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Trace the evolution of organic matter in interplanetary objects using residue analogues

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Abstract

This contribution focuses on one aspect of our work, which is related to the analysis of refractory residues formed from the UV irradiation and the subsequent warming-up to room temperature of astrophysical ice analogs, the RAHIIA project. The understanding of the chemical composition of these refractory residues, commonly called "yellow stuff", as well as the possible pathways to their formation in astrophysical environments, is an important step to establish what kind of organic matter could be available within interplanetary objects such as comets or asteroids, part of which end up as preserved meteorites on telluric planets.

1. Residue analogues for studying the chemical evolution in astrophysical environments

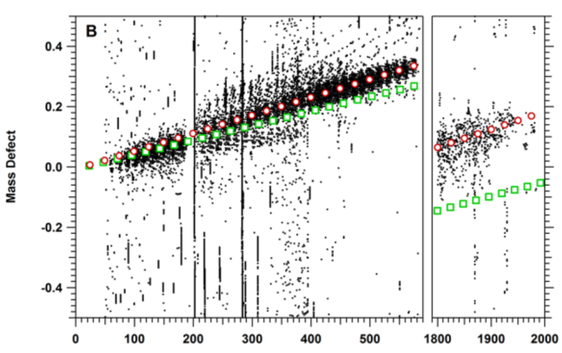

Figure 1. Mass defect vs Exact Mass diagram corresponding to mass spectra of the ^{13}C residue analyzed in the negative ESI mode [1].

We present here the first results obtained by spectrometric analysis with high resolution mass spectroscopy (LTQ-XL-Orbitrap) of these residues [1]. These analyzes show that residues are composed of thousands of molecules of high molecular weight (m / z> 4000), and present an average elemental composition H/C= 1.6, N/C= 0.4, O/C= 0.4 for an initial ice standard ice mixture, containing H_2O:CH_3OH:NH_3 3:1:1 (Figure 1).

We also develop specific data representation in order to obtain information on the residue composition [2]. These representations allow to define that three different groups of molecules are present in these residues, molecules bearing only CHN, CHO or CHNO atoms. These representations also give important information on the family composition of each molecular group. All these developments will be used for the comparison of various residues as well as for the development of more specific analytical methods such as UHPLC-MS or GC-MS. These results demonstrate that from only three simple molecules CH_3OH, H_2O and NH_3, a very complex chemistry occurs when these molecules are subjected to physical processes in the solid state such as those possibly present in the bulk of interstellar grains in the primordial molecular cloud at the time of the Sun formation and possibly then incorporated in comets and/or asteroids.

2. Residue analogue composition vs. meteorites

Furthermore we tentatively compare the abundance of the molecular families constituting our residue to molecules detected from meteorite analyses [2]. Not so surprisingly, an excellent qualitative and semi-quantitative agreement is obtained between our residues and the soluble organic matter extracted from the Murchison meteorite, demonstrating that such residue can be used for tracing the chemical history that leads to the formation of the organic matter found in meteorites for instance.

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[2] G. Danger, A. Fresneau, N. Abou Mrad, P. de Marcellus, F. Duvernay, L. Le Sergeant d’Hendecourt, R. Thissen, T. Chiavassa, *Geochim. Cosmochim. Acta* **2015**, *Submited*.