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Numerical and optical investigation of flash boiling of highly volatile e-fuel microdroplets in a monodisperse stream

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To reduce the greenhouse gas and pollutant emissions, ‘e-fuels’ produced from renewable electricity and carbon sources can be a major form of energy for the transportation sector in the foreseeable future. Highly volatile e-fuels, such as short-chain oxymethylene ethers (OME_x), have already emerged as a promising alternative to conventional fossil fuels due to their almost soot-free combustion characteristics. Furthermore, they have the potential to improve the mixture formation and the subsequent combustion. However, due to their high volatility, these e-fuels undergo a rapid phase change when injected into an environment where their vapor pressure is higher than the surrounding gas pressure. In this study, the flash boiling phenomena of dimethoxymethane (OME_1) have been investigated numerically and experimentally for various degrees of superheat to unravel the effect of flashing phenomenon on evaporation of highly volatile fuel droplets. A three-dimensional (3D) two-way coupled Lagrangian-Eulerian framework is used to simulate the flash vaporization of microdroplets. Whereas existing single droplet flash vaporization models in the literature do not account for non-equilibrium thermodynamics in the superheated regime, we develop a quasi-steady one-dimensional (1D) model that incorporates the effect of non-equilibrium thermodynamics through the definition of vapor mole fraction at the droplet surface [1]. The simulation results are compared in terms of droplet diameter with the experimental data from high-magnification backlit imaging of a microdroplet stream under superheated conditions.

REFERENCES

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