**Autonomous Graphene Vessel for Collecting Liquid Body of Spilled Oil**

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## Abstract

Oil spills have caused sea and river pollution resulting in severe environmental and ecological problems[1]. A large number of studies have been conducted on oil removal, either for oil absorption[2] or oil/water separation[3]. However, the strategy for spilled oil collection has remained almost the same as it was for 1969 oil spill in Santa Barbara. Skimmers are still used to collect the oil gathered in containment boom. Workers mop up oil on the beach using sorbents. The thin layer of oil on seawater, however, hinders effective collection of spilled oil with the traditional macro-scale skimmers.

On the other hand, there have been a large number of studies on oil removal, either for oil absorption or oil/water separation. For oil absorption, nanomaterial sponges have extensively been used due to their low density and superhydrophobicity. Reduced graphene oxide, carbon nanotube (CNT), carbon fiber, and polymer were mainly utilized as a raw material for sponge fabrication, showing outstanding oil absorption capacity, efficiency, and reusability. For oil/water separation, superhydrophobic or superhydrophilic membrane and mesh, made by CNT, polymer, metal hydroxide, or silicate, were used to selectively pass oil or water for oil/water separation. In particular, membrane type was efficient for separating emulsion of oil and water due to its small pore size while mesh type yielded high flux with large pores.

Here we show that a graphene vessel devised here can bring about a basic change in the strategy for spilled oil collection. The graphene vessel selectively separates the oil, collects, and stores the collected oil in the vessel all by itself without any external power inputs, when it is placed on the oil-covered seawater (Figure 1a). To construct the vessel, we developed an ion-mediated assembly process followed by annealing to deposit reduced graphene oxide (rGO) from a solution of graphene oxide (GO) nanoplatelets on copper mesh. This graphene vessel is essentially an enclosed empty container, the hull of which is made of copper mesh that is, in turn, coated with rGO foam covering the whole surface, inside and out. Countless pores in rGO foam quickly suction spilled oil by capillary force like sponge, and the suctioned oil flows into the vessel by gravity.

Capillarity and gravity work together to fill this proto-type graphene vessel with the spilled oil at a rate that is higher than 20,000 liters per square meter per hour (LMH) with oil purity better than 99.9% (Figure 1b), and allow the vessel to withstand a water head of 0.5 m. The vessel has a superb chemical stability and recyclability. An expanded oil contact area forms at the reduced graphene oxide (rGO) foam interface upon contacting the spilled oil, which is considerably greater than the oil layer thickness. This expanded contact area is little changed even when the oil layer thins out. As a result, the oil collection rate is maintained high to the end of the recovery of spilled oil.

## References

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## Figures

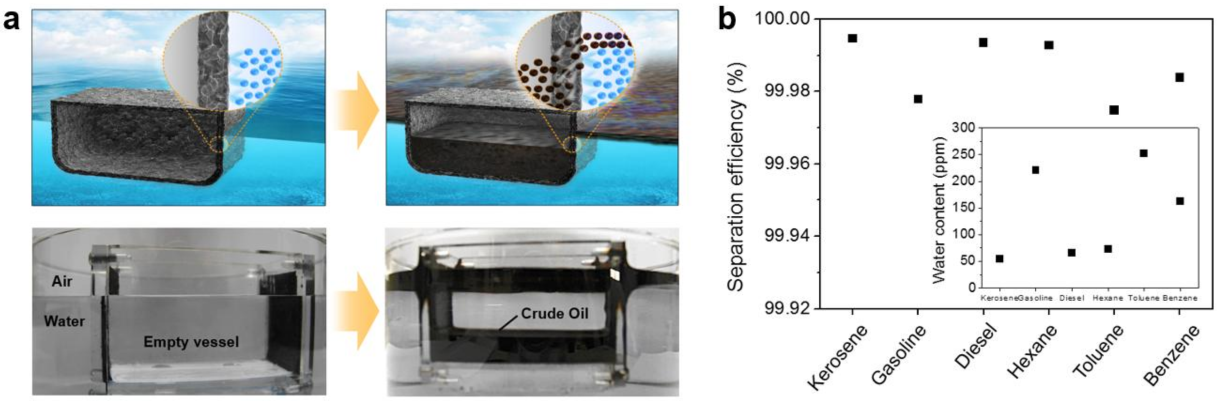


Figure 1. (a) Schematic illustration and optical images of oil collection by graphene vessel. (b) Separation efficiency of various oils and organic solvents.