

A KIND OF SEEDING AGENT
FOR DRAWING HIGH LIQUID WATER CONTENTS OFF STRONG
CONVECTIVE CLOUDS : REALITY OR NOT ?

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Abstract. Laboratory experiments prove the existence of organic compounds (e.g. sodium alginate) easily coalescing with water droplets which, on impinging on their surface, are quickly taken in charge in the bulk by absorption. The growth of particles of such material by collision-coalescence in the liquid parts of a cloud results in large drops of viscous solution less sensitive to the breaking up process than water drops of same size.

It is suggested to use this material pulverized to an appropriate size for seeding strong convective clouds in order to induce fastly inside them some modifications which are examined in details. The feasibility of such seedings is considered under several aspects (seeding vector, amounts to be used, etc ...).

1. INTRODUCTION

For forty years, the techniques used in attempting to modify clouds and, consequently, to affect the weather have become more refined and diversified. But in the same time the principles of the methods involved in this field do not seem to have known some important changes.

The more consistent principle is to replace cloud droplets by a much smaller number of larger particles which precipitate. In the supercooled parts of the clouds this can be done by seeding with ice-forming nuclei according to the Bergeron-Frideisen theory. For instance, in order to modify the clouds developing into hailstorms, overseeding with AgI nuclei owing to natural ways (updrafts) (J. Dessens, 1985) or by appropriate airborne vectors (B.K. Sulakvelidze, 1967) is usually suggested unless the validity of this principle is demonstrated indisputably by the results of field experiments. (P. Schmid, 1967).

2. CHARACTERISTICS OF HAIL PRODUCING CLOUDS

Beside experimental or operational programs undertaken in order to modify the weather, extensive and eminently creditable efforts have been carried out for achieving a better understanding of the mechanisms involved in the formation and development of the cloud and precipitation elements.

For convective clouds which, isolated or belonging to cells or squall lines, are likely to produce large amounts of devastating hailstorms, some physical conditions to be completed by further researches may be briefly summarized like this :

- high surface temperatures,
- cloud-top temperatures in the range -10°, -25°,
- thermal atmospheric profiles partially super-adiabatic inducing strong updrafts able to maintain at high levels in the atmosphere precipitation elements during lapses of one minute or more and hence to localize in the clouds or cells high liquid water content zones including large super-cooled drops (A.K. Sulakelidze, 1965)

3. A NEW APPROACH FOR MODIFYING HAIL PRODUCING CLOUDS ?

From the point of view of a preventive action leading to impede the development of hail producing clouds, we can imagine a principle of intervention

consisting in inducing precipitations from the cloud if possible entirely in liquid phase according to the chain reaction theory (I. Langmuir, 1948). This method can be suggested before or as soon as the cloud top reaches the -10 °C level and, in all the cases, before the cloud reaches its maximum development stage. In that purpose, water drops or hygroscopic material finely powdered can be used. The subsequently scheme of development leading to the precipitation by seeding with such agents will not differ from the natural one comprising the splintering of the largest drops reaching their breaking size under the influence of vibrations they are undergoing while falling through the air currents supplying the cloud and contributing to the development of the latter.

It will be different if we use a substance - such as sodium alginate - which, while facilitating the coalescence of cloud droplets, introduces in addition viscosity forces inside growing elements in order to strengthen their cohesion and delaying their breaking.

4. PHYSICO-CHEMICAL PROPERTIES OF SODIUM ALGINATE

Sodium alginate is a solid product derived from alginic acid extracted from brown algae. It is a good absorbent of vapor and liquid water and forms with the water a viscous colloidal solution so that large drops of such a solution can reach, before breaking, maximum sizes larger than those of pure water falling in the atmosphere whether subjected or not to the updrafts.

In an atmosphere saturated with water vapor, the sodium alginate particles are likely to absorb several times their weight in water.

When a liquid water droplet comes in contact with the surface of a sodium alginate particle, it is immediately taken up by the particle in bulk, the volume of the latter increasing instantaneously. This is an absorption process clearly illustrated by the Figure 1.

Both above described processes have been tested in the course of fog and orographic cloud seedings with this material :

- Figure 2 shows the visibility improvement resulting from a seeding achieved on 15 September 1971 inside a fog with a device of blowers grounded

on Brest-Guipavas Airport (France).

- In the summer time of 1977, during a series of field experimentations the aim of which was to initiate precipitation elements from orographic clouds formed in the vicinity of Puy de Dôme, echos were recorded on the screen of the radar Rabelais (8 millimeters wavelenght) short lapses after ponctual dispersions of sodium alginate spread from the T.V. tower inside cloud layers which did not produce echos before.

5. BEHAVIOUR OF VISCOUS ELEMENTS IN HIGHLY SUPER-COOLED ZONES OF THE CLOUDS

It seems reasonable to expect that the dispersion of sodium alginate particles in the super-cooled parts of clouds where strong trubulences are prevailing will have the effect of inhibiting and braking the process of droplet multiplication because of the rapid formation of large drops consisting of viscous solution. These drops will fall without undergoing the breaking and will be able to remain suspended in strong updrafts at lower levels where the risk of freezing in bulk is considerably less.

In the most favorable cases, a part of the liquid water of the cloud could be precipitated before the cloud achieves a development leading to the formation of big hailstones.

It should be of great interest to carry out field experiments for demonstrating the reality of this process.

Because a colloïdal solution freezes at temperatures lower than the freezing point of the pure solvent, the viscous drops having reached the regions where the pure water drops of similar size are normally expected to freeze will remain a longer time without freezing : the collision-coalescence process will continue to work in these regions. Even if it happens they freeze, the resulting precipitation elements will assume elastomechanical properties different from the hailstones, making them more sensitive to plastic shear strain therefore less damaging (*).

In this respect too, systematic laboratory tests carried out in various conditions but as close as possible to those prevailing in the clouds should be needed for verifying this behaviour.

6. OTHER PROPERTIES OF SODIUM ALGINATE WITH RESPECT TO ITS INSERTION IN OUR ENVIRONMENT

When gaseous, liquid or solid chemicals are introduced in the atmosphere for activities related to weather modification, it is essential to examine the type of influence - harmful or not - they may have upon our environment.

a) Because sodium alginate produces viscous solutions with the liquid water of the clouds, the drops of such solutions when falling on roadway, runways, metallic or plastic structures, etc ..., may make them locally slippery. The remedy for this nuisance is to wash the surfaces with water in order to dilute the solution.

b) Compared with numerous inorganic salts, sodium alginate is much less chemically and biologically active and hence is less harmful to

(*) It may be remembered indeed that sodium alginate is manily used in the manufacture of ice creams in which it serves as a stabilizing agent acting to prevent the development of large ice crystals.

flora and fauna on which rain falls. Moreover, the algae from which it is extracted serves some-times as natural manure.

7. OPERATING METHODS AND ESTIMATED AMOUNT OF SODIUM ALGINATE TO USE

In order to activate the coalescence of cloud droplets with alginate particles, the latters have to be in the range 30 μ m, 70 μ m.

It is quite out of the question to disperse the powdered alginate from gounded blower devices since most of the particles then fall down close to their source.

On might also imagine using either rockets or airplanes which will disperse the product along their trajectories in the suitable zones of clouds.

In fact, the choice between these two kinds of carrier depends upon the amount of product to bring into operation.

The amount of sodium alginate has been estimated in the case of a hail producing cloud giving a stretch of hail of 10 km lenght and 1 km width corresponding to a height of 20mm of precipitated water.

By using a sodium alginate of high viscosity which remains efficient when it has absorbed several hundred times its own weight in water, a seeding with about 200 tons of such product would be necessary for supressing the hail precipitation according to the above defined principles.

8. CONCLUSION

It is clear that the hail-producing cloud seeding with sodium alginate as above considered is financially prohibitive as much at the level of the cost of the product as for its bringing into operation. Nevertheless, in the present state of our knowledge about the natural development and supply of hail precipitations, and without serious laboratory and field experiments being done on this subject, we cannot reject the idea that amounts of alginate 10 to 100 times less suitably introduced into the cloud at the correct place and time would be sufficient to inhibit a set of processes which, without intervention and by amplification, would assume the proportions of a highly damaging hailstorm.

9. REFERENCES

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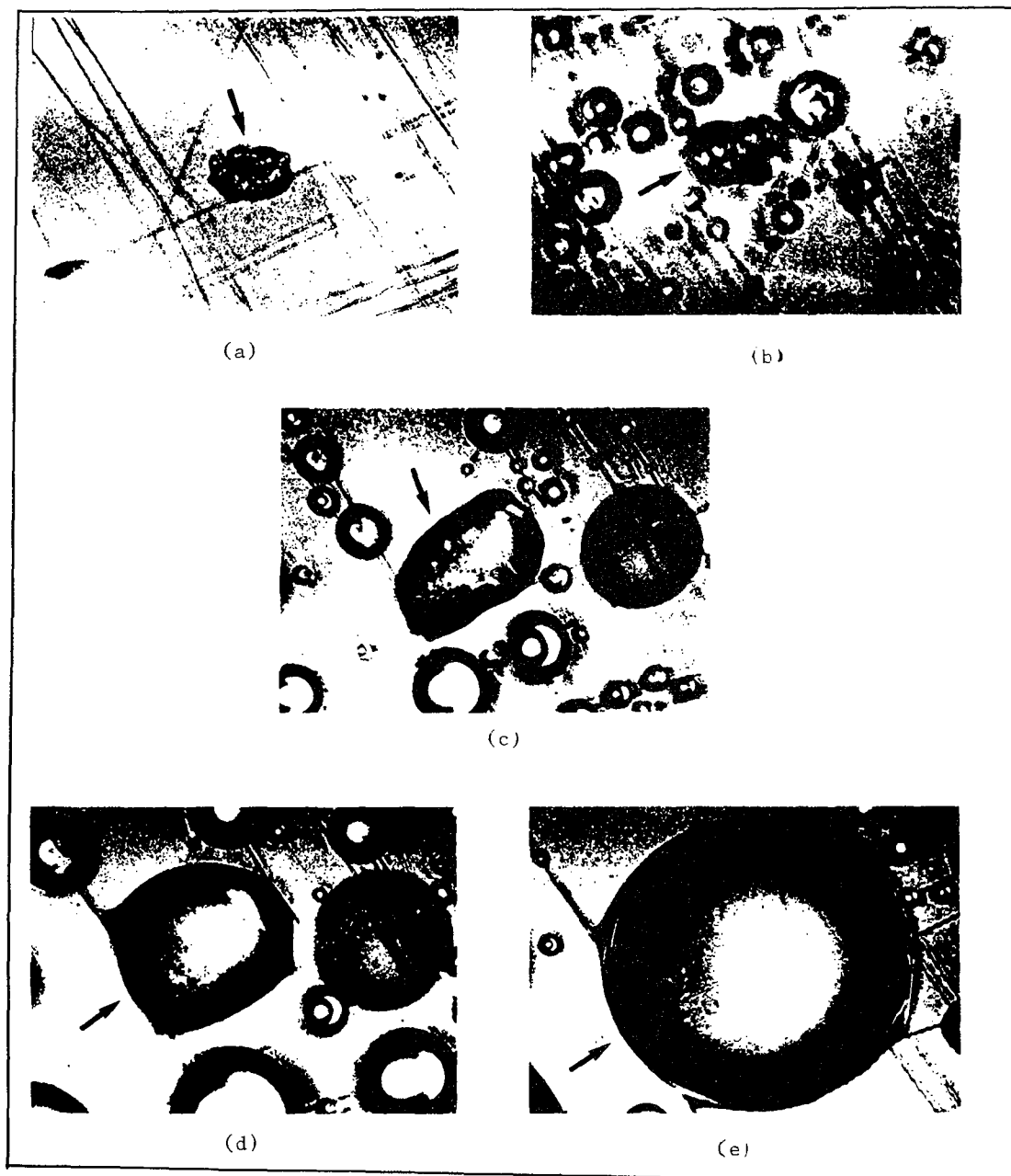


Fig. 1.- Different growth stages of a single sodium alginate particle of about $40 \mu\text{m}$ in size (arrow) suspended on a web's thread (a) in a stream of cloudy air. The growth proceeds by direct capture of cloud droplets or by coalescence with other drops captured by web's threads in its vicinity (b to e). Let us note the opacity of the particle during the growth process and the final size reached (about $160 \mu\text{m}$).

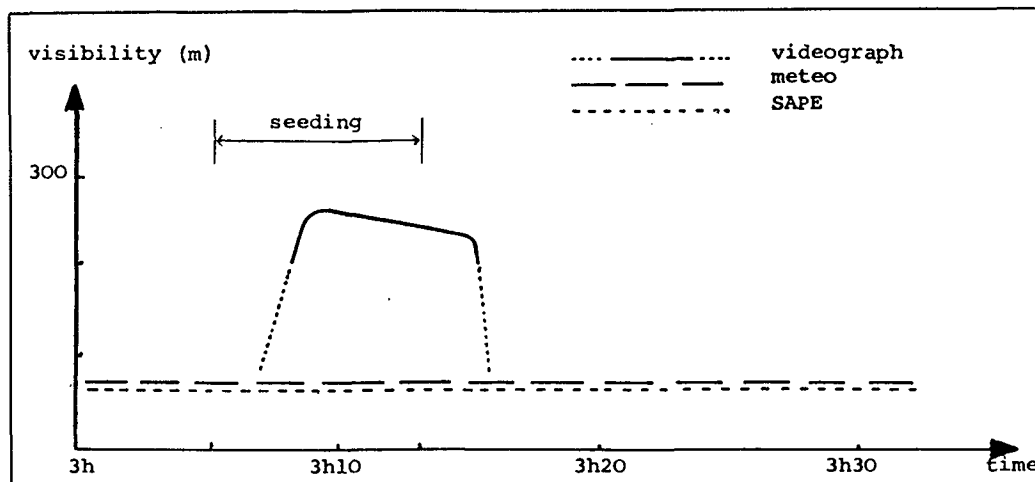


Fig. 2 - Visual range variations versus time during a field experiment (15 September 1971) in a natural fog seeded with sodium alginate. Meteo and SAPE measurements are recorded in sites located out of the seeded area. Let us note the low and constant level of these values.