hot atom chmemistry and radiation efeects in solid hy drocarbons and minerals

shoukar tawfik mohamed atwa

In the present work we have studied the stability of five organic solid hydro-carbons versus approx. 20 MeV ion irradiation in order to simulate the destruction of complex organic molecules in space by cosmic radiation. The samples selected for a representative overview were: tetracosane C24HSO, a long chain paraffm; androstatte C 19H32, a steroid used here as a kind of polycylic saturated hydrocarbon; naphth-alene C101-18 and anthracene C141-110, two simple polycyclic aromatic hydrocarbons (PAHs); kerogen, a natural product from oil slater containing long aliphatic chainsand polycyclic aromatic compounds.Irradiations were carried out at LN2 temperature in cryostats with 20(18) MeV H±, 36(24) MeV 3He2+, and 26.5(20) MeV 4He2+ ions from CV 28 Compact Cyclotron of KFA Julich. The fluences ranged from some few to some 100 eV/ carbon atom, thus, simulating 10-3 to 10-i of the total radiation dose delivered in the lifetime of the solar system (4.6*109 years).Analysis of the irradiated samples was carried out by Fourier transform infrared spectroscopy (FT-IR) in transmission and diffuse reflectance and gaschrom-atography of volatile reaction products after heating of the residues or dissolving them in organic solvents. The analysis of organic substances by GC/FID yielded fragments up to C10. Their amount changed with the radiation dose. The strongest GC peaks were from C6 and Cg.The results show that the stability of the five organic solid hydrocarbons under study can be concluded as the following : kerogen is relatively stable at highest radiation dose; only weak new peaks are formed (S- and 0- bonds). Antlu-acene, tetracosane and naphthalene show a medium stability. Tetracosane is damaged by scission of chains to C4, C6 and C8 units, formation of C=C doublebonds and new CH3 groups. The polycyclic aromates naphthalene and anthracene formed mainly smaller ring systems : benzene, toluene and naphthalene, i.e. part of the aromatic system survived. Androstane proved to be the less stable compound and suffered from split-off of CH3 groups rather than from ring breakage. C=C double bond were formed, but no aromatic structures. The overall destruction rates ranged from 0.2 (a-damage in kerogen) to 40 % for a dose of 1 eV per C atom (proton damage in androstane). When normalized to the same dose, protons in general yield a destruction by a factor of 3 to 10 higher than He2+ ions, except for tetracosane, where the a-damage is by a factor of 2 higher.The sequence of destruction rates Rd per eV per C atom is as follows for proton irradiation : kerogen (3 %), naphthalene (9 %), tetracosane (9 %), anthracene (12 %), androstane (40 %) and for He2÷ ions : kerogen (0.2 %),

naphthalene (1 %), anthracene (4 %), androstane (10 %), and tetracosane (18 %). Supratheimal chemistry via multicenter reaction seems to take place in particuler during He2+ ionirradiation.Parallel experiments with approximately five-molecular layers of tetracosane and androstane on mineral grains which are discussed for some sites in space: siderite, pentlandite, and pyrrhotine, did not yield an enhanced destruction of organic molecules. Irradiations of pure organic samples and thin layers on grains with vacuum—ultraviolet light (VUV,100-300 inn) yielded a minor change. Equal doses (in eV per C atom) of energetic ions can induce more changes than electromagnetic radiation. In ring systems, protons are more effective for damage, whereas in linear aliphatic structures the heavier He2+ ions induce more structural change. In conclusion, one can say that this first set of quantitative data on radiolysis may help to evaluate the stability or destruction rates, respectivly, of other organicsolid compounds under solar and cosmic radiation. The gaseous and solid fragments which were detected may play an important role in chemistry and organic chemicalevolution in space, in particular that of the atmospheres.