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Opinion Article

Emulsification of Bio-Renewable Raw Materials in Surfactant Analogues

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DESCRIPTION

Surfactants are one of the most used commodity chemicals, that are commercialized in high volumes and finding applications in many different fields (household, industry, agriculture, personal care, oil and gas, food, and pharmaceuticals). Sulfonated Alkyl Furoates (SAF) is a new bio-based surfactant that can replace oil-based analogues providing superior performances by exploiting fatty alcohol and furoic acid. The importance of these compounds has different sectors which make them one of the most important synthetic chemicals to produce globally. An optimum surfactant design for a specific application is based on the chemical structure of hydrophilic and hydrophobic parts as these structures strongly affect the surfactant's properties. For example, it is desired that surfactants used for home care products have a low Critical Micelle Concentration (CMC), a low Kraft temperature (KP), high solubility and resistance to hard water, low toxicity, and high biodegradability.

The emulsifying properties are important parameters for detergents and applications in enhanced oil recovery. The increasing demand for more sustainable and greener products has added an extra requirement to the surfactant industry since product formulators are demanding bio-based surfactants with equal performance to the traditional petrochemical derivatives in the final application and remove all the petrochemical additives that are used to improve surfactant performance, which cause harm to the environment.

Currently, the most used surfactants in industrial applications are anionic surfactants, and they account about 20% of a typical household product, particularly Linear Alkyl Benzene Sulfonates (LAS) and Sodium Dodecyl Sulfate (SDS). Linear Alkyl Benzene Sulfonates (LAS) is a petroleum-based surfactant, while in Sodium Dodecyl Sulfate (SDS) it is a bio-based surfactant with several limitations such as low water solubility, low resistance to hard water, and low performances due to high Critical Micelle Concentration (CMC).

A solution to improve the detergent formulations in terms of sustainability and competitiveness is needed. This solution should be focused on synthesizing surfactants derived from low cost, bio-renewable raw materials. This surfactant should exhibit at high performance with a minimum use of additives. Consequently, researchers have sought bio-based and biodegradable anionic surfactants that have performance and costs comparable to those of Linear Alkyl Benzene Sulfonates (LAS).

Synthesis of sulfonated alkyl furoates

The furoate ester (10 g) was added to dry chloroform (5 ml) and mixed at room temperature until the full dissolution is achieved. Chloroform was needed to avoid foaming, which are large batches that represent an operative problem. The reaction flask was then connected to a water-filled bubbler through which the produced Hydro-Chloric Acid (HCA) was vented.

Sustainability of sulfonated alkyl furoates

The usage of furan building blocks has attracted much interest in the last 20 years for the production of different bio-based chemicals which can substitute bulk petrochemicals. For example, different catalytic pathways like HMF, furfural, or furan have been used.

Evaluation of surfactant properties

The properties of surfactant were evaluated under salt-free conditions (<100 ppm) according to the procedure reported in the methodology. The results reported in demonstrate that Sulfonated Alkyl Furoates (SAF) displays some unique behaviour compared with traditional anionic surfactants (LAS and SDS). Of particular note, Sulfonated Alkyl Furoates (SAF) has favourable Critical Micelle Concentration (CMC) and solubility in water which suggests the potential for superior detergency as low CMC is desirable in cleaning formulations. SAF-8 exhibits a lower Critical Micelle Concentration (CMC) than commercial SDS, while SAF-12 and SAF-16 have a lower Critical Micelle Concentration (CMC) than LAS, indicating that SAF could function as a replacement for traditional surfactants in a variety of home and personal care products. While the Critical Micelle

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Concentration (CMC) is a good estimation for micelle formation, it remains a rough estimation for the performance that the surfactant can have in specific applications such as in oil recovery or detergency. A more rigorous estimation comes from measuring the decrease in surface tension between water and hydrophobic solvents.

CONCLUSION

The advantages in using Sulfonated Alkyl Furoates (SAF) lie on the efficient formation of the hydrophobic part of the molecule at high yield simply using sulfuric acid as a catalyst and without the requirement of a purification step, reducing the energy requirements of the plant. This can significantly reduce the operating costs of a scale-up which can guarantee an acceptable MSP in association with low CO_2 emissions related to the processing, which gives the prospective of a competitive market price. Ultimately, the low-cost production of FA and the compatibility of the sulfonation step in the falling film reactor will define the success of this technology.