Organic Nanoparticles in Space

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Recent research has discovered that complex organic matter is prevalent over the Universe. In the Solar System, it is found in meteorites, comets, interplanetary dust particles, and planetary satellites. Spectroscopic signatures of organics with aromatic/aliphatic structures are also found in stellar ejecta, diffuse interstellar medium, and external galaxies.

From space infrared spectroscopic observations, we have found that complex organics can be synthesized in the late stages of stellar evolution. Shortly after the nuclear synthesis of the element carbon, organic gas-phase molecules are formed in the stellar winds, which later condense into solid organic particles. This organic synthesis occurs over very short time scales of about a thousand years.

In order to determine the chemical structures of these stellar organics, comparisons are made with particles produced in the laboratory under simulated space conditions. Using the technique of chemical vapor deposition, artificial organic particles have been created by injecting energy into gas-phase hydrocarbon molecules. These comparisons led us to believe that the stellar organics are best described as amorphous carbonaceous nanoparticles with mixed aromatic and aliphatic components.

The chemical structures of the stellar organics show strong similarity to the insoluble organic matter found in meteorites. Isotopic analysis of meteorites and interplanetary dust collected in the upper atmospheres have revealed the presence of pre-solar grains similar to those formed in old stars. This provides a direct link between star dust and the Solar System and raises the possibility that the early Solar System was chemically enriched by stellar ejecta with the potential of influencing the origin of life on Earth.

References

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Prof. Sun Kwok's research areas are astrochemistry and stellar evolution. He is best known for his theory on the origin of planetary nebulae and the death of Sun-like stars. His recent research has been on the topic of the synthesis of complex organic compounds in the late stages of stellar evolution. He is the author of several books, including The Origin and Evolution of Planetary Nebulae (Cambridge, 2000), Cosmic Butterflies (Cambridge, 2001), Physics and Chemistry of the Interstellar Medium (University Science Books, 2007), Organic Matter in the Universe (Wiley, 2012), and Stardust: the cosmic seeds of life (Springer, 2013).