MIXING AND FLOW IN MICRO-REACTORS

by

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ABSTRACT

In recent years chemical reactors have undergone a major size reduction. These days chemical reactions can occur in devices that are in the range of 10-100 micrometers. This work anticipates a further reduction in size of micro-reactors to cross-channel dimensions of 0.1-10 micrometers over the next decade. Continuum mechanics and, in particular the bulk molecular diffusivity, remain generally applicable in this size region, but characteristic values for dimensionless parameters are far outside their conventional ranges. Reynolds numbers are low, typically well less than 1. Results are presented for the reaction engineering aspects of prototypical reactions in these micro-reactors. Two situations are considered: a first order reaction occurring in a specified reaction zone and a second order reaction between initially unmixed components.

A continuous gradient model is developed to study two-phase flow of miscible components in micro-channels. This technique combines a single version of the Navier-Stokes equations for flow to the modified Cahn-Hilliard equation for nonlinear diffusion. A body force based on gradient energy provides the coupling between two sets of equations. Composition and velocity profiles are easily calculated at far downstream locations, including the case where the viscosity is a function of composition. An entrance length problem of a single phase fluid, phase separating under the influence of temperature is studied using the continuous gradient model in a torus geometry. The method of false transients used in this work is robust, relatively fast and applicable to a broad class of equilibrium and steady state problems.