# LABORATORY EXPERIMENTS ON THE EFFECT OF TRACE CHEMICALS ON CHARGE TRANSFER DURING ICE CRYSTAL- HAIL COLLISION

Jish Prakash.P[1], P.Pradeep Kumar[1]

[1]*Department of Physics, University of Pune, India, jish@physics.unipune.ernet.in*

(Dated: September 12, 2007)

## I. INTRODUCTION

One of the major mechanism which tries to explain the thunderstorm electrification is the charge transfer during ice crystal – graupel collision also known as non inductive charging mechanism. Several experiments conducted world wide show that the sign and magnitude of charge transfer depends on the size and velocity of the impacting ice crystals, the liquid water content, temperature, rime accretion rate (RAR) and relative humidity at which the ice crystals grow and the surface properties of the interacting ice crystals and graupel (Reynolds et al, 1957; Takahashi, 1978; Jayaratne et al, 1983; Keith and Saunders, 1990; Saunders, 1994; Pereyra et al, 2000; Berdeklis and List.2001)

It is interesting to study the charge transfer in the presence of trace amount of chemicals (Jayaratne, 1999). The present laboratory study involves the charge transfer experiments with trace amount of chemicals involving small ice crystals at low values of RAR

## II. PRESENTATION OF RESEARCH

Laboratory experiments were carried out to investigate the charge transfer during the collisions between ice crystals and graupel at an impact velocity of 2.2 m/s using pure water (Milli-Q 18.2 Mohm/cm) and trace amount of chemicals at low RAR and crystal size below 50 µm diameter.

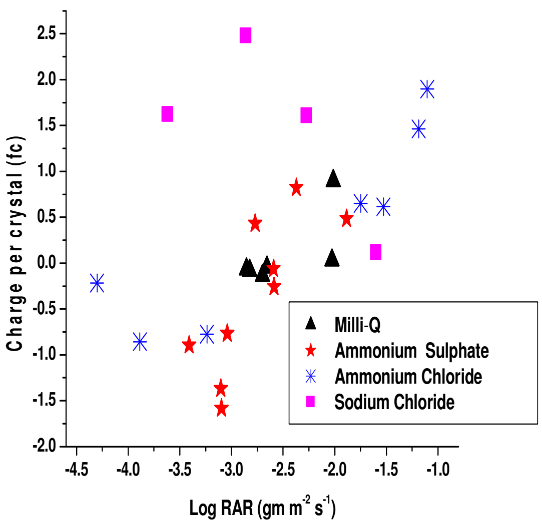


FIG. 1: Ice crystals interacting with graupel made from pure water (Milli-Q) and different chemical solutions at 5 * 10 $^{-5}$ N at temperatures ranging from - 16 to - 19 °C.

Experiments were conducted inside the cylindrical steel chamber kept inside the walk - in cold room which can reach a temperature of –30 °C. The cloud temperature varied from –6 to –25 °C. A charge detecting amplifier measures charges of the order of $10^{-15}$ Coulombs (fc). The target is made of platinum plate and is attached to the amplifier input.

Experiments were carried out with pure water alone and also with solutions of ammonium sulphate, ammonium chloride and sodium chloride at 5 * 10 $^{-5}$ N. A cloud of supercooled droplets and vapour are formed inside the experimental cloud chamber by heating the solution and ice crystal formation in the cloud is initiated by momentarily introducing a rod dipped in liquid nitrogen. The cloud of supercooled droplets and ice crystals are drawn past the graupel grown on the platinum target through a side tube attached to the experimental chamber. The charge transferred to the graupel is measured

Formvar coated slides having the same size of target are kept inside another tube below the charge transfer tube, on which ice crystals and droplets are collected at the same impact velocity. These slides are used for microphysical analysis and computation of RAR.

## III. RESULTS AND CONCLUSIONS

In this work, it is shown that ice crystals interacting with graupel made from pure water obeys the charge sign regimes (Saunders, 1994) as a function of temperature and RAR for all temperatures ranging from -6 to -25 °C.

Fig. 1 shows the values of charge transfer against RAR at temperatures ranging from -16 to -19 °C for pure water and solutions of Ammonium Sulphate, Ammonium Chloride and Sodium Chloride. It is seen that charge transfer to the graupel made from the solution of pure water and ammonium sulphate at $5*10^{-5}$ N changes sign from negative to positive as the RAR increases and also the magnitude of charge increases. Ammonium chloride also shows almost the same trend at the same normality and temperature range. But for sodium chloride it shows decrease in positive charging first and going towards the negative charging with increasing RAR.

Our experiments were done in the temperature regions of -6 to -10 °C, -16 to -19 °C and -21 to -25 °C. It is seen that for all the three solutions the sign of charge transfer and the trend agrees with that of Jayaratne (1999) only for higher values of RAR. Our crystal sizes are small and less than 50 µm. Jayaratne (1999) used a constant cloud water content of 1.0 g m$^{-3}$ with crystal size of about 50µm and an impact velocity of 3 m s$^{-1}$.

## IV. AKNOWLEDGMENTS

The authors would like to acknowledge the financial support received from Department of Science and Technology (D.S.T), India (Grant no: SR/S4/AS-220/03) for this work.

## V. REFERENCES

Berdeklis P., List R., 2001: The ice crystal-graupel collision charging mechanism of thunderstorm electrification. *J. Am. Met. Soc.* 58 2751-2770.

Jayaratne E.R., Saunders C.P.R; Hallet J., 1983: Laboratory studies of the charging of soft hail during ice crystal interactions.*Q.J.R.Met.Soc.* 109 609-630.

Jayaratne E.R.,1999.Thunderstorm electrification:The effect of chemical impurities in cloud water. *Proceed. 11th international conference on atmospheric electricity*, 312-315.

Keith W. D., Saunders C.P.R., 1990: Further laboratory studies of the charging of graupel during ice crystal interactions. *Atmos. Res*, 25 445-464.

Pereyra R.G., E. E. Avila., N. E. Castellano, and C.P.R. Saunders., 2000: A laboratory study of graupel charging. *J. Geophys. Res,* 105(D16) 20 803-20 812

Reynolds., S. E Brook., M. F Gourley., 1957: Thunderstorm charge separation. *J. Met*, 14 426-437.

Saunders C.P.R., 1994: Thunderstorm electrification laboratory experiments and charging mechanisms. *J.Geophys. Res*, 99 10773-10779.

Takahashi T., 1978: Riming electrification as a charge generation mechanism in thunderstorms. *J. Atmos. Sci*, 35 1536-1548