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A multi-component droplet vaporization model for non-ideal fluids

Authors

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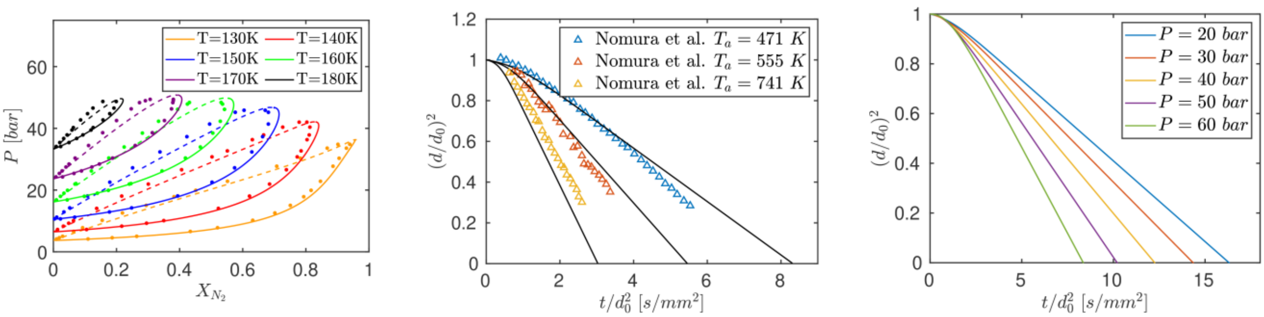
Abstract

The vaporization of multi-component liquid droplets into a gaseous environment is a phenomenon of relevance in many chemical aerospace propulsion systems such as liquid-rocket-engines and gas-tune jet engines. In recent years, it has been the subject of various experimental, theoretical, and numerical studies [1-5]. In real applications, the injected liquid droplets are inhomogeneous mixtures with many different components, implying complex vaporization behaviors, w.r.t to single species droplets, which are triggered by the influence of different volatilities on the evaporation rate of each component. The Raoult's law is typically used to compute the thermodynamic equilibrium at the liquid-gas interface. However, for non-ideal mixtures, and at high-pressure conditions, Raoult's law is no longer applicable [3,6,7]. In the present work, the non-ideal droplet vaporization is addressed in the context of a 0-dimensional Infinite-Thermal-Conductivity (ITC) model. Two methods are used to compute the thermodynamic condition at the gas-liquid interface namely the Universal-Functional-Activity-Coefficient (UNIFAC) [7] method and the concept of Vapor-Liquid-Equilibrium (VLE) with an Equation-of-State (EoS) [6]. The former is a correction of the Raoult's law while the latter impose the equality of the chemical potential for each component in both liquid and gaseous phase. Moreover, the non-ideal effects at high-pressure conditions are assessed by comparing the results in terms of droplet lifetime using ideal and real-fluid EoS. The following figures display preliminary results in terms of VLE solver validation for a Methane-Nitrogen binary mixture (left panel); comparison w.r.t Nomura et al. [1] experimental measurements of the temporal variation of the normalized droplet radius for a a single Heptane droplet (center panel); temporal variation of the normalized droplet radius for a LOx droplet in Methane environment at different pressures (right panel).



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