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The order of micromixing and segregation effects on the biological growth process in a stirred-tank reactor

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Abstract

Depending on the hydrodynamic conditions, a stirred tank reactor may be divided into two micromixing environments: maximum mixing followed by complete segregation (case 1), or vice versa (case 2). The Ng–Rippin two-environment model simulates case 1, whereas the Fan reversed two-environment model covers case 2. The micromixing concepts of Danckwerts and of Zwietering have been applied to both models in terms of the degree of segregation J to evaluate the influence of the order of micromixing–segregation effects on biological growth processes. The model predictions for both endogeneous and exogeneous cell metabolism show that case 2 gives more substrate conversion and cell production than does case 1, for the same extent of micromixing, particularly at low dilution rates. At high dilution rates, both models predict the same reactor performance, independent of the micromixing phenomenon. The substrate conversion and cell production decrease with increasing dilution rate, following a similar trend. Further, the effects of micromixing are found to be strong functions of dilution rate. At high dilution rates for case 2, the micromixing effects are pronounced only when the reactor approaches complete segregation. However, for case 1, the effects are appreciable when the reactor deviates slightly from perfect mixing. For some intermediate dilution rates, the Fan model, unlike the Ng–Rippin model, shows that the reactor output decreases linearly with increasing degree of segregation. Beyond a critical value of the dilution rate, the reactor output falls linearly with dilution rate for exogeneous cell metabolism (case 2). On the contrary, for case 1, the output decreases exponentially throughout the entire range of dilution rates.