IIT Guwahati uses superhydrophobic cotton to remove oil-spill

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Removing up to 95% of oil-spill of different densities — light and heavy oils — repetitively at least 100 times using superhydrophobic (extremely water repelling) medical cotton has been demonstrated by a team of researchers led by Dr. Uttam Manna from the Department of Chemistry at the Indian Institute of Technology (IIT) Guwahati.

The researchers turned the medical cotton, which is extremely water absorbing, into a superhydrophobic (water contact angle of 157 degrees) material and used it for absorbing oil both in air and under water. The efficiency of absorption is very high — above 2,000 weight percentage for both heavy and light oils. This translates to one gram of the superhydrophobic cotton absorbing 20 grams of either heavy or light oils. The results were published in the *Journal of Materials Chemistry A.*

The absorbed oil can be recovered through physical compression. The superhydrophobicity remained intact even when the cotton was manually compressed up to 1,000 times and subjected to other physical manipulations.

“The other important characteristic is its ability to absorb oil from three complex phases — light oil that floats in the air–water interface, sediment oil that settles at the bottom as it is heavy, and from water-in-oil emulsion,” says Dr. Manna. The superhydrophobic property was intact even when exposed to UV light for ten days, the material was able to absorb oil from river and sea water, and extremely acidic (pH 1) and alkaline (pH 12) water.

Treating emulsions

While the cotton is able to efficiently absorb oil from water-in-oil emulsion, it is inherently incapable of removing oil from oil-in-water emulsion. In the case of water-in-oil emulsion, very little of water is present in oil and so it is easy to remove all the oil leaving the water behind. But in the case of oil-in-water emulsion there is very little of oil present. “Since there is more water present, the superhydrophobic material does not come in contact with oil and so will be unable to remove oil efficiently from oil-in-water emulsion,” clarifies Adil Majeed Rather from the Department of Chemistry at IIT Guwahati and the first author of the paper.

Filtering oil

The researchers were able to achieve selective filtration of oil under water against gravity in the case of heavy oil that has settled at the bottom. To do this, the researchers plugged one end of a tube with the superhydrophobic cotton and dipped the tube so it comes in contact with the oil.

“Once in contact with the sediment oil, the cotton absorbs the oil and due to hydraulic pressure the oil gets removed from the cotton and accumulates inside the tube,” says Dr. Manna. “So there is no need to apply pressure to collect the sediment oil from cotton.”

In the case of gravity-driven filtration, heavy oil mixed with water is poured into a funnel, the tip of which is closed with the superhydrophobic cotton. The heavy oil settles to the bottom and comes in contact with the cotton which filters it leaving the water in the funnel. “This method can be used in industry to remove the oil component from water before letting out the waste water,” says Rather.

Cotton processing

The hydroxyl group seen in cotton is first modified with branched poly(ethylenimine (BPEI) to make it functionalised with amine group. A nanocomplex is prepared separately by mixing BPEI with dipentaerythritol pentaacrylate (5Acl) and added to the functionalised cotton. The nanocomplex provides essential topography and makes the cotton chemically reactive, thus making it possible to further optimise the appropriate chemistry of the material. The nanocomplex reacts with amine-based small molecules of choice to make the cotton hydrophobic to varying degrees.

“We can tune the hydrophobicity — from hydrophilic to superhydrophobic — by using different amine-containing small molecules,” Dr. Manna says. “It is a green synthesis without the use of any catalyst or hazardous material. The process of making superhydrophobic cotton is a simple three-step process and scalable.”

Life is not always a serious affair, there is lightness, humour and nonsense, too, which we enjoy

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