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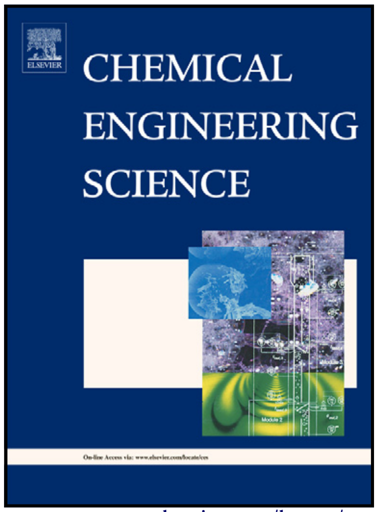

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Effect of the irreversible A+B →C reaction on the onset and the growth of the buoyancy-driven instability in a porous medium

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Abstract

The effect of irreversible $\mathrm{A+B \rightarrow C}$ reaction on the growth of a buoyancy-driven instability is analyzed theoretically. For the limiting cases of infinitely fast and infinitely slow reaction, new linear stability equations are derived without the quasi-steady state assumption (QSSA) and solved analytically and numerically. The main parameters to explain the present system are the Damköhler number and the dimensionless density difference of chemical species. The present initial grow rate analysis without QSSA shows that the system is initially unconditionally stable regardless of the parameter values of G_A, G_B and G_C, however the previous initial growth rate analysis based on the QSSA predicted the system is unstable if $G_A > G_B$ [14]. For time evolving cases, the present growth rates obtained from the spectral analysis and pseudo-spectral method support each other, but quite different from that obtained under the conventional QSSA. Chemical reaction can induce the fingering instability in the physically stable system, and accelerate the growth of instabilities in the physically unstable ones. According to the present analysis without QSSA, even for the physically unstable system, $G_A > G_B$, there exists a critical time below which the system is unconditionally stable and therefore, convective motions cannot be expected. Linear stability analysis is confirmed by the nonlinear direct numerical simulations.

Keywords: Density driven fingering, irreversible reaction, linear stability analysis, spectral analysis, direct numerical simulation.

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