

## Abstract

The atomization of blended liquid droplets with biofuels as the additives has the potential to reduce the harmful pollutant emissions as well as increase the combustion efficiency. Since droplets form the sub-grid level component of a spray, it is of utmost significance to understand the physical mechanisms responsible for the atomization in such blended droplets during their combustion. In this dissertation, the sequence of events associated with the breakup phenomena in burning multi-component droplets comprising components with large volatility differential is studied using time-resolved high-speed imaging. The droplets consist of alcohols as the higher volatile components while jet fuel and tetradecane are chosen as the lower volatile components. The occurrence of physical processes such as nucleation, bubble growth, and bubble breakup are studied in detail. It is shown that along with bubble growth via micro-bubble coalescence; vapor growth also occurs through the merging of large bubbles due to an increase in the rate of bubble nucleation in the droplet. For the blended droplets with a relatively low volatility difference between the components, only bubble expansion contributes to the breakup. In contrast, for blends with high volatility differential, both bubble growth, as well as the Rayleigh-Taylor (RT) type of instability at the interface, contribute towards droplet breakup. After the inception of RT instability, capillary wave propagation is also witnessed on the droplet surface. The breakup of the vapor bubble results in the creation of ligament that subsequently undergoes pinch-off into one or more secondary droplets depending on its aspect ratio. The ligament pinch-off mechanisms are observed to govern the diameter and velocity of secondary droplets along with succeeding volumetric shape oscillations in the parent droplet. The observation of a crown-like sheet expansion and its subsequent atomization is also studied in burning fuel droplets with significant volatility differential (ethanol/tetradecane). The breakup of high-pressure vapor bubble results in the formation of radially expanding crown-like hemispherical sheet. The expansion of the liquid sheet and the development of radial ligaments on its destabilized rim results in the creation of several secondary droplets.

**Keywords:** Multi-component droplets; Bubble breakup; Ligament breakup; Plateau-Rayleigh instability; Rayleigh-Taylor instability; Crown formation.