71j Mass Transfer and Separation of Species in Oscillating Flows with a Wavy-Walled Boundary: an Analytical Study

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Oscillating flows have shown to greatly increase the mass transfer of dilute species over that due to pure molecular diffusion. Previous studies have also demonstrated that if two dilute species are present in a carrier, the rate at which each species travels down a tube varies depending on the frequency of flow oscillation. Therefore, because the species transfer rates are different, a mechanical separation is then possible. The separation and relative mass transfer are dependant on the oscillating flow field, so changing the geometry of the system so that it alters the flow field will then change the mass transfer and separation. This work examines the mass transfer and separation that is possible in a two-dimensional geometry with oscillating plates that have periodic recesses placed upon them. This is an analytical study that uses perturbation methods to re-map a system about a base case of a flat plate to that of a wavy-walled boundary. The velocity and concentration profiles can then be solved for a wavy-walled configuration based on results from the case of a flat plate. Ultimately, the flow field and the mass transfer of species down the plates can then be determined. Results show that the wavy-walled boundary causes the flow to produce regions of recirculations within the recesses of the boundary that inhibit the transport of species along the plates as species become trapped in these regions. When analyzing the relative transport between two different dilute species present in a carrier, the wavy-wall geometry favors the faster diffusing species when compared to a flat wall boundary. A large separation between the two species is then possible so that a system can be designed to give a high throughput with a high separation.