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Laboratory studies of VUV photochemistry of thin water ice films: H_2O_2 production and its implication for Noctilucent Clouds

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Noctilucent Clouds (NLC) are the highest clouds of the Earth's atmosphere. They are formed during summer at middle to high latitudes in an altitude range between 80 and 90 km when the air temperature drops below 150K. The particles of NLC consist primarily of water ice [1] and are formed as a result of water vapor condensation. In the day time, NLC are subjected to strong solar Lyman - alpha irradiation with the wavelength of 121.6 nm which penetrates into ice particles and is absorbed essentially. This leads to photodissociation of H_2O molecules and to formation of mobile and chemically active components in the solid phase which can diffuse inside the ice, participate in chemical reactions with formation of secondary products (H_2O, HO_2, HO_3, H_2O_2, O_2, O_3), accumulate in the ice matrix and escape into the gas-phase.
We have carried out first VUV-photolysis laboratory studies of water ice to acquire detailed knowledge about physicochemical processes inside the NLC particles initiated by solar irradiation. The experimental set-up used includes a high-vacuum chamber, a gas-inlet system, a refrigerator-cryostat with temperature controller, a FTIR spectrometer, a vacuum ultraviolet hydrogen lamp emitting the wavelength of 121.6 nm and a microwave generator. Our previous studies [2] were devoted to measurements of the absolute photodesorption rate (loss of substance due to the escape of photoproducts into gas phase) from thin water ice samples under temperatures typical for the upper part of the Earth's mesosphere. The results obtained show that the flow of photoproducts into the gas phase was insignificant. Nearly all the photoproducts remain in the solid phase, and the principal chemical reaction between them is the recombination reaction H+OH->H_2O.
This work is devoted to identify the formation of hydrogen peroxide and measure its concentrations inside the VUV irradiated thin (20-100 nm) water ice samples in the temperature range of 80-140K. H_2O_2 production was monitored via measuring its absorption band near 2855-2860 cm^{-1}. In particular, it was found that H_2O_2 could rich relative concentrations up to 0.2%. The obtained estimates demonstrate that total absolute concentrations of H_2O_2 accumulated in NLC particles can be essentially more than the gas phase concentrations of this component at the relevant altitudes of the upper mesosphere. Also, we discuss additional applications of the obtained results in astrophysics.

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