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Measurements of dielectric properties of tholins in a cryogenic environment

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Abstract

The Cassini-Huygens mission has provided major in situ measurements of Titan environment. The Cassini radar offers a significant dataset useful to surface dielectric properties investigations. After numerous flybys, Cassini spectrometers have contributed to the study of ionospheric processes and surface features. The Permittivity, Waves, and Altimetry (PWA) analyzer [1], an element of the Huygens Atmospheric Structure Instrument (HASI) [2] onboard the Huygens Probe, measured the dielectric properties of the surface at the landing site.

The interaction of Titan atmosphere and ionosphere with solar photons, charged particles of Saturn's magnetosphere and of the solar wind favours the formation of nitriles, complex hydrocarbons, and solid aerosols. These solid aerosols are responsible for the colours of the hazy atmosphere. Solid aerosols precipitate to form large organic deposits (tholins) on the surface. They are likely part of the surface material assessed by PWA and the Cassini radar.

The characterization of Titan bulk composition and of the processes taking place on the surface requires multidisciplinary investigations. The permittivity and conductivity PWA measurements made after landing are useful, for example, to constrain substrate composition, study geological processes, and determine electromagnetic wave surface reflection coefficients. Additionally, the dielectric properties can be used as ground truth for Cassini radar measurements made at a larger scale.

In order to understand the measurements of electrical properties of Titan surface, laboratory analogues must be produced. In this work we report the dielectric properties of tholins synthesised using a low pressure RF plasma discharge produced in a N_2-CH_4 mixture of 98%-2% and 90%-10%. With this plasma, tholins are produced as powder in the gas phase and show a regular quasi-spherical shape [3]. They are collected out of the plasma discharge and compressed to form dense tablets.

The dielectric properties of the tholin tablets are measured at room temperature and, for the first time, under cryogenic conditions. The dielectric properties of the tholins synthesised in laboratory for different CH_4 amounts show significantly different behaviours at room and cryogenic temperatures, mainly in the extremely and very low frequency ranges.

We discuss these results in the frame of Titan atmospheric and surface investigations made by the PWA analyzer.

References

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