Photolytic Activation of the Ice-Nucleating Properties of Silver Iodide Hydrosols

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The ice-nucleating ability of silver-iodide aerosols has been found to decrease with ultraviolet (UV) irradiation in laboratory tests by Reynolds et al. (1951), Inn (1951), Birstein (1952), and St. Louis and Steele (1968), among others. Under actual cloud seeding conditions, Smith et al. (1955) also found a decay with time in the ice-nucleating activity of AgI smoke and attributed this effect to the photolytic action of the UV radiation in sunlight. Though the rates of decay varied widely in these experiments, in no case was an increase in activity due to irradiation reported. In an attempt to more accurately determine the rate of decay of the ice-nucleating properties of silver iodide under known conditions of UV radiation, Bryant and Mason (1960) illuminated a freshly-formed silver iodide surface with a mercury-arc lamp for varying periods of time and counted the number of ice crystals that then formed on the exposed surface under identical conditions of temperature and ice supersaturation. They reported an initial tenfold increase in activity but that with increased exposure times the numbers of crystals which formed fell quite rapidly. After radiation doses equivalent to an hour’s exposure in strong sunlight they measured an activity somewhat less than one-tenth the maximum value. Thereafter the activity decayed more slowly. Rowland et al. (1964) reported a similar effect, the number of ice crystals increasing with exposure for several seconds, remaining about the same for exposures of 5–10 min, and then decreasing gradually. The light source used was a zirconium arc lamp. More recently, Dobissik et al. (1971) irradiated AgI powders with γ-rays from a Co60 source and placed them in aqueous suspensions. They, too, found an increased nucleating activity, though in this case there was no decay for at least 48 hr after irradiation.

In conjunction with other experiments on the nuclea-
example, the concentration of active nuclei increased by four orders of magnitude. The increase did not, however, remain this large at colder temperatures. Much more uniform in this case was the temperature increase for equal numbers of freezing nuclei.

Though the magnitudes of the changes in activity for the two suspensions were different, the results were on the whole similar. But when the first suspension was mixed with aqueous solutions of NaI or NH₄I, measurable increases in activity with UV irradiation were not noted. It should be mentioned, too, that irradiation did nothing to enhance the freezing nucleus concentration in distilled water. Nor did it affect certain natural leaf-derived nuclei.

Perhaps the most interesting experimental effect, and that which differentiates the present work from those cited above, is the reversibility of the activation process. Successive runs with the same set of drops under illuminated conditions consistently yielded the same spectrum. Runs in the dark, though not so consistent, always produced lower activity curves. Series of experiments in which the illuminating conditions were alternately changed from light to dark and vice versa produced no change in this pattern. In fact, experiments at constant supercoolings have shown that irradiation creates freezing nuclei continuously, that this process becomes effective within the first minute of irradiation, and that it ceases within a minute after the illuminating source is turned off. Apparently, then, the nuclei thus formed retain their enhanced activity for times short in comparison to the time of an experimental run; irradiation, however, quite readily re-activates them. The fact that nuclei are being created continuously makes the illuminated spectra shown above ambiguous to some extent because the freezing nucleus content may no longer be considered constant. Other experiments are now being analyzed to remove this ambiguity by determining the rate of creation more exactly.

No attempt will be made here to explain the physical mechanism responsible for the increased activity, though it must be assumed that the photolytic reactions responsible for decay (see, for example, Fletcher, 1959) were operative in this case also. It may well be that the photo-decay products re-combine or that they further react with impurities present in the droplets to form more active sites on the particle surfaces.

The implications of this series of experiments for operational cloud seeding with silver iodide may only be important if the contribution to crystallization in treated clouds by bulk freezing is significant. At present this is uncertain. Many techniques for measuring ice nuclei, however, must certainly be viewed with this finding in mind. It is for this reason that we felt it important to report this work before our investigation has been completed.

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REFERENCES


