

**Activated salt surfaces in ice nucleation and growth,  
and the formation of droplets<sup>1</sup>**

BY HENRY M. PAPÉE

*University of Ottawa<sup>2</sup>*

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It has been suggested [1] that lattice dislocations in crystals may promote initiation of solidification of slightly supercooled water vapor, and it has been found [2] that freshly prepared or ground compounds were more effective towards ice nucleation than seasoned ones. Birstein [3] showed that a considerable number of layers of water molecules can be formed on surfaces of lead-iodide and silver-iodide crystals so as to make their outer surfaces similar to those of ice particles.

It was recently found in this laboratory that sintering (decrease of specific surface) of lead-di-iodide microcrystals, when the salt is exposed to water vapor [4], is very slow in comparison to that of sodium chloride [5]. Lead iodide is known for its excellent nucleating properties, whereas the role of sodium-chloride particles in ice nucleation and cloud precipitation has so far been considered controversial. Since adsorption on a nucleus must precede coalescence or ice growth, it seems natural to associate the nucleating and coalescent power of an agent with its surface properties and to a large extent, therefore, with its specific surface. It may thus be concluded that a substance the surface of which will maintain itself stable, or sinter very slowly when exposed to water vapor, will induce ice nucleation and water coalescence better

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<sup>2</sup> Present affiliation: Division of Applied Chemistry, National Research Council, Ottawa, Ontario.

than a substance whose surface will undergo a fast degradation under the same conditions.

When lead mono and di-iodides were exposed to water vapor, the heat released followed similar patterns with time [6]. The heat release took a very long time in both cases; this indicates that lead mono-iodide which was produced from di-iodide by heat [4] may have similar nucleating properties to those of the original and only slightly heated product. The pattern of heat evolution with time during the adsorption of water vapor on the surface of sodium chloride [7] indicates an entirely different process and, together with a kinetic study of sintering of surfaces of sodium chloride microcrystals [5], points to an initial *short* adsorption during which the surface remains constant. This is followed by a *rapid* decrease of specific surface and, subsequently, by penetration of water into the crystal lattice.

Both silver and lead iodides which are known to be excellent ice-nucleating agents, are photosensitive, and give rise to the photoelectric effect. Photodecomposition will no doubt bring about changes of the surface structure, whereas the photoelectricity may promote clustering of water molecules (a sort of electrostriction) around the particular sites of the nucleus. The influence of both phenomena on the nucleating power of the particle will depend on the available surface of the nucleating agent.

These data lead to the tentative conclusion that to exert good nucleating properties, a nucleating agent should have:

1. a somewhat distorted lattice in the immediate vicinity of the surface [1]; and
2. a surface which would not sinter too quickly under exposure to water vapor; and perhaps
3. a surface which might become electrically charged under the influence of conditions available in the atmosphere.

It is known that colored varieties of *NaCl* exist in nature [8], the color being due to lattice defects [9]. Such sodium-chloride crystals can be obtained from normal *NaCl* by placing it in electron beams, X-rays, electric discharges [10], or by heating *NaCl* with sodium [11]. The experiments of Benson and collaborators [10] indicate, furthermore, that nitrate impurities can be generated in *NaCl* particles in electric discharges (cf. [12]) if the carrying nitrogen gas contains oxygen.

Accordingly, batches of sodium chloride of different specific surface areas were stirred in an electrodeless discharge. Small increases of surface areas occurred in most cases. The kinetics of sintering, under water vapor, of the blue product obtained [5] indicate a

surprisingly low rate of sintering with respect to that of the "untreated" product. Experiments on the microcalorimetry of water vapor adsorption on this product [13] indicate very large heat evolutions (probably due mainly to the reaction of water with occluded sodium) as compared to those obtained with normal *NaCl*. At the same time the amount of water used in the process is many times that used by the untreated salt.

Since sodium chloride is present in the atmosphere where processes leading to strong radiochemical excitation take place, these results seem to be significant.

Because of mobility differences between elementary chlorine (found occluded in the "treated" crystals), sodium in the lattice of sodium chloride, and the sodium and chloride ions and F-centres in the salt, electrical gradients across a *NaCl* particle of a 'blue' surface are possible. Hence, experiments are being performed to establish qualitatively whether adsorption of water vapor on the 'blue' surface, and its reaction with the products contained in the outer strata of the lattice, will destroy the gradient, thus giving rise to the production of electric charges on the surface of the particles.

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