International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

Shock-induced Breakup and Combustion of Liquid Dodecane Droplets

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Practical detonation-based propulsion devices, such as rotating detonation engines, must be able to leverage the higher energy densities of liquid fuels. For these fuels to support stable detonation propagation, fuel droplets must atomize, evaporate, mix, and react with surrounding oxidizer prior to reaching the sonic plane of the detonation. As such, the time scales associated with shock-induced droplet breakup and subsequent combustion processes are of paramount importance. To examine these processes in greater detail than is typically feasible with experimental diagnostics, this work presents two-dimensional numerical simulations of liquid dodecane droplets interacting with shock waves traveling at detonation-relevant speeds. Adaptive mesh refinement is utilized in a volume of fluid solution framework to highly resolve droplet surface instabilities, secondary atomization and evaporation, and subsequent reaction dynamics. The results will detail the breakup timescales and secondary droplet size distributions, making comparisons to existing literature for comparable non-reacting configurations. Furthermore, the reaction timescales and combustion efficiency will be discussed, potentially providing insight into the structural differences observed in liquid-fueled detonations relative to their gaseous counterparts.