Clathrate hydrates FTIR spectroscopy to understand cometary ices

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Résumé

Comet nuclei, when stored in the transneptunian region, are subject to heating at temperatures from 30 to 50 K over the age of the solar system. The timescale for sublimated volatiles to escape the objects at these temperatures is long though, so that a gas phase remains in contact to an icy matrix on such long timescales. Once these nuclei enter the inner solar system and become active, subsurface sublimation puts once again a gas phase in contact of the porous and tortuous ice structure of cometary material. In this context, the formation of clathrate hydrates may be considered as a plausible trapping mechanism of these gases, occurring in subsurface layers, and allowing some of the most volatile species to subsequently survive in cometary material at temperatures higher than the sublimation temperature of the corresponding pure solid.
Gas hydrates only form and remain stable in specific temperature and pressure regimes that depend on the nature of the guest molecules. Theoretical phase diagram of clathrate hydrates show that it would be possible to form clathrates at very low pressure (10-10 bar) and temperature ($<$ 80 K), but there is a critical lack of experimental data using these preparation methods. Could clathrate hydrates be formed under conditions relevant to the interior of comet nuclei? The formation and characterisation of these ice-like structures under such conditions could provide valuable experimental evidence for understanding the preservation of some volatile species during the thermally-induced evolution of comets.

In an effort to assess whether hydrates may play a role in maintaining volatile species in cometary material, FTIR spectroscopic identification of several species have been performed. We present results related to carbon dioxide and methane hydrates, in conditions relevant to cometary nuclei, i.e. at low temperature (10 K) and pressure (base pressure 10-7 mbar)

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*Intervenant

regimes. To understand the nature of the gas hydrates formed under these conditions, vibrational spectra of distinct gas/ice interactions (clathrate hydrate, gas in/on water ice) were compared. The behaviour of the water crystalline skeleton interactions with the trapped molecules at different temperatures, as well as the influence of the gas mixture and the deposition method, will be presented.