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Predicting polydisperse granular segregation

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ABSTRACT

Most granular materials in industrial applications and natural settings are size-polydisperse, but most models and simulations of segregation consider only bidisperse particle distributions. Here, we extend our recently developed theoretical advection–diffusion–segregation model to polydisperse particle distributions. To test the theoretical approach, we model and simulate grains log-normally distributed by size in a chute flow. In steady state, material near the free surface is dominated by large particles, whereas the lower regions are composed of mostly small particles. The segregation pattern depends on a single dimensionless control parameter, which is a function of the particle sizes, the diffusion coefficient, the shear rate, and the flowing layer depth. Interestingly, for all values of the control parameter, the overall log normal particle size distribution is approximately maintained at each spatial location, but with different mean and variance than the overall particle distribution. To confirm the theoretical results, we use discrete element method (DEM) simulations using a general purpose graphics processing unit. Quantitative agreement is found between theory and DEM simulations. Funded by the Dow Chemical Company.