N92-13618

PRODUCT AND RATE DETERMINATIONS WITH CHEMICALLY ACTIVATED NUCLEOTIDES IN THE PRESENCE OF VARIOUS PREBIOTIC MATERIALS, INCLUDING OTHER MONO- AND POLYNUCLEOTIDES

A. Kanavarioti*, D. J. Alberas, M. T. Rosenbach, C. F. Bernasconi,
Chemistry Department, University of California, Santa Cruz
and
S. Chang
Planetary Biology Branch, NASA Ames Research Center

Template-directed syntheses of polynucleotides in the absence of enzymes provide a promising model for the evolution of replicating systems and the concurrent transfer of information from one generation to the next. In today's enzymatic systems, polynucleotide synthesis uses the triphosphate mononucleotides as building blocks. Although these molecules are chemically activated and serve as the energy source in most biological syntheses, they exhibit a large barrier to non-enzymatic reaction. Hence, in order to compensate for the large reductions in rates that occur when no enzyme catalysts are present, modeling experiments are performed with similarly activated but chemically more labile monomeric precursors. Indeed, phosphoimidazolide activated nucleotides, so called ImpN's, have found widespread application in template-directed chemistry.

The most interesting reaction of ImpN's is the template-directed oligomerization in the presence of the appropriate template. However, the efficiency of this reaction depends dramatically on the competition with other reactions that consume ImpN's. Therefore we are investigating the reactions of ImpN's in the presence of a number of prebiotically plausible materials, such as metal ions, phosphate, amines and other nucleotides and hope to learn more about the stability/reactivity of ImpN's in a prebiotic aqueous environment. Although ImpN's hydrolyze readily, we find that, in the presence of phosphate, ImpN form substantial amounts of diphosphate nucleotides. These diphosphate nucleotides are not very good substrates for template-directed reactions, but are chemically activated and are known to revert to the phosphoimidazolides in the presence of imidazole under solid-state conditions. With respect to our studies of the oligomerization reaction, the determination of the dimerization rate constant of a specific ImpN (guanosine 5'-phospho-2-methylimidazolide) both in the absence and in the presence of the template lead to the conclusion that at 37°C the dimerization is not template-directed although the subsequent polymerization steps are. In other words this specific polynucleotide synthesizing system favors the elongation of oligonucleotides as compared with the formation of dimers and trimers. This favoring of the synthesis of long as opposed to short oligonucleotides may be regarded as a rudimentary example of natural selection at the molecular level.