Lightning-induced prebiotic chemistry in rarefied gas-grain medium

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Electric discharges in rarefied gas-grain atmospheres will serve not only energy source for synthesis of biochemical compounds. For prebiotic chemistry will have the important consequences that plasma of these discharges will have properties of dusty plasma. First, it is the presence of the charged micron-size particles (1…10 μm). These grains can be charged up to values 10^3-10^5 elementary charge at sticking of high-energy electrons (=1eV), which are produced at lightning discharge.

The purpose of this paper is the attempt to estimate the influence of parameters of gas-grain medium on such lightning-induced chemistry. As basis for these estimations are used the parameters of discharges (sprites) [1] in high layers of Earth's atmosphere (50…90km) and supposing that sprites happens in gas-grain medium. The similar case can be realized at interaction with comet and ingress the cometary's matter in region of sprites. This gas-grain medium would represent the ideal medium for lightning-induced prebiotic chemistry, as the atmosphere of a comet contains species (H_2O, CO, HCN, NH_3, ?H_4, CH_3OH, H_2CO, SO_2, CS_2, H_2S) for synthesis of biochemical compounds. The second case is the hypothetical possibility of lightning in near-surface cometary atmosphere [2].

For further estimations will be necessary to determine the dependence from altitude of the energy and concentration of electrons and ions. At altitude 50 km (pressure – 0,6 torr, free length – 0,07 mm, electrical field - 500 V m^{-1}) the average electron energy is approximately 1eV and average ion energy is approximately 0,04eV. At altitude 90 km (pressure – 0,001 torr, free length - 30mm, electrical field – 50 V m^{-1}) the average electron energy is approach up to 10eV and average ion energy is greater than 1eV. The electron concentration at altitude 90 km is also greater than at altitude 50 km [1]. The increase of electron energy and concentration will cause the strong dependence of accumulated charge on grains with altitude. The estimation shows that at the altitude 90 km charge on grains with the identical size approximately in 100 times more, than at altitude 70 km. Further we can estimate quantity potentially of possible formations of some compounds on a surface of grains, as the recombination of ions in dusty plasma happens largely on negatively charged grains. For example, it is possible to estimate the value of formation of $CH_2(OH)_2$ on charged ice-grains (size - 10 μm, charge - 10^4 e) in reaction of hydrolysis H_2CO

$H_2CO – (H_2O)_2$? $CH_2(OH)_2 - H_2O$

Thus it is possible to tell that lightning-induced chemistry can have additional capabilities for synthesis of biochemical compounds in rare gas-grain medium with density, which corresponds to density of Earth's atmosphere at altitudes 70…90 km (pressure 0,04 … 0,001 torr). The limiting altitude of existence of sprite determines both the lower border of pressures (0,001 torr) and the deceleration of increasing electron energy because of the inelastic scattering. The selection of high bound of pressures (0,04 torr) is highly arbitrary. However taking into account the strong dependences from pressure both the energy of electrons and ions and charge of grains, it should be expected much

smaller efficiency of chemical reactions on a surface of grains at increasing of pressure.

1. **V.P. Pasko, U.S. Inan, T.F. Bell, Y.N. Taranenko, *"Sprites produced by quasi-electrostatic heating…" J. Geophys. Res. Vol. 102, No. A3, pages 4529-4561, March 1, 1997*.**

Yu. G. Serezhkin, *"Formation of ordered structures of charged microparticles in near-surface cometary gas-dusty atmosphere," SPIE Proceedings, Vol. 4137, pp.1-12*