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D-rich carbonaceous materials in NWA 801 CR2 chondrite

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Insoluble organic matter (IOM) extracted from carbonaceous chondrites is considered to have formed in the cold molecular cloud, because of its enrichment of D and 15N (e.g. 1). However, occurrences of IOM in chondrite are poorly understood. This is because most of the previous study for meteoritic organic matters are studied extracted-IOM. In this study, we observed organic materials in chondrite by hydrogen isotope imaging to reveal their morphologies and occurrences. The sample used in this study is a polished thin section of NWA 801 CR2 chondrite. We obtained 1 H, D and 12C images of ~50 micrometers in diameter by isotope microscope of Hokkaido University (2). We obtained 63 image areas in the NWA 801 matrix. We discovered 78 D-rich carbonaceous materials from the 31 areas. Hydrogen isotopic composition of matrix was normalized to a reported value of phyllosilicate in Renazzo, which is estimated to be 730 permil (3). The hydrogen isotopic compositions of carbonaceous materials are ranged from 1700 permil to 9600 permil of delta-D. The occurrences of these materials in NWA 801 matrix are distributed heterogeneously. We identified the location of 40 D-rich materials by X-ray elemental C mapping by FE-SEM-EDS. The 40 D-rich materials were classified into 4 groups according to their morphologies; Round particles, Irregular particles, Aggregate particles and Ring particles. Round particles are round shaped materials and Irregular particles are irregular shaped materials. Aggregate particles are aggregate of carbonaceous materials and silicates and Ring particles are ring shaped carbonaceous materials that have silicate or void in their interior. Number of Round particles, Irregular particles, Aggregate particles and Ring particles are 6, 7, 21 and 6, respectively, and size distribution of these materials are 0.3 - 0.8 micrometers, 0.2 - 1.0 micrometers, < 0.3 micrometers and 0.3 - 0.8 micrometers, respectively.
The materials found in this study are mainly composed of H and C and enriched in deuterium. These characteristics indicate that these materials correspond to organic material formed in a cold molecular cloud and/or outer solar nebula. Formation processes of Round particles, Irregular particles and Ring particles can be explained by the formation model of organic materials in the molecular cloud (e.g. 4). In the molecular cloud, gaseous molecules and atoms are accreted on a core material such as silicate or ice grains and form ice mantle. Catalytic atom addition reactions and additional chemical reactions driven by UV photons and cosmic rays can occur on the surfaces of this ice mantle. Complex refractory organic mantle can be formed as a result of these reactions. We suggest that the differences of morphology of Round particles, Irregular particles and Ring particles depend on the differences of the core material and the size. The sizes of individual carbonaceous material in Aggregate particles are similar to other carbonaceous particles. Thus, Aggregate particles seem to be composed of these carbonaceous materials and silicates. The heterogeneous spatial distribution of D-rich carbonaceous materials in NWA 801 suggests heterogeneous distribution of organic materials in molecular cloud and/or solar nebula.

References:
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