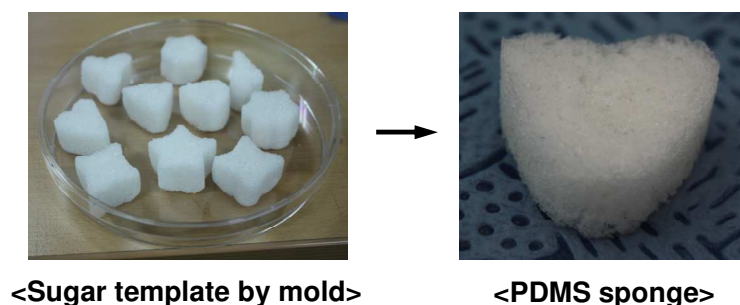


Figure S1. Replication of the PDMS sponge from the hand-made sugar template.

Measurement of elastic modulus in the PDMS sponge

The elastic modulus of the PDMS sponge was measured with an Instron 4206. The measured data are shown in Figure S2. In this measurement, we used a PDMS sponge measuring 1 cm × 1 cm × 1 cm. Based on the slope of the load versus the displacement, we calculated the elastic modulus of the PDMS sponge at 0.00002 GPa. For comparison, the elastic moduli of other materials are summarized below.

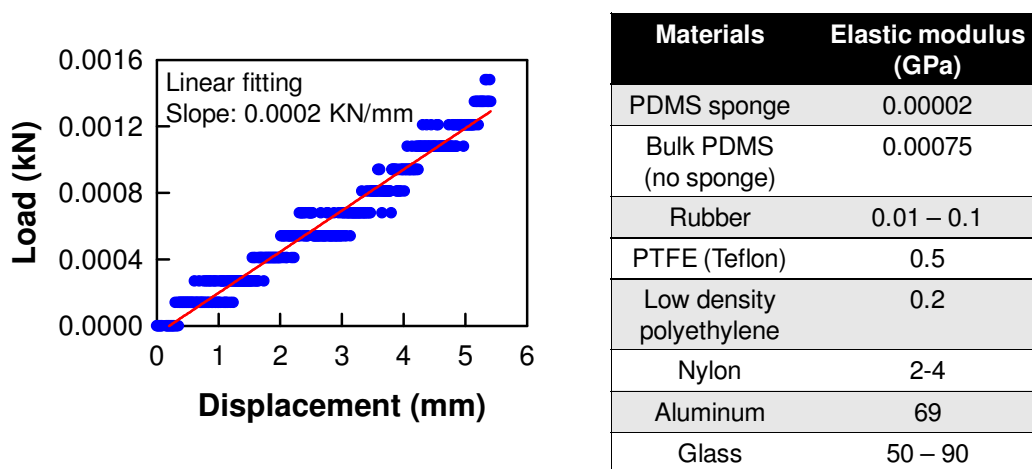


Figure S2. Measurement of elastic modulus of the PDMS sponge and comparison of elastic moduli of other materials.

Floating and cleaning capability of the PDMS sponge

Transformer oil with an area of approximate 51 cm² was spread on water, and the PDMS sponge was placed in the center of the pool. The white-colored region along the path of the drifting PDMS sponge indicated the removed area of oil film and the filtered zone of fresh water.

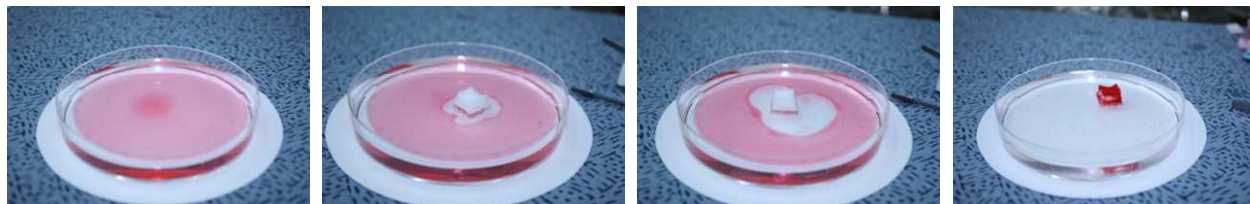


Figure S3. Snapshots of the PDMS sponge floating on a mixture of water and oil, which demonstrates the sponge’s “floating-and-cleaning” capability.