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Homochiral growth through enantiomeric cross-inhibition

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The chirality of molecules in living organisms must have been fixed at an early stage in the development of life. All life that we know is based on RNA and DNA molecules with dextrarotatory sugars. The introduction of chiral molecules is assumed to have taken place at a stage when there was already growth and self-replication, possibly via PNA as genetic code carrier. It is therefore plausible to assume that the existence of chiral molecules has an autocatalytic effect in producing new chiral molecules of the same chirality. This is the basis of the recently proposed polymerization model of Sandars [1]. The purpose of the present paper [2] is to reconsider this model (or a slightly modified version of it) and to analyze its stability behavior and conservation properties.

The achiral (racemic) solution is found to be linearly unstable once the relevant control parameter (here the fidelity of the catalyst) exceeds a critical value. The growth rate is calculated for different fidelity parameters and cross-inhibition rates. A truncated version of the model is used to derive a set of two ordinary differential equations and it is argued that these equations are significantly more realistic than those used in earlier models of that form. Finally, a chirality parameter is defined and shown to be conserved by the nonlinear terms of the model.

References

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Molecular-scale analysis of adsorbed and decomposed RNA on the surfaces of minerals

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Interactions between dissolved species with mineral surfaces could have been significant to prebiotic chemistry. However, most of the experiments performed have been syntheses. Other than temperature alone, very few studies, if any, have shown the reverse pathway of destruction of prebiotic organics in the presence of minerals. Hydrogen peroxide (H_2O_2) has been detected from O_2 -free aqueous suspensions of the most common metal sulfide, pyrite (FeS_2) [1]. Hydroxyl radical ($\cdot OH$) generation through Fenton's reaction— $Fe(II) + H_2O_2 = Fe(III) + \cdot OH + -OH$ —with iron provides a hitherto unknown source of this highly reactive radical species. $\cdot OH$ is capable of oxidizing all biomolecules and has been shown to destroy RNA [2]. RNA, as a representative organic species, has also been shown to decompose in the presence of pyrite [3]. A full understanding of the H_2O_2 generation mechanism is unknown at this time. The goals of this contribution are several fold: 1) use RNA as a representative scavenger of $\cdot OH$ to spectroscopically (horizontal attenuated total reflectance Fourier transform infrared spectroscopy HATR-FTIR) determine its fate in the presence of minerals, 2) to investigate the formation of H_2O_2 from pyrite and several other iron sulfides and common minerals, and 3) gain a better understanding of the H_2O_2 generation mechanism. The potential of H_2O_2 and $\cdot OH$ generation from mineral-aqueous reactions could have fundamental implications for the stability of prebiotic building blocks and biomolecules during the origin and evolution of life.

References

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