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Production of sucrose esters through solid-liquid transesterification

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PURPOSE OF THE ABSTRACT

Production of sucrose esters can be done by letting sucrose and fatty acid methyl esters to react in the presence of a solid catalyst. Sucrose esters are used in alimentary industry, in cosmetics and in pharmaceuticals. They have good green properties such as rapid biodegradability, biocompatibility, and biocide potential for certain microorganisms [1].

One of the processing alternatives proposed to overcome reactants incompatibility is the use of emulsifiers to provide contact and enhance solubility of sucrose in FAME [2?5]. Main emulsifiers used are fatty acid soaps (mono- and divalent). However, in this heterogeneous reaction, solid-solid-liquid interfaces are present between catalyst, typically potassium carbonate, sucrose and FAMEs, respectively. Two different reaction mechanisms have previously been proposed to explain the interaction between the solid sucrose and the solid catalyst that leads to the formation of active species during the solvent-free transesterification. One study proposed that the interaction of the solid sucrose with the solid catalyst leads to the formation of solid sucrate, which further reacts with FAME through a solid-liquid to form sucrose monoester [6]. A more recent study suggested that solid sucrose dissolves at some extent in FAME, and that the dissolved sucrose and the liquid FAME can interact on the catalyst surface where the reaction to produce sucrose monoester takes place [7].

In this work we revisited the sucrose transesterification reaction in a laboratory-scale batch reactor, in order to obtain kinetic data and to model the complex system quantitatively. The complete set of experiments to validate the proposed kinetics were carried out in batch reactors of 100ml of volume using sodium stearate (NaS) as emulsifier, and K₂CO₃ as catalyst. Consumed FAME and produced sucrose esters of different esterification degree were quantified using high performance liquid chromatography (HPLC). Two rival reaction mechanisms were considered. The proposed model of reaction considered that sucrose was solubilized in FAME and that this solubility was enhanced by the presence of sucrose monoester and temperature. The laboratory-scale experiments showed that the sucrose dissolution up to the saturation limit was quickly reached, so the process was operated in the kinetic regime. A non-linear behavior of the reaction rate with the catalyst concentration was observed and it was attributed to a solid-liquid interaction. The experimental evidence strongly supports that the catalyst order is the one of a spherical particle [8]. The kinetic parameters were adjusted using the experimental data obtained at different operating conditions: temperature between 120 and 160°C, 7 wt.% NaS, sucrose/FAME molar ratio between 0.5 to 1.5, and catalyst concentrations ranging between 1 to 5 wt.%.

The obtained data validated the proposed reaction mechanism, and a good agreement of the experimental data with the kinetic model was observed. Then, the obtained model can be used in a conceptual process design and in the preliminary economic evaluation of the production of sucrose esters in a solvent-free reaction system.

FIGURES

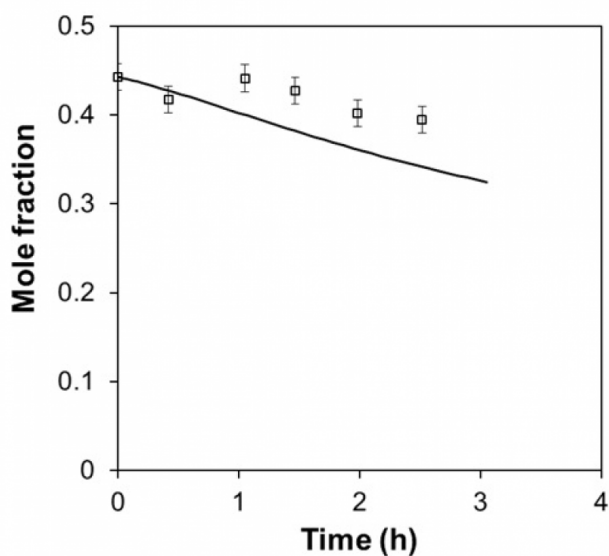


FIGURE 1

Figure 1

Consumption of methyl palmitate. T=136°C, 5wt.% catalyst, sucrose/FAME 1 w/w

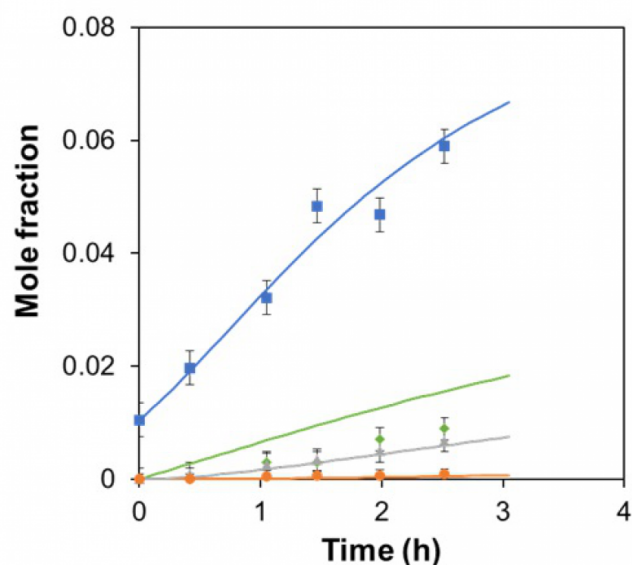


FIGURE 2

Figure 2

Production of mono (blue), di (green), tri (grey), tetra (orange) sucrose esters. T=136°C, 5wt.% catalyst, sucrose/FAME 1 w/w

KEYWORDS

Sucrose esters | FAME | Kinetics | Mechanism

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