Alcohol Ethoxylate Sulfation in a Microreactor Operated in a Pilot Plant Environment

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Anionic surfactant manufacturing is typically accomplished using a high throughput process in a few world-scale plants worldwide. Today, the state-of-the art technologies are multi-tubular or annular gap falling film reactors. These units are well optimized over the last several decades. A drawback of the current technology is that these large scale plants lack flexibility and agility from a product or throughput change point of view (long change-over times, long start-up times, etc...). Furthermore, the current process needs highly diluted SO_3 (sulfating agent) thus utilizing relatively large amounts of dry air. This in turn leads to the need for relatively high capital in air pre- and post-treatment and a large environmental footprint of the whole plant.

Step changes in the base technology could lead to different supply chains, in particular towards (but not limited to) more distributed, less transport intensive supply chain scenarios. The main objective of this paper is to focus on the development of a new intensified reactor for sulfation and/or sulfonation reaction which reduces change-over times and can use much higher SO_3 concentrations, thus reducing capital in pre- and post-treatment of the air.

Based on hydrodynamic studies of two-phase flow in small capillaries the new concept of the sulf(on)ation reactor has been developed. The reactor concept comprises a high intensity gas-liquid contactor where the organic liquid is injected into a stream of gaseous SO_3 forming small droplets. The gas-liquid mixture flows further in a capillary of few mm in diameter with high turbulence as the reactions proceed.

The microreactor was integrated into a surfactant making pilot plant located in the P&G R&D facilities in Brussels. The microreactor and the existing falling film reactor (FFR) were operated in parallel. This enabled side by side comparison of both reactors. The microreactor operation was successfully demonstrated with both sulfonation and sulfation reaction. This paper presents the results of the sulfation reaction in more detail. The temperature profile along the reactor, alcohol ethoxylate conversion as well as product color and free acid (H_2SO_4) content were analyzed.

The product quality is comparable with traditional FFR technology at low SO_3-organic molar ratios. A fatty alcohol ethoxylate conversion up to 95 % was achieved at stoichiometric SO_3-organic molar ratios; however the other product quality attributes (color, free acid content) are worse when compared to the traditional FFR technology.

The prototype microreactor showed a stable and robust operation with reproducible results. To meet the minimum success criteria on color and free acid, further optimization is necessary.

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