

Chapter 11

Summary and Recommendations for Future Work

11.1 Summary

11.1.1 Understanding chemiluminescence formation

The study showed that the formation of OH* chemiluminescence is better modeled by a reaction between HCO and atomic oxygen. The proposed formation mechanism does not contradict the experimental evidence thought to support the old formation path via CH and molecular oxygen.

CH* chemiluminescence formation and consumption was found to be difficult to model due to the lack of a complete and accurate quenching model for the molecule. The trial and error method used to arrive at the final quenching model used in modeling calculations underlined the importance of temperature in the quenching process of CH*.

11.1.2 Dependence of chemiluminescence on other flame parameters

The study showed the dependence of chemiluminescence on major flame parameters such as flow-rate and equivalence ratio. With the help of modeling calculations, the experimental measurements were able to be interpreted in terms of other secondary flame parameters such as heat-loss.

The study confirmed the existence of a wake above the Bunsen type flame tip, as shown by Poinso et al. (1992). The experimental data was able to show not only the burning deficiency in the center of the flame but also the fuel deficiency predicted by Poinso et al. (1992).

11.1.3 Quantitative modeling of chemiluminescence

The study showed that quantitative modeling for OH* chemiluminescence is possible. Both a semi-empirical model for a Bunsen type flame and a detailed 1-D model for a honeycomb burner flat flame were developed. Both models were successful in predicting OH* chemiluminescence emission. CH* chemiluminescence emission was not predicted well for the 1-D honeycomb burner model but was predicted with reasonable accuracy for the Bunsen type burner flame.

11.1.4 Measurement applications

The application of chemiluminescence light emissions in the measurement of heat-release rate was scrutinized using the detailed information available from the chemiluminescence model output. The calculations showed that OH* chemiluminescence is a superior indicator of heat-release rate compared to CH* chemiluminescence due to the high equivalence ratio sensitivity of CH* chemiluminescence.

The quantitative interpretation of chemiluminescence in terms of heat-release rate is difficult when a wide range of equivalence ratios is considered. For constant equivalence ratio, chemiluminescence is a linear function of flow-rate. When variations in equivalence ratio are considered, the excessive sensitivity of chemilumines-

cence to equivalence ratio, renders the functional relationship less transparent. For dynamic measurements, the time-derivative of OH* chemiluminescence can be related to the time-derivative of heat-release rate by a single proportionality coefficient. The proportionality coefficient is not a significant function of equivalence ratio, except at very lean equivalence ratios. Care must be taken in this regime to obtain the correct interpretation of the measured OH* signal. The proportionality coefficient between the time-derivative of heat-release rate and CH* chemiluminescence is a significant function of equivalence ratio over a wide range of equivalence ratios and interpretation of CH* chemiluminescence dynamics in terms of heat-release rate should be made very carefully. For both OH* and CH* chemiluminescence, the proportionality coefficient increases as the equivalence ratio decreases.

The higher equivalence ratio sensitivity of CH* chemiluminescence can be exploited to obtain a measure of equivalence ratio. Based on the present study, an excellent indicator of equivalence ratio is given by the ratio of OH* to CH* chemiluminescence. The measurement of CH* chemiluminescence must be verified to be free of contamination from background radiation.

11.2 Recommendations for future work

11.2.1 Unsteady measurements and modeling

The most important extension of the present work is to make both measurements and modeling calculations in unsteady combustion environments. Such measurements and calculations are required to provide a more solid foundation for the acceptance of OH* chemiluminescence emission not only as an indicator of mean heat-release rate but also of time-varying heat-release rate.

11.2.2 Flame configurations

Another important step forward in the research of chemiluminescence emissions is the study of turbulent flame chemiluminescence emissions. Most industrial applica-

tions exhibit turbulent and therefore inherently unsteady combustion. With the study of turbulent flames, the light sensing setup will need to evolve to a more application-friendly design. As the design evolves, chemiluminescence measurement for less than complete experimental access will have to be validated.

11.2.3 Fuel variability

Although most industrial applications of gaseous combustion involve natural gas as the fuel, the variability in the composition of natural gas may cause significant variations in the heat-release rate sensitivity of OH^* chemiluminescence. To make OH^* chemiluminescence a viable component in industrial systems, all variable environmental factors must be studied, including natural gas composition.