Organic Molecules on Saturn’s Satellites: Relationship to Kuiper Belt Objects, Interstellar Dust, and the Solar Nebula

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Three of Saturn’s satellites, Phoebe, Iapetus, and Hyperion, have aromatic and aliphatic molecular material (hydrocarbons) on their surfaces, as revealed in near-infrared spectra obtained with the Cassini VIMS (Visible-Infrared Mapping Spectrometer). The spectroscopic signature for the aromatic hydrocarbons (the C-H stretching mode at 3.28 \( \mu m \)) is proportionally significantly stronger (relative to the aliphatic bands near 3.4 \( \mu m \)) than that seen in other Solar System bodies (e.g., comets) and materials (Stardust samples, IDPs, meteorites). Particles spiraling inward from the dust ring surrounding Saturn (in which Phoebe is embedded), is the likely source of the organic-bearing materials on Iapetus and Hyperion. The ring probably originated from a collision with Phoebe. Phoebe is considered to be a captured object that originated in the region beyond the present orbit of Neptune, where the solar nebula contained a large fraction of original interstellar ice and dust that may have been processed to a lesser degree than nebular material closer to the Sun. Debris from Phoebe now resident on Iapetus and Hyperion, as well as on Phoebe itself, thus presents a unique blend of hydrocarbons (among objects studied so far), and affords a direct comparison to interstellar hydrocarbons and other Solar System materials, as well as transneptunian bodies. A quantitative analysis of the Saturn satellite data in progress indicates that the amount of carbon in CH groups in aromatic molecules is \(~20\) times greater than that in CH functional groups in aliphatic molecules; in interstellar dust particles this ratio is \(~1\). This large difference, plus a difference in the ratio of \(-CH_2-\) to \(-CH_3\) in the aliphatics of the Saturn satellites compared to organics in interstellar dust, can be attributed to various kinds and degrees of processing of the interstellar organics.