In-situ heating infrared microspectroscopy of organics from carbonaceous chondrites

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In-situ heating experiments by infrared (IR) microspectroscopy for organic materials from carbonaceous chondrites were conducted for determining thermal stability of organics during the formation of parent body and the collision-ejection processes. Matrix grains of Murchison and Orgueil meteorites were pressed on an Al foil, and measured by an IR microscope equipped with a heating stage. Firstly, step heating experiments were performed with a temperature increase rate of 10C/min to record IR spectral changes with temperature. Secondly, constant temperature kinetic heating experiments were conducted to follow IR spectral changes with time. Among the observed IR absorption bands such as aliphatic C-H, C=O and aromatic C-C bands in organics from Murchison and Orgueil, the most significant aliphatic C-H peaks (2960, 2930, 2860cm-1) were analyzed quantitatively.

By the step heating, C-H peaks decreased from around 50C and disappeared around 350-400C. By the constant temperature kinetic heating experiments at 150C, 170C, 200C, 220C, 250C, the 1st order reaction rate constants k for aliphatic C-H decrease were determined from IR peak height changes with time. Activation energies were determined from the changes in reaction rate constants k [s-1] with temperature T [K] by the Arrhenius equation lnk = lnA – E/RT (A: frequency factor, R: gas constant). Obtained activation energy E values were 44+-26 kJ/mol for Murchison and 44+-24 kJ/mol for Orgueil, giving a similar low values.

Same types of experiments were also conducted for terrestrial high molecular weight organics, humic acid (Wako and Aldrich). During the step heating, C-H decrease of Aldrich humic acid (25C /min) indicated 2 steps of decrease and the first step was similar to the C-H decrease for cosmic organics. C-H of chondrites ware generally less stable than the humic acids. Activation energies of C-H decrease for the humic acids were different from carbonaceous chondrits (Wako: 135+-25 kJ/mol, Aldrich: 18+-22 kJ/mol), yielding their decreasing order: Wako humic acid, carbonaceous chondrites, Aldrich humic acid.

By constructing a diagram between the temperature T [K] and the half life t1/2 [sec] for aliphatic C-H decrease obtained by these experiments, temperature-time scales for survival of aliphatic organics can be evaluated during the parent body formation and collision-ejection processes.