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Far infrared properties of Titan's tholins

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Abstract

In this work we present the first experimental spectra of Tholins in the far and mid infrared range. Tholins have been produced with the PAMPRE experimental setup. The spectra have been measured at the French SOLEIL synchrotron facility. Results are compared to absorbance spectra derived from existing models and Cassini CIRS observations.

1. Introduction

The atmosphere of Titan is mainly made of N_2 and CH_4. Organic chemical reactions are induced by solar irradiation and electrically charged particles accelerated in Saturn's magnetosphere and lead to the production of an opaque layer of organic solid aerosols in the atmosphere.

Titan's aerosols have a major impact on several atmospheric parameter of the Titanian atmosphere. Since most of the characteristics of these aerosols are still unknown, it is necessary to study their laboratory produced analogues, so called tholins.

Particularly, it is necessary to know the optical properties of these aerosols in order to interpret observations of Titan's atmosphere.

Up to now the optical properties used for these comparisons were taken from a model extrapolated from mid infrared properties of tholins [1] and not from actual measurements of these properties.

We propose a measured dataset for the far infrared spectra of tholins from 1500 cm^{-1} down to 50 cm^{-1} (6.7 to 200 µm) produced on the PAMPRE experimental setup [2].

2. Tholins production and absorption measurement

A description of the experimental setup PAMPRE can be found in [2], [3]. We recall here the main characteristics of this experimental set up. The energy deposition is made by a radiofrequency plasma discharge in a reactive gas mixture varying from 0 to 10% of methane in nitrogen. Pressure is 0.9 mbar and temperature is room temperature.

Thin films are produced by positioning substrates on the grounded electrode of the setup. For the present work, thin films were produced on silicon wafers (one centimeter diameter, one mm thickness). Three films have been produced to ensure repeatability of the measurements. Deposition times for the thin films were of 2 hours. The inlet gas mixture, 5% CH_4 in N_2, was chose since it well represents Titanian atmosphere and is the maxima of production of tholins [4].

Analyses were performed at the SMIS beamline of SOLEIL synchrotron. We used a NicPlan microscope coupled to a Nicolet Magna System 560 Fourier Transformed InfraRed spectrometer. The IR source used for this work is the internal Globar lamp of the microscope. The detector is a silicon doped bolometer from Infrared Laboratories, cooled down to 4.2K with liquid helium.

3. Results

A typical absorbance spectrum of tholins is presented in figure 1. The full curve represents our experimental data while the dashed curve is the absorbance obtained from model extrapolation [1].

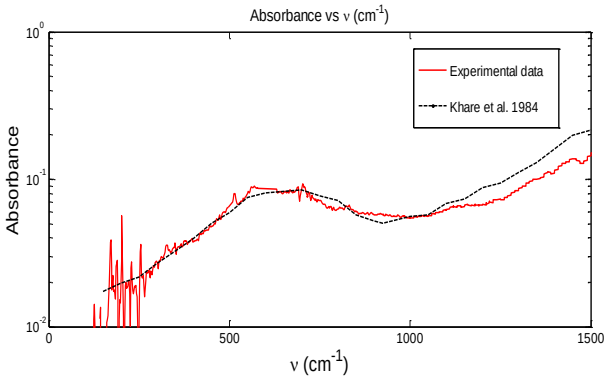

Figure 1: Measured absorption spectra of tholins thin film (full red line) compared to predicted spectra of [1] (black dashed line).

As one can see on Fig. 1, the experimental spectrum of tholins we obtained is in agreement with the spectrum from [1] below 750 cm^{-1}. For wavenumbers above 750 cm-1, a slight di is observed between the measured curve and the predicted one. Indeed the experimental spectrum reaches a minimum at 750 cm^{-1} and stays at a plateau until 1100 cm^{-1} while the modeled spectrum derived from optic indexes reaches its minimum at 900 cm^{-1} and increases for larger wavenumbers. This slight difference still has to be explained.

4. Summary and Conclusions

The results of our measurements are partially in agreement with the nowadays used constants for the interpretation of Titan's aerosols spectra, but still present some slight differences.

The optical data currently used in the FIR range for interpretation of CIRS observations and for radiative models are nowadays only coming from a model extrapolation and not from an actual measurement [5], [6]. Therefore the measured spectra presented in this work might help for a better comparison and interpretation of data/models.

References

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