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A micro-Raman-IDroNES study of ice nucleation and crystal habits on CAST soot particles and reference substrates

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We implemented a novel Ice and Droplet Nucleation Experimental Setup (IDroNES) for the optical and spectroscopic monitoring of nucleation processes occurring on Combustion Aerosol STandart (CAST) soot particles and metallic surfaces in deposition mode (from water vapor). Soot particles produced by CAST burners exhibit physical and chemical properties that reasonably resemble those of diesel or aircraft engines soot when specific fuel-to-air ratios are supplied to the flame. 1-3 Consequently, they are commonly used as surrogates to experimentally simulate the evolution of solid-state particles emitted from aircraft engines in the troposphere (due to incomplete fuel combustion), as they might exert a potentially large impact on the climate system4 in affecting the atmospheric cloud formation and resulting precipitations. Great chemical and morphological (density, roughness, defects, crystallite and particle size, etc.) variabilities are observed at the particles' film surfaces depending on the initial parameters setting the burner.2 These are of paramount importance in nucleation events as they can provide unique nucleation sites for water molecules to interact with. Consequently, our CAST soot samples were thoroughly examined via mass spectrometry (Two-step Laser Mass Spectrometry (L2MS) and Secondary Ion Mass Spectrometry (SIMS)), micro-Raman/FTIR and optical techniques before being processed in the IDroNES reactor. Their ice nucleation activities have been studied in the 15°C to 57°C temperature range and crystal habits growing at these different temperatures and onto various substrates have been analyzed. Because of its optical capabilities, the IDroNES further permits the differentiation of supercooled droplets (cloud condensation nuclei) from ice nuclei. Although all CAST soot sample tested in this study appear active at low supersaturation ratios with respect to ice,5 no predominant parameter (chemical composition versus morphology) has been identified as the main ice nucleation trigger. A subtle combination of both seems particularly efficient at nucleating ice on these soot particles.

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