A Biodegradable, Non Toxic, Inexpensive Superabsorbent for Effective Removal of Underwater Heavy Oil Using Radiation Technology

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With the increase of offshore drilling of oil, production and transportation, the chances of oil spillage has enormously increased.[1] Materials with selective wettability, that is superhydrophobicity and superoleophilicity, or superhydrophilicity and superoleophobicity, can be used to separate the oil/water mixture.[2,3] In the last few years development of materials with special wettability for oil-water separation has received tremendous research and industrial interest. But easy and scalable methods for efficient absorbent preparation, separator with capability to separate oil from layered and emulsified oil-water mixture is not sufficient as per demand. Moreover, another severe problem is the removal of heavy oil from the underwater environment[4].

In this work, we have modified a gauze cotton (hydrophilic and oleophilic in nature) by gamma radiation assisted long chain hydrocarbon grafting. Upon modification the cotton turns its surface wettability by 360°, from superhydrophilic (water contact angle < 10°) to superhydrophobic (water CA more than 158°) without sacrificing its liking towards oil (Fig. 1). In water environment it forms a unique interface around it, which functions like a 'no water zone' and that remains underwater for several days without allowing any water to get in. In the underwater environment it picks up heavy oil very fast and efficiently (25 to 35 times of its weight depending on oil density), when it comes into the contact of oil (Fig. 3). 1gm of cotton takes around 30gm of oil in 10 sec thereby attaining a complete saturation, when the system is layered (Fig. 4). For emulsion it takes 10-20 min to remove oil from oil/water mixtures (Fig. 5). The absorbed oil can be completely recollected by centrifuging the absorbent at 700 rpm (Fig. 6) and the same piece of absorbent can be repetitively used for more than 50 times for the same purpose without compromising with its mechanical & special wetting properties. Oil absorption capacity of the cotton has been studied by varying different kinds of oils namely, motor oil, diesel, edible oil (mustard oil), toluene, chloroform, dichloromethane etc.

More interestingly, the modified cotton is found chemically robust in various pH environments (Fig. 7). We have developed this material in a large scale. Thus, this biodegradable, non toxic, inexpensive, robust (chemically and mechanically) superabsorbent can be used as an efficient and fast underwater heavy oil remover. It can be extensively used for removal of oil from any part of water starting from surface to the bottom-most layer.

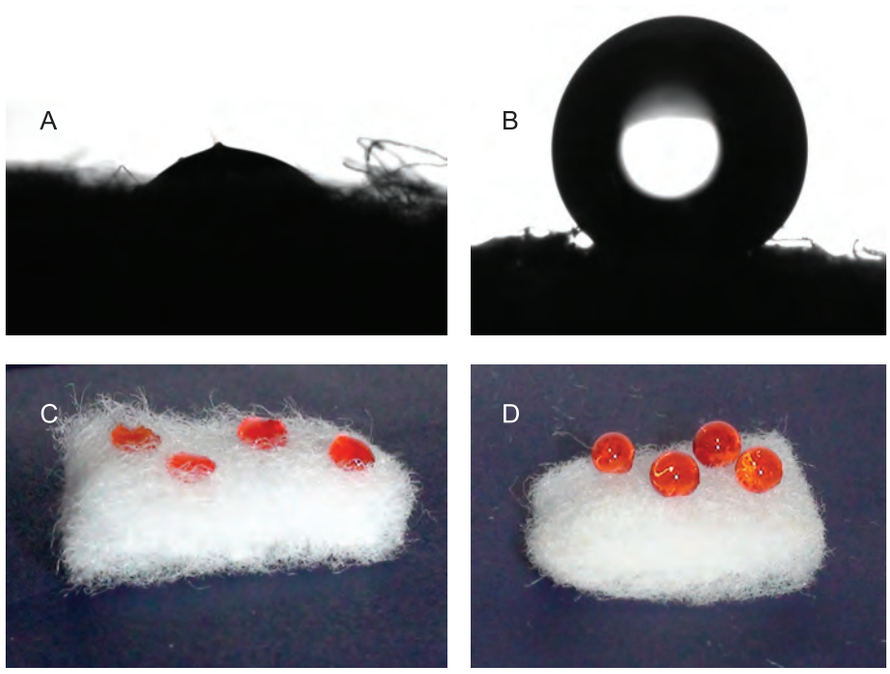

Fig. 1: Contact angle and beading of dyed liquid water on both the pure cotton (A,C) and grafted cotton (B-D) [superhydrophilicity and superhydrophobicity

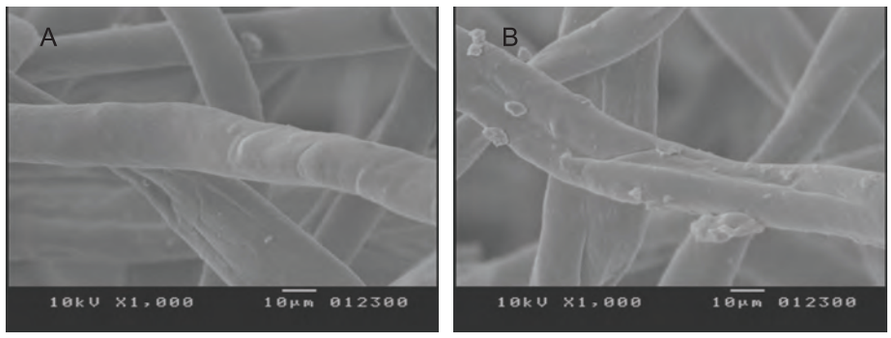

Fig. 2: SEM Images of (A) pure cotton and (B) grafted cotton

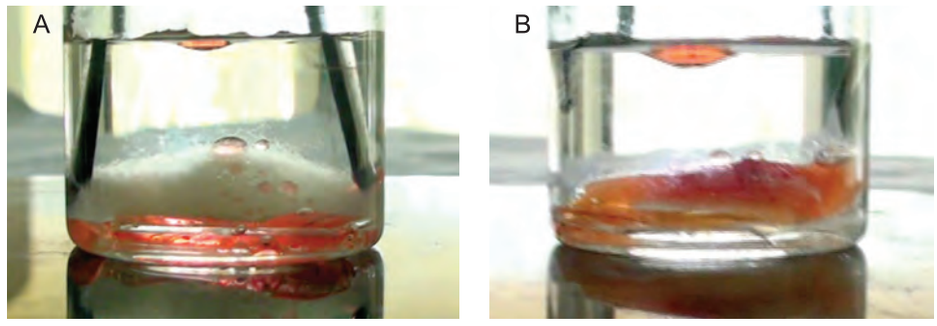

Fig. 3: Underwater (A) oleophobicity of pure cotton and (B) oleophilicity and rapid oil absorption by modified cotton

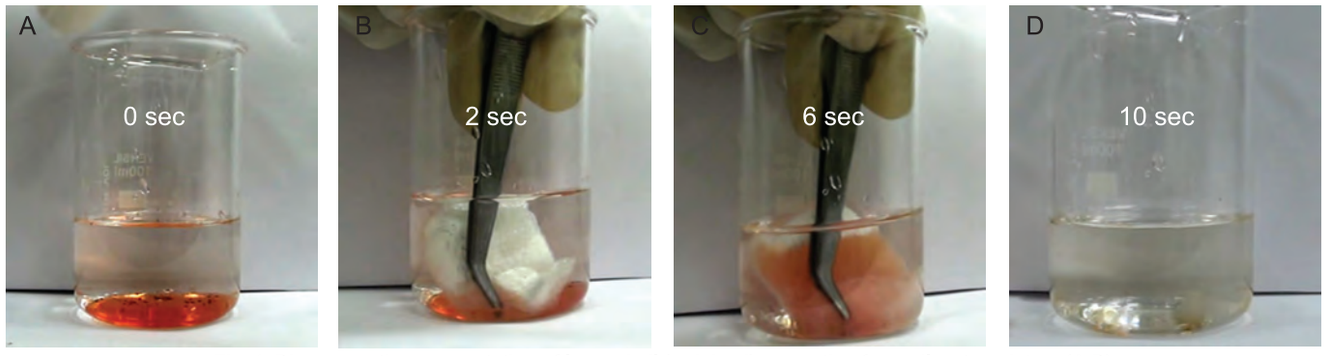

Fig. 4: Diagrammatic representation of layered oil (red dyed) separation from oil-water mixture (A-D)

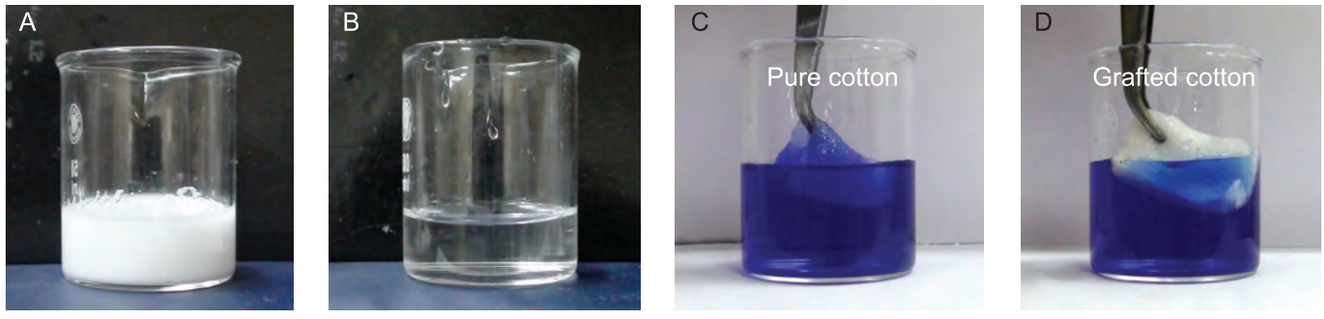

Fig. 5: A-B: Oil-water emulsion separation and C-D: underwater superhydrophilicity of pure cotton and superhydrophobicity of grafted cotton [blue solution is crystal violet added water]

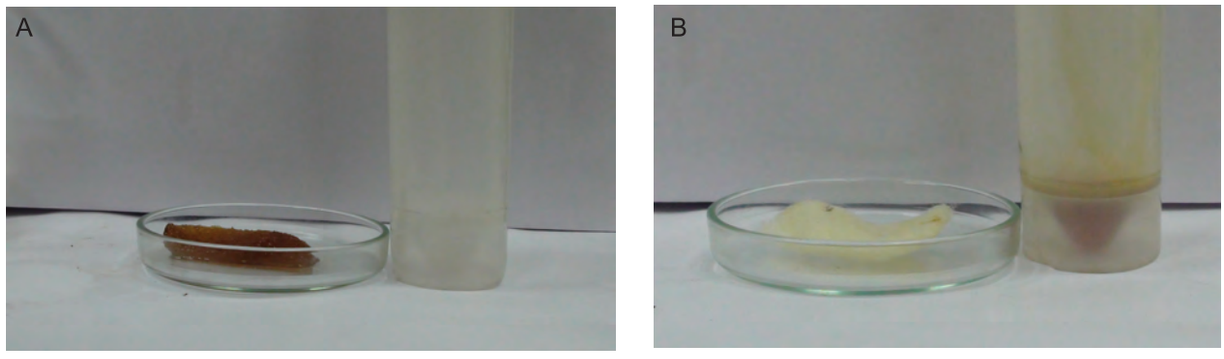

Fig. 6: Recollection of absorbed oil by centrifugation at 700 rpm (A,B) in 1 min

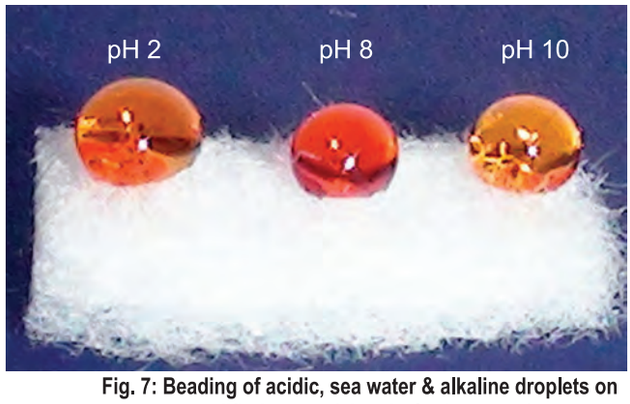

Fig. 7: Beading of acidic, sea water & alkaline droplets on modified cotton (chemical robustness)

References:

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