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Tracking the origins of organic matter in ultra-carbonaceous Antarctic micrometeorites: a combined STXM-XANES and NanoSIMS study

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Ultra-carbonaceous Antarctic micrometeorites (UCAMMs) probably originate from the irradiation of C- and N-rich ices at the surface of objects orbiting beyond Neptune [1-3]. Their N-rich organic matter (OM) presents highly heterogeneous H, C and N isotopic compositions that reflect the physico-chemical conditions of their synthesis environment in the cold regions of the outer Solar System. Recently, the N isotopic compositions of UCAMMs were proposed to be a tracer of the presence or absence of the primordial N_2 reservoir on the parent bodies of UCAMMs [3]. Constraining the abundances, speciation and isotopic compositions of N in UCAMMs is crucial for understanding their origins and the complex chemistry of remote objects in the Solar System.

Here, we present the results of a combined NanoSIMS and STXM-XANES study of the OM of UCAMM DC19-201. This remarkable UCAMM is characterized by bimodal $^{15}N/^{14}N$ compositions with ^{15}N-rich ($\delta^{15}N \approx 93$ ‰) and ^{15}N-poor ($\delta^{15}N \approx$ -40 ‰) poles coexisting at a scale of 10 µm. Synchrotron based-XANES analyses performed at the C K-edge on a FIB section extracted from UCAMM DC19-201 identified three main features at 284.8 eV, 286.5 eV and 288.5 eV associated with aromatic and olefinic, ketone and phenol, and carboxyl groups, respectively. The OM of UCAMM DC19-201 appears, thus, to be characterized by oxygenated functional group chemistry as reported in previous UCAMMs [4], where fine scale mixing of OM characterized by different atomic N/C ratios and mineral contents were observed. Such heterogeneity was attributed to the association of OM formed in different conditions during the journey of UCAMMs in the Solar System. UCAMM DC19-201 may have formed from an O-rich and N-fractionated reservoir, or may have resulted from the aggregation of smaller grains that formed independently. Additional high spatial resolution data of the isotopic and chemical composition will help clarifying the carriers of N atoms and isotopic anomalies in the OM of DC19-201.

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