

Soot Formation in Butanol Isomer Diffusion Flames

Pradeep Singh, Xin Hui, and Chih-Jen Sung*
Department of Mechanical Engineering
University of Connecticut

ABSTRACT

Harnessing energy to meet the current demand through conventional means is limited to the availability of the conventional fossil-based fuels. In addition, combustion of conventional fuels creates relatively more potential health and environmental concerns caused by particulate or soot emissions. Ethanol is one such bio-fuel currently used as a gasoline additive and it has been studied extensively for sooting propensity. However, ethanol has low energy density, high vapor pressure and is hydroscopic in nature, due to which it is difficult to transport.

n-Butanol and its isomers, namely iso-butanol, sec-butanol, and tert-butanol, are high in energy density, relatively low in vapor pressure, and immiscible in water. Due to those benefits, these fuels are easy to transport. These fuels potentially can meet demands for alternative fuels. Tert-butanol is a petroleum-derived product and is currently used as an octane enhancer in gasoline. Biological production pathways have been identified for n-, iso-, and sec-butanol.

In terms of sooting propensity, these butanol isomers have not been well studied. Few mechanisms have been developed to be able to predict the soot formation for bio-fuels. Experimental data on soot volume fraction in counterflow diffusion flames could be valuable to understand the soot formation chemical kinetics of these fuels.

Laser Induced Incandescence (LII), is an *in-situ* non-intrusive measurement technique and has become a preferred method for determining soot volume fraction because of its capability to provide temporally and spatially resolved measurements. LII in conjunction with Laser Extinction as a calibration technique can provide quantitative information of soot volume fraction in various combustion environments.

Maximum soot volume fraction measured along the centerline of the flame can provide a basis for comparison of alternative fuels with conventional fuels. A systematic comparative study of sooting propensity of butanol isomers and butane isomers would reveal structural effects in the presence of hydroxyl (-OH) group. The individual effects of peak flame temperature, flow straining, and fuel mole fraction on soot formation will be investigated. Earlier studies on oxygenated fuels suggest that these fuels tend to have less sooting propensity compared to the same C-number alkane counterparts, as stronger C-O bonds inhibit the production of ring structure that are one of the soot precursors in the initial stages of combustion. Recognizing that the presence of oxygen in fuel structure is expected to affect soot nucleation to soot growth in these flames and also soot investigation on butanols is meager, the objectives of this study are to acquire new diffusion flame sooting data for those fuels under varying conditions. These data can not only provide a better understanding of soot formation in these bio-fuel flames, but also can be used for the development and validation of soot models.

* Corresponding Author, cjsung@engr.uconn.edu.