Nanofur for cleaning up accidental oil spills in water

Accidental oil spills such as those following oil disasters, on the ground at petrol stations or in car washing facilities need to be cleaned up as quickly as possible. However, conventional cleanup methods either cause secondary pollution or are not very effective. Researchers from the KIT in Karlsruhe have now developed an environmentally friendly process that can eliminate oil spills effectively. Nanofur is a material that imitates the fine hairs of aquatic ferns and is capable of absorbing large amounts of oil within a relatively short time.

The risk of environmental pollution with crude or mineral oil is high, especially in oceans, lakes and rivers that not only run the risk of oil spillage due to damaged pipelines, oil tanker disasters or accidents on oil extraction rigs, but are also exposed to contamination from the land. Although methods for cleaning up oil exist, they all have more or less specific drawbacks: the combustion of oil or the use of chemicals is far from environmentally friendly; natural materials such as sawdust or plant fibres are not effective enough as they absorb large amounts of water along with the oil.

Nanofur absorbs oil quickly and effectively

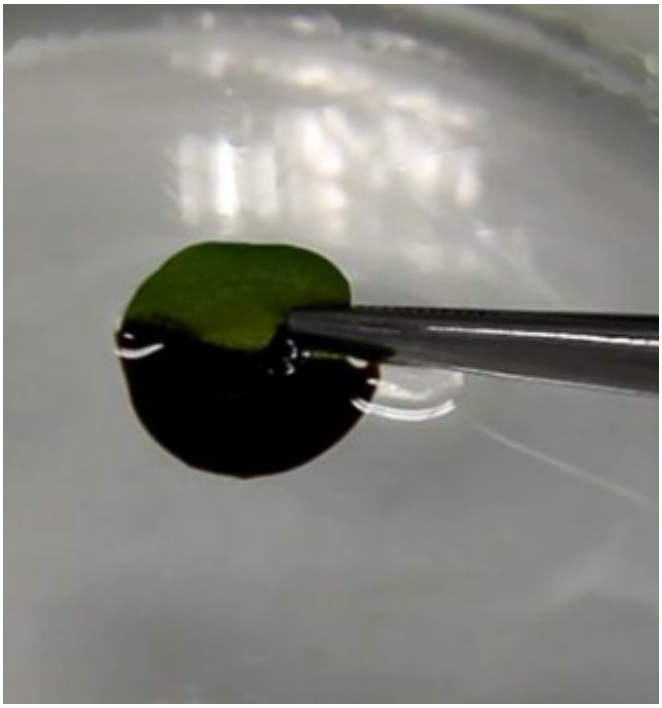
Photo showing Hölscher's team of researchers © KIT

Dr. Hendrik Hölscher from the Institute of Microstructure Technology (IMT) at the Karlsruhe Institute of Technology (KIT) and his team of researchers have been working for quite some

time on ways of removing oil contaminations sustainably and effectively. The IMT is specifically focused on identifying and analysing nano- and microstructured natural surfaces and using them as models for producing polymeric materials for application in technical areas. "In our search for solutions for effective oil spillage cleanups and other applications, we are looking at nature to find interesting structures that might be suitable for different purposes. Such structures include the surface of lotus flowers that are self-cleaning and the adhesive structures on gecko feet that can basically stick to any surface. Quite a few natural surfaces are covered with hair-like structures," says Hölscher.

Based on this knowledge, the KIT researchers went on to develop a hair-like polymeric material, which they called Nanofur. Nanofur is made of polycarbonates, but can also be produced from almost any other polymer. Hölscher comments, "Nanofur consists of small, fine hairs, and we discovered that they are very well suited for separating oil and water. The Nanofur surface is extremely hydrophobic – like lotus leaves – as well as oleophilic because the large number of hairs greatly enlarge the surface. The material is therefore able to absorb oil quickly and easily." The special characteristics of Nanofur gave the scientists the idea to use it as an oil absorber. Hölscher also pointed out that the material is easy to collect once it has absorbed the oil.

Aquatic fern as a model



Aquatic Salvinia fern species have fine hairs on the leaf surface, and are therefore superhydrophobic and superoleophilic. © C. Zeiger / KIT

In order to further improve the environmentally friendly oil absorber, Hölscher and his team were looking for natural surfaces that achieved the same effect. They came across aquatic ferns of the genus Salvinia, native to South America, but now also endemic in parts of Europe. Salvinia propagates so quickly that it has already become a weed in some places. The aquatic ferns have trichomes on the leaf surface, tiny hair-like mini-offshoots between 0.3 and 2.5 millimetres long. The ferns use the trichomes to absorb large amounts of oil in a very short

time. “The plants usually use the trichomes to keep their surface clean rather than to absorb oil,” said Hölscher. “But we discovered that the ferns absorb at least as much oil as our artificial structures. As a matter of fact, Salvinia leaves reach their maximum absorption after 30 seconds.”

In theory, it would be possible to clean polluted water with Salvinia ferns. They are virtually cost-free. However, only the leaves absorb oil, so they would have to be plucked off the stalks. “This could be done mechanically,” says Hölscher. “The use of aquatic fern as an oil absorber is quite conceivable. However, for the time being, the plant is only being used as a model for the further optimisation of Nanofur.”

Eggbeater-shaped trichomes are best

The KIT researchers compared the oil absorption capacity of four different species of Salvinia and identified four different trichome types. Interestingly, the trichome shape of Salvinia molesta, which looks like a small eggbeater, is particularly effective when it comes to absorbing oil. “Unfortunately, this shape is difficult to reproduce,” says Hölscher. “But we've discovered that rather than copying the shape exactly, we only need to use a few specific parameters, i.e. the length of the trichomes and the distance between them. The trichomes are normally between 100 and 200 micrometres apart.”

Eggbeater-shaped, wax-coated hairs make the leaves of Salvinia ferns very hydrophobic. However, these types of hairs are difficult to reproduce artificially. © W. Barthlott / Nees Institute

“In general, producing Nanofur is surprisingly easy,” said Hölscher. All that is required is a steel plate that is roughened by sandblasting, strongly heated, pressed into a suitable polymer and immediately pulled apart again. This leads to the formation of thin hairs. “The structures look like the cheese threads you get when you eat a pizza,” says Hölscher, describing the process. “Getting the temperature right is key. We are currently working on finding materials suitable for producing hairs of different length and spacing.” The researchers hope at some stage to be able to produce the superhydrophobic material using a rolling process. The resulting films can

then be crushed and transferred into a mesh bag that can be collected after use.

Nanofur can also keep petrol stations clean

Nanofur can also be used for completely different applications: for example, it can be used to create an air layer underwater, thus reducing friction in this area. "This has the potential to be used for developing microfluidic chips in the field of medical technology," says Hölscher. "Another vision is to coat boats. This would generate enormous energy savings; the quantity of diesel used by ships could be reduced by up to ten percent. "This is a very attractive field of research and several research groups are already working on turning this into reality." In addition to broadening the application range of Nanofur, the researchers from Karlsruhe are currently working on upscaling the process for industrial application. "We are unable to do this on our own," Hölscher says. "We need to produce very large areas, which is very costly. And we also need customers of course." It will therefore be some time before the environmentally friendly oil absorber is placed on the market.

In the meantime – and until suitable cooperation partners are found – the KIT researchers have plans to establish a small start-up company for marketing small quantities of Nanofur. "We would like to develop membranes that can absorb small amounts of contaminated liquids in petrol stations or car washing facilities. "Establishing a company and starting off with small quantities of Nanofur would help us enter the market and find out whether Nanofur is attractive or not."

Article

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Dr. Petra Neis-Beeckmann

Further information

PD Dr. Hendrik Hoelscher
Karlsruhe Institute of Technology (KIT)
Institute of Microstructure Technology (IMT)
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Phone: +49 (0)721 608-22779
E-mail: hendrik.hoelscher(at)kit.edu

- Institute of Microstructure Technology

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