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THE ROLE OF ORGANIC POLYMERS IN THE STRUCTURE OF COMETARY DUST

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Abstract

Several phenomena observed in P/Halley and other comets indicate additional fragmentation of dust particles or dust aggregates in cometary atmospheres. The disintegration of dust aggregates may be explained by sublimation of polymerized formaldehyde - POM - which play a role as binding material between submicron individual particles.

Introduction

In situ obtained data concerning the size and composition of the dust in Comet Halley indicate that a high percentage of the dust particles are composite grains containing organic species among the may be also polymerized molecules. One of the very first proposed candidate for polymers in cometary material was formaldehyde in form of polyoxymethylene or POM (Vanysek and Wickramasinghe 1975). After the discovery of repeating mass spectral pattern at 45, 61, 75, 91 and 105 *amu* in inner coma of comet Halley by the PICCA experiment on board of the space craft GIOTTO (Mitchell *et al.* 1986, 1987) the possible presence of POM or similar compounds in comets was widely discussed (Huebner 1987, Huebner *et al.* 1989 and reference therein). Also within the frame of the model of agglomerated grains for cometary dust the possible role of organic polymers as gluing material between the individual building blocks of submicron size was outlined (Boehnhardt *et al.* 1990). In here outlined study this problem is newly reviewed in regard to some recently published laboratory results.

Fragmentation process

The fragmentation of polyoxymethylene has been studied experimentally by mass spectrometry of sublimated POM (Möller and Jackson 1990) and by mass spectroscopy of sputtered POM by protons (Moore and Tanabé 1990). These experiments show that polymeric forms can be produced from the pure solid by sublimation or by bombardment of POM or a silicate-POM composite by protons of several hundreds keV energy. The mass distribution of fragments corresponds with the spectrum obtained by space experiment. The intensity of peaks on the laboratory spectrograms (Moore and Tanabé 1990), decreases with increasing mass as does the PICCA data. Typical masses of fragments produced by laboratory experiments are summarized in Table 1. However, the sputtering mechanism initiated by energetic protons seems to be much less effective in the interplanetary environment and the yield may be 10^{-3} smaller as requires the estimated number density of formaldehyde monomers in the inner coma of P/Halley at the time of GIOTTO space craft fly-by (Mitchell *et al.*1987). Thus, the only acceptable process remains the sublimation from solids.

Table 1 Mass of fragmented $(H_2CO)_n$ X

amu	n	X	amu	n	X
30	1		90	3	
47	1	OH	91	3	H
60	2		105	3	CH_3
61	2	H	119	3	HCO
73	2	CH	121	4	H
74	2	CH_2	131	3	CO...CH
75	2	CH_3	133	4	CH
89	2	HCO	135	4	CH_4

POM may grow into long chains resulting in relatively stable solids with melting point about 400 to 500 K. Nevertheless, the growing process is terminated by the saturation. If we assume, that equilibrium state could be reached in the interstellar dense clouds as well in the primordial solar nebula about the mass between 120 to 150 *amu*, i.e approximately with mass ≃ monomer mass × n , where n = 4 to 5, then such a compound must be regarded rather as a heavy molecule than as solids. But in such a state can be accreted and preserved in the CHON particles. On the other hand, the formaldehyde monomers easily polymerize on the silicate solids and form the silicate-POM composite, which may serve as a binding material between individual submicron particles in fluffy dust grains. The disintegration of such a structures by heating may be very efficient, because at heliocentric distances about 0.5 AU the submicrons grains achieve temperatures above the melting point for POM. Very small fragments of POM may be heated by absorption of UV photons by thermal impulse up to 1000 K and disintegrated immediately to monomers of completely dissociated. However, at low temperatures only few POM binding "bridges" between individual particles may contribute to the stability of dust aggregates. For fragile dust aggregates, where are only few bridges, the estimated tensile strength should be in range 10^4 to 10^5 dyn cm^{-1}, which is the lower limit for submicron particles which may withstand the fragmentation by electrostatic charging in the cometary plasma (Boehnhardt 1986, Boehnhardt and Fechtig 1987). The disappearance of the POM binding bridges is followed by disintegration of the dust aggregates and increasing number density of submicron particles in larger distances from the cometary nucleus. There are many phenomena which indicate the fragmentation of cometary dust. Boehnhardt *et all.* (1990) discussed in regard to the POM role following of them: Changes of mass distribution of dust with the nuclear distance, identical boundaries of particles with very different masses, appearance of clusters and packets of dust grains in coma, missing smallest grains in the dust jet while high count rates of these particles in general coma background, and production of CHON particles in coma. The sublimation of "gluing " material of POM type between individual submicron particles may be able to explain both the fragmentation of particle aggregates and additional gas production in the coma of P/Halley. From the CHON particles may be also released polymerized molecules, which however occured only in shorter chains.

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