A Low-cost, Natural Material for Oil/Water Emulsion Separation

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Summary

Superhydrophilic materials are of great advantages in the case of oily mixture filtration process. In this study, natural sand particles were characterized and tested for oil in water emulsion separation. The sand particles were characterized using standard instruments and based on which the separation mechanisms were proposed. Wettability of the natural sands was checked through WCA and underwater OCA measurements. The top surface morphology of was characterized with SEM (scanning electron microscope). Separation efficiency was evaluated by testing Reduction of Turbidity and Rejection of Total Organic Carbon. Experimental results revealed that: 1) The naturally available cleaned sands show superhydrophilicity and underwater superoleophobicity; 2) Porous Sands bed could realize even higher separation efficiency than commercial PES and Nitrocellulose microfiltration membranes, with rejection of total organic carbon higher than 90% for Dodecane in water Emulsion, higher than 99% for Hexane in water emulsions.

Introduction

The Enhanced Oil Recovery (EOR)/Oil Refinery produce huge amount of process water, with oil droplets of different sizes (Oil in Water, or O/W emulsions). Offshore oil spillage event also produce large quantity of oily waste water. Worldwide stringent legislations set discharge limit at (~15-40 mg-oil/L) subject to local legislations. O/W emulsions are thermodynamically stable, can not be efficiently separated by conventional technologies such as gravity/mechanical or simple filtration process. Therefore efficient and economical separation of O/W emulsions constitutes a great challenge for Chemical Engineers [1,2].

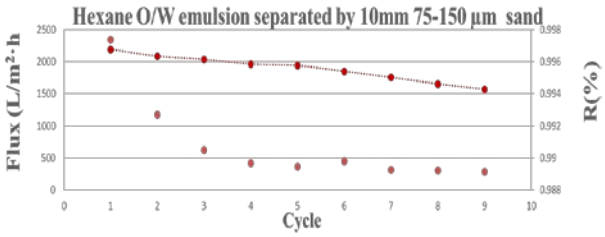
Superhydrophilic materials are of great advantages in case of oily mixture filtration process. In this study, natural sand particles were characterized and tested for oil in water emulsion separation. The sand particles were characterized using standard instruments and based on which the separation mechanisms were proposed. Wettability of the natural sands was checked through WCA and underwater OCA measurements. The top surface morphology of was characterized with SEM (scanning electron microscope). Separation efficiency was evaluated by testing Reduction of Turbidity and Rejection of Total Organic Carbon. Experimental results revealed that: 1) The naturally available cleaned sands show superhydrophilicity and underwater superoleophobicity; 2) Porous Sands bed could realize even higher separation efficiency than commercial PES and Nitrocellulose microfiltration membranes, with rejection of total organic carbon higher than 90% for Dodecane in water Emulsion, higher than 99% for Hexane in water emulsions.

Theory and/or Method

N-Hexane, SDS (Sodium Dodecyl Sulfate) were purchased from Sigma-Aldrich. Nitrocellulose membrane was from Merkmillipore, PES (Polyether sulfone) was from CELLTREAT. Deionized water was used for all experimental purposes. Natural sands were taken from PI. Two O/W micro-emulsions (hexane + SDS & Dodecane + SDS) were stabilized by SDS and used as model emulsions for separation.

Sand particles were purified and sieved into 3 different size ranges. Separation experiments were conducted on a filtration rig.

Underwater OCA of almost 180°WCA of almost 0°. It shows that the sand is super-hydrophilic. The separation performance were studied on sand column with different particle size and depth, and was compared to two commercial microfiltration membranes [3,4]. One example of results were shown in Figure below. It is seen that the sand bed present good efficiency and recyclability.



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Conclusions

Naturally available sand particles have intrinsic super hydrophilic property. It can separate O/W emulsions stabilized by surfactant with high separation efficiency.

Cyclic tests proved that sand particles possess outstanding reusability. Driving force, depth of sand bed, and sizes slightly affect separation performance. More studies are needed on saturation capacity, surface properties, and operation conditions to commercialize this technology.

References

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