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Flow Dynamics on the Reconstitution of Lyophilized Products
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Due to stability concern, pharmaceuticals are often freeze-dried before shipping and storage. When needed, sterile water can be injected into the vial to reconstitute the medication. Finding an optimal reconstitution condition for dissolving lyophilized pharmaceutical products is difficult without basic understanding of the relevant fluid dynamics and multiphase mass transfer phenomena. The reconstitution efficiency strongly depends on the normal and shear motions in the solution. The right combination of vial size, shaking pattern, and the amount of solvent would enhance the dissolution rate and reduce the clump formation during the reconstitution process. Here we present the theoretical analysis of shaking pattern in terms of cylindrical traveling and resonant free surface waves under the small-amplitude assumption, and compare the results with direct simulation that can be extended to nonlinear and large-amplitude regimes. The analysis and experimental validation are used to predict a range of pharmaceutical dissolution conditions.

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