Geophysical Research Abstracts
Vol. 14, EGU2012-6054, 2012
EGU General Assembly 2012

IR reflectance spectroscopy of carbon dioxide clathrate hydrates. Implications for Saturn's icy moons.

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A CO_2 spectral band was discovered by VIMS on the Saturn's satellites Dione, Hyperion, Iapetus and Phoebe [1]. The band position on the three first satellites corresponds to CO_2 trapped in a complex material, but no indication exists whether this latter is water ice or some mineral or complex organic compound [1]. On Phoebe, the CO_2 spectral band is consistent with solid CO_2 or CO_2 molecules trapped in the small cages of a clathrate hydrate structure [2]. It is thought that clathrate hydrates could play a significant role in the chemistry of the solar nebula [3] and in the physical evolution of astrophysical objects [4]. But so far, no clathrate hydrate structure has been observed in astrophysical environments. Moreover, identification of molecules trapped in a clathrate hydrate structure is extremely difficult because of the strong IR vibration modes of the water ice matrix.

In this work, experimental IR reflectance spectra for CO_2 clathrate hydrates are studied on grains and films. Clathrates are synthesized in a high pressure autoclave at low temperatures. IR spectral analysis is made with a low pressure and low temperature cryostat. These experimental conditions – $80 < T < 110$ K, P$\sim 10^{-5}$ bar - are relevant to icy moons' surfaces. We have observed that the IR reflectance, in the spectral region (3 - 5 μm) characterized by H_2O and CO_2 high absorption coefficients, is strongly dependent on physical (size, surface) and optical (n and k) properties of the samples. The impact of these parameters on the CO_2 clathrate IR reflectance spectrum will be presented. A comparison between the absorption bands of CO_2 clathrate hydrates obtained in our lab and CO_2 absorption bands as detected by VIMS on the icy satellites of Saturn will be shown. This experimental work confirms that VIMS data are not consistent with the presence of structure I CO_2 clathrate hydrates on the surface of the icy moons. Possibility of having metastable structure II still remains unsolved and will be discussed.

[1] Dalton et al., *Space Sci. Rev*. 2010, **153** : 113-154.

[2] Cruikshank D.P. et al, *Icarus*, 2010, **206**: 561-572.

[3] Mousis O. et al , *Ap. J.* 2009, **691**: 1780-1786.

[4] Choukroun M. et al, *in Solar System Ices*, edited by Castillo-Rogez, J. et al., 2011.