How Contact Angle Measurements Can Help to Lower the Adverse Effects of an Oil Spill

Separation of oil/water mixtures is an important procedure in wastewater treatment or when dealing with oil spills to lower the impact on environment. Many cases have shown that oil-leakages/spillages during marine transportation or oil production can lead to environmental catastrophes severely damaging marine ecosystems. A typical mining operation produces 140 000 L of oil-contaminated water per day which also needs to be cleaned before passing it back to the operation cycle. For these cases, efficient ways to separate oil/water mixtures are dearly needed and novel materials might lead to new innovative procedures.

Currently several types of mechanical devices, including oil skimmers or booms, are being used to separate oil/water mixture in industry. However, these devices need an input of energy and high pressure to operate. In addition, some porous materials are applied to absorb oil from water. Unfortunately, these materials often absorb both water and oil as a mixture making it difficult and time-consuming to recycle them leading to a low overall efficiency. To overcome these issues, Liping and his team have recently developed a new kind of modified sponge as a selective oil absorber material, which is recyclable, facile and highly effective in the oil/water separation processes.

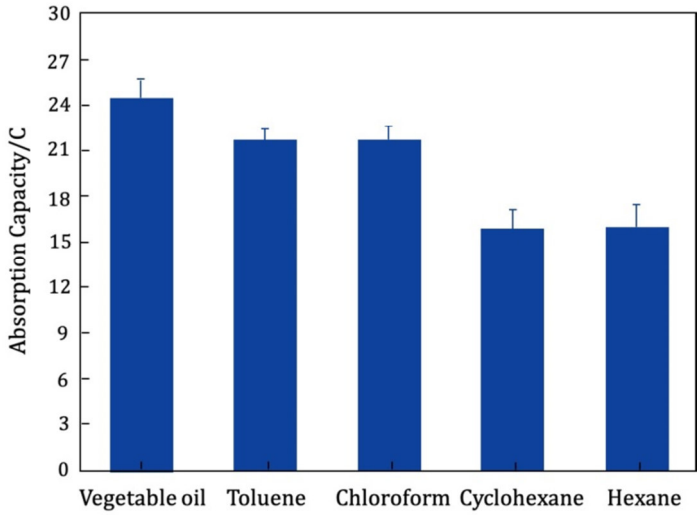
The new sponge material can be furnished from a commercially available polyurethane sponge which was modified by a one-step thiol-ene click reaction giving it

superhydrophobic/superoleophilic properties. The surface wettability of the original and modified sponges was evaluated by contact angle measurements. As summarized in **Table 1**, the water and oil contact angles of the original sponge were both 0° indicating a high wettability for both polar and unpolar liquids (superhydrophilic and superoleophilic). For the modified sponge the water contact angle increased to 159° while the oil contact angle was still 0° (superhydrophobic and superoleophilic). The water droplet could maintain a stable sphere on the modified surface, while the oil droplet spread and permeated into the modified sponge. SEM pictures show that not only the surface chemistry was modified but also the surface of the modified sponge was much rougher compared to the original sponge.

Table 1: *The water contact angle (WCA) and oil contact angle (OCA) of the PU sponge before and after modification*

	Water contact angle	Oil contact angle
Before modification	0°	0°
After modification	159°	0°

To underline a broader applicability, different oils and organic solvents, such as vegetable oil, toluene, chloroform, cyclohexane, and hexane were investigated and the respective absorption capacities were calculated for each liquid. **Scheme 1** illustrates that the absorption capacities of various organic liquids were all quite good (> 15).



Scheme 1: *Absorption capacities C of the modified sponge for various types of oils ($C = ((n - n_0)/n_0)$ with n_0 and n being the weight of the modified sponge before and after absorption of oil)*

In order to study the selective adsorption for the oil/water mixtures, the modified sponge was put into a toluene/water mixture. This test resulted in a quick absorption of toluene and a separation from the water phase by removing the sponge. The modified sponge could easily be recycled by mechanical squeezing.

In summary, a modified sponge material was developed that shows a high selectivity, efficiency and recyclability for oil/water separation. The modified sponge could be synthesized from a commercial PU sponge with standard chemical modifications leading to the required superhydrophobic and superoleophilic properties. This work gives a deeper understanding for the underlying principles of materials for oil/water separation and generates a good platform for developing new functional materials that might be useful in wastewater treatment or the cleanup after oil spills.

An OCA 50 optical contact angle measurement device (DataPhysics Instruments GmbH, Germany) was used in this research.

For more information, please refer to the following article:

Modification of Polyurethane Sponge Based on the Thiol–Ene Click Reaction and Its Application for Oil/Water Separation; Liping Liang, Yanyan Dong, Yuqing Liu and Xu Meng; *Polymers* **2019**, 11, 2072; DOI: 10.3390/polym11122072