

## Composition diversity of insoluble organic matter in carbonaceous and ordinary chondrites by infrared spectroscopy

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The molecular structure of insoluble organic matter (IOM) isolated from chondritic meteorites provides a record of chemical and thermal processes that occurred in the parent bodies and possibly before accretion. Infrared (IR) spectroscopy is a powerful technique for the identification of organic functional groups in organic solids. Surprisingly, a systematic IR study of meteoritic organic matter from a wide variety of chondrites has not been performed. Here we report such a study of carbonaceous and ordinary chondrites spanning classes, groups and petrologic types, and discover interesting structure-meteorite relationships.

Based on common IR spectral features, we find that IOM naturally falls into 4 groups (designated here as A through D). We note, that these designations are, in some cases, not easily correlated with mineralogic and compositional designations of chondrite class, groups and petrologic types. We find that group A includes all type 1 and 2 chondrites (except heated CM chondrites), and their spectra are characterized by a broad 3400cm<sup>-1</sup> band due to OH (including alcohol, carboxyl and water), a weak 3060cm<sup>-1</sup> band due to aromatic CH, an intense band around 2900cm<sup>-1</sup> due to aliphatic C-H, an intense 1710cm<sup>-1</sup> band due to C=O, an intense 1590cm<sup>-1</sup> band due to aromatic CC, and fine structure vibrational modes in the range of 1500-1000cm<sup>-1</sup>. Group B includes the least equilibrated type 3 chondrites, and is characterized by an intense OH band, a relatively strong aromatic CH band and a weak aliphatic CH band. The CH<sub>2</sub>/CH<sub>3</sub> ratio is higher and the C=O band is weaker in group B IOM than in group A. Group B IOM also exhibits an intense aromatic CC band and a broad band spanning the 1500-1000cm<sup>-1</sup> region. The high oxygen content and the presence of appreciable aliphatic carbon indicates that group B has experienced minimal thermal metamorphism compared to the other type 3 chondrites studied, consistent with their type designation at or near 3.0. Group C, includes more equilibrated type 3 chondrites, and is characterized by a weaker carbonyl band, and a sharp intense aromatic CC band that appears at lower frequency (1583cm<sup>-1</sup>) than groups A or B. Group D, also includes type 3 chondrites, but is clearly distinct from group C principally by exhibiting no intensity in the 1720-1710cm<sup>-1</sup> region (carboxyl C=O), but exhibiting variable intensity at 1667 cm<sup>-1</sup> that is likely due to quinonic C=O.

We note that both groups C and D have a relatively narrow band at 1210cm<sup>-1</sup> as compared with groups A and B. Intensity in this region is most likely associated with multiple aromatic skeletal modes. The narrowing of the spectral region peaking at 1210cm<sup>-1</sup> in groups C and D likely indicates the formation of more condensed aromatics. Interestingly, the 1210cm<sup>-1</sup> band width correlates with a reduction in the Raman D-band (1350cm<sup>-1</sup>) width [1], consistent with structural ordering of the aromatic moieties. Increasing organization of the aromatic structure (perhaps due to aromatic polycondensation) is an anticipated response to increased thermal metamorphism. It is also noteworthy that groups C and D exhibit no or very weak OH and aliphatic CH stretching bands.

FTIR analysis of chondritic IOM spanning class, group, and type provides a unique perspective on

the molecular structure and evolution of these complex organic solids. Whereas these IR groups are consistent with petrologic type and what has been discovered using Raman [1], NMR [2], and C-XANES [3], there is no obvious correlation with chondrite group or apparent mineralogical oxidation state. These new data strongly suggest that there was considerable complexity in the response of IOM to parent body processing. These IR spectra do support the idea, however, that there was a common precursor of IOM that was subsequently altered by various parent body processes.

#### References

- [1]Busemann et al. 2007, M&PS 42:1387.
- [2]Cody & Alexander 2005, GCA 69:1085.
- [3]Cody et al. 2008, EPSL 272:446.