EFFECTS OF HEATING ON INSOLUBLE ORGANIC MATTER IN SMALL PARTICLES DURING ATMOSPHERIC ENTRY.

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Introduction: Some Interplanetary Dust Particles (IDPs) and micrometeorites have experienced very little parent body alteration and are among the most primitive Solar System samples available to science [1]. The organic matter in these samples has received a lot of attention as it sometimes has characteristics indicative of a very primitive nature. Yet, in general, IDPs and micrometeorites are not as isotopically anomalous as the Insoluble Organic Matter (IOM) in the most primitive meteorites, perhaps because they have been modified by atmospheric entry heating [2]. Given the considerable scientific interest in organic matter in IDPs and micrometeorites, it is important to be able to characterize modifications of the organic matter that might have occurred during atmospheric entry heating. In this study, we are experimentally investigating the effects of atmospheric entry heating on IOM extracted from the meteorite Cold Bokkeveld to assess the effects such heating might have on IOM in IDPs and micrometeorites.

Methods: IOM was extracted from Cold Bokkeveld (CM2) by the method described in [3]. Small amounts of IOM (typically ~0.5 mg at a time) were flash heated in Ar-flow using a CDS 1000 pyroprobe. Samples were heated to 400°C, 600°C, 800°C, and 1000°C respectively for 4s with a temperature increase of 500°C/s to simulate atmospheric entry conditions [4]. Aliquots of the heated and unheated samples were analyzed for H, N, and C elemental and isotopic compositions with a Thermo Finnigan Delta^{Plus} XL mass spectrometer (H) and a Thermo Delta V^{Plus} isotope ratio mass spectrometer (C, N). In addition, the IOM samples were analyzed with a Witec α- SNOM (Scanning Near Field Optical Microscope) with 532 nm Confocal imaging Raman spectrometer.

Results and Discussion: Flash heating clearly modified the IOM. In general, H was lost to a higher degree than C and N, lowering H/C and H/N ratios with increasing heating. The H/C ratio decreased from 0.58 in the unheated sample to 0.29 in the 1000°C sample. Increased heating also produced isotopically lighter H (unheated δD ~ 725‰, 1000°C δD ~ 567‰), N (unheated δ^{15}N ~ -2‰, 1000°C δ^{15}N ~ -15‰), and to some degree C (unheated δ^{13}C ~ -18.0‰, 1000°C δ^{13}C ~ -18.9 ‰) bulk IOM compositions. These results indicate that the thermally unstable part of IOM is isotopically heavier in H and N than the thermally stable part, as also observed in shock experiments and in residues from pyrolysis of Murchison IOM [5,6]. The data collected from the IOM heated to 400°C did not fall on the same trends as that of the other samples, but instead had higher δD and δ^{15}N than the unheated IOM. Higher δD in the residues from low temperature steps than in the starting material was also observed by [5], who suggested that this could be due to exchange of carboxyl, hydroxyl, and carbonyl groups during laboratory treatment of the IOM. These labile, and after exchange with terrestrial groups isotopically light, species would be driven off during mild heating and result in a higher than original δD of the low temperature residue.

Variations in Raman signal between the different samples are more subtle than the effects seen in the elemental and isotopic changes. Most of the D and G band parameters remained unchanged with heating. There is a weak trend in which the G band becomes narrower and shifted towards higher wavenumbers with increased heating. The shift in peak position between the unheated and the 1000°C IOM sample is in the order of a few wavenumbers and the decrease in width of the G band in the order of 10 wavenumbers. Thermal metamorphism of IOM on parent bodies drives the G band characteristics in the same direction as observed here and is likely due to the development of small graphitic domains [7]. The small effect of flash heating on the Raman signal of IOM indicates that whereas the heating drives off the labile material, as seen in the elemental and isotopic compositions, it does not have any major effects on the polyaromatic carbon responsible for the D and G band. Hence, Raman spectroscopy may not be a sensitive indicator of atmospheric entry heating [c.f. 8] and, therefore, the primitiveness of IOM in IDPs and micrometeorites. We are exploring whether FTIR may provide a better indicator of atmospheric entry heating.

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