

of the underlying water. Since there is no means of guaranteeing absence of organic impurities down to this infinitesimal concentration (the impurities possibly including weak electrolytes), the only safe course is entirely to avoid using de-ionized water in critical research in surface chemistry. Triply-distilled water condensed in silica, having a conductivity of, say, $0.3 \mu\text{mho cm.}^{-1}$, is preferable to de-ionized water of conductivity $0.07 \mu\text{mho}$ because the trace impurities in the distilled water are not highly surface-active whereas those in the de-ionized water are.

J. A. KITCHENER

Department of Chemistry,
Imperial College of Science and Technology,
London, S.W.7.

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Photosynthesis of Amino-Acids from Paraformaldehyde involving the Fixation of Nitrogen in the Presence of Colloidal Molybdenum Oxide as Catalyst

APART from the various physico-chemical methods used in industry for the fixation of atmospheric nitrogen, it is well known that quite a number of micro-organisms¹ are able to fix under mild conditions a considerable quantity of atmospheric nitrogen. In this bacterial fixation, it has been observed that molybdenum takes a prominent role² as a catalyst.

The possibility of achieving amino-acid synthesis without the help of micro-organisms has involved also some aspects of the problem of the origin of life. Oparin³, Urey⁴ and Bernal⁵ have stressed the idea that life is based upon organic compounds which were formed when methane, ammonia, water and hydrogen were the components of the atmosphere. Miller⁶ succeeded in testing this hypothesis, producing amino-acids synthetically by circulating methane, ammonia, water and hydrogen past an electric discharge.

Bahadur⁷ observed that when an aqueous mixture of paraformaldehyde and potassium nitrate, in the presence of ferric chloride as a catalyst, is exposed to sunlight, about a dozen amino-acids are formed in it. We have now investigated the possibility of nitrogen fixation without the help of bacteria and subsequent utilization of the fixed nitrogen in the formation of amino-acids, in an aqueous mixture containing paraformaldehyde as the source of carbon and colloidal molybdenum oxide as catalyst, by merely exposing the mixture to a 500-W. electric light.

To detect amino-acid formation, we used circular paper chromatography⁸. The sensitive ninhydrin test for amino-acids was helpful in detecting even a trace of amino-acids formed in the experiments. Heating the paper on an electric heater helped in developing the rings of even those amino-acids which were present in extremely small quantities.

Two mixtures each containing 5 gm. of paraformaldehyde, 200 c.c. of distilled water and 10 c.c. of colloidal molybdenum oxide were prepared in 500 c.c. conical flasks. The flasks were plugged with cotton-wool and sterilized. To be sure that there was no trace of any amino-acid as impurity in the mixture at the beginning, a sample of each was tested chromatographically. Both the mixtures gave negative results. One of these flasks was covered with a thick

black cloth, and both were then kept 45 cm. below a 500-W. electric bulb and exposed to light for 600 hr.

After exposure, both mixtures were tested for sterility and chromatographically for the presence of amino-acids. The circular chromatograms of the mixture exposed to light showed the presence of rings with R_F values of glycine, alanine, valine, histidine, glutamic acid, aspartic acid and ornithine, according to our calibration. Of these, the glycine and alanine rings were very distinct, whereas the other amino-acid rings were faint. Chromatograms of the mixture which was kept covered with black cloth and was thus deprived of the influence of light showed extremely faint rings of glycine and alanine.

The above experiment is consistent with the hypothesis that paraformaldehyde when mixed with colloidal molybdenum oxide and water and exposed to light fixes atmospheric nitrogen, and this fixed nitrogen soon appears as amino-acids in the mixture. This conclusion is dependent on the results obtained by use of a chromatographic method which is considered quite definite for identification of amino-acids. We are trying now to provide additional evidence of amino-acid photosynthesis.

We are grateful to Dr. R. Bianco for his assistance in various phases of this work.

K. BAHADUR
S. RANGANAYAKI
L. SANTAMARIA

Chemistry Department,
University of Allahabad,
India.

Institute of General Pathology,
University of Milan,
Italy.

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Influence of Amino-Acids on Actinomycin Biosynthesis

A NUMBER of nutritional and cultural factors have been shown to influence the qualitative and quantitative nature of the actinomycin mixture produced by a given *Streptomyces*¹⁻⁵. In particular, the nitrogen source supplied may affect the composition of the complex formed⁵. Generally, it has been possible to change the proportion of any particular component in a natural mixture to a limited degree; in a few instances, however, a component normally produced in small amounts may increase to the extent that it represents the major constituent of an actinomycin complex. For example, we have observed⁶ that actinomycin-V was the major component in the actinomycin mixture produced by *Streptomyces antibioticus* when L-threonine was sole nitrogen source, whereas actinomycin-IV represented the main constituent when L-glutamic acid was employed³. Schmidt-Kastner has shown that actinomycin-IV (C₁) increased from 10 to 83 per cent of the actinomycin