Impact of organic carbon on soot light absorption

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Carbonaceous nanoparticles (e.g., soot, carbon black and quantum dots), nanotubes and graphene are produced by fuel-rich combustion in aerosol and biomass reactors. The light absorption of these nanoparticles is essential for their characterization by laser induced incandescence and light extinction [1]. For example, carbon black and graphene absorb strongly light due to their similar composition of sp^2-bonded aromatics. In contrast, the optical properties of soot may differ significantly from those of carbon black and graphene [10]. This is due to the fact that light absorption of soot depends on its C/H, maturity [2], morphology [3] and organic carbon (OC) content [4]. Here, the impact of OC on the light absorption of soot is determined by discrete element modeling coupled with the discrete dipole approximation for computing the scattering of radiation by soot particles. The mass absorption cross-section (*MAC*) of soot is used widely to determine its light absorption. Typically *MAC* is obtained from the mass average refractive index of OC and elemental carbon (EC) with large C/H that make up mature soot. As such, *MAC* can be overestimated by a factor of 3 in fuel-rich flames where newly-formed young soot contains EC with small C/H and OC that predominantly scatters light reducing its absorption by soot. Here a relation for the soot refractive index is derived accounting for soot morphology, maturity and OC content through its band gap at wavelength, λ = 266 - 1064 nm. Using this relation, the *MAC* of soot containing OC (up to 50 wt%) is in excellent agreement with carbon black, graphene and soot data at λ = 300 - 840 nm. This confirms that soot morphology, maturity and OC content greatly influence light absorption during characterization of in-flame and freshly-emitted soot by laser induced incandescence and light extinction, especially in fuel-rich flames, and need to be properly accounted for in the soot refractive index.

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