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Image analysis of heating behavior of emulsion droplets under high temperature environment

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Abstract

An experimental study was conducted to investigate the behaviors of the emulsions of 30% hydrogen peroxide solution blended with pure diesel when they were exposed to hot environments. The mixing ratios of hydrogen peroxide in the blends were 10%, 20% and 30% and the preparing time for the blends was 40 minutes in total. These two immiscible liquids were fully emulsified by a mixing system, and then the droplet size of the dispersed phase (hydrogen peroxide) in the emulsified fuel was observed and analyzed using an optical microscope. Afterwards, the heating behaviors of emulsion droplets at high temperature environments of 300 oC, 400 oC and 500 oC were carried out by simultaneously measuring the droplet temperature with a K-type thermocouple and recording the images with a high speed camera during the heating process. Finally, the behaviors including evaporation, expansion, puffing and micro-explosion for the emulsion droplets at high temperature environments were explored. The results showed that the emulsions with 20% hydrogen peroxide have the smallest droplets and a more uniform droplet size distribution. For pure diesel droplet, its diameter decreases nearly linearly with heating time, and the higher ambient temperature results in the larger evaporation slope and the shorter complete evaporation time. These characteristics agree well with d2-law. For the hydrogen peroxide /diesel emulsified droplet, the higher ambient temperature will result in earlier occurrence of expansion and micro-explosion. In addition, the droplet with a higher content of hydrogen peroxide will cause stronger expansion, puffing or micro-explosion.

Tables and figures

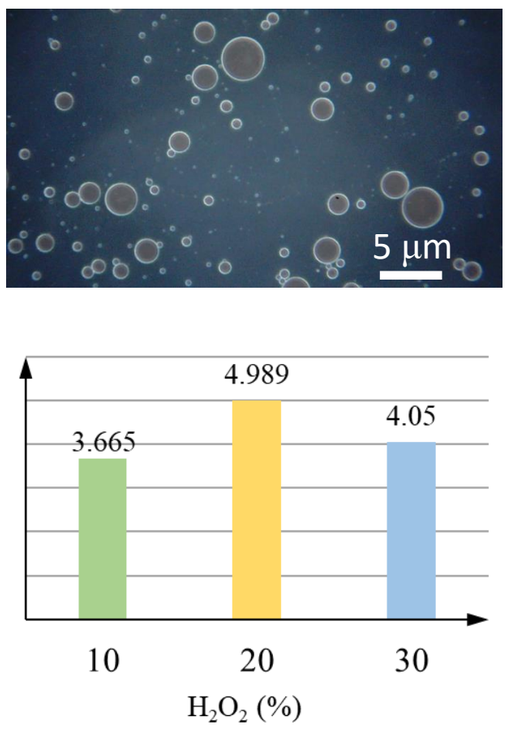

Figure 1. (a) OM images of a hydrogen peroxide/diesel mixture containing 30% hydrogen peroxide at a zoom factor of 380 and (b) Average diameter of hydrogen peroxide droplet for various H_2O_2 blending ratios.

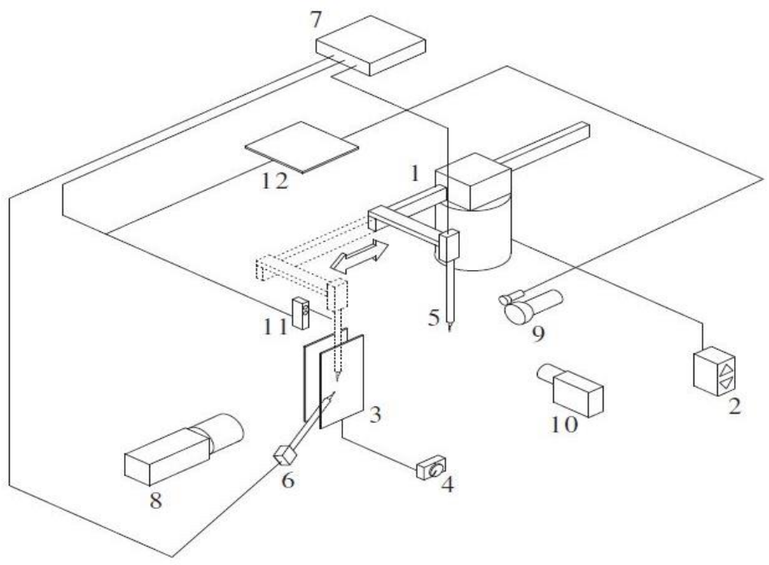

Figure 2. Experimental system for a suspended droplet in a hot environment.

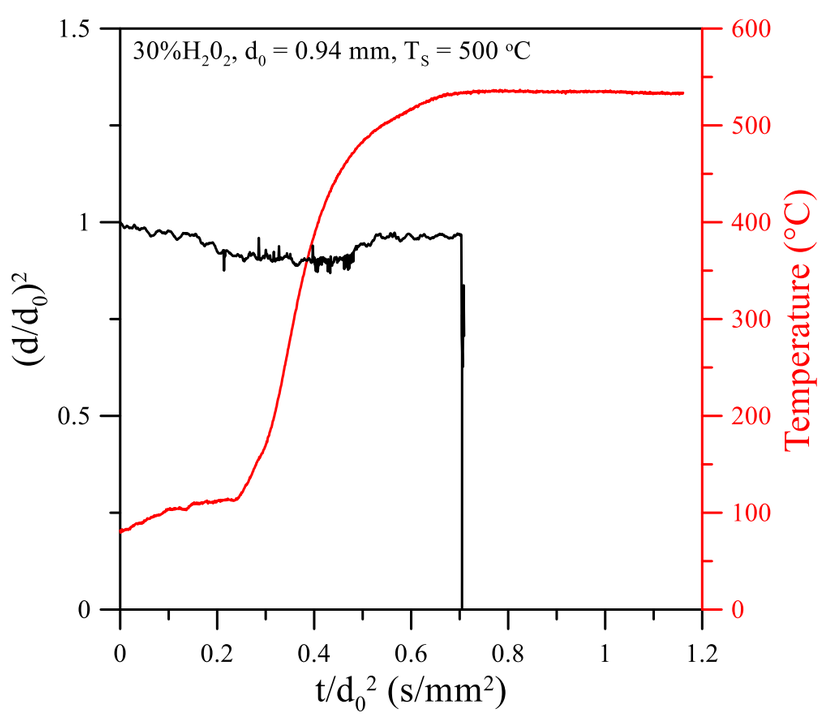

Figure 3(a). $(d/d_0)^2$ vs t/d_0^2 and temperature vs t/d_0^2 for an emulsion droplet (d_0 = 0.94 mm, 30% hydrogen peroxide content) at T_S = 500 °C.

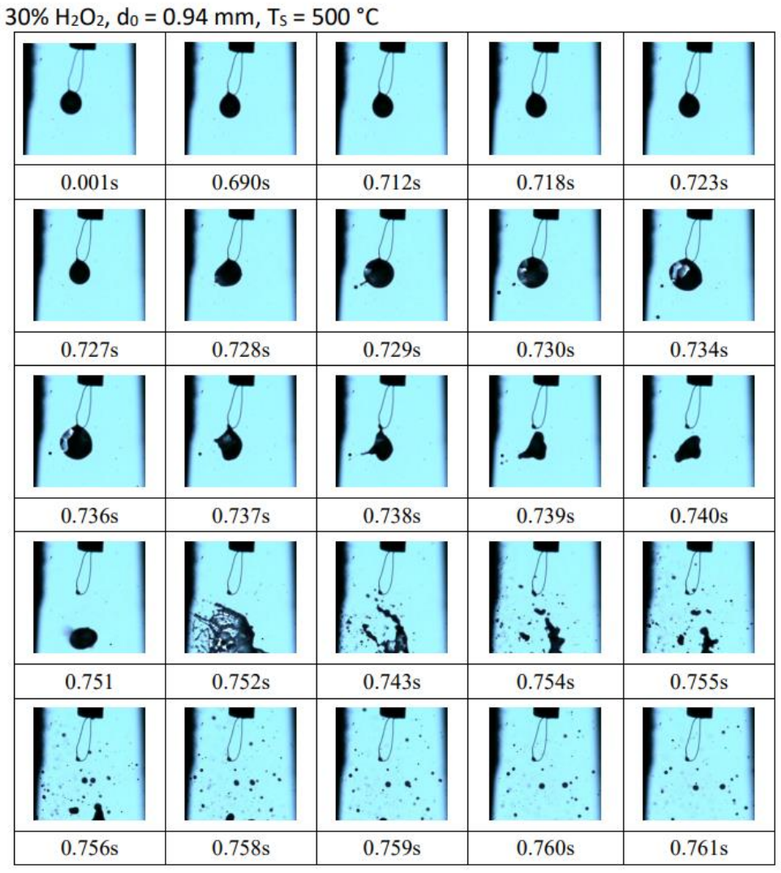

Figure 3(b). Droplet shape image versus heating time for an emulsion droplet (d_0 = 0.94 mm, 30% hydrogen peroxide content) at T_S = 500 °C.

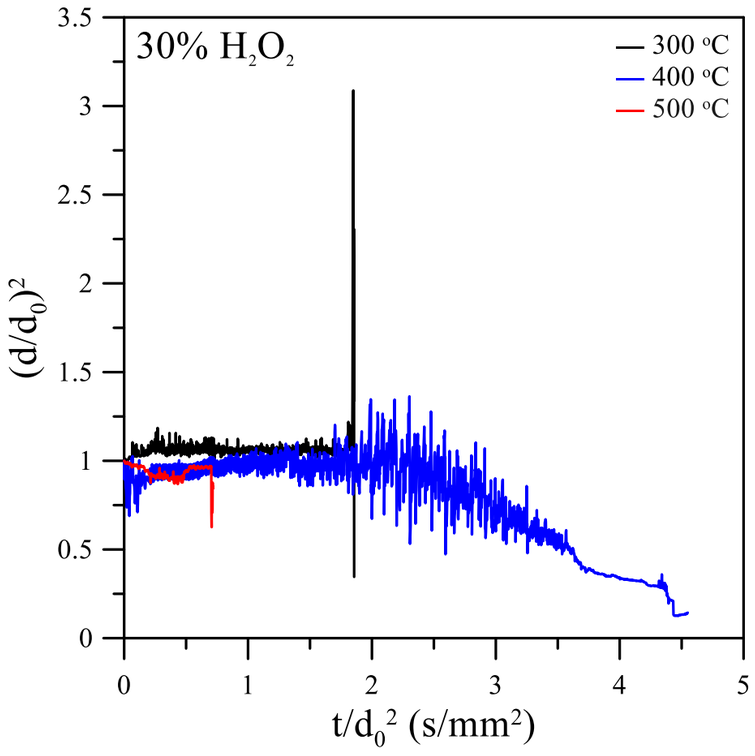

Figure 4(a). $(d/d_0)^2$ vs t/d_0^2 for the emulsion containing 30% hydrogen peroxide content under various environment temperatures (300 °C, 400 °C, 500 °C).

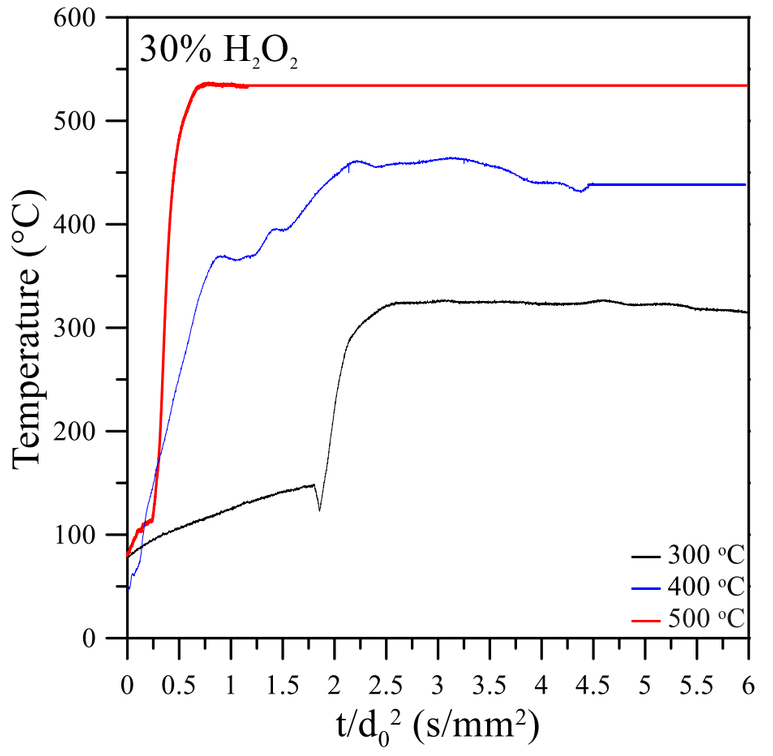

Figure 4(b). Temperature vs t/d_0^2 for the emulsion containing 30% hydrogen peroxide content under various environment temperatures (300 °C, 400 °C, 500 °C).