The effect of mineral mesoporosity on amino acid adsorption

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Organic matter (OM)-mineral interactions may explain diverse phenomena such as sequestration of pollutants and preservation of OM in soils and sediments. Mineral mesopores (2-50 nm diameter) have been suggested as sites of organic matter (natural and pollutant) sequestration and protection from enzymatic degradation in soils and sediments. To test this idea, we carried out batch aqueous experiments to examine adsorption of amino acid monomers and polymers onto synthetic mesoporous and nonporous alumina and silica with controlled intraparticle porosity and of similar surface chemistries.

Nearly all amino acid monomers and polymers tested exhibited significantly greater adsorption to mesoporous (8.2 nm mean pore diameter) versus nonporous alumina when normalized to surface area. Diffuse reflectance infrared Fourier transform (DRIFT) spectra show carboxylate absorption bands for sorbed glutamate and diglutamate reside at 1615 cm^{-1} and 1570 cm^{-1} for the nonporous and mesoporous alumina, respectively. In addition, amino acid dimers and hydrophobic monomers sorbed to mesoporous alumina exhibited adsorption-desorption hysteresis. However, a larger protein (albumin; 67 kD) adsorbed to the mesoporous alumina to a lesser extent than to the non-porous alumina. This is attributed to exclusion of albumin from the mineral mesopores where the vast majority of surface area exists. By contrast, nonporous silica adsorbedmore amino acid and protein, perhaps due to the smaller pore size of mesoporous silica (3.4 nm mean pore diameter).

Adsorption of amino acids to mineral surfaces is, therefore, enhanced by mesoporosity due to stronger bond energies (perhaps bidentate versus monodentate) for organic compounds sorbed to internal versus external surfaces. Since we observe that larger macromolecules (such as enzymes and proteins) are hindered from entering mesopores, these findings provide a potential mechanism for selective sedimentary OM preservation.

Isotopic compositions of small presolar dust grains

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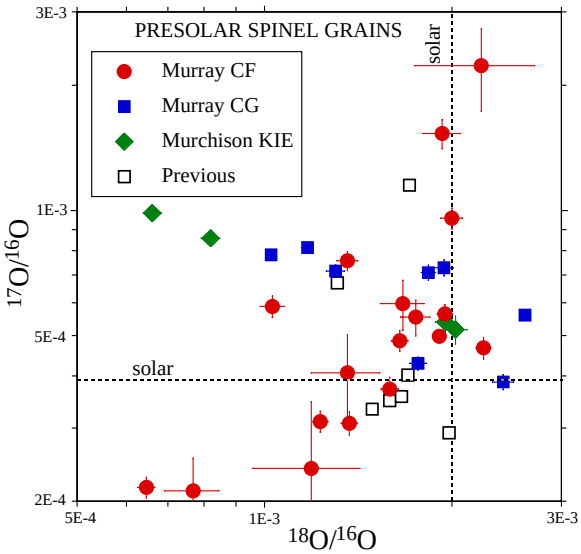
The last ten years have seen the accumulation of a wealth of isotopic data on presolar dust grains obtained with the ion microprobe [e.g., 1]. Most of these measurements were performed on grains ≥1 µm in size. A new type of ion probe, the NanoSIMS, with its high sensitivity and high spatial resolution [2] offers the opportunity to analyse much smaller grains, in the size range typical for interstellar dust.

We have initiated a series of NanoSIMS presolar grain studies that exploit these new capabilities. In one example we have extended C and N isotopic measurements to much smaller SiC grains by analysing grains from Murchison separate KJB (grain diameters 0.25–0.45µm) and Indarch IH6 (0.25–0.65µm) [3]. The distributions of the C and N isotopic ratios are quite similar to those of larger (1.8–3.7µm) grains from Murchison separate KJG [4, 5], the only difference being a higher fraction of grains with $10<{}^{12}C/{}^{13}C<40$. Indarch IH6 contains also Si_3N_4 grains and we tentatively identified some of them as presolar with isotopic characteristics similar to mainstream SiC grains.

Another study is concerned with O isotopic measurements of small spinel grains. The abundance of >1µm presolar spinels is very low and before the start of our study only 7 such grains had been identified. We analysed spinels from Murray CF (average size ~0.15µm), Murray CG (~0.45µm) and Murchison KIE (~0.5µm) and identified 30 presolar grains (Figure 1). The abundance of presolar spinel is ~3% among the smallest size fraction (CF), much higher than among larger grains.



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