# Kinetics of the thermal decomposition of organic matter within Murchison meteorite for evaluating parent body thermal history

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Carbonaceous chondrite meteorites contain up to a few wt% carbon. These meteorites are known to be the most primitive meteorites and contain records of the early solar system. The larger fraction of the organic carbon (70-99%) is a complex insoluble organic matter (IOM). Structural changes of IOM have been used to evaluate parent body thermal processes. Recently, Cody et al. (2008) demonstrated that the development of graphene sheets observed using carbon X-ray absorption near edge structure (XANES) spectroscopy appeared to correlate well with other estimated degrees of the thermal metamorphism of the chondrite parent bodies. These experiments revealed that modification of IOM is a kinetically controlled process. The kinetic expression derived by Cody et al. (2008) is most effective for the petrologic type 3 chondrites. Therefore kinetic studies for relatively lower temperatures are needed to evaluate the type 1 and 2 chondrites.

In order to evaluate kinetic parameters for thermal decomposition of organic matter, in-situ heating experiments of bulk and IOM of Murchison (CM2) meteorite were conducted under Fourier transform infrared (FTIR) micro-spectroscopy combined with a heating stage. Bulk and IOM of Murchison grains are heated at 240-300$^{o}$C isothermally in the heating stage under Ar gas flow for several hours. Infrared spectra are collected in-situ during heating.

Decreases of aliphatic C-H peak heights with time at each temperature are well fitted with Ginstling-Brounshtein's three dimensional diffusion model, and the rate constants for decreases of aliphatic C-H were determined. Activation energies and frequency factors are estimated from these rate constants at different temperatures using Arrhenius equation. The activation energy and frequency factor for bulk Murchison are 72 kJ/mol and 48 $s^{-1}$, respectively, while these for Murchison IOM are 107 kJ/mol and 5.2 x $10^4$ $s^{-1}$, respectively. Activation energy values of aliphatic C-H decrease are larger for IOM than bulk of Murchison. Hence, the mineral assemblage of Murchison meteorite might have catalytic effect for the organic matter decomposition. The time scales for metamorphism can be estimated for given temperatures with aliphatic C-H peak heights, otherwise temperatures of metamorphism can be estimated for given time scales.

Kinetic heating experiments allow us to constrain the time and temperature range of thermal changes of organic matter in carbonaceous chondrites by using obtained kinetic parameters such as activation energies. By the constraints on time scale for alteration, the depth limit of parent body could be estimated. Constraining the minimum size of the C chondrite parent bodies will also help identify their heating mechanism(s). Enhanced and additional kinetic studies of thermal processing of organic matter may further help sorting out the thermal history of the parent bodies.