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Soot Aerosol Particles as Cloud Condensation Nuclei: from Ice Nucleation Activity to Ice Crystal Morphology

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Emissions of solid-state particles (soot) from engine exhausts due to incomplete fuel combustion is considered to influence ice and liquid water cloud droplet activation [1]. The activity of these aerosols would originate from their ability to be important centers of ice-particle nucleation, as they would promote ice formation above water homogeneous freezing point. Soot particles are reported to be generally worse ice nuclei than mineral dust because they activate nucleation at higher ice-supersaturations for deposition nucleation and at lower temperatures for immersion freezing than ratios usually expected for homogeneous nucleation [2]. In fact, there are still numerous opened questions as to whether and how soot's physico-chemical properties (structure, morphology and chemical composition) can influence their nucleation ability.

Therefore, systematic investigations of soot aerosol nucleation activity via one specific nucleation mode, here deposition nucleation, combined with thorough structural and compositional analyzes are needed in order to establish any association between the particles' activity and their physico-chemical properties. In addition, since the morphology of the ice crystals can influence their radiative properties [3], we investigated their morphology as they grow over both soot and pristine substrates at different temperatures and humidity ratios. In the present work, Combustion Aerosol STandart soot samples were produced from propane using various experimental conditions. Their nucleation activity was studied in deposition mode (from water vapor), and monitored using a temperature-controlled reactor in which the sample's relative humidity is precisely measured with a cryo-hygrometer. Formation of water/ice onto the particles is followed both optically and spectroscopically, using a microscope coupled to a Raman spectrometer. Vibrational signatures of hydroxyls (O-H) emerge when the particle becomes hydrated and are used to characterize ice crystals.

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[3] Schumann et al. Journal of Applied Meteorology and Climatology. 51, 1391-1406 (2012)