Selective adsorption of L-aspartate onto [Mg(OH)$_2$] brucite with Ca^{2+}

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A possible scenario for the geochemical origin of life may involve interactions between biomolecules at the mineral/water interface leading to the selection and concentration of key prebiotic constituents at the mineral surface. Serpentinite-hosted hydrothermal vents have been proposed as a plausible Early Earth environment for this process to occur although little is known about the interactions between biomolecules and minerals in this system. We conducted batch adsorption experiments with a 1:1 ratio of the amino acids aspartate, lysine, glycine, phenylalanine, and leucine at initial ligand concentrations 10-150 μM onto powdered brucite [Mg(OH$_2$], a thermodynamically stable phase of serpentinization. The batch experiments were done in triplicate both with and without added salts and 4x10^{-3} M Ca^{2+}. We observed that up to 8.9% of aspartate and 5% of each of the remaining four amino acids adsorbed onto brucite in the experiments without Ca^{2+}. When Ca^{2+} was added, we found that up to 37.3% of aspartate adsorbed onto brucite, whereas the other amino acids adsorbed up to 3.5% each. Additionally, an average of 15.9% of Ca^{2+} adsorbed onto brucite. Our results suggest that the adsorption of Ca^{2+} onto brucite promotes the adsorption of aspartate while competing with other amino acids. Whereas the other amino acids are electrostatically inhibited from doing so, it is likely that the negatively charged aspartate molecule readily forms a calcium-ligand complex on the surface of brucite, and this complex preferentially adsorbs onto brucite in addition to other Ca^{2+} species. The selection of aspartate among a suite of other amino acids is relevant for the emergence of cell metabolism, and the conditions of this study may hold implications for the importance of Ca^{2+} rich aqueous environments, such as the serpentinite-hosted hydrothermal environments, in the evolution of biocomplexity.