Microwave-driven synthesis of cyanide polymers under plausible hydrothermal conditions

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Abstract

HCN is a ubiquitous molecule in the Universe and the aqueous oligomerization/polymerization of cyanide is considered of high interest in the field of prebiotic chemistry and in the researches about the origin of life (Sutherland 2016 and Ruiz-Bermejo et al. 2013). On the other hand, the hydrothermal vents are suggested as potential places to the development of a complex organic chemistry that may lead to the emergence of life. Besides, the presence of HCN in hydrothermal vents has been proved in a terrestrial context (see e.g. Huber et al. 2012). In addition, one of the main goals of the next astrobiological space missions is to study the habitability of the ocean worlds of the Solar System. In this way, the existence of hydrothermal environments analogous to those found in the Earth, under the freeze surfaces of the ice moons, such as Europa and Enceladus (see e.g. Waite et al. 2017 and Sparks et al. 2017), encourages to investigate the cyanide chemistry under hydrothermal conditions.

As a first approach, the cyanide polymerization according with plausible hydrothermal conditions was carried out using equimolar aqueous solutions of KCN and NH4Cl (1M) driven by microwaves at 180 °C under anoxic conditions, using an inert N2 atmosphere. The kinetic of the process was studied by a gravimetric method (Fernández et al. 2018), and the insoluble cyanide polymers obtained were characterized by elemental analysis, Fourier transform infrared (FTIR) spectroscopy, x-ray diffraction (XRD) and scanning electron microscopy (SEM). The aqueous soluble oligomers/polymers fractions were examined by means of UV-vis spectroscopic measurements; and the acid hydrolysed insoluble polymers were also analysed by gas chromatography-mass spectrometry (GC-MS). With this last technique were found amino acids, carboxylic and dicarboxylic acids and N-heterocycles; some of them with biological/exobiological interest. In addition, for comparative reasons, analogous reactions were carried out under air conditions, revealing significant differences both in the polymerization kinetic and in the spectroscopic characteristic of the insoluble polymers.

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