Sedimentation of a single soluble particle

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In this study, we investigate the dissolution and sedimentation process of individual soluble particles. We chose butyramide as the solute because it does not change the density of the surrounding water when it dissolves [1]. The particles sediment in a small tank with a two-layer fluid, where the upper layer is a saturated butyramide solution and the lower layer is a low concentration NaCl solution, as shown in Fig.1(a). To ensure optimal resolution in detecting particles during the dissolution process, we designed a particle tracking system that moves the camera vertically using a stepper motor with real-time feedback to maintain camera aligned with the particle position. This setup allows for high magnification of particles and detailed observation of the dissolution process, as shown in Fig.1(b). Our experiments were conducted under the conditions of small particle Reynolds number and large Péclet number.

Through theoretical derivation, we found that the radius reduction rate of a particle during dissolution depends only on the characteristics of the salt and the solution, and is thus constant over time. From experiments, we obtained the reduction rate of a particle directly from the shrinking of its radius (Fig.1(b)) and from its sedimentation dynamics. Both estimates of the reduction rate give consistent results, similar to the theoretical prediction.

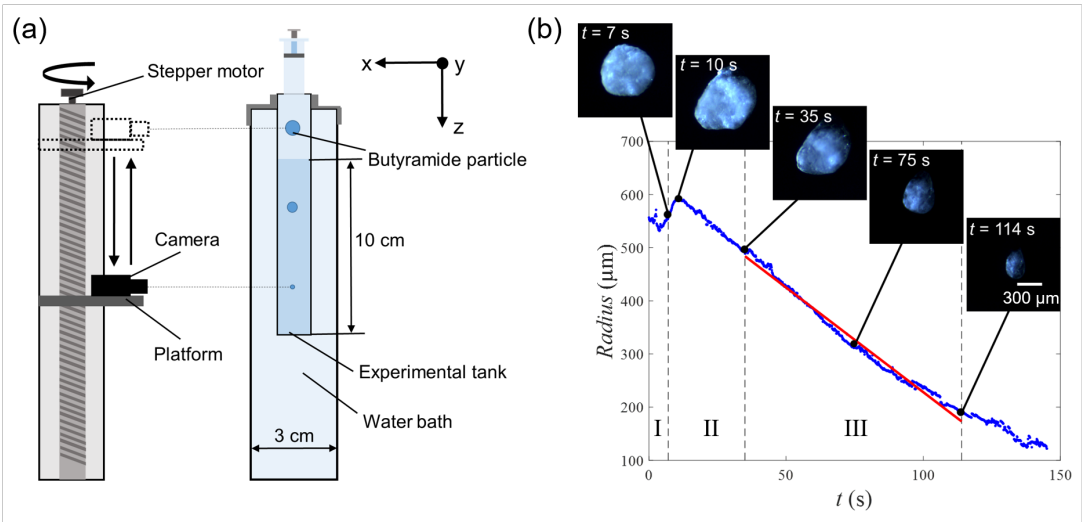

Figure 1. (a) Schematic diagram of the experimental setup; (b) Radius of the particle versus time. The blue points represent the equivalent radius from the projection of the particle, and the red line is a linear fit. Regime I corresponds to the saturated butyramide solution. Regime II corresponds to the intermediate transition of two layers. Regime III corresponds to the low concentration NaCl solution.

Références

1. Y. Cui, Experimental investigation of plumes of soluble particles. Ph.D. thesis, Sorbonne Université (2022).