Complex organic molecules in comet 21P/Giacobini-Zinner

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Comet 21P/Giacobini-Zinner is a Jupiter-family comet with an orbital period of ~6.6 years, which is considered a parent body of the October Draconids meteor shower. It is very important to study comet 21P because the comet is peculiar; (i) it is depleted in carbon-chain molecules, NH2, and highly volatile species, and (ii) has a negative linear polarization gradient produced by grains.

We observed comet 21P/G-Z in the mid-infrared with the Cooled Mid-infrared Camera and Spectrometer (COMICS) on the 8.2 m Subaru Telescope on Mauna Kea, Hawaii, on UT 2005 July 5, just after the perihelion passage. The heliocentric and geocentric distances of the comet were 1.04 and 1.43 au, respectively. The spectrum of comet 21P/G-Z shows distinct emission peaks at approximately 8.5, 9.2, and 11.2 micron and weak peaks at approximately 8.2, 11.6, 11.9, and 12.7 micron. The thermal emission model commonly used for cometary dust grains failed to reproduce the observed spectrum of comet 21P. More materials, in addition to silicate materials, are needed to reproduce the emission peaks at 8.2, 8.5, 9.2, and 12.7micron. Those unidentified infrared (UIR) band features have never been observed in previous mid-infrared observations of other comets. The features at ~8.2, ~8.5, ~11.2, and ~12.7 micron could be attributed to polycyclic aromatic hydrocarbons (PAHs) or hydrogenated amorphous carbons (HACs) contaminated by N- or O-atoms, although part of the feature at ~11.2 micron comes from crystalline olivine. The UIR features found in the mid-infrared spectra of classical novae are similar to the emission features in the spectrum of 21P/G-Z.

Laboratory experiments suggest that the carrier of the ~9.2 micron feature observed in the spectrum of comet 21P/G-Z may be some organic molecules contaminated with nitrogen, including aliphatic hydrocarbons that experienced several hundred-K. Comet 21P is depleted in simple organic molecules but enriched in complex organic molecules. The birthplace of comet 21P/G-Z in the solar nebula might be warmer or closer to the Sun than the birthplace of other comets (usually considered to be ~5–30 au from the Sun). The mass fraction of the crystalline component in silicate is, however, typical (~0.45) for comet 21P/G-Z. This indicates that comet 21P/G-Z formed at a similar distance from the Sun in the solar nebula as other comets formed. From this point of views, we propose that the comet might have originated from a circumplanetary disk of giant planets (similar to Jupiter and Saturn) where was warmer than the typical comet-forming region (5–30 au from the Sun) and was suitable for the formation of complex organic molecules.

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