Water as a solvent for life

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"Follow the water" is our basic strategy in searching for life in the universe. The universality of water as the solvent for living systems is usually justified by arguing that water supports the rich organic chemistry that seeds life, but alternative chemistries are possible in other organic solvents. Here, other, essential criteria for life that have not been sufficiently considered so far, will be discussed.

Life is based on non-covalent interactions. They might be either specific (enzyme-substrate interactions, selective ion transport) or nonspecific (lipid-lipid or lipid-protein interactions). Their strength needs to be properly tuned, and this is mediated by the solvent. If interactions are too weak, there might be undesired response to natural fluctuations of physical and chemical parameters. If they are too strong it could impede kinetics and energetics of cellular processes. Thus, the solvent must allow for balancing these interactions, which provides strong constraints for life [1].

Among many solvents, water exhibits a remarkable trait that it promotes both solvophobic and solvophilic interactions. Solvophobic (hydrophobic in the case of water) interactions are necessary for self-organization of matter. They are responsible, among others, for the formation of membranes and protein folding. The diversity of structures supported by hydrophobic interactions is the hallmark of terrestrial life responsible for its diversity, evolution and the ability to survive environmental changes. Solvophilic interactions, in turn, are needed to ensure solubility of polar species. Water offers a large temperature domain of stable liquid and the characteristic hydrophobic effects [2-5] are a consequence of the temperature insensitivity of essential properties of its liquid state [1,4]. Water, however, might not be the only liquid with these properties. Properties of water and other pure liquids or their mixtures that have a high dielectric constant and simultaneously support self-organization will be compared. Properties that appear to be unfavorable to life (e.g. its chemical activity against polymerization reactions) will be discussed and the requirements for alternatives to water to support life in space will be summarized.

References:

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