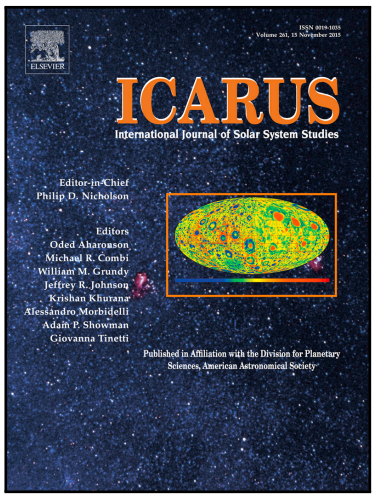

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Evolution of interstellar organic compounds under asteroidal hydrothermal conditions

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Abstract

Carbonaceous chondrites (CC) contain a diversity of organic compounds. No definitive evidence for a genetic relationship between these complex organic molecules and the simple organic molecules detected in the interstellar medium (ISM) has yet been reported. One of the many difficulties arises from the transformations of organic compounds during accretion and hydrothermal alteration on asteroids. Here, we report results of hydrothermal alteration experiments conducted on a common constituent of interstellar ice analogs, Hexamethylenetetramine (HMT - $C_6H_{12}N_4$). We submitted HMT to asteroidal hydrothermal conditions at 150 °C, for various durations (up to 31 days) and under alkaline pH. Organic products were characterized by gas chromatography mass spectrometry, infrared spectroscopy and synchrotron-based X-ray absorption near edge structure spectroscopy. Results show that, within a few days, HMT has evolved into (1) a very diverse suite of soluble compounds dominated by N-bearing aromatic compounds (> 150 species after 31 days), including for instance formamide, pyridine, pyrrole and their polymers (2) an aromatic and N-rich insoluble material that forms after only 7 days of experiment and then remains stable through time. The reaction pathways leading to the soluble compounds likely include HMT dissociation, formose and Maillard-type reactions, *e.g.* reactions of sugar derivatives with amines. The present study demonstrates that, if interstellar organic compounds such as HMT had been accreted by chondrite parent bodies, they would have undergone chemical transformations during hydrothermal alteration, potentially leading to the formation of high molecular weight insoluble organic molecules. Some of the diversity of soluble and insoluble organic compounds found in CC may thus result from asteroidal hydrothermal alteration.

Keywords

Hexamethylenetetramine | Hydrothermal alteration | Carbonaceous chondrites | interstellar organic compounds |IOM | GC-MS | FTIR | XANES