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Experimental tests of peculiarity of ice nucleation on different materials

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Abstract: The analogy of heterogenic ice nucleation in bulk immersion freezing of the atmospheric droplets with aerosol particle in it and freezing of moisture within the wet grounds was considered. For the experiment there were taken modeled sandy and kaolinite grounds with the weight wetness of about 25% and 90% and with the total mass of about 100 g and 80 g respectively. The samples were placed in the stainless steel or plastic dishes and were cooled down in the refrigerated chamber with ambient temperature of about -5°C. The ground samples' temperatures were measured and recorded. The temperatures of the moment of ice nucleation in the grounds were determined. The performed experiments of the ground samples freezing indicated that ice nucleation in the considered experimental samples of sandy and kaolinite grounds happen at the temperatures of about -4°C (close to the ambient temperature of refrigerated chamber (-5°C)). The results of the authors experiments are compared to the results of the heterogenic ice nucleation on the particles of sand and kaolinite immersed in the water droplet presented in the previous works [1-3].

Keywords: aerosol particles; ice nucleation; ground freezing

1. Introduction

Aerosol particles are of the micrometer size and once blown from the Earth surface may travel in the atmosphere long around the globe. At the height of 2000-10000 m they may interact with the clouds in the way which is known (like in [4-6]) in the range of temperatures of about 0 - ~ -36°C there goes only heterogeneous ice nucleation. So the aerosol particles become the ice nucleus and the centers of growth of ice crystals, which descent then on the ground surface with the different intensity according to relief and in the form of snowfalls. The intensity of ice nucleation and growth depends on water vapor super saturation and the material of aerosol particles which defines the temperature of water vapor ice nucleation on it. Comparison of ice nucleation on the particles in the atmosphere and in the ground and immersion freezing of water by particles acting as ice nuclei there is considered here.

Problem of aerosol-cloud interactions i.e. freezing of the water droplet with the particle in it can be considered as a similar to the problem of the water freezing within the disperse grounds. So, in the works [7-8] there are presented the study of ice nucleation on the aerosol particles. According to [7] "are presently three mechanism of heterogeneous ice nucleation known by aerosol particles – deposition, condensation-freezing including immersion freezing, and contact freezing". There is an attempt in [7] to distinguish between condensation and immersion freezing as follows: "In the process of condensation-freezing nucleation, liquid water forms on the ice nucleus surface before freezing nucleation takes place in it. If the liquid has existed for some time on the nucleus surface before the freezing nucleation starts, the process is considered as immersion-freezing".

2. Experiments

In the works [1-3] the results of heterogeneous immersed ice nucleation are presented. The differential scanning calorimeter (DSC, TA Instruments Q10) was used in that study, which allowed the determination of the phase transition temperatures in the range between 130 and 600 K with a precision of 0.01 K. The cooling and heating rates were of 10 and 1 K min-1, respectively and the heat flux on the sample was measured. So, the determination of temperature of heterogeneous immersed ice nucleation is done by means of freezing of samples of water – oil emulsion and water suspension. The water contained natural mineral particles and prepared modeling mineral powder. The portions of emulsion 4-15 mg and the droplets of suspension 1.8-2 mg were coated with oil and placed in aluminum crystallizing pan. Few cycles of freezing and thawing with given cooling intensity were conducted and the temperatures of phase transition were recorded according to the methodic developed by [1]. The freezing temperature was determined as the onset point of the freezing peak on the heat flux curve. That presented there on a figure 1

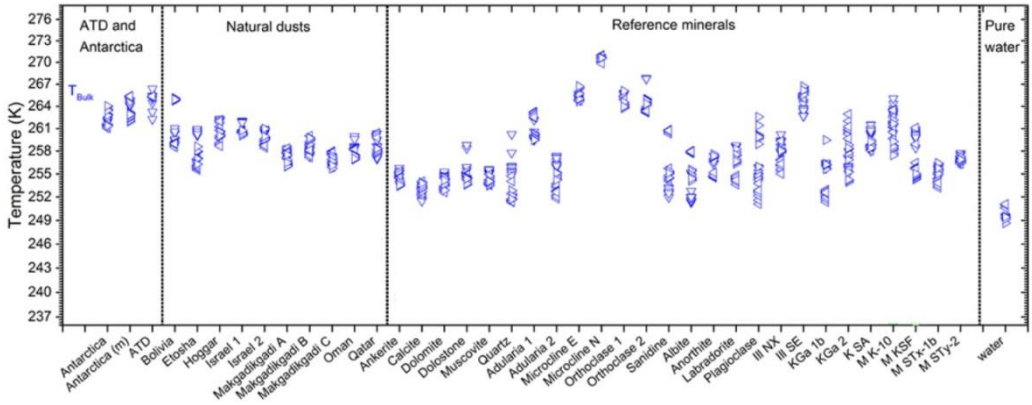

Figure 1. The temperatures of samples ice crystallization. The temperatures of heterogenic ice nucleation there lay within the range of 252-270 K and the temperatures of pure water ice nucleation lay on the graph below 252 K.

These results of these experiments of immersion-freezing meet the results of experiments of the freezing on the contact of water droplets on the different materials from the other works with an agreement.

In our experiment we considered the analogy of heterogenic ice nucleation in bulk immersion freezing of the atmospheric droplets with aerosol particle in it and freezing of moisture within the wet grounds. For the experiment there were taken modeled sandy and kaolinite grounds with the weight wetness of about 25% and 90% and with the total mass of about 100 g and 80 g respectively. The samples were placed in the stainless steel or plastic dishes and were cooled down in the refrigerated chamber with ambient temperature of about -5°C. The ground samples' temperatures were measured and recorded. The temperatures of the moment of ice nucleation in the grounds were determined. The variation of the experimental sandy ground samples' temperature with weight wetness of 25% placed in the refrigerated chamber can be seen on the graph (figure 2):

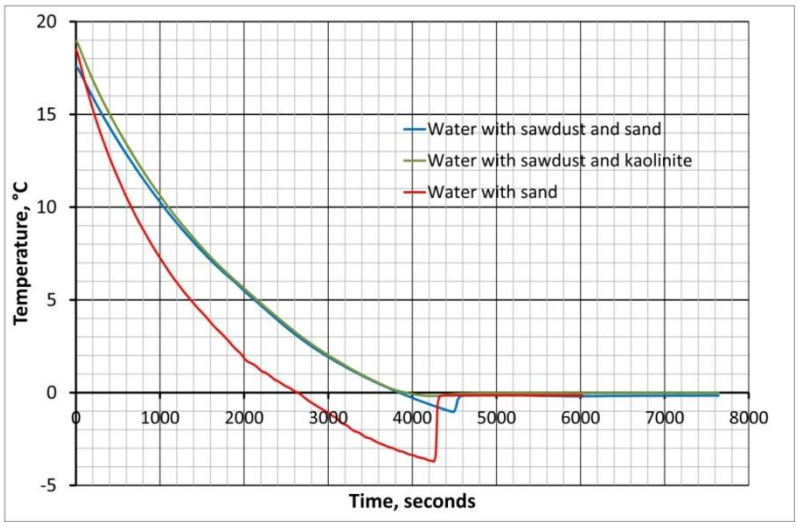

Figure 2. Variations of the temperature on the freezing samples.

3. Results

The performed experiments of the ground samples freezing indicated that ice nucleation in the considered experimental samples of sandy and kaolinite grounds happen at the temperatures of about -4°C (close to the ambient temperature of refrigerated chamber (-5°C)). This may be compared to the results of the heterogenic ice nucleation on the particles of sand and kaolinite immersed in the water droplet presented in the works [1-3]. Relatively high ice nucleation temperature for the experimental samples of the modeled grounds can be also explained with possibility of the interaction of not only ground moisture with the ground particles but also of the ground moisture with the stainless steel or plastic material of the dish which have higher ice nucleation activation material factor and the temperature of ice nucleation on it respectively.

5. Conclusions

The results of the authors experiment are compared to the results of the heterogenic ice nucleation on the particles of sand and kaolinite immersed in the water droplet presented in the previous works [1-3] and show good agreement.

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Conflicts of Interest: The authors declare no conflict of interest.

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