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Editorial

Editorial of the Special Issue "Novel Oil–Water Separation Technologies Applied in Marine Environmental Science"

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1. Introduction

The marine environment, a vital component of the Earth's ecosystem, is increasingly threatened by pollution, and notably by oil spills. Oil–water separation is a critical process in marine environmental science. This process is essential not only for mitigating the devastating effects of oil spills on marine life [1,2] and habitats, but also for preserving the ecological balance and ensuring the sustainability of ocean resources [3]. The urgency and importance of this technology in the marine context is emerging, as it plays a pivotal role in settling one of the most pressing environmental challenges of our time. Novel and efficient oil–water separation techniques can significantly reduce the environmental footprint of maritime activities, safeguarding marine biodiversity and helping maintain the health of our oceans [4]. The development and improvement of this technology are necessary for preventing marine oil pollution, which remains a significant threat to the environmental integrity and biological richness of our seas.

Traditionally, oil–water separation in marine environments has relied on a range of methods, each with its own unique advantages and limitations. Mechanical methods for oil–water separation, such as gravity separation and filtration, require a large footprint and often struggle with limited separation capacity and poor treatment effects on emulsified oil [5]. Chemical methods, including the use of dispersants and sorbents, alter the chemical properties of oil to facilitate its removal, yet they can introduce secondary pollutants [6]. Biological treatments, which use microbes to degrade oil, offer an eco-friendly alternative but are often slow [7] and dependent for efficiency on environmental conditions [8]. These conventional methods, while having contributed significantly to oil spill management in offshore environments, often fall short in terms of efficiency, environmental impact, or adaptability to different types of oil spills.

Novel oil–water separation technology is, therefore, not just an environmental imperative but also a socioeconomic necessity. It is crucial for the rapid containment and remediation of oil spills, to minimize their environmental impact and reduce the economic burden on affected communities. Additionally, as the maritime transportation of oil continues to grow, the likelihood of accidental spills also increases, making the development and implementation of efficient oil–water separation technologies even more vital.

2. An Overview of the SI and Published Articles

This Special Issue (SI), titled 'Novel Oil–Water Separation Technologies Applied in Marine Environmental Science', is a collection organized by Dr. Qiang Yang of East China University of Science and Technology and Dr. Sohrab Zendehboudi from Memorial University. This issue is dedicated to showcasing the latest advancements and research breakthroughs in the realm of oil–water separation technologies within marine environments. Our objective is to present a comprehensive overview of cutting-edge developments in this critical field, ensuring rapid review and publication processes. Additionally, this SI is committed to broadening access to this vital information by offering all articles free of charge, thereby supporting research and educational endeavors and serving as a valuable reference resource.

In the article entitled "Study on the Performance of an Electric-Field-Enhanced Oil–Water Separator in Treating Heavy Oil with High Water Cut", an experimental study on an electric-field-enhanced oil–water separator designed for treating heavy oil with high water content is presented (contribution 1). The study focused on the performance of the separator under various conditions, such as different electric field frequencies, flow rates, and with the use of chemical agents. Key findings included the identification of optimal operating parameters for the separator, which significantly improved the dehydration efficiency of heavy oil. The study demonstrated that the electric-field-enhanced oil–water separator is effective in treating heavy oil with a high water cut, achieving significant dehydration rates and reducing the need for chemical agents.

In the study proposed by Fengqin He et al. (contribution 2), they explored the impact of vortex finder depth on the flow field and separation efficiency of mini-hydrocyclones used for desanding purposes. Using both experimental validation and numerical simulation, the study investigated different vortex finder depths and their effects on various parameters such as axial, radial, and tangential velocities, as well as separation efficiency. The results indicated that the depth of the vortex finder plays a significant role in the separation performance, with an optimal depth identified for maximum efficiency. The paper provides valuable insights into the design and operation of mini-hydrocyclones for improved desanding performance in marine environments.

In the paper entitled "Research on the Enhancement of the Separation Efficiency for Discrete Phases Based on Mini Hydrocyclone", the efficiency enhancement of mini hydrocyclones (MHCs) for separating discrete phases with varying densities and sizes was investigated (contribution 3). The research utilized numerical simulation methods to compare the performance of MHCs and conventional hydrocyclones across different parameters. Findings revealed that MHCs are particularly effective in oil–water separation for oil droplet sizes of 60–300 μm and in silica particle–water separation for particle sizes of 10–40 μm. This paper provides critical insights into the optimal application of MHCs in marine environments, highlighting their potential for more efficient oil–water separation processes.

The paper produced by Silong Feng et al. introduced an innovative approach to demulsify water-in-oil (W/O) emulsions, combining a direct current electric field with medium coalescence (contribution 4). The study designed an electric-medium demulsifier for the deep purification of W/O emulsions and examines its efficiency under various conditions. Results showed a significant improvement in demulsification efficiency compared to using electrostatic demulsification or medium coalescence alone. The proposed method is particularly effective for emulsions with strong emulsification, offering a rapid and thorough treatment process with wide operational flexibility and a high tolerance for deteriorated emulsion characteristics.

Focusing on offshore oil production, the research conducted by Yudong Li et al. presented a highly efficient pre-treatment core tube, coupled with main and secondary cavities, for treating produced water in heavy oilfields (contribution 5). The study explored the system's optimal inlet Reynolds number and processing capacity, demonstrating significant improvements in treatment efficiency and space reduction. The system effectively reduced oil content in effluent to below 200 mg/L from an influent averaging 1772.81 mg/L, achieving nearly 94% separation efficiency. This method shows substantial enhancement over traditional systems, emphasizing its potential for efficient and compact water treatment solutions in offshore settings.

3. Conclusions

This SI forms a comprehensive exploration of novel methodologies and enhancements in oil–water separation, crucial for marine environmental science. The five publications underscore the significance of innovative approaches in tackling the complex challenges posed by oil spills and pollution in marine ecosystems. Each paper, while distinct in its focus, collectively contributes to a broader understanding of how technological advancements can lead to more efficient, space-effective, and environmentally friendly oil–water separation solutions, highlighting a concerted effort towards sustainable marine resource management.

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