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The composition of comets – overview of 30 years of investigations

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The study of comets is important for understanding the origin of our solar system and as such ultimately for identifying the prerequisites for the development of life. As comets are considered remnants of the early solar system formation and spent most of their lifetime at temperatures below 50 K, their chemical composition, particularly in view to organic compounds, is very important for understanding whether the complex organics, from which life might have developed, were formed from simpler molecules on the surface of the primitive Earth or were supplied as ready by impacting comets. The latter would mean that such complex molecules were already present 4.6 billion years ago. Also the intimate mixture between minerals and organic molecules is an essential aspect for the origin of life. Different grain surfaces provide different catalytic properties, and can locally lead to a decrease of entropy on the expense of the entropy elsewhere in the closed system of multigrain dust.

The first major breakthrough in identifying the organic composition of a comet nucleus dates back to 1986, when three spacecraft (VEGA 1&2 and Giotto) passed through the inner coma of comet Halley and obtained in-situ measurements of its gas and dust composition. A number of small organic molecules, known to be present in the interstellar medium were detected in the gas coma, and the presence of organic macromolecules was discovered in the comet dust. About 10 years later (1996-1997) the apparition of the extraordinary bright comet Hale-Bopp in combination with the availability of new sophisticated observing facilities at sub-mm wavelengths, led to a quantum leap in our understanding of the evolution of the gas coma composition as a function of heliocentric distance. In 2006, after another decade, the Stardust mission returned a sample of dust particles collected in the coma of comet Wild-2 which permitted the detailed analysis of the returned material in laboratories available on the Earth; and in 2016, again about 10 years later, the Rosetta mission concluded its 2-year rendezvous-mission with comet Churyumov-Gerasimenko. In these 30 years of comet compositional investigations important progress was made in identifying the composition and chemistry of comets. An overview will be given of the most important milestones with special emphasis to organic material.