Think bigger

With the publication of a method for fast oil spill clean-up we reflect on the importance of addressing scalability from an early stage when reporting techniques aimed at improving the environment.

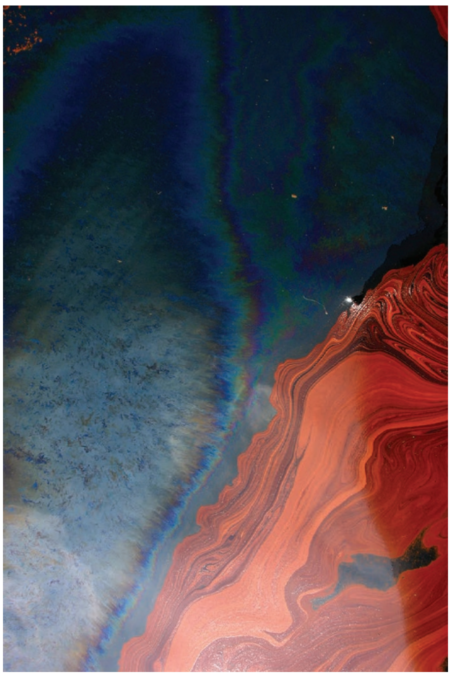
On 20 April 2010 an explosion at the Deepwater Horizon rig in the Gulf of Mexico started what would result in one of the worst oil spills in history. After massive operations to contain the spill, the leaking well was declared closed five months later. More than 500 tonnes of crude oil had been released into the ocean, covering an area of 175 km^2. Oil spills associated with major disasters are the ones that tend to be covered in the news. The coverage tends to be limited to a few months, but the damages to the ecosystem of the marine environment and of coastal areas, and eventually also to the socio-economic activities in those areas, such as the fishing industry, can last for several years. Furthermore, oil pollution is not just due to accidents like that of the Deepwater Horizon rig and can occur in many other ways, including constant and difficult to control leaks from drills, wells, tankers and storage units.

If the world's energy economy moves towards the replacement of fossil fuels with clean and renewable sources in order to decrease CO_2 emissions, the problems related to oil spill pollution will be solved as a by-product. Realistically this is unlikely to happen, if at all, for at least several decades. Thus, looking for efficient ways to clean up oil spills remains essential.

Can nanotechnology be the solution to a problem like oil spill pollution? The fairest answer to this question is that, like in all cases of environmental and societal challenges, nanotechnology in itself will not solve the problem, but could play a role, potentially an important one. There are a number of approaches aimed at using nanotechnology to develop techniques to separate oil from water and absorb the oil in an efficient way. A promising route is based on functionalizing the surfaces of polymer sponges with engineered nanomaterials to enhance hydrophobicity and oleophilicity simultaneously, hence creating high-performance absorbent sponges. One of the advantages of using polymer sponges is also that, in contrast with currently used sorbents, they can be used a number of times, thus reducing waste.

Despite research efforts, no application of oil spill clean-up involving nanomaterials has reached the real world yet. The main reason is that although fundamental research may provide interesting results in terms of absorption volumes, absorption speed and even reusability, these are usually obtained with small, bench-top type experiments, and the translation to the large scales at which phenomena like oil spills occur is not at all straightforward. First of all, the nanomaterials and the sponges need to be produced in large quantities and the functionalization processes involved during the production of the final sorbents should be energy and cost efficient with respect to established methodologies. The process of separation, absorption and potentially recycling of the sorbents in large quantities should also be energy efficient. These are only a few scalability challenges to be addressed. (As a side note, we should mention that a slightly unrelated but fundamental problem is that nanomaterials used to improve the environment may themselves be harmful, and a clear understanding of their potential toxicity is still missing.)

Scientific papers tend to report fundamental results, leaving discussions related to real applications and further work to developers rather than scientists. Although this is generally acceptable, it is worth emphasizing the added significance provided by addressing, at least partially, issues related to scalability already when initial demonstrations of a technique are reported. The paper by Jin Ge *et al.* on graphene-wrapped sponges for oil spill clean-up, which is included in this issue on page 434, is a perfect example.



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Ge and co-workers coated polymer sponges with graphene and then used a voltage to induce electrical current in the graphene layers. The current produced a local temperature enhancement via Joule heating that resulted in reduced oil viscosity and eventually a considerably faster oil absorption by the polymer sponge. The concept of the paper is intriguing for its simplicity and the results at a small scale are promising. However, following comments by the reviewers prior to acceptance of the paper, the researchers addressed the issue of scalability with estimates and dedicated experiments. In particular, scalability was addressed in terms of the material cost necessary to fabricate large amounts of graphene-wrapped sponges and in terms of the electric energy needed to apply voltages to a large-size material. Perhaps most importantly, initial experiments showed that the oil absorption speed does not decrease by increasing the size of the sponges.

In our view, the attention paid to scalability in the paper by Ge *et al.* is a first essential step if the technique is ever to be considered for real applications, even if, to be clear, we are perfectly aware that much more work is needed before any decision on implementation can be reached. Indeed, we feel that papers reporting nanotechnology-based techniques aimed at solving environmental issues should include considerations on scalability to reach the level of significance that we look for in a publication in our journal. We shall pay closer attention to this point in the future and we ask authors and reviewers to collaborate with us in addressing this, thus helping us to continue increasing the value of the research that we publish. ❒