Heating effects on the structures and elemental ratios of IOM in Jbilet Winselwan and Y 793321 CM chondrites

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Organic compounds in carbonaceous chondrites record heating and mechanical modifications induced by parent-body and nebular processes. In particular, insoluble Organic Matter (IOM) has been modified by thermal and aqueous processes and its irreversible carbonization has proceeded during alteration. Using solid-state ^{13}C nuclear magnetic resonance (NMR) spectroscopy, Raman spectroscopy, light elemental composition analyses, and electron microscopy, we investigated chemical structure of carbon, C, H, N elemental abundance, and morphology of IOM. The IOM extracted from two CM2 chondrites, Jbilet Winselwan and Y 793321, which may be a good analog for C-type asteroid Ryugu of the Hayabusa2 sample-return mission. These meteorites are classified to heating stage- II in the mineralogical classification scheme based on Nakamura (2005) and experienced a similar degree of aqueous alteration. However, it was suggested that they might have undergone a different thermal history: Jbilet Winselwan was subjected to long-term internal heating by short-lived radionuclide ^{26}Al (Fujiya et al., 2019), while Y 793321 was subjected to short-term impact-induced heating (Nakamura, 2006).

The results of Raman analysis of both IOMs show negligible difference from IOMs in other unheated and heated CM chondrites. The solid-state ^{13}C NMR spectra indicate that low molar ratios of aliphatic carbon to aromatic carbon (~0.14) for both IOM. These ratios are clearly lower than that ratio of lower heating stage-I samples (~0.5) (Yabuta et al. 2005). This indicates that the loss of aliphatic component or the increase of aromatic component of IOMs during heating of the meteorites in asteroids. Elemental analysis shows low H/C ratios (~0.40) in the two meteorites. These ratios are lower compared with stage-I samples (~0.70) (Yabuta et al. 2005). Therefore, the structural and elemental properties of IOMs in both two CM chondrites are similar and consistent with heating stage-II samples.

The results of Raman analysis of IOMs in the two meteorites show no difference from heating stage-I samples in contrast to the NMR and elemental analysis results. The difference suggest that the stage II heating transformed most organic carbon into aromatic but did not transform the carbon to graphitic. The results suggest that incipient structural changes by low-temperature heating of IOMs can be better characterized by NMR and elemental analysis, and further graphitization at high temperature can be well detected by Raman spectroscopy (e.g., Busemann et al. 2007).

Keywords: CM chondrite, C-type asteroid, Insoluble Organic Matter

