Morphology, Composition and Optical Properties of Jet Engine-like Soot Made by Flame Spray Pyrolysis

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Particulate matter soot emissions from aviation is a major source of anthropogenic pollution at high altitudes. Reference soot is needed for calibration of realtime optical instruments used for regulatory measurements of non-volatile PM (nvPM) from jet engines that have average mobility, d_m, and primary particle, d_p, diameters less than 70 and 20 nm, respectively with mass mobility exponent (D_{fm}) of 2.5, elemental to total carbon ratios (EC/TC) larger than 0.8 and mass absorption cross section (MAC) of 7.46 m^2/g at 532 nm. Such soot agglomerates are difficult to make with current gas-fueled soot generators that use laminar flames where agglomerates experience high-temperature particle residence times that are quite different from those of jet engine combustors. Here flame spray pyrolysis (FSP) is used to generate soot agglomerates from turbulent flames made by spraying liquid jet fuel. The d_m of FSP made soot agglomerates is systematically modified from less than 13 to more than 91 nm by changing common FSP process parameters while agglomerates maintain EC/TC > 0.8. The FSP made soot with $2.39 < D_{fm} < 2.65$ has effective densities similar to emissions from turbofan and turboshaft engines and MAC = 8.23 and 5.21 m^2/g at 532 and 870 nm, respectively, in excellent agreement with recent measurements for nvPM emissions from jet engine turbines.