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Nanocomposite Microreactor Fabricated by Indirect 3D Printing

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Abstract – Innovative rapid prototyping process uses computer-aided design systems for the fabrication of microreactors bearing in mind the relationship between design, control and optimization of chemical processes in an early stage of development. Microreactors are studied in the field of micro process engineering, together with other devices (such as micro heat exchangers) in which physical processes occur. The microreactor is usually a continuous flow reactor in contrast to a batch reactor. The goal of microreactors is the optimization of conventional chemical plants, and also to open the way to research new process technologies and the synthesis of new products by Green chemical. Microreactors exhibit advantageously in development of product such as quality and safety, high surface-to-volume ratios, optimum mix of the reactants, and very precise control of the kinetic of reaction.

Rapid prototyping of microcomponents have been attracting many application fields in this new millennium [1,2]. The emergence of nanocomposite materials and design generation by 3DP rapid prototyping systems can be of significance to rapid advances in microtechnologies. In this work, the nanocomposite studied was DGEBA (diglycidyl ether of bisphenol A), DETA (diethylenetriamine) as epoxy curing agents and nanosilica (NS) powder as filler. The nanocomposites were prepared by the simple blending of silica nanoparticles with epoxy resin and curing agent [3]. An experimental analysis, using Differential Scanning Calorimeter (DSC), was used to determine the fractional conversion, reaction rate, heat of reaction, and activation energy at which the curing process starts. The results show dynamic curves concerning DGEBA/DETA/NS system for the curing process with different heating rates. These curves were analyzed by the Vyazovkin method (Free Kinetics Model) [4]. The activation energy (E_α) as a function of conversion (α) was calculated, unlike the isothermal mode, which considers the activation energy isoconversional (α=cte). The mechanism and kinetic curing was studied using a computational modeling to describe the main features of the curing process, presenting a good agreement with experimental and predicted values. With NS particles dispersed in the epoxy matrix, the study on the material behavior of nanocomposite layers was analyzed by a scanning electron microscopy (SEM) to obtain information about relationship between the kinetics data and morphologic properties, which is a convenient way to develop the nanocomposite materials. This study describes an indirect 3DP, where molds are printed and the nanocomposite materials are cast into the mold cavity. The 3DP construct layer by layer from CAD 3D data of the mold design to the microreactor to be build. The employment of 3DP to fabricate microreactor offers many advantages with well-defined architectures and controllable design. CFD simulation using ANSYS CFX revealed the dependence of the volume flow, pressure and temperature to geometrical parameters of the microreactor and operating conditions, and results of coefficient heat transfer between nanocomposite material and the wall and intern of the microreactor.

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