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Biodesulfurization of DBT in an integrated system of ultrasonication and biodesulfurization

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Abstract

Sonication is a technique for enhancement the kinetics of biochemical processes involving enzymatic or biochemical transformations [1]. The integration of Biodesulfurization (BDS) with ulta-sonication may increase the BDS performance [2]. During ulta-sonication, the exposure of liquids to ultrasonic waves of high intensity causes acoustic cavitation that induces better surface chemistry of catalysts by enhanced micro-mixing and oxidation of the organo-sulfur compounds. Ultra-sonication can be integrated with the BDS process, because it can solubilize the insoluble or slightly soluble organo-sulfur compounds into aqueous solution. Especially for bunker oil, which has higher viscosity than gasoline and diesel, the low solubility in aqueous phase might be one of major limitations of BDS. Reducing the viscosity of bunker oil and increasing the contact of bunker oil with biocatalyst is a critical step in BDS. Moreover, hydroxyl radicals and hydrogen peroxide can be formed by the decomposed of water under ultrasound in aqueous solutions [2,3], and this can contribute to oxidation of organosulfur compounds such as the oxidation of thiophenes into sulfones. Moreover, the volatile and semi-volatile thioethers, and thiophenes can also be decomposed by sonication in the aqueous solution. The oxidative desulfurization of liquid fuels can be considerably accelerated by ultrasound treatment.

The present study examines the ddevelopment of a high intensity ultrasonic system for removing sulfur from DBT. The respective ultrasonic system was developed to increase the performance of BDS process, and for this a software for controlling the high intensity ultrasonic system was also developed. The software interface to control the ultrasonic system was written in C## and includes the following tasks: (i) Ultrasound control (frequency, voltage or power, pulse duration, continuous or pulse mode, pulse repletion frequency (PRF), delay between exposures, and number of exposures); (ii) Temperature measurement; (iii) Command history.

A circular unfocused ultrasonic transducer operating at 28 KHz was also developed to be used at a small volume BDS process. A simple system with a single transducer was delivered so that to fully cover the sonication area with ultrasounds. In another configuration, 6 ultrasonic transducers operating at 28 KHz with a diameter of 35 mm and a thermal insulation foam were used to cover larger volumes of BDS process.

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