Sedimentation of a single soluble particle at low Reynolds and high Péclet numbers

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We investigate experimentally the dissolution of an almost spherical butyramide particle during its sedimentation, in the low Reynolds high Péclet regime. The particle sediments in a quiescent aqueous solution, and its shape and position are measured simultaneously by a camera attached to a translation stage, as shown in Fig.1(a). The particle is tracked in real time, and the translation stage moves accordingly to keep the particle in the field of the camera. The measurements from the particle image show that the radius shrinking rate is constant with time, as shown in Fig.1(b), and independent of the initial radius of the particle. We explain this with a simple model, based on the sedimentation law in the Stokes' regime and the mass transfer rate at low Reynolds and high Péclet numbers. The theoretical and experimental results are consistent within 20%. We introduce two correction factors to take into account the non-sphericity of the particle and the inclusions of air bubbles inside the particle, and reach quantitative agreement. With these corrections, the indirect measurement of the radius shrinking rate deduced from the position measurement is also in agreement with the model. We discuss other correction factors, and explain why there are negligible in the present experiment. We also compute the effective Sherwood number as a function of an effective Péclet number and show agreement with the power law $\mathrm{Pe}^{1/3}$ predicted by the theory. More information can be found in the pre-print paper [1].

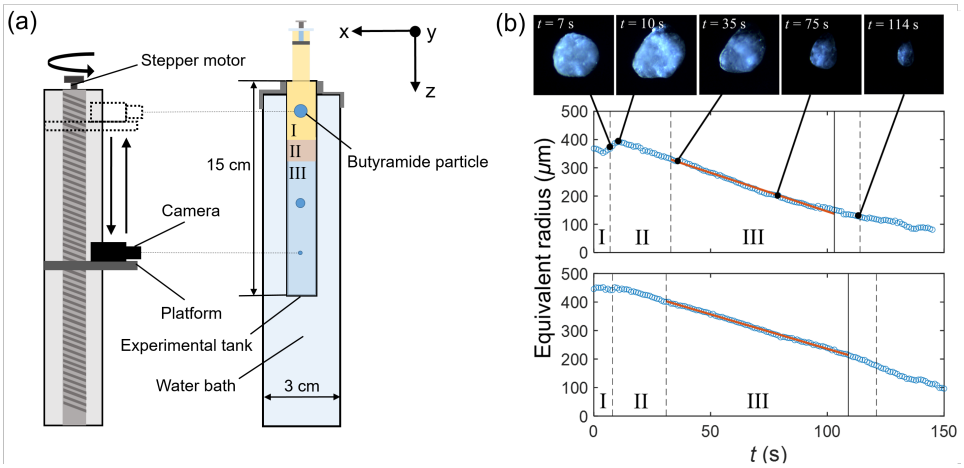

Figure 1. (a) Schematic diagram of the experimental setup ; (b) Two examples of radius of the particle versus time. The blue points represent the equivalent radius from the projection of the particle, and the red line is a linear fit. Regime I corresponds to the saturated butyramide solution. Regime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

Références

1. N. He, Y. Cui, D. Chin, et al. Sedimentation of a single soluble particle at low Reynolds and high Péclet number. ArXiv, 2310.14737V1 (2024).