

Compatibility and feasibility analysis of sugar as cloud condensing nuclei

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Abstract-

This report brings about the various phases involved in cloud seeding which means creating or hailing rain with the help of artificial agents. Various methodologies involved in cloud seeding along with their consequences has been discussed. Also, a little introduction of various types of clouds has been discovered. Since, 1839, when for the first time James P Espy proposed that it is possible to create rain artificially by the use of huge convective currents causing various particles to reach the upper portion of atmosphere; cloud seeding has been the area of interest for various scientists. Since then, time to time, cloud seeding has suffered various reforms and new methods and particles were introduced. This report is focused on the use of sugar as CCN and has been tried to prove the hygroscopic nature of sugar. Sugar can be easily used as condensing particles as it has got almost no side effects when inhaled in a very little amount. Traditional Schaeffer's method has been followed which involves the bringing up of the cabinet of a refrigerator below freezing point of water and dispersing the test specimen to check whether the test specimen can act as a seeding agent or not and what was the actual seeding time required by the particle.

Introduction-Cloud seeding[1] refers to the methods or processes to modify the weather whose sole effect can be either to cause rain or block rain using chemicals or different physical processes. Not being a new concept, the history of cloud seeding can be traced back to mythologies. In Greek mythology, Poseidon can be seen provoking rain by penetrating his trident into the clouds. In Hindu mythology, Lord Rama can be seen forcing the clouds to rain by shooting arrows into the clouds. Various instances can be found where priests pray the clouds to cause rain by burning fires.

However, seeding has always been a controversial issue and was never untouched from the negativities of human behavior and brain, abnormal precipitation, use of seeding as military tactics to hurdle the way of army, unpredictable behavior of the process and sometimes loss of human life and property lead many countries to draw resolutions against cloud seeding.

1.1 CLOUDS-: Clouds[2] could be described as visible mass of droplets or crystals which are made up of either water or different frozen crystals of chemicals suspended in the atmosphere. These suspended particles are called aerosols. Cloud formation takes place either because of the cooling of air or addition of water vapor, or both. After having enough saturation this precipitation falls to the surface and is called rain. In a very general sense clouds could be described as a bulk collection of tiny droplets of water or ice crystals which are so small that they can float in the air and are carried away by the flowing wind. All the air contains water and near the ground it is in the form of water vapor. When warm rises because of the heat received from sun's radiation or from the heat received from the surface of the earth, it tends to expand and expansion takes place, because of the expansion it cools and thereby loses the capacity to hold water vapor. These vapors then starts to condense on tiny dust particles floating in the air and when billions of particles coagulate like this, they become visible cloud.

The nomenclature of clouds was done by English scientist Luke Howard who classified clouds using Latin words. Basically cloud can be categorized in three categories- :

- a. Cirrus
- b. Stratus

c. Cumulus

Further classifications are done on the basis of their mean height from above the ground. Generally all the above explained clouds can be found at varying altitudes and are classified further on the same accord. They could be termed as:

- a. High Level Clouds
- b. Medium Level Clouds
- c. High Level Clouds

1.1.1 Cirrus clouds -: These are the most common of the clouds. They are formed because of ice crystals blown into high winds. These are white in color and predict a pleasant weather. These are carried away by the wind and their direction could be easily predicted. The most important thing is that encountering a cirrus clouds is an indication of a change in weather. Cirrus clouds can be further classified into cirrostratus and Cirrocumulus clouds. Cirrostratus Clouds are very thin in depth and are sheet like clouds that cover the entire sky as bed sheets. They are so thin that even SUN and MOON can be seen through them and encountering cirrostratus clouds means that there is a possibility of rain. Cirrocumulus clouds occurs at an altitude of 5 kilometers and unlike the other cirrostratus or cirrus, they include a very moderate amount of liquid droplets, which are super cooled in state and contains ice crystals as dominating component. These ice crystals basically forces the super cooled water drops in the clouds to freeze and getting transformed into cirrostratus clouds which further produces precipitation in the form of snow or ice..

1.1.2 Stratus Clouds: Stratus clouds are grayish in appearance and cover the entire sky in the form of fog and results in light mist or drizzle. They resemble fog which doesn't reach the surface of the earth. These are associated with storm systems under low pressure and form along the warm fronts extending from the systems to the east. A warm moist layer of wind is lifted by the front that ultimately changes into a thin layer of cloud. Cooling to their dew point temperature, they appear as fog over the surface of lakes and rivers.

1.1.3 Cumulus Clouds: These are pure white puffy clouds resembling to pieces of soft cotton floating in air and that is the reason they are often referred to as "fair weather clouds". In appearance they have a flat base and the top looks like round shaped tower which sometimes also resembles to the head of a cauliflower. These clouds when carried upwards get transformed into giant cumulonimbus clouds and result in thunderstorm. they occur at an altitude of around 6000 meters from the sea level and are the hotspots for creating artificial rain. Containing both warm and cold clouds, it also contains the maximum amount of water vapors and is believed to be always in saturation state. Cumulus clouds can be easily depicted and in general they occur everywhere on the planet.

The liquid water density has been seen to change in cumulus clouds with varying height. As the height increases, the concentration goes on increasing. They form lines stretching over miles and forming cloud streets which cover a large area and may be broken or discrete and because of this they result in Wind Shear causing circulations in the air. These clouds indicate fair weather but also threaten of heavy rain with lightening and may also in rare cases lead to Tornadoes. Cumulus clouds are most often responsible for acid rain because of the huge oxidation of sulfur dioxide.

LITERATURE REVIEW:

For the very first time ever in the history of cloud seeding, in 1839, James p. Espy[4] in the issue of *National Gazette And Literary Register Of Philadelphia* published his article that burning large fires

can generate cumulous clouds which are themselves responsible for rain. These large fires when sustained for a prolonged period of time can create a huge updraft of convective currents of winds.

Then again in 1939, Gorog And Rovo[5] two scientists from Hungary supported James's hypothesis and proposed that convective rains can be generated using huge fires on the surface of the earth. To support their hypothesis, they both generated fire on a lake of oil and made their own calculations concluding that this method which although doesn't seem environmentally feasible, can be responsible for creating artificial rain.

1875 was the time when for the very first time when French scientist Coulier[6] proposed his hypothesis that particle floating in the air can serve as nuclei around which condensation of water vapor can take place. Coulier was the first person to propose that the certain particles have inherent affinity towards moisture or water and may be used tactically as cloud condensing nuclei. Although he was unable to describe whether all particles can nucleate up to the same extent or not?

However in 1965, John Aitkin [6] using his Aitkin nuclei chamber demonstrated that there are two kinds of nuclei: Hygroscopic and non Hygroscopic. Hygroscopic nuclei are the one which have inherent affinity towards water vapor and non hygroscopic nuclei are those which need to be supersaturated before the condensation takes place. Aitkin also discovered his own meter to measure the concentration of condensation nuclei and proposed that there could be around 1000/cc such nuclei in pure air and the concentration goes on increasing as the air gets more and more polluted. But a little of those are hygroscopic in nature and thus serves no other function rather than contaminating the air. Aitkin proposed that the concentration of such nuclei goes on increasing with the human activities. The concentration of nuclei increases during day and goes on decreasing as the day passes. Not only at the ground level, he also measured the concentration of nuclei above the ground level using airplane getting the unfiltered air for which airplanes were specially designed without filter bags.

Major reform in the era of cloud seeding was brought about by Vincent J. Schaefer[7] who was an assistant to Irwin Langmuir. Schaefer obtained a home refrigerator unit which was used for food storage and made up some modifications and after bringing the temperature below freezing point, breathed into it so that to saturate the air. Due to the moisture present in his breath the moisture in the box got condensed and formed fog particles which were similar to cloud particles but were not heavy enough to form precipitate. He then introduced a block of frozen dry ice (carbon dioxide) which was at a temperature of "-79 degree centigrade". Instantaneously the box was full of ice crystals which quickly transformed into snowflakes and dropped themselves to the bottom. Fig.14 shows a glimpse of the Schaefer experimenting over the refrigerating unit. Figure.14 Shafer and Langmuir experiment (Science Reporter, July 2013, P.8-13)

Another major contribution was given by Dr. Bernard [8] in November 1946 who proposed that dispersing silver iodide can nucleate water vapor to form ice crystals. Silver iodide was chosen because its molecular size was very much similar to the ice crystals and proved to be much more efficient than the dry ice particles. Not only he invented silver iodide as a superior cloud condensing nuclei but also gave a very much practical way of injecting particles. He made a mixture of silver iodide and lead iodide in acetone, sprayed through the nozzles to make droplets and then burned them due to which one silver iodide crystal produced around 10¹⁶ nuclei for ice crystals.

Based on the proposal of Schaefer, in 1948, around fifteen experiments were conducted over the islands of Hawaii by Leopold and Mordy[9]. The whole idea included dropping of dry ice particles using aerial cloud seeding. The plane used was a twin engine beech craft carrying 400-500 pounds of dry ice and was dispersed from a hopper having a sliding door. The hopper had the capability of dropping 150 pounds in a time period of 5 to 7 seconds and the plane was flying at a speed of around 140 mph. Within 45 minutes of the seeding, 1.75 inches fell over the lanai city and a total of 3.40

inches fell over the Palawai basin which was recorded to be the largest rainfall on any day. But the duration was not so appreciable, in most of the cases rainfall remained for around 15 to 30 minutes following seeding. But these experiments were still not considered to be an authentic data as the time during which the experimentation was done was the period of usual rainfall, however the intensity of the falling rain could be marked because of cloud seeding.

J. Warner and S. Twomey[10] reproduced the experiments over around 35 super cooled clouds by releasing silver iodide as a smoke from aircraft flying through the upper layer of the clouds. The experimentation included seeding using 3 aircrafts in which two of them were general and the third one was fitted with special radar to monitor the precipitation. The experiment was done over South Wales about 100 km from the coast. The methodology included injecting an acetone solution prepared with silver iodide and injecting into the engine exhaust

Another encouraging experiment was done by F H Ludlam[11] of imperial college London who seeded super cooled mountain clouds to prevail snowfall on Central Swedish Mountains. The experimentation was done using ground cloud seeding using generators and dry ice as the condensing nuclei. After the seeding was done, snow began to fall around 1600 seconds after the seeding, after around 2500 seconds investigating aircraft flew and recorded larger snowflakes .After 2800 seconds these snowflakes started to fall.

Another experiment was done by E. E. Adderley and S. Twomey [12] of division of radio physics Australia using silver iodide as condensing nuclei and performed long termed observations. The experimentation was done over the catchment area of the snowy river in southern part of Australia. Special designed aircraft were used with each wing having a generator unit and a pump inside the cabin to inject silver iodide into the generator. The inflammable injected silver iodide was first transformed into fine atomic particles and ignited further by a spark plug. Thermocouples were installed to monitor the proper working of the burners. The solution containing a mixture of silver iodide in a mixture of lead acetate was used and the generator was giving an output of 500 to 800gm of silver iodide per hour.

In an another attempt, J.A. Martins Et.Al.[13]studied the impact of biomass burning aerosols on precipitation in the Amazon .The numerical simulation indicated that when CCN concentration was high the hydrological cycle was getting affected. The increase in CCN by polluting the air forced the mean liquid water path to decrease. It was found that along with the concentration of the CCN the time period for which seeding was done played an important role in the precipitation.

Biswas, Kapur and Karunga[14]from National Physical Laboratory of India performed certain seeding experiments using table salt over the areas of Delhi, Jaipur and Agra in the north western part of India. Two different approaches were followed under which they not only dispersed the salt particles in their dry state but also sprayed the particles by diluting them in a solution of water. Ground based seeding was employed for the dispersal of the particles.

Louis J Batten[15] from the University of Arizona after studying various naturally occurring rainfalls and the artificially provoked rainfall concluded that not only the amount of particles and the physical properties of cloud are responsible for rain but also the atmospheric conditions play a vital role in causing rain. He also concluded that the thickness of the cloud also played a substantial role and clouds with little thickness can never be seeded. The basic idea behind this concept was related to presence of very little super cooled water vapors in those kind of clouds. Also, his studies reflect that clouds with more clear and sharp edges symbolizes the increased density of water vapors and it should be chosen for seeding as not only they will require less number of particles but also the seeding time would be very less as compared to the other irregular shaped clouds. He also stated that introducing ice particles in the clouds extracts the latent head of water vapors and are forced to transform into ice crytslas.

In order to study and predict the exact composition and amount of particles to be used, Pena and Caimi[16] studied the properties of sodium iodide and investigated about the hygroscopicity of silver iodide particles. They employed the traditional Vonnegout’s method and prepared a solution of silver iodide with potassium iodide in a solution of Acetone. A little excess of silver iodide was used until the solution started reflecting yellowish transparent color. The mixture was heated and boiled until all the acetone evaporated and the solid residue was only the leftover.

Heimbach et. al.[17]performed cloud seeding experiments over the plateaus of Utah using propane as the major cloud condensing nuclei. They used ground based seeding in which a propane dispersing cylinder was used. The arrangement consisted of three dispensers having two nozzles each and each of them released propane at the rate of 3-4 gallons per hour. Proper arrangements were made to ensure the premature vaporization of liquid propane. The effects of dispersing particles were much satisfying and ensured the used of liquid propane as condensing nuclei as much of the experimentation was done during the dry season. Liquid propane when dispersed into the base of the clouds extracted the latent heat from the super cooled vapors and forced them to nucleate as ice crystals. The latent heat release further initiated more and more condensation of the particles.

A khain et al, [18] from the Hebrew university of Jerusalem studied the effect of atmospheric aerosols that affected the cloud microphysical properties using a spectral microscope. He found that the maritime aerosols lead to rapid formation of raindrops. Also when he increased the concentration of cloud condensing nuclei, he encountered a sudden growth in the number of droplets with a reduced collision rate. The whole study was performed over a 2-dimensional cloud model where it was numerically simulated. Due to the reduced collision rate, there was a time lag between the formation of droplets and in the rain. Due to that time delay, the reduction in the velocity of falling raindrops was reduced and it gave a prolonged release of latent heat by condensation. Similar kind of experiments ran through different parts of the world and not only positive but negative results were also encountered. United States of America even performed Operation Popeye [19] between 1967 and 1972 to extend rainfall and modify the weather to block the enemy army.

Abu Dhabi [20] introduced a very new method of seeding clouds without any actual release of any chemical. They installed large ionizers to produce ions. The negative and positive ions got separated and the negatively charged ion started rising to the top, carrying away with them the dust particles which when reached the top, acted as cloud condensing nuclei. Fig.15 gives a general idea of the whole process. But this whole idea can rarely be applied as the rising dust particle do not assure of proper seeding and in most of the cases do not work as the condensing nuclei.

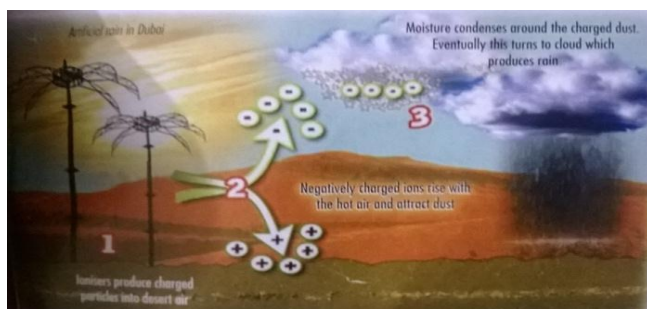


Figure.15 Ionized cloud seeding(Science Reporter, July 2013, P.8-13)

In 1952, United Kingdom performed “Operation Cumulus” [21] which was not very much different from the older concepts of cloud seeding but led to the season’s heaviest rainfall and caused environmentalist to think over it. Working on the good old concept, salt was sprayed in the

atmosphere. Conducted on 16 august, 1952, it led to heavy flood in Lyn mouth, North Devon, England.

India in 2009 [22] performed a series of experiments in Andhra Pradesh over the areas of Hyderabad. The operation was started on 20th July and ended on 20th November. Another operations were done in Anantpur between 27th July to 23rd november2009.A total of 356 mandals were covered from 11 RSAD districts. Table 1 also shows a comparison of the effect of seeding on the rainfall.

District name	No Of seeding	No Of seeded days	% seed ing of the total	Tota l mandals	Influe nced manda ls	% influe nced manda ls	Total cumul ative rainfal l in the distric t	Total cumul ative rainfal l in the influe nced manda ls	Ave rage rainfal l per man dal	Tots l rain fall due to seed ing	Rain fall per sedd ing	Ave rage rain fall per man dal	% in cr ea se
Anantpu r	155	38	28.8 5	63	60	95.24	26621 .3	24898 .7	422. 56	241 4.4	15.6	40.2 4	9. 7
chittoor	34	9	6.28	66	37	56.06	32019 .8	17009 .3	485. 15	927. 6	27.3	25.0 7	5. 5
kadapa	74	29	13.6 8	51	46	90.2	22592 .6	19854 .5	442. 99	131 1.4	17.7	28.5 1	6. 6
kurnool	79	26	14.6	54	44	81.48	30937 .3	23378 .2	572. 19	150 8.4	19.1	34.2 8	6. 5
mahubu b Nagar	72	30	13.3 1	64	56	87.5	37599 .9	32869 .1	587. 5	352 9.1	49	63.0 2	10 .7
karimna gar	9	3	1.66	57	13	22.81	24706 .5	4991. 9	433. 45	165. 2	18.4	12.7 1	3. 3
nalgond a	43	14	7.95	59	37	62.71	22559	14315 .6	382. 36	226 3.4	52.6	61.1 7	15 .8
medak	30	11	5.55	46	30	65.22	20025 .6	12926 .2	435. 34	660. 6	22	22.0 2	5. 1
nellore	7	4	1.29	46	10	21.74	32634 .2	5871. 1	709. 44	72.4	10.3	7.24	1. 2
prakasa m	6	6	1.11	56	7	12.5	26195 .9	3351. 8	467. 78	141	23.3	20.1 4	4. 2

Table-1Source-Centre for Earth Atmosphere and weather Modification Technologies, JNTU, Hyderabad

3. Methodology--: Cloud Seeding refers to the method of artificially generating clouds and forcing them to rain. Although the reverse is also true in which clouds are seeded either to drive them away or tending them to become barren so that to block away the rain. The very basic idea of cloud seeding refers to injection of some physical particles into the already present clouds and tends the water

vapors to condense over those particles. After getting condensed these particles become heavy and fall towards the surface of earth, depending on the level of seeding and ambient conditions, they may fall in water droplets or fog or snow or ice. Technically it could be described as modifying weather or more precisely the amount of precipitation received from the clouds by distributing substances which serves as condensation platform for the water vapors. The particles which are dispersed into the air are called Cloud Condensation nuclei as they serve as the nuclei for the condensation of vapors. These are very small particles of size around 0.2 μm or 1/100th the size of a cloud droplet. To get condensed the water vapors generally require a surface which is non gaseous and at a temperature lower than them so that to reject heat to make transition from vapor to liquid state. A typical raindrop is of around 2mm in diameter and the size of the CCN is around .0001mm. A number of CCN particles are itself in the atmosphere such as dust, clay, soot, sea salt, smokestacks, sulphates from volcanic activities, soot from factories and other artificial chemicals. The ability of different particles to seed cloud depends not only on their size but also on their composition.

At altitudes above 5 to 6 kilometers, super cooled water vapors are present. Different chemicals sprayed into the clouds force these water vapors to condense, resulting in the increased mass of these particles which ultimately leads to their fall carrying the liquid droplets in form of rain. There are basically two concepts followed in cloud seeding[23]-:

- a. Warm Cloud Seeding:- This process involves working over the clouds that are above freezing level(above 0° celcius).Hygroscopic particles like table salt are carried away by the convective currents into the base of these clouds. The hygroscopic particles have a tendency to absorb water vapor. due to which, the water vapor particles get attracted towards them which further leads to the formation of emulsions of the water droplets and salt particles which further concatenates range of water droplets which ultimately fall as rain.

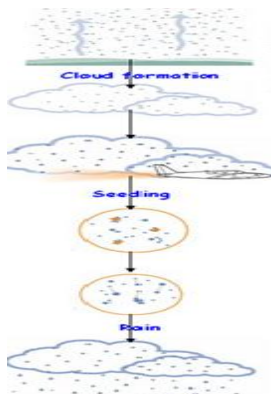


Figure 16 Effect Of Dispersing Salt Particles (Source-Centre For Earth Atmosphere And weather Modification Technologies, JNTU, Hyderabad)

- b. Cold Cloud Seeding:- Cold seeding is done over the clouds where the temperature of the air inside the cloud is below freezing point of water, i.e.,0 celcius. Under cold seeding, particles like silver iodide, dry ice pallets, liquid carbon dioxide are sprayed over the top of the clouds via airplanes or any other medium. The sublimation of super cooled water vapors to ice crystals not only aides the local droplets to shrink but also catalyst the vertical air motion inside the clouds resulting in their convective growth.



Figure 17 Effect Of Dispersing Silver Iodide Or Dry Ice Particles(Source-Centre For Earth Atmosphere And weather Modification Technologies, JNTU, Hyderabad)

From the above discussion, it is very clear that in order to seed clouds; certain foreign particles need to be sprayed into the clouds. Different approaches have been followed by different agencies. Some of the basic approaches [24] are-

- a. **Aerial Cloud Seeding**:- It involves the method of seeding clouds using aero planes. The particles to be used are carried along with the aero planes and are dispersed from above the clouds. Although the method is quite efficient, but economically it proves to be less versatile. Fig.11 shows the spraying up of particles from over the clouds.

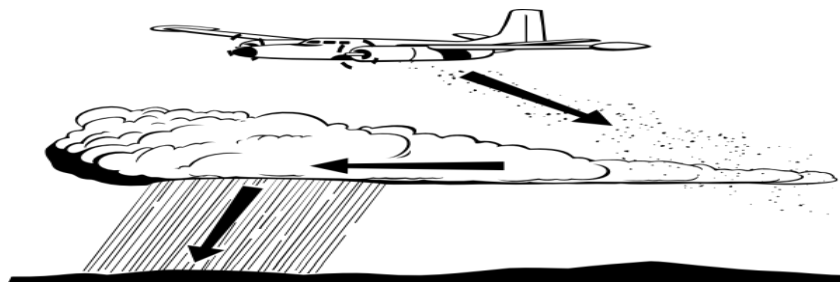


Figure.18 Aerial cloud seeding(Science Reporter, July 2013, P.8-13)

- b. **Ground Based Cloud Seeding**:- In this approach larges flares of the particles are generated using cylinders or may be fired along with the rockets to the above of the clouds where they just reach and explode, thereby releasing the cloud condensing nucleuse. Fig.12 shows flakes of the particles being generated on the earth only and being carried to the upper atmosphere along with the convective currents.



Figure.19 Ground based seeding(Science Reporter, July 2013, P.8-13)

Rather than the above most commonly used approaches, nowadays other methods like Electronic Cloud Seeding and Bio Precipitate Seeding are also being used. The former refers to the firing of laser pulses and the latter focuses on artificially generated Biological Pathogens which serves as condensation nuclei. However the concept of pathogens didn't work so well as in most of the cases , pathogens got eroded due to some reasons before reaching to that height. Still, researches are going on to produce feasible pathogens which may act as cloud condensation nuclei. The concept of laser pulse firing has also not been that successful and gives a very little success rate.



Figure.20 green laser pulses being fired (Science Reporter, July 2013, P.8-13)

Experimentation and Results-: The experiment set up here involves the traditional method given by Vincent shauffer. A simple refrigerating unit which was capable of maintaining cabinet temperature below freezing point was used. These kinds of refrigerators are mostly employed for preserving medicines and offer a wide range of temperature. The very basic problem while working or replicating the behavior of clouds inside the laboratory is to ensure the absence of any foreign particle such as any kind of soot or dust as it may itself act as condensing nuclei and may affect the result. To ensure this, the refrigerator was thoroughly cleaned and defrosted for around 3 times. After this, hot dry air was blown for around 15 to 20 minutes to remove any kind of moisture or water vapor, if present. The supply was switched on and the refrigerator took around 15 minutes to go below the freezing point. The refrigerator was itself equipped with the digital thermometer which at the time of experiment displayed around -12°C . sugar, which is the main test specimen for this experiment was sieved so that to ensure again there are no foreign particles getting carried away with it. Figure 21 and 22 shows the inside area of the cabinet of the refrigerating unit which has been cleaned thoroughly to ensure that no other particles by any means are present to affect the result. As presence of any other particle may lead to the saturation and may deviate the results with that of table sugar. a temperature of around -5°c was maintained inside the refrigerator cabinet.



Figure 21 inside cabinet of the refrigerator



Figure 22 inside cabinet of the refrigerator

After that, sugar particles were dispersed inside the cabinet and the cabinet was closed so that no foreign particles should enter and also to maintain the required cabinet temperature. The basic objective behind this experiment was to check the hygroscopicity of the particles and the seeding time, i.e. the time taken by the sugar particles to nucleate water vapors around them



Figure 22 cabinet after the particles were dispersed



Above figure shows the particles dispersed inside the refrigerator cabin. The particles were a combination of small and large particles to ensure maximum effectiveness



Figure 23 cabinet after 30 minutes of the particles dispersal



Above figure shows the pictures taken after 30 minutes of the dispersal of sugar particles. The particles have started to gain moisture but until now, the saturation is so small that it could not be easily predicted.



Figure 24 cabinet after 180 minutes of the particles dispersal

Above figure is the picture taken after around 3 hours of seeding and it is very clear that the particles have started to gain moisture and they also have started to coalesce along with each other and thereby growing in size.



FIGURE 23 cabinet after 300 minutes of the particles dispersal

Further and a closer examination after 5 hours of seeding clearly shows how water has agglomerated near the table sugar particle crystals.



FIGURE 23 cabinet after 360 minutes of the particles dispersal

Pictures taken after 6 hours of the dispersal of the particles clearly shows how water particles have deposited around the table sugar crystals and also have forced them to grow in size. Also a careful examination of the cabinet clearly shows the deposit of water vapors on the cabinet walls due to the latent heat release of the water vapors.



FIGURE 23 cabinet after 420 minutes of the particles dispersal

A closed examination of the refrigerator cabinet after around 7 hours of dispersing the sugar particles inside the cabinet clearly reflects how sugar can be used as a cloud condensing nuclei. The agglomeration of water particles around the sugar particles increases the net weight of the droplets and is pulled down due to the gravitational force of earth and depending upon the further ambient conditions may result in drizzle or rain. Within 10 hours of seeding the inside cabinet, the sugar particles have completely dissolved along with the nucleating water vapors and ice crystals were formed.

Conclusion-:

The above pictures taken during the process of nucleation clearly explains the hygroscopic nature of sugar. Although, seeding time taken by the sugar particles is very long. They take around 10 hours to properly seed the surrounding ambience. However, it may be attributed to the fact that a combination of particle sizes were used which may have affected the speed of process. Generally fine powdered particles are taken which are mixed with acetone solution to rate up the seeding time. But this experiment has completely focused on the use of sugar only. As in the traditional method, where salts are dissolved in acetone and then acetone is boiled off and particles reach the upper layer due to the vapors of acetone, is not environmentally friendly. Acetone not only is carcinogenic but also is not good for the herbal and plant vegetation. Sugar can be blended with some other highly hygroscopic particles such as calcium chloride or sodium chloride. But, these particles should be added in a very little amount as these are not benign and may create long term environment effects. Other particles should be added only up to that extent that they just speed up the nucleation phase or just catalyze the beginning stage of nucleation. However, as compared to silver iodide, carbon dioxide, propane, potassium iodide or some other seeding agents, sugar can be efficiently used as a safe seeding agent as the amount which would be liberated in the atmosphere is far less than the human oral intake and is completely benign.

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