From Interstellar Ices to PAHs

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INVITED TALK

PAHs in the ices of Saturn's Satellites: Connections to the Solar Nebula and the Interstellar Medium

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Aliphatic hydrocarbons and PAHs have been observed in the interstellar medium (e.g., Allamandola et al. 1985, Pendleton et al. 1994, Pendleton & Allamandola 2002, Tielens 2013, Kwok 2008, Chiar & Pendleton 2008) The inventory of organic material in the ISM was likely incorporated into the molecular cloud in which the solar nebula condensed, contributing to the feedstock for the formation of the Sun, major planets, and the smaller icy bodies in the region outside Neptune's orbit (transneptunian objects, or TNOs). Additional organic synthesis occurred in the solar nebula (Ciesla & Sandford 2012). Saturn's satellites Phoebe, Iapetus, and Hyperion open a window to the composition of one class of TNO as revealed by the near-infrared mapping spectrometer (VIMS) on the Cassini spacecraft at Saturn. Phoebe (mean diameter 213 km) is a former TNO now orbiting Saturn (Johnson & Lunine 2005). VIMS spectral maps of Phoebe's surface reveal a complex organic spectral signature consisting of prominent aromatic (CH) and aliphatic hydrocarbon ($^{=}$CH2, $^{-}$CH3) absorption bands (3.2-3.6 μm). Phoebe is the source of a huge debris ring encircling Saturn, and from which particles ($\sim$5-20 μm size) spiral inward toward Saturn (Verbiscer et al. 2009). They encounter Iapetus and Hyperion where they mix with and blanket the native H_2O ice of those two bodies. Quantitative analysis of the hydrocarbon bands on Iapetus demonstrates that aromatic CH is $\sim$10 times as abundant as aliphatic CH_2+CH_3, significantly exceeding the strength of the aromatic signature in interplanetary dust particles, comet particles, and in carbonaceous meteorites (Cruikshank et al. 2014). A similar excess of aromatics over aliphatics is seen in the qualitative analysis of Hyperion and Phoebe itself (Dalle Ore et al. 2012). The Iapetus aliphatic hydrocarbons show $CH_2/CH_3\sim4$, which is larger than the value found in the diffuse ISM ($\sim$2-2.5). Insofar as Phoebe is a primitive body that formed in the outer regions of the solar nebula and has preserved some of the original nebula inventory, it can be key in understanding the content and degree of processing of that nebular material. A dynamical subset of TNOs define the Kuiper Belt, from which the short-period comets originate. Particles collected from comet 81P/Wild contain PAHs with an interstellar signature of deuterium. By inference, the PAHs contained in Phoebe and now dusted on the surfaces of two other Saturn satellites share that interstellar origin. There are other Phoebe-like TNOs that are presently beyond our ability to study in the organic spectral region, but JWST will open that possibility for a number of objects.

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