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Hydrogenation of aqueous sugar solutions from renewable resources: Selection of a suitable reactor concept

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PURPOSE OF THE ABSTRACT
Nowadays, the majority of chemicals are produced from fossil resources like crude oil or natural gas. Considering the high related emissions of carbon dioxide, alternative sustainable processes based on renewable resources become attractive [1].
An example for such sustainable synthesis is the production of polyols from sugars. These polyols are primarily applied in the polymer industry. Additionally, due to good emulsifying properties, they can be used for colorants, antioxidants and enzymes in chemical, pharmaceutical, cosmetic and food applications. These polyols are currently produced in industrial scale by direct hydrolysis of the respective epoxide obtained predominantly from the chlorohydrin process or by direct oxidation of the respective alkene, depending on the starting material and process [2]. Alternatively, biomass-derived sugar can be used whereby the sugar is obtained in aqueous solution [3].
The aim of our present research is to develop a reactor concept for the hydrogenation of aqueous sugar and/or sugar alcohol solution (e.g. xylitol) to produce polyols (e.g. propylene glycol and ethylene glycol). Besides the determination of the reaction kinetics by performing systematic experiments at high pressure in a stirred tank reactor, the selection of a suitable catalyst and reaction conditions for the respective reactor concept are of importance. Furthermore, the transport of the three-phase reaction medium through a continuously operated reactor has to be considered. In order to select a suitable reactor concept, various reactor types are modelled and reviewed for their suitability for the given reaction system.
In this contribution we will present results aiming at the identification of the reaction network for the hydrogenation of aqueous sugar and/or sugar alcohol solutions (e.g. xylitol) and the selection of a suitable reactor concept. Concentration profiles for all reacting components were received from the hydrogenation experiments. As a result, a reaction network for the analyzed components was developed and validated using a basic kinetic model (figure 1). This allowed the modelling of various selected reactor concepts by implementation of the kinetic model. The batch operated stirred tank reactor, the stirred tank reactor cascade and the jet loop reactor as examples for suspension reactors were compared with the trickle bed reactor as an example for a fixed bed arrangement of the catalyst in order to achieve a high catalyst efficiency, reactant conversion and selectivity to the target products. The specific advantages and disadvantages of these reactors with respect to their technical implementation are discussed.

FIGURES

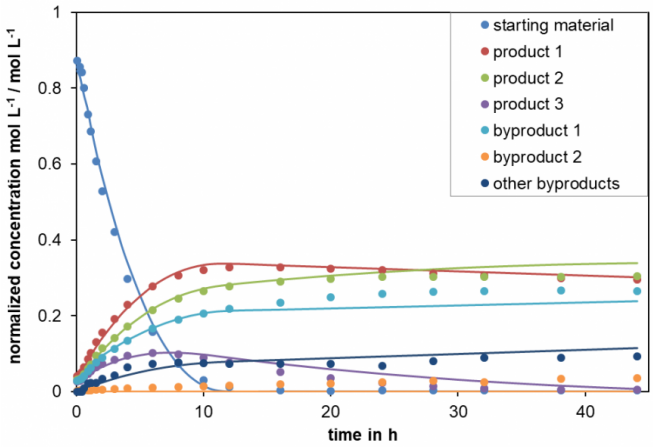

FIGURE 1

Concentration profiles during the hydrogenation of aqueous xylitol solution

experimental data (symbols) and kinetic model (lines) (170 °C, 80 bar, c0,Xyl: 10 wt.%)

FIGURE 2

KEYWORDS

biomass conversion | reactor concepts | kinetics | modelling

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