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Production and study of Titan's aerosols analogues with a RF low pressure plasma discharge

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The atmosphere of Titan, the biggest satellite of Saturn, contains aerosols produced by the organic chemistry induced by the photochemistry of N2 and CH4, the major gaseous atmospheric compounds. These organic aerosols are important as: i) they have a significant influence on the properties of the atmosphere, linked to their optical properties; ii) they represent the best known example of transition from the gaseous to the solid phase by chemistry; iii) they represent the most complex organics produced in Titan's atmosphere, making them particularly interesting from the astrobiological point of view. However, only few direct information are available about them, and their processes of formation and growth are not understood. In order to contribute to the understanding of the Titan's chemistry, we developed a new type of laboratory simulation relying on a low pressure Radio Frequency plasma discharge. This experiment is designed to produce analogues of Titan's aerosols from a N2-CH4 gaseous mixture, to study their properties and the physico-chemical processes involved in their formation and growth. This experiment, where electrons simulate photochemistry in Titan's atmosphere, is suitable for Titan's atmosphere because: i) the amount of produced particles is large enough to get enough samples for several analyses; ii) the mean electron energy is on the order of that of the UV solar photons; iii) the electron energy distribution function is one the same energy range as the solar spectrum; iv) all organic compounds detected in the Titan's atmosphere are present in our laboratory simulation. Moreover, in the capacitively coupled RF plasma, solid particles are produced and grow into the gas phase, without wall or surface interaction. Indeed, the particles are electrically charged, and they are maintained between the discharge

electrodes by an electrostatic force. This fact must be pointed out, because in other plasma devices, solid deposit are obtained on plasma wall or solid substrates. It is expected that the electrostatic charge increases proportionally to the solid particle radius R, when the weight increases proportionally to R3. Then, solid particles grow up to the size when their weight is no more balanced by electrostatic force. They are ejected out of the plasma and collected into an glass vessel. With this device, the production and the recovery of solid particles are separate. We initiated our investigations by a systematic study of the properties of the produced particles and of the plasma as a function of the plasma operating conditions, i.e. CH4 proportion in N2, pressure, gas flow, and RF power. Our objective is to characterize the plasma conditions: (gas composition and temperature, electron energy) and to correlate them with the properties of the produced solids particles (elementary composition, molecular composition, size, IR properties). Hence, we create a data bank which can be used as a reference to treat and interpret the information collected from the Cassini-Huygens space mission and observations of the Titan's atmosphere. We hope that the correlation between the gas phase properties and solid particles properties could be transpose to the Titan's atmosphere case. We present in this paper the results of these investigations relying on ex-situ analyses of the particles properties with conventional laboratory techniques (electronic microscopy, pyr-GC-MS, elemental analyses, IR spectroscopy), and in situ studies of the reactive plasma by optical emission UV-vis spectroscopy. The results obtained with this experiment should be a contribution to the knowledge of the nature of Titan's aerosols and should also contribute to the interpretation of the data collected by the Cassini-Huygens space probes which currently investigate the system of Saturn.