Glycol Contamination in Nucleation Counters

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Traces of vapor contamination may produce drastic effects on the habit and electrical charges produced on ice crystals grown from a supercooled fog (Odencrantz, 1968a). They may also modify the measured value of the nucleation efficiency of AgI pyrotechnic smokes (Odencrantz, 1968b). Many chambers utilize 1,2-ethanediol (glycol) to prevent frost formation in the chamber. This impurity can produce a significant change in the measured value of the nucleation efficiency at temperatures warmer than -12C, a region that is important for cloud seeding to produce precipitation. The experimental values of the nucleation efficiencies of AgI pyrotechnic smokes are dependent on the equipment and techniques used for the measurement; caution should therefore be used if the results are to be extrapolated to atmospheric conditions.

Samples of a standard silver iodate pyrotechnic were tested in a 24-m^3 cold chamber that normally does not have glycol contamination. Frost is removed from the walls of the chamber between experiments with cold dry air. The background count of ice crystals in the chamber is at least a factor of 1000 below the normal count in the chamber. Glycol was evaporated from a small electrically heated cup to produce deliberate contamination in the chamber. At the colder temperatures some of this glycol condensed in the air and formed a thin fog of droplets which were visible in the beam of a spotlight. Steam was then added to the chamber, and the supercooled fog was allowed to come to thermal equilibrium with the walls of the chamber. If glycol droplets were initially present in the chamber, a large number of water or water-glycol droplets ($\sim 20\ \mu$ diameter) settled to the floor of the chamber during this equilibration time. It was not determined how much of the contaminant remained as a vapor, how much was associated with the water droplets, or how much was removed by precipi-

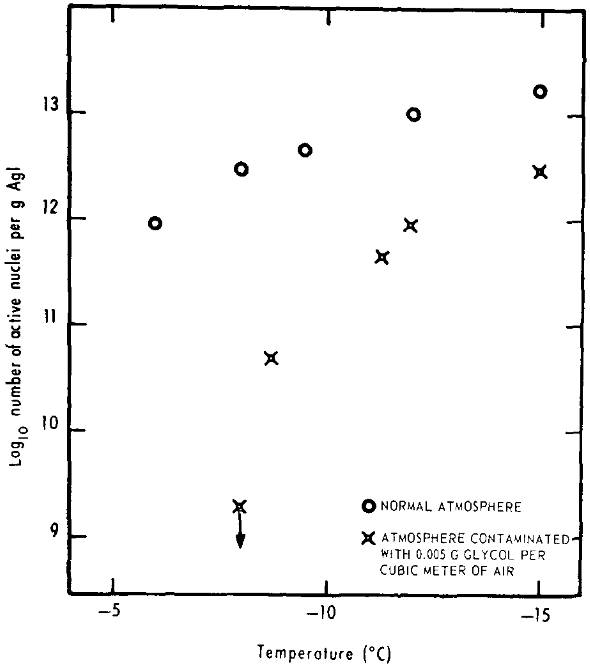

Fig. 1. Nucleation efficiency of a silver iodide smoke in the presence of glycol contamination.

tation prior to the seeding with the silver iodide smoke. If ice crystals appeared during the several minutes prior to the seeding the chamber was flushed with air and dried and then the experiment was rerun. The supercooled fog was then seeded with the smoke from a silver iodate pyrotechnic which was burned in the chamber. Normally a large number (more than 10^8) of ice crystals were apparent in the chamber within 20 sec after seeding, and the supercooled fog was gone 1 min after seeding. In the presence of glycol at the warmer temperatures, the fog was more persistent. The ice crystals which were produced and grew large enough to fall on a Formvar-coated microscope slide were replicated with the chloroform vapor technique and counted under a microscope.

The measured nucleation efficiencies as a function of temperature with 0.005 gm of glycol contaminant per cubic meter of air are shown in Fig. 1. The arrow associated with an experimental point in the figure indicates that the plotted point is an estimated upper limit of the nucleation efficiency obtained with a particular set of experimental conditions. The chromatographic-grade glycol was reported to be 99.8% ethylene glycol, 0.078% water, and undetermined residual impurities. Similar results were obtained with an unanalyzed technical grade glycol. Addition of an excessive quantity of steam reduced the effect of the glycol contamination on the nucleation efficiency. Some of the glycol was apparently washed out with the precipitating water drops. The addition of larger quantities of glycol resulted in a greater decrease in the measured value of the nucleation efficiency.

The observed results may have been due to the action of the contaminant on the nucleating agent, on the crystal growth process, or on the water. Introduction of additional water vapor to the contaminated and seeded chamber produced a large number of additional ice crystals. Glycol contamination did not appear to affect the nucleation by the adiabatic expansion of a small quantity of compressed moist air. This suggests that the decrease in the measured value of the nucleation efficiency of the AgI smokes is due to the decreased vapor pressure of the water, or due to glycol modification of the effectiveness of nucleation.

Glycerol and tetraethylene glycol also produce a decrease in the measured value of the nucleation efficiency of AgI if their fogs are present in the chamber prior to the addition of water vapor. Substitution of glycerol, tetraethylene glycol, or a lower-vapor-pressure glycol should be considered for the nucleation chambers where the ethylene glycol problem exists. The nucleation chamber geometry and the mode of operation will determine the degree of consideration that must be given to the problem of contamination.

REFERENCES

Odencrantz, F. K., 1968a: Modification of habit and charge of ice crystals by vapor contamination. *J. Atmos. Sci.*, **25**, 337–338.

——, 1968b: Modification of the measured nucleation efficiency of pyrotechnically produced AgI smoke by atmospheric contamination. (To be published).