Wettability-Dependent Breakup of Thin Films Formed by Droplet Impact

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Abstract

The effect of droplet-substrate wettability on droplet splashing and breakup during impact at high velocities was studied experimentally. 0.6 mm diameter water droplets were produced by a pneumatic drop-on-demand droplet generator. High velocities of impact (V_o=10-30 m/s) were achieved by mounting the substrate on the rim of a rotating flywheel, giving impact Reynolds and Weber numbers between 6000-18000 and 800-7300, respectively. Droplet-substrate wettability was varied over a wide range, from hydrophilic to superhydrophobic conditions, by changing the material of the substrate (glass, Plexiglas, wax, and Alkylketene Dimer (AKD)). Both smooth and rough wax surfaces were tested. Photographs of impact showed that the droplets spread into a thin film at maximum extension, followed by a receding phase. However, as the impact velocity increased and film thickness decreased, films became unstable and ruptured internally through formation of holes. Furthermore, the impact velocity at which rupture occurred was found to first decrease and then increase with the liquid-solid contact angle θ: on glass (θ=47^o), rupture was observed only at the highest impact velocity, whereas on wax (θ=105^o), rupture occurred at all impact velocities tested. On the AKD surface (θ=164^o), films did not rupture until V_o=30 m/s, but showed significant splashing from edges at all V_o, especially during the receding phase. On the rough wax surfaces, extensive film rupture occurred at all impact velocities with the formation of a large number of holes. The above results suggest that during high velocity impact, internal rupture through formation of holes may be the dominant mechanism preventing droplets from complete deposition on a solid surface.

Key words: Impact, wetting, thin film rupture, wettability

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