

Reaction fronts with arbitrary Damkohler numbers

Aditya Bandopadhyay, Yves Méheust, and Tanguy Le Borgne

*Université de Rennes 1, CNRS, Géosciences Rennes UMR 6118, 35042 Rennes, France
(adityabandopadhyay@gmail.com)*

Reaction fronts where two reactive fluids interact with one another play an important role in a range of applications, including contaminant plume transport and reaction, soil and aquifer remediation, CO₂ sequestration, geothermal dipoles and the development of hotspots of reaction in mixing zones. The background flow induces enhanced mixing due to stretching of material lines, and therefore reaction, through interfacial shear. Hence the coupling of fluid flow with chemical reactions is pivotal in understanding and quantifying effective reaction kinetics in reaction fronts. While this problem has been addressed in the limit of fast reactions, in natural systems reactions can span a large range of Damköhler numbers since their characteristic reaction times vary over a large range of typical values. Here the coupling of shear flow and reversible chemical reactions is studied for a reaction front with initially separated reactants at arbitrary Damköhler numbers. Approximate analytical expressions for the global production rate are derived based on a reactive lamella approach. We observe three distinct regimes, each of them characterized by different scalings of the global production rate and width of the reactive zone. We describe the dependency of these scalings and the associated characteristic transition times as a function of Damköhler and Péclet numbers. The study is expected to shed light on the inherently complex cases of reactive mixing with varying reaction rates under the influence of an imposed flow.