Influence of trace elements on the adsorption of nucleotides onto clays: implications for the origin of life

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Chemical evolution of early life requires concentration of monomers to polymerize from the diluted primordial ocean. UV radiation and heating threaten the stability of biomolecules in the early seawater and hydrothermal fluid. Transition metals such as Fe, Mn, and Zn could reach considerable levels in the early seawater and hydrothermal fluids, but their influences on adsorption of biomolecules have not been stressed. In this study, we conducted batch adsorption experiments to explore effects of various metal cations (Li, Mg, Ca, Zn, Ni, and Mn) on adsorption of selected nucleotides (dGMP, dAMP, and AMP) and a nucleobase (adenosine) onto nontronite and montmorillonite. We also varied the concentration of cations and the pH of the solution to test their effects. Our results suggest that Zn and Ni could significantly enhance the adsorption of nucleotides and nucleobase, compared with traditionally used salts (Na, Mg, and Ca). This enhancing effect depends little on the concentration of salts, but heavily on the pH of the solution. Elevation of pH promoted the adsorption of nucleotides in presence of transition metals. The enhancing effect is primarily attributed to the surface adsorption of metals onto the clays, which bridge the adsorption of nucleotides and nucleobase onto mineral surfaces. Enhanced adsorption of biomolecules mediated by transition metals would potentially ease the origin of life in two aspects: concentration of simple organics for polymerization and protection of early biomolecules against UV radiation and heating in early seawater and hydrothermal fluid.