Hydrogen Cyanide Polymers Connect Cosmochemistry and Biochemistry

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Data from the chemical analysis of IDPs, cometary particles returned by the Stardust Mission, and Titan’s atmosphere by the Cassini-Huygens probe are all compatible with the presence of hydrogen cyanide polymers. These darkly colored red-orange-brown-black solids are complex, heterogeneous materials that have been shown to incorporate both amino acid (peptide-linked?) and nucleobase substructures, thus providing a plausible connection between organic cosmochemistry and biochemistry (Matthews, C. N. and Minard, R.D., 2006, Faraday Discuss., 133, 393-401). Here we present ongoing studies of hydrogen cyanide polymerization:

1. Production of HCN polymers under different phase, temperature and catalyst conditions that are plausible models for the different environments available in interstellar nebulae and during development of planetary systems.

2. Many experimental simulations of Titan atmospheric chemistry involving high-energy reactions of methane/nitrogen mixtures can produced composites of aromatic-aliphatic hydrocarbons and HCN polymers (tholins?). A model explaining Titan’s orange aerosol chemistry will be discussed.

3. Application of solid state NMR, TMAH thermochemolysis/GC-MS, MALDI-MS, HPLC-ESI-MS and MS-MS, ESR, and IR for structural elucidation of these polymers and the products derived from them by contact with water.

4. Analysis of products formed by reaction of HCN polymer with other possible prebiotic species such as formaldehyde, acrylonitrile, and sulfur compounds.

Implications for prebiotic chemistry are profound. Following persistent bolide bombardment and/or energetic reactions in a reducing atmosphere, primitive Earth may have been covered by water and carbonaceous compounds, particularly HCN polymers which would have supplied essential components for establishing protein/nucleic acid life.