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Development of Ultra-Precise Oil Droplet Coalescing Medium Installed in Marine Oil Separator for Marine Pollution Prevention

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Summary

Wastewater generated during marine transportation often contains substantial quantities of oil. Although the continuous oil phase can be separated from water due to specific gravity difference, the wastewater typically includes emulsified oil droplets dispersed in water, known as oil-in-water (O/W) emulsions. To comply with the regulations governing the discharge of oily wastewater, there is an urgent need for effectively to removing these emulsified oil droplets.

Here, we focused on nanofiber nonwovens due to their high specific surface area, tunable wettability, and controllable pore structure. These materials are typically used as filters to separate O/W emulsions into oil droplets and water. However, the surfaces of nonwoven filters inevitably become contaminated with oil, posing challenges for long-term use and leading to noticeable decrease in cycling performance. Additionally, the repelled oil droplets result in a high-concentration emulsion that requires further treatment to mitigate its adverse environmental effects.

To address these issues, we developed nanofiber nonwovens as coalescers for use in marine oil separators based on the coalescence separation mechanism. This approach effectively separates O/W emulsions and facilitates the recycling of oil. The electrospun polyacrylonitrile (PAN) nanofiber nonwovens were fabricated and an in situ growth strategy was employed to decorate zeolitic imidazolate framework-8 (ZIF-8) on PAN nanofibers. The process began with the pretreatment of the PAN nonwovens to activate it and create anchor sites for zinc ions, followed by immersion in ZIF-8 precursors. The incorporation of ZIF-8 enhanced the membrane's amphiphilicity, roughness, and imparted a positive charge, which effectively demulsified and coalesced negatively charged oil droplets. The ZIF-8/PAN nanofiber nonwoven demonstrated a separation ratio exceeding 99.9% for surfactant-free emulsions and 97.1% for surfactant-stabilized emulsions. It also exhibited an ultra-high permeation flux of 21,200, and 14,100 L m^{-2} h^{-1}, respectively, during continuous separation processes.