Non-enzymatic synthesis of peptides in an ionic liquid

Virginia F. Smith,[1] Hugh C. De Long,[1] Paul C. Trulove[2] and Thomas Sutto[2]

[1]United States Naval Academy
Chemistry Department
572M Holloway Road
Annapolis, MD 21402
US

[2]Air Force Office of Scientific Research
801 North Randolph St, Rm 732
Arlington, VA 22203-1977
US

Amino acids, the monomers that comprise proteins, are abundant in nature and have even been found in environments that do not support life, such as meteorites. The origin of proteins, however, is mysterious because the condensation reaction that forms the peptide bond linking two amino acids is thermodynamically disfavored in the aqueous solutions that are required for life. In nature, elaborate and energetically costly enzymatic methods for synthesizing proteins have evolved to overcome this thermodynamic limitation. However, all these methods require proteins, which begs the question of where the first proteins came from. Ionic liquids, which are polar but non-aqueous and which are stable over a wide temperature range, are an ideal medium for testing whether peptide bonds could form spontaneously between amino acids in the absence of water. We have demonstrated that polyglycine peptides can form non-enzymatically in the molten salt butyl, methyl imidazole-PF6 (BMI-PF6) by incubation of the dipeptide glyclglycine at temperatures above 100 C. Analysis of an aqueous extract of the mixture by reversed-phase HPLC revealed the presence of condensation products, including tetra- and hexa- and, probably, octaglycine. Incubation at temperatures below 100 C did not produce peptides, even when performed under vacuum. Results for other peptide and amino acid mixtures, as well as the implications for prebiotic formation of peptides, will also be discussed.