# Modeling laser-induced incandescence of coated soot by a thin layer of glycerol

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# Modeling Laser-Induced Incandescence of Coated Soot by a Thin Layer of Glycerol

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To understand the potential impact of condensed organic compound on laser-induced incandescence measurements of soot from diesel engine exhaust, an LII model developed for dry, uncoated soot particles was extended for a coated soot particle by glycerol, which acts as a surrogate of condensed matter on soot emitted from engines. The shell/core model was employed in the formulation of the energy and mass conservation equations of a coated primary soot particle. The temperature of the coated soot particle was lower than the uncoated one due to some loss of absorbed laser energy to the evaporation of the liquid coating layer.

## Introduction

Particular matter (PM) emitted from diesel engines consists of a significant amount of volatiles. Only the elemental carbon (EC) portion of the emitted PM responds to the pulsed laser heating to produce incandescence single in LII experiments. The presence of organic volatile compounds in the PM can potentially affect the laser heating of EC and the subsequent heat and mass transfer processes. Therefore, it is important to understand how the organic volatiles affect the temperature and particle size history during LII. Although the mixing state between EC and organic volatiles in PM can be quite complex, the simple shell/core model, where the EC forms a spherical core and the organic volatiles are treated as a shell enclosing the core, is still valuable to gain useful insights into the effect of organic volatiles on LII experiments conducted in diesel engine exhaust.

Almost all existing LII models were formulated for dry, uncoated soot particles. The only exception is perhaps the study of Moteki and Kondo [1], who formulated an LII model for a single spherical graphite particle based on the shell/core model.

## Theory

Under the shell/core assumption, the energy and mass conservation equations can be formulated for a spherical coated soot particle having a diameter of $d_p$, which is the core diameter $d_c$ plus twice the coating thickness $\delta$. With the shell/core model, the laser energy absorption rate of the coated soot particle can be calculated using the Mie theory as given as the BHCOAT code [2]. The coating layer was assumed to be glycerol in this study to simulate the organic volatiles in diesel engine PM, with its physical and optical properties taken from Moteki and Kondo [2].

Numerical results obtained with a laser wavelength $\lambda$ = 532 nm, $T_g$ = 400 K, p = 1 atm, $m_c$ = 1.56 + 0.57i (soot), $m_s$ = 1.474 (coating), $d_c$ = 30 nm, $\delta$ = 2 nm, and F = 1.25 mJ/mm$^2$ indicate that the temperature of the coated soot particle is lower than the uncoated one by about 150 K and the coating liquid is fully evaporated before the peak of the laser pulse. The temperatures with and without coating are compared in Fig. 1. At a higher laser fluence, the temperature difference is somewhat smaller due to the greater sublimation cooling of the uncoated soot particle.

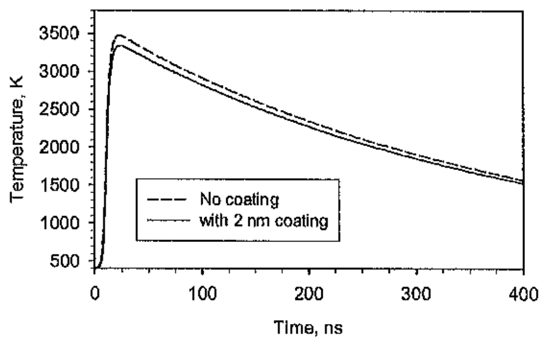


*Fig. 1 Temperature history of the soot particle in the low-fluence regime with and without a 2 nm glycerol coating.*

## References

[1] N. Moteki, Y. Kondo, Aero. Sci. Tech., 41, 398-417 (2007)..
[2] C. F. Bohren, D. R. Hoffman, Absorption and Scattering of Light by Small Particle, Wiley, 1983.

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