LABORATORY STUDIES OF IMMERSION MODE HETEROGENEOUS ICE NUCLEATION

V.V. CHUKIN¹, V.N. NIKULIN¹ and A.F. SADYKOVA¹

¹ Russian State Hydrometeorological University, Saint-Petersburg, Russia

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INTRODUCTION

Aerosols affect the climate system not only by changing the opacity of the air, but also due to the formation of water droplets and ice crystals in the clouds (Sadykova et al., 2014). Ice crystals play a significant role in the formation of radiation properties of clouds and precipitation processes. To build a model of the phase state of the clouds we carried out laboratory experiments on immersion mode heterogeneous ice nucleation in aqueous solutions.

METHODS

The experimental setup LINC for investigation of the ice nucleation was created in Laboratory of Meteotehnology, RSHU (Nikulin et al., 2015). The experimental installation consists of an optical microscope, digital microscope, temperature sensors, freezer and Peltier module. The optical microscope is used for the preparation of substrates and drops. The temperature of Peltier module is controlled by a programmable power supply. The images of freezing droplets are obtained with the help of the digital microscope. Moment of droplet freezing is determined automatically by computer vision system. The experimental installation allow one to carry out experiments at 243 K and below.

The particles of kaolin and quartz were used in laboratory experiments. According to the experience, the surface area of the substrate plays an important role in the ice nucleation. The substrate properties of ice nuclei formation are described by the parameter, named specific linear energy (SLE) (Chukin and Platonova, 2009). In the theory of ice nucleation by Chukin-Platonova this parameter characterizes the properties of substrates: the less SLE, the easier the formation of ice crystals on a substrate.

DATA AND ANALYSIS

The amount of experiments on the crystallization of supercooled droplets of aqueous solution with the water activity in range from 0.97 to 1.00 equals 359. Example comparison of the experimental data and the model is shown in Figure 1. Analysis of the experimental data showed that the average values of the SLE of kaolin and quartz particles are 16.1 ± 1.8 and 17.8 ± 0.9 pJ/m², respectively.

The temperature dependence of SLE was found. It can be approximated by the equations

\[ SLE_{\text{kaolin}} = 1.379 \times 10^{-10} - 4.782 \times 10^{-13}T, \]  

(1)

\[ SLE_{\text{quartz}} = 1.134 \times 10^{-10} - 3.821 \times 10^{-13}T. \]  

(2)
CONCLUSIONS

The phase state of cloud can be determined on the basis of the obtained results as a function of temperature and concentration of aerosols. This will not only allow to simulate the effect of aerosols on the radiative properties of clouds, but also to determine the crystallizing properties of the aerosols from satellite data.

REFERENCES

Sadykova, A.F., Nikulin, V.N., Chukin, V.V. (2014). Particles quartz as the crystallization nuclei. Modern High Technologies, 5-2, 235.
