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Advancing Produced Water Treatment: Hollow-Fiber Membrane Efficiency in Oil-Water Separation

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Extended Abstract

The management and treatment of produced water, a significant byproduct of oil and gas extraction, faces considerable environmental and operational challenges. Annually, the industry generates approximately 75 billion barrels of produced water worldwide, characterized by a complex composition of hydrocarbons, surfactants, salts, and suspended solids. Efficient treatment methods are essential for reuse and disposal. This study investigates the treatment of produced water, emphasizing the removal of total suspended solids (TSS), total oil and grease (TOG), and the efficacy of selective oil permeation using a Hollow Fiber Membrane Contactor system.

This introductory investigation sets the stage for a critical analysis of current treatment technologies, underscoring the urgent need for innovative solutions that not only address the environmental impacts but also enhance the operational efficiency of produced water management. The deployment of HFMC systems, with their potential for high-efficiency separation processes, represents a significant advancement in the field.

Our research focused on hydrophobic microporous polypropylene hollow-fiber membranes for oil-water separation. We quantitatively evaluated the performance of these membranes in separating oil-water mixtures under various operational conditions, measuring oil flux and recovery rates to assess the selective oil permeation process's efficiency.

The results revealed a significant enhancement in produced water treatment, demonstrating the ability to manage high salinity levels effectively and maintain oil removal efficiency. Specifically, experiments showed oil recovery rates varying significantly with salinity levels, with a notable recovery of 79.2% ± 1.3% at 0 g/L NaCl, increasing to 85.2% ± 0.6% at 10 g/L NaCl, before slightly decreasing to 81.7% ± 1.0% at 50 g/L NaCl. These findings highlight the membranes' capacity to perform efficiently across a spectrum of salinity levels, thereby broadening the scope of their applicability in produced water treatment.

Moreover, the study underscores the critical role of membrane conditioning, with conditioned membranes outperforming virgin membranes significantly. Pre-exposure to oil led to a substantial increase in performance, facilitating the development of an oil film on the membrane surface which in turn promoted oil permeation. For instance, continuous operation under low pressure (0.35 bar) and an influent flow rate of 3.8 liter/min over a ten-day period achieved consistent oil recovery performance, showcasing the durable effectiveness of the treatment process.

In conclusion, our research affirms the potential of the Hollow Fiber Membrane Contactor (HFMC) system as a viable solution for the treatment of produced water. The findings of this study underscore the system's high efficiency in oil recovery and its robust performance across a range of salinity levels, marking a significant step forward in the quest for sustainable produced water management strategies. These insights pave the way for further innovation in the field, presenting a promising avenue for environmental protection and resource conservation. The efficacy of HFMC systems in addressing the complex challenges of produced water treatment highlights their importance in promoting sustainable practices within the oil and gas industry, ultimately contributing to the broader goal of minimizing environmental impacts and enhancing the stewardship of water resources.