Abstract Submitted
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Impact of internal transport on the convective mass transfer from a droplet into a submerging falling film[1] JULIEN R. LANDEL, DAMTP, University of Cambridge, AMALIA THOMAS, UNCPBA, HARRY MCEVOY, DSTL, UK, STUART B. DALZIEL, DAMTP, University of Cambridge — We investigate the convective mass transfer of dilute passive tracers contained in small viscous drops into a submerging falling film. This problem has applications in industrial cleaning, domestic dishwashers, and decontamination of hazardous material. The film Peclet number is very high, whereas the drop Peclet number varies from 0.1 to 1. The characteristic transport time in the drop is much larger than in the film. We model the mass transfer using an analogy with Newton's law of cooling. This empirical model is supported by an analytical model solving the quasi-steady two-dimensional advection-diffusion equation in the film that is coupled with a time-dependent one-dimensional diffusion equation in the drop. We find excellent agreement between our experimental data and the two models, which predict an exponential decrease in time of the drop concentration. The transport characteristic time is related to the drop diffusion time scale, as diffusion within the drop is the limiting process. Our theoretical model not only predicts the well-known relationship between the Sherwood number and the external Reynolds number in the case of a well-mixed drop $\mathrm{Sh} \sim \mathrm{Re}^{1/3}$, it also predicts a correction in the case of a non-uniform drop concentration. The correction depends on Re, the film Schmidt number, the drop aspect ratio and the diffusivity ratio between the two phases. This prediction is in good agreement with experimental data.

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