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Effect of Formaldehyde on the Abiogenesis of Nucleic Acid Bases in the Irradiated Mixtures of Jeewanu, the Protocells

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ABSTRACT. The effect of formaldehyde has been studied on the abiogenesis of nucleic acid bases in a sterilised aqueous mixture consisting of ammonium molybdate, diammonium hydrogen phosphate and biological minerals. It was observed that the formation of nucleic acid bases increases with increasing concentration of formaldehyde up to 60 ml formaldehyde/200 ml mixture and thereafter decreases. Jeewanu, the protocells were formed by exposing sterilised aqueous mixture containing ammonium molybdate, diammonium hydrogen phosphate, biological minerals and formaldehyde to sunlight (Bahadur and Ranganayakee, 1970). The presence of nucleic acid bases (Ranganayaki, Raina and Bahadur, 1972), amino acids (Bahadur, Verma and Singh, 1974), sugars (Raina, 1973) and lipids (Singh 1974) have been detected in the particles as well as in the environmental medium of these mixtures. Formaldehyde has been used as a source of carbon in the above mixture. The main reason for choosing formaldehyde as a source of carbon is that formaldehyde can be very easily synthesised by exposing an aqueous solution of carbon dioxide to ultraviolet light (Garrison, Morrison, Hamilton, Bensen and Calvin, 1957). Moreover formaldehyde has been detected in large quantity in interstellar space ((Synder et. al. 1969).

EXPERIMENTAL

A set of six mixtures was prepared each having the following constituents:

Ammonium molybdate	8 g
Diammonium hydrogen phosphate	18 g
Sodium chloride	3 g
Calcium acetate	0.5 g
Magnesium sulphate	0.5 g
Potassium sulphate	0.5 g

All these constituents were taken in six separate conical flasks of 250 ml capacity. 30 ml of distilled water was added to each flask. Each mixture was boiled and concentrated hydrochloric acid was added dropwise to each flask till a clear solution was obtained. The flasks were cooled and the total mixture of each flask was made up to 100 ml with distilled water. These flasks were closed with a cotton plug and then sterilised in an autoclave at 15 lb pressure for half an hour. After sterilisation, the flasks were cooled and 36% formaldehyde solution was added aseptically to each flask as follows:-

	formaldehyde	+ sterilised distilled water
Flask A	0 ml	100 ml
Flask B	20 ml	80 ml
Flask C	40 ml	60 ml
Flask D	60 ml	40 ml
Flask E	80 ml	20 ml
Flask F	100 ml	0 ml

These flasks were shaken gently and exposed to sunlight for six hours each day. The nucleic acid bases were detected both in the particles and the environmental medium after 4 days and 8 days of exposure.

The nucleic acid bases were identified after hydrolysing the particles and the environmental medium with 72% perchloric acid. For hydrolysis of the particles, 100 mg of the dried particles were taken in a hard glass ampule of 5 ml capacity. To this 0.5 ml of 72% perchloric acid was added. The tube was sealed and heated in a water bath for 2 hours. After cooling, the contents of the tube were taken out on a watch glass and evaporated to dryness to remove excess of perchloric acid. The residue was taken up in 0.5 ml of distilled water.

For hydrolysis of the environmental medium 2 ml of the environmental medium were taken and the hydrolysis was carried out in a similar manner as described above.

The nucleic acid bases were identified by one dimensional and two dimensional paper chromatography and finally by simultaneous running with standard compound. The developing solvents used were:-

(1) isopropanol: HCl: water : 65:16.6:18.4 (v/v)

(2) ethanol : methanol: HCl: water:25:50:6:19 (v/v)

(3) methanol : formic acid:water:160:30:10 (v/v)

The spraying reagent used was 0.25M mercuric nitrate in 0.5N nitric acid and freshly prepared ammonium sulphide solution (Voicher and Chargaff, 1951).

Quantitative estimation of adenine in the particles:

Adenine was estimated colorimetrically using zinc dust, sodium nitrate ammonium sulphamate and Bratton-Marshall reagent (Wood House, 1950).

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RESULTS

The nucleic acid bases identified both in the particles as well as in the environmental medium are tabulated below:-

TABLE NO. 1

Nucleic acid bases identified in the particles of different mixtures containing varying concentration of formaldehyde.

Volume of formaldehyde taken	Nucleic acid bases identified	
	After 4 days exposure	After 8 days exposure
A(0 ml)	no particles were formed	no particles were formed
B(20 ml)	adenine, uracil, guanine	adenine, adenosine, guanosine
C (40 ml)	adenine, adenosine, guanosine	adenine, uracil, cytosine, guanosine
D (60 ml)	adenine, guanine, cytosine, guanosine	adenine, adenosine, uracil, cytosine, guanine
E (80 ml)	adenine, uracil, cytosine	adenine, adenosine and uracil
F (100 ml)	adenine, cytosine	adenine, adenosine, uracil

TABLE NO. 2

Nucleic acid bases identified in the environmental medium of different mixtures containing varying concentration of formaldehyde.

Volume of formaldehyde taken	Nucleic acid bases identified	
	After 4 days exposure	After 8 days exposure
A (0 ml)	no nucleic acid bases could be detected	No nucleic acid bases could be detected
B (20 ml)	adenosine, cytosine	adenine, uracil
C (40 ml)	adenine, adenosine, uracil	adenine, adenosine
D (60 ml)	adenosine, adenine, guanosine, cytosine	adenosine, guanosine
E (80 ml)	adenosine, uracil	adenine, cytosine
F (100 ml)	adenine, uracil	adenine, adenosine

TABLE NO. 3

Quantitative estimation of adenine formed in 100 mg of the particles in different mixtures containing varying concentration of formaldehyde.

Volume of formaldehyde taken	adenine formed in mg/100 mg of the sample	
	after 4 days	after 8 days
A (0 ml)	no particles formed	no particles formed
B (20 ml)	0.58	0.61
C (40 ml)	0.92	0.96
D (60 ml)	1.07	1.12
E (80 ml)	0.74	0.79
F (100 ml)	0.66	0.71

DISCUSSION

Formaldehyde plays a vital role in the abiogenesis of nucleic acid bases. In the mixtures without formaldehyde, no nucleic acid base could be detected. In the mixture containing 20 ml of formaldehyde, adenine, uracil and guanine were detected in the particles after 4 days exposure. As the concentration of formaldehyde was increased, the formation of nucleic acid bases also increased both in the particles as well as in the environmental medium. Maximum formation of nucleic acid bases was observed in mixture containing 60 ml of formaldehyde/200 ml of the mixture. On further increasing the concentration of formaldehyde the formation of nucleic acid bases decreased.

On increasing the period of exposure to 8 days, the formation of nucleic acid bases was increased but the increase was only about 5 to 10% more than what is observed after 4 days of exposure.

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