Toluene PLIF

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Overview

In addition to ketones, aromatics also are good candidates for fluorescing tracers. In particular, toluene is a natural constituent of many fuels, making it even more fuel-like than 3-pentanone. Moreover, toluene absorbs at 248 and 266 nm, making it readily accessible to high powered lasers, and it generates a higher fluorescence signal than 3-pentanone under some conditions. Unlike 3-pentanone, however, toluene's fluorescence signal is highly dependent on oxygen concentration, making it possible to use toluene as an indicator of fuel-air ratio.

In order to further understand toluene fluorescence, measurements of fluorescence signal as a function of temperature were undertaken. The fluorescence quantum yield decreases with increasing temperature for both 248 and 266 nm excitation. In addition, the shape of the fluorescence spectrum changes with temperature, as indicated in the figure below on the left. The ratio of the integrated signal in the grey areas of the figure, which are regions of the fluorescence spectrum passed by the BP280 and WG535 filters, is an approximately linear function with temperature, as shown in the figure below and to the right. This relationship makes it possible to use a single wavelength excitation and two cameras capturing different portions of the spectrum to make temperature measurements, significantly reducing equipment requirements.

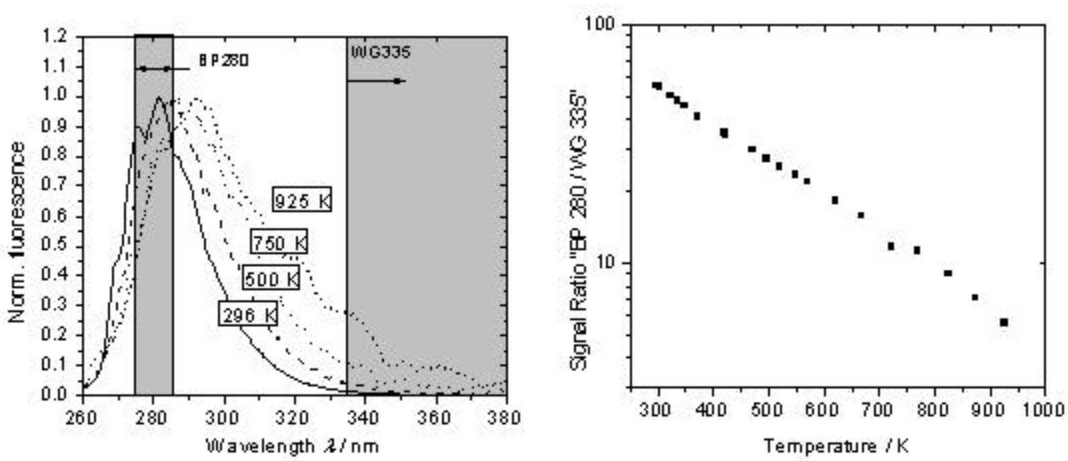

Figure 1: Measurements of fluorescence signal as a function of temperature

Measurements of oxygen quenching on fluorescence signal were also undertaken. Ideally, toluene fluorescence signal should be inversely proportional to the oxygen concentration, which is known as Stern-Volmer behavior. However, measurements indicate that this is not the case for 248 nm excitation, and that this behavior is only true below about 500 K for 266 nm excitation. These results are indicated in the figures below, where the straight lines indicate Stern-Volmer behavior, and the points is the actual fluorescence behavior. Furthermore, the proportionality constant between inverse signal and oxygen concentration is a function of temperature, and thus, for non-isothermal systems, measurements of fuel-air ratio can be somewhat complicated. However, efforts are underway to model the behavior of toluene fluorescence with varying temperature and varying oxygen concentration, allowing toluene to still be a useful tracer in measuring fuel-air ratios.

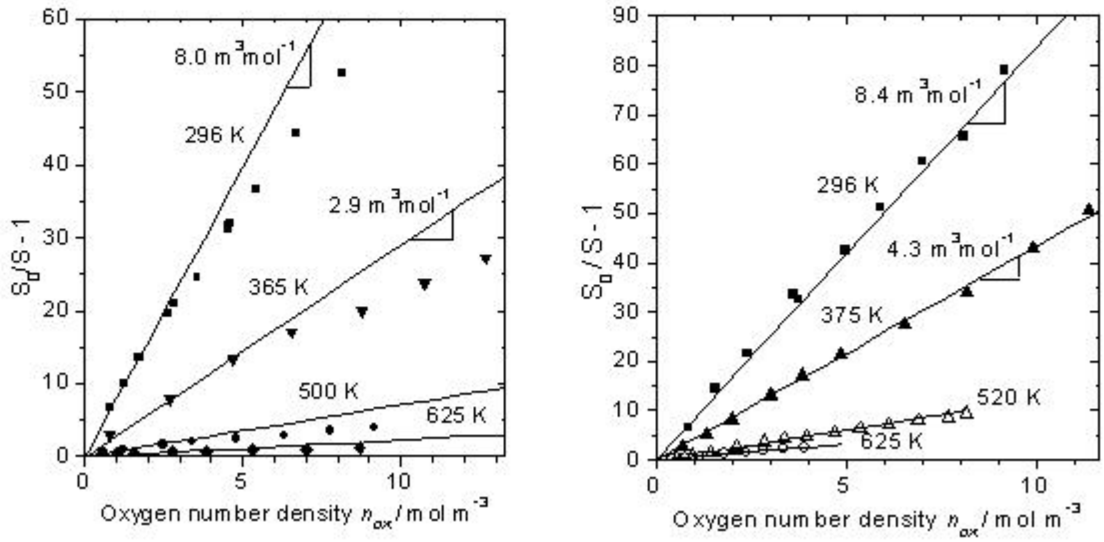

Figure 2: Measurements of oxygen quenching on fluorescence signal

References

1. Koban W, Koch J., Sick V., Wermuth N., Hanson R., Schulz, C. "Predicting LIF signal strength for toluene and 3-pentanone under engine-related temperature and pressure conditions." submitted to 30th International Symposium on Combustion.
2. Koban W., Koch J., Hanson R., Schulz C. "Absorption and fluorescence of toluene at elevated temperatures." Phys Chem Chem Phys in press.
3. Koban W., Koch J., Hanson R., Schulz C. "Oxygen quenching of toluene fluorescence at elevated temperatures: non-constant Stern-Volmer factors and implications for combustion diagnostics." submitted to Applied Physics B.