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A possible spontaneous generation of silicon utilizing minimal containers as precursors of life in the cosmos

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ABSTRACT

Although experiments suggested that silica may help in early chemical evolution on Earth, however, their exact role in genesis of life is still unknown. In this experiment silicon utilizing specific coacervates was developed in a reaction mixture under solar energy with chemicals which are commonly present in GMCs, comets, and asteroids. When these coacervates were applied on a thin silica layer they were converted into multiplying structures morphologically similar to primitive algae. Under an electron microscope they found morphologically similar to the cells which were present in rain water in Kerala in 2001 after a meteor airburst. These proto-algae like bodies thus may mimic the common ancestor of life on the Earth. Similarly these specific coacervates may originate spontaneously in GMCs and are transferred throughout the universe by various routes to initiate life processes on suitable surfaces. Thus they may be found in the stratosphere of the Earth; however, as they could not penetrate the tropopause in the present atmosphere they may not be found on earth surface except in rare conditions like volcanic eruptions, blue lightning etc. Thus this simple study may support the famous panspermia theory and we should search for possible biosignatures of these peculiar bodies throughout the cosmos.

1. Introduction

Many notable scientists like Epicurus, Aristotle, Lucretius, Paracelsus, Helmont, and Arrhenius searched the inquisitive problems of biogenesis and the past two Centuries have witnessed many important experiments, observations, and ideas of the famous scientists like Pasteur, Operin, Darwin, Fox, Miller, Ponnamperuma, Matthews and many others regarding this. In the well known experiment of Miller, he observed formation of several amino acids when a mixture of methane, ammonia, hydrogen and water was exposed to electric discharge [28].

These conditions, according to Miller, resemble or are similar to the conditions of the Earth long before the first living unit appeared on its surface. However, factors like temperature, UV ray (~10 times), volcanic activities etc. were different in the primitive Earth. The primitive atmosphere on the Earth contained hydrogen, nitrogen, ammonia, methane, water vapor, and small amounts of hydrogen cyanide, hydrogen sulfide, formaldehyde, ethane, helium and argon. Thus an ideal condition of the primitive Earth is very difficult to achieve in a laboratory.

Again the atmosphere was neutral from 3.8 until about 2 eons ago, when molecular oxygen first appeared after photosynthetic organisms began to produce free oxygen in large quantities. Thus experiments on the origin of life with a reducing atmosphere may not be the appropriate one.

Bahadur published one important paper [2] regarding origin of life in 1954, just one year after the publication of Miller's experiment. In this experiment, Bahadur demonstrated formation of amino acids in an aqueous solution of para-formaldehyde, which was exposed to sunlight in the presence of colloidal molybdenum oxide. Later experiments

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of Bahadur in between 1954 and 1957 indicated possible formation of amino acids even in the present physico-chemical conditions on the earth [3]. Afterwards Bahadur and Ranganayaki could demonstrate formation of coacervates along with ribose, deoxyribose, glucose and fructose in a similar system [4–9]. However, the results of these experiments were not accepted by many scientists as the coacervates failed to grow in subcultures. In recent past, many experiments have already been done on the origin of proteins, membrane, RNA and DNA [11,29], in relation to the origin of life on the Earth, but still there is no integrated speculation on origin of life. In this experiment a salt-silicate-molybdate-formalin medium was used to produce modified coacervates so that they could grow in subcultures on silica surface containing a thin film of an algae culture medium.

2. General methods

2.1. Media used in this experiment and general study procedures

2.1.1. Salt-molybdate-formalin medium

This is a slightly modified Krishna Bahadur's medium [6] resulting better yield of coacervates and was used as a control medium in this experiment. The medium was comprised of potassium dihydrogen phosphate (KH_2PO_4) 0.5 g and magnesium sulfate ($MgSO_4$) 0.07 g mixed with 50 mL distilled water in a glass flask (in plastic flask only scanty growth was found), followed by addition of 10 mL ammonium molybdate (4% w/v) and 20 mL diammonium hydrogen phosphate (3% w/v) with it. The mixture was then sterilized at 15 lb pressure for 15 min and then 10 mL formalin (36% formaldehyde) was added with it. It was then exposed to direct sunlight in clear days ($\sim$1368 W m^{-2} or 1.95 cal cm^2 min^{-1} solar radiation per second) in between 7 a.m. and 9.30 a.m. and then to filtered sunlight passing through a colorless frosted glass in between 2 p.m. and 4.30 p.m. for 4 days. The solution was kept at room temperature ($\sim$20–25 °C) in a cool dark place in between the exposures to sunlight. Intervals between the exposures in a day were allowed so that after 2½ h of chemical reaction the formed granules could settle down permitting better reaction in the second half; filtered sunlight was used to protect living cells from scorching afternoon sunshine. Thus the mixture was exposed to sunlight for a total period of 20 h in 4 days. The average maximum atmospheric temperature was 36 °C and minimum temperature was 24 °C; the average specific humidity was 73%. The experiment was repeated in different lots and all together it was repeated more than 50 times and in each lot control solutions were used which were not exposed to sunlight.

Although most of the constituents of this medium were derived from Krishna Bahadur's medium [6], the rationality of addition of the component chemicals was considered before the experiment. Thus potassium dihydrogen phosphate was used as a source of phosphorus and potassium and with ammonium salts present in the medium; it also acts as a buffering agent and minimizes escape of ammonia from the medium. Phosphate component is also important in many metabolic and enzymatic pathways. Magnesium sulfate which is naturally present in mineral water is used in agriculture to improve crops. Magnesium is the second most common intracellular cation. Magnesium is essential for solar energy dependent reactions in plants, and an important cofactor for enzymatic reactions. Sulfur is an important micronutrient. Molybdenum is widely used in catalysis and used in this experiment as a catalyst. It helps in nitrogen fixation and plays an important role in nutrition of living beings. It is an essential trace element in plants and animals for proper functioning of molybdoenzymes.

Ammonium salts – ammonium molybdate and diammonium hydrogen phosphate were used as sources of nitrogen and for buffering action with potassium dihydrogen phosphate. Ammonium compounds also stabilize osmotic pressure in cells. Formaldehyde used in the medium was the first polyatomic organic molecule detected in the outer space and is found in many extraterrestrial bodies and in giant molecular clouds. In atmosphere, methane is converted into formaldehyde. It is also ubiquitous in living organisms in trace amounts which occur due to metabolism of endogenous amino acids. It was used in this experiment as a source of carbon.

2.1.2. Salt-silicate-molybdate-formalin medium

This test medium was developed following our previous experiments indicating that silicon utilizing organisms could tolerate different stresses and they could grow slightly without any carbon source in the medium [12–16], although trace amounts of carbon should always be present in such a system. We also inclined to develop such a medium as we came to know that all isolated cultivable organisms from stratosphere [31,32] and the suspected extraterrestrial organisms found in the red rain of Kerala [25] contained high amounts of silica and thus formally may be categorized under “silicon utilizing organisms” [16] group. This medium was comprised of potassium dihydrogen phosphate (KH_2PO_4) 25 g and magnesium sulfate ($MgSO_4$) 0.175 g mixed with 50 mL distilled water; 18 mL of this solution was then mixed with 18 mL sodium metasilicate solution (11.8 g/dL) and autoclaved at 15 lb pressure for 15 min. It was then partially neutralized with 5 mL sterilized phosphoric acid (16% v/v) to keep it in a liquid state consisting of silicon di-oxide (SiO2), sodium phosphate and unperturbed sodium metasilicate in its usual form. Then sterile10 mL ammonium molybdate (4% w/v) solution and 20 mL diammonium hydrogen phosphate (3% w/v) solution were mixed with it one after another and finally 10 mL formalin (36% formaldehyde) was added. It was exposed to direct sunlight as described in Section 2.1.1. All chemicals used in this experiment were of AR/GR grade. Sodium metasilicate/phosphoric acid neutralization was standardized in each lot, approximately 80% quantity of the total volume of the acid which was required for neutralization and solidification was used for partial neutralization.

2.2. Morphological study of the coacervates

Granules of coacervates, formed within 2.1.1 and 2.1.2 media were observed directly, by light microscopy and by a SEM (Scanning electron microscope) and a TEM (Transmission electron microscope). SEM observation was done with a FEI Quanta 200 NK2 instrument. Two drops of the medium containing the particles were placed on 1 cm × 1 cm glass