The roles of droplet size and viscosity in binary droplet collisions

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Droplet collision is an important phenomenon in both natural and industrial processes. In most spray applications, e.g. spray drying, combustion engines, etc, droplets usually vary in size and viscosity. This work experimentally investigates the roles of droplet size and liquid viscosity in binary droplet collisions using 2% and 4% of hydroxypropyl methylcellulose solutions in water. Monodisperse nozzles were used to generate the droplets, while the collision events were captured using high-speed imaging techniques. The collision outcomes – namely bouncing, coalescence, reflexive separation, and stretching separation – were mapped in the parameter space of Weber number (We) and the impact parameter (offset) for the two solutions. Surprisingly, for equal-sized collisions, the regime maps are not universal in terms of scale (droplets size). The work reported here finds that reducing the size of the droplets enhances the coalescence regime by shifting the bouncing regime towards lower We, the reflexive separation regime toward higher We, and the stretching separation regime toward higher impact parameter. This is attributed to the fact that, for a given value of We, the smaller droplets have lower Reynolds number thus it is more difficult for them to achieve separation compared to the larger droplets. Moreover, due to higher capillary pressure, the small droplets have higher penetration potential through the air layer that causes the bouncing, and hence easier coalescence. Collisions of droplets with a size ratio of 0.6 shift the separation regimes even more than the small droplets collisions. This is attributed to the break in the dynamics' symmetry, which leads to more mixing and hence more viscous dissipation. Increasing the viscosity also enhances the coalescence regime by suppressing the separation regimes. Thus, in applications where the droplets are relatively small and possess high viscosity the coalescence regime is expected to dominate collision behaviour.

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