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From simple to complex prebiotic chemistry in a carbon-rich universe

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Abstract

It is well known that the main components of important biomolecules are quite common not only in the Solar System, but also in other planetary systems and in the Galactic ISM. The ubiquitous presence of C in the Universe and the unique carbon chemical properties and carbon bonding thermodynamics supports the spontaneous self-replication of monomers into larger polymers, yielding the formation of large molecules. The detection of an ever increasing number of organic molecules in the interstellar medium (ISM) by radio-telescopes and chemical analysis of meteorites boosted astrochemical theories on radiation-induced chemistry, supported by laboratory experiments. In this scenario of exogenous origin of carbon compounds, polyaromatic hydrocarbons (PAHs) may represent a resilient way of accumulating carbon as a robust cosmic reservoir. Consisting of a family of compounds with fused aromatic rings, the abundances of its larger members (50-100 carbon atoms) were estimated to be on top scores just after H2 and CO. PAHs have been detected in the ISM, in star-forming regions, ~14% of low-mass pre-mainsequence stars, and, remarkably, in some 54% of intermediate mass stars. They have also been detected by SPITZER in distant galaxies up to z = 3. PAHs were promptly photolysed into a family of radicals if exposed to UV and oxygen-bearing molecules in laboratory. The presence of oxygen-bearing molecules was shown in the laboratory to bring aromatic rings into an unstable chemistry leading to the production of e.g. alcohols, ketones and ether radicals. It has already been observed that carbon-and oxygen-rich stellar envelopes
give rise to richer carbon chemistry. It appears very tempting to think that key prebiotic fragments should appear along planetary formation as C-O reaction by-products such as methanol (CH3OH), formaldehyde (H2CO) and also simpler hydrocarbons as methyl acetylene (CH3CCH). Under an Astrobiology perspective it is plausible to map PAHs and oxygen compounds together in the same target – envelopes of young stars – with the ALMA facility. We intend to do it in the frame of a CNRS funded international collaboration between Brazilian groups, OCA and ESO.