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Correlation of pH-dependent surface interaction forces to amino acid adsorption: Implications for the origin of life

HUGH CHURCHILL,[1] HENRY TENG,[2] AND ROBERT M. HAZEN[3,]*

[1]Department of Physics, Oberlin College, Oberlin, Ohio 44074, U.S.A.
[2]Department of Earth and Environmental Sciences, George Washington University, Washington, D.C. 20006, U.S.A.
[3]Carnegie Institution of Washington and NASA Astrobiology Institute, Washington, D.C. 20015, U.S.A.

ABSTRACT

We used an atomic force microscope (AFM) with a modified tip to measure interaction forces between a silica microsphere and surfaces of quartz, calcite, and albite over a range of pH. Minima in the magnitude of electrostatic repulsion or attraction appeared near the point of zero charge (pH_{pzc}) values for quartz (≈2.8), calcite (9.5), albite (2.6), and silica glass (3.5). We observed small, but significant, differences in pH_{pzc} values for the (100), (101), and (011) faces of quartz. In order to correlate mineral surface charges with ionic characteristics and corresponding isoelectric points (pI) of amino acids, we immersed quartz and calcite in solutions of six amino acids. Quartz ($pH_{pzc} \approx 2.8$) tends to adsorb amino acids most strongly when pH_{pzc} and pI differ significantly. Thus quartz adsorbs lysine (pI = 9.74) more strongly than amino acids with lower pI. In contrast, calcite ($pH_{pzc} = 9.5$) adsorbs a variety of amino acids with a range of pI. Calcite thus represents a more plausible template than quartz for prebiotic selection and organization of homochiral polypeptides.