Experimental investigation of 2D plumes of soluble particles

Yutong CUI, Benoît SEMIN, Phlippe CLAUDIN

PMMH, CNRS, ESPCI Paris, PSL Research University, Sorbonne Université, Université Paris Cité, F-75005, Paris, France
yutong.cui@espci.fr

In this study, several mixtures of particle and water are injected with constant injection rates at the top of a 2D water tank. We compared two types of particle plumes with similar densities : plastic beads (which are not soluble) with water, and butyramide particles (which are highly soluble in water) with its saturated solution. We chose butyramide particles because they do not change the density of the aqueous solution when they dissolve, meaning that buoyancy effects only occur due to solid particles. The injection of particles leads to the formation of a plume in the tank since the density of particles are slightly larger than the one of water.

We used light absorption to quantify particle concentration and particle image velocimetry (PIV) to measure velocity fields. As showed in Figure. 1, the average plume shape for butyramide plume is much narrower than the plastic bead plume due to dissolution. The velocity on the side, called the entrainment velocity, is almost constant for plastic bead plume, but decreases along the vertical direction for butyramide. From these measurements, we also derived the entrainment velocity as a function of the particle injection rate and analyzed the plume shape.

Our research is relevant to understand the behavior of localized rain, where water droplets evaporate while falling through the air. This process can be mimic by the dissolving of soluble chemicals in water.

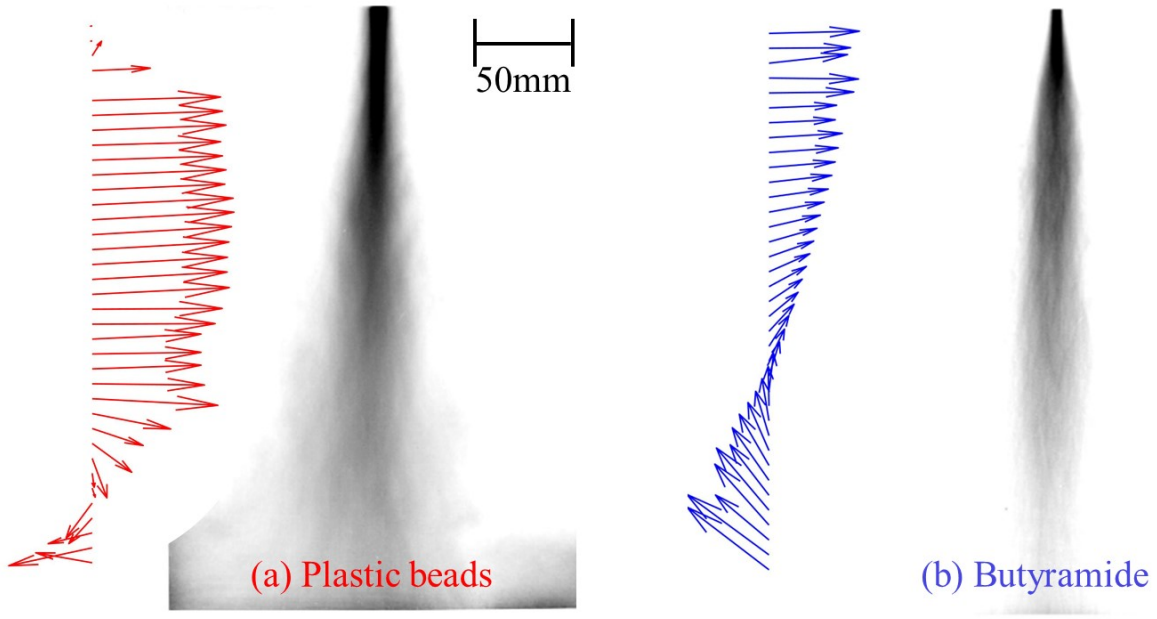

Figure 1. Comparison between plastic bead plume (red) and butyramide plume (blue) with similar injection rate, including the average image of concentration in grey level and the time-averaged velocity profile in color on the side of the plume (150 mm away from the plume middle line) . (a) Plastic bead plume, injection rate 0.59 g/s ; (b) Butyramide plume, injection rate 0.53 g/s.