Toward Sustainable Detergency in Marine Context

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Context: Industrial cleaning and detergency play a crucial role in numerous sectors, including food processing, healthcare, and manufacturing, where high standards of hygiene and surface decontamination are required. However, conventional cleaning formulations still rely heavily on petrochemical-derived surfactants, which are often associated with significant environmental and human health concerns, including poor biodegradability, persistence, and aquatic toxicity. In addition to terrestrial applications, detergency is of critical importance in marine environments, particularly in the context of oil pollution.
Detergency is essential for routine maritime operations, including the cleaning of ship hulls, tanks, and equipment contaminated with hydrocarbon residues. In some cases, these operations may result in the release of cleaning waters into the sea, thereby causing oil slicks to form. Another type of pollution, more dramatic, may be accidental oil spills that represent a major threat to marine ecosystems [1]. These events lead to the formation of persistent oil slicks that can severely impact marine life and coastal habitats [2]. One of the primary response strategies involves the use of chemical dispersants, which are designed to break down oil slicks into fine droplets, thereby enhancing their dilution and promoting microbial biodegradation. However, conventional dispersants are predominantly formulated using petrochemical-derived surfactants and solvents, which may pose risks to aquatic organisms and contribute to secondary pollution. Moreover, their effectiveness can vary depending on environmental conditions, raising further challenges in real-world applications.
The challenge is therefore twofold: to ensure efficient removal and dispersion of hydrophobic pollutants in saline conditions, while minimizing the ecological footprint of the cleaning agents themselves. In this context, the development of bio-based alternatives derived from renewable resources represents a promising and more sustainable alternative. Developing efficient, safe, economically and ecologically viable detergency systems is therefore essential to reconcile performance requirements with environmental protection, particularly in the sensitive context of marine pollution.

Materials and Methods: In the detergent and dispersant industry, commonly used surfactants include anionic and non-ionic compounds such as dioctyl sulfosuccinate (DOSS), as well as sorbitan esters (Span) and ethoxylated sorbitan esters (Tween)[3]. In this study, several model formulations were developed and investigated with the use of both petroleum and bio-based alternatives. A comprehensive physicochemical characterization was conducted including pH and ionic strength monitoring, surface tension measurements and CMC determination through the Du Noüy ring method to document stability under different aqueous conditions and ability to reduce interfacial tension. The dispersion efficiency of the formulations was further evaluated using the Baffled Flask Test (BFT), a standardized method commonly used to assess the effectiveness of dispersants for oil spill remediation.

Conclusion and Discussion: The results obtained in this study highlight the promising potential of bio-based alternatives in detergent and dispersant formulations. Particular attention was given to the medium's influence by comparing performance in deionized water and artificial seawater to better reflect both standard laboratory conditions and more realistic marine environments. While some variations were observed depending on the formulation and the tested conditions, the overall results suggest that bio-based alternatives can achieve relevant performance levels in terms of interfacial activity and dispersion efficiency. These findings underline the importance of considering physicochemical parameters such as ionic strength and salinity, especially for applications related to marine pollution and industrial cleaning processes involving saline media. However, further optimization of the innovative strategies remains necessary to achieve full equivalence with conventional systems, particularly in terms of stability, robustness, and cost-effectiveness.

References:

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