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A critical evaluation of the thermal accommodation coefficient of soot determined by the laser-induced incandescence technique

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Data of several laser-induced incandescence (LII) experiments reported in the literature were re-analyzed to obtain the values of the thermal accommodation coefficient (TAC) of soot. The present analysis shows that the TAC of soot falls in a relatively narrow range between 0.23 (in N_2 and flames) and 0.45 (in Argon). Using an aggregate based low-fluence LII model, the TAC of soot in a laminar diffusion flame was found to be 0.38.

Introduction

Knowledge of TAC of carbonaceous materials is critical in the determination of primary particle diameter of soot and carbon black. Conversely, LII can be used to determine the value of TAC of soot [1-4]. Unfortunately, the reported values of TAC of soot vary over a wide range from 0.07 [1] to 1 [2].

The objective of this study is to re-analyze the experimental data reported in [1-4] for the purpose of extracting the TAC of soot.

LII Model

The LII model used in this study was that developed at NRC. The model simulates the entire temperature history of soot particles. Unless otherwise stated, the single primary particle version of the model was used in the evaluation. The heat conduction sub-model used is the Fuch's approach.

Results

The particle temperature data of the lowest fluence case shown in Fig.3 of [1] was used to extract of TAC of soot in the atmospheric pressure premixed flame. Fig. 1 shows the temperature history and the best estimate of TAC of soot is 0.23 rather than 0.07 [1].

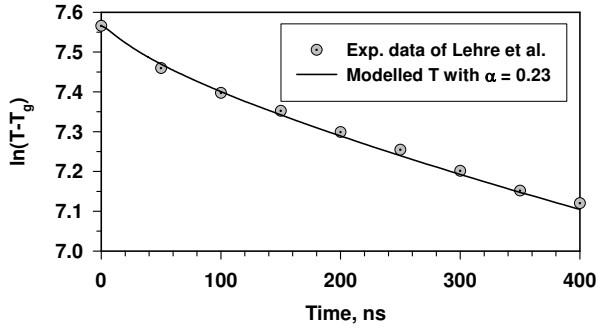

Fig. 1 Comparison of particle temperature.

The normalized LII signal shown in Fig.3 of [2] was calculated using the present LII model and the results are shown in Fig. 2. The TAC of soot in Argon was found to be 0.45, not 1 [2].

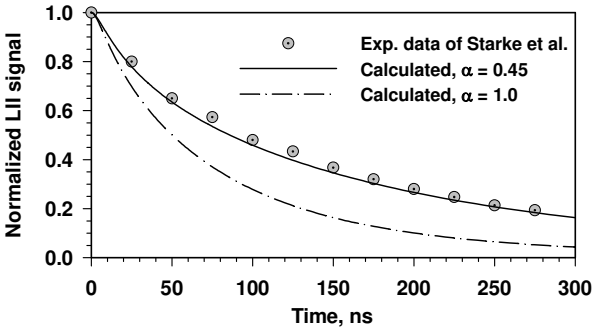

Fig. 2 Comparison of normalized LII signal.

The study of Kuhlmann et al. [4] employed high-fluence laser. The found the TAC of soot to be 0.23. High-fluence LII suffers the problem of soot sublimation which reduces the soot particle diameter. As a result, the TAC of soot is subject to large uncertainty unless the particle diameter at the end of soot sublimation is available, see Fig.3.

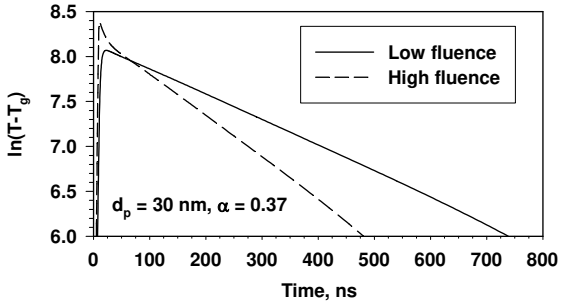

Fig. 3 Particle temperature decay: T_g = 300 K, p = 1 atm.

Application of an aggregate based low-fluence LII to the data in [3] obtained the TAC of soot of 0.38.

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