Aerosol charge distributions in Dielectric Barrier Discharges

N. Jidenko, E. Bourgeois and JP. Borra

Laboratoire de Physique des Gaz et des Plasmas (UMR 8578 CNRS –Univ. Paris Sud Orsay, F-91405)
Equipe Décharges Electriques et Aerosol, SUPELEC, F-91192 Gif sur Yvette Cedex, France

Keywords: electrical discharge, aerosol charging, electrical mobility.

Aerosol particle charging is involved in many scientific and industrial applications such as electrostatic precipitation, coating, post-production particle assembly, particle self-repulsion to preserve high interfacial areas, neutralization to prevent dust explosion, coulombian agglomeration of bipolar aerosols and measurements based on electrostatic techniques. Depending on the application, high charge level, or high particles penetration through the charger, control charge distribution, a mix of these criteria is required. Non-thermal Atmospheric Pressure Electrical Discharges are an efficient way to charge particles (Borra 2005).

Charging mechanisms by collection of ions and related charging laws are defined and have been validated in quasi-stationary ions densities, especially in DC corona discharges (Fuchs 1963). Dielectric Barrier Discharges (DBD) are constituted of two electrodes that are separated by a gas gap spacing with at least one dielectric material in the gap. The dielectric barrier prevents arc formation but involves an alternative polarization of the system (typically a few kV at 50 Hz–1 MHz). In air, at atmospheric pressure, DBD occur as thin and brief Filaments Discharge (a few 10's of μm, a few 10's of ns) homogeneously distributed over the dielectric surface (Petit et al. 2002). Thus, DBD produce high transient charging conditions (bipolar ions densities and electric field) in which particles charging is investigated.

Post discharge ions densities and mobilities as well as particle charge distributions and losses are investigated versus plasma and hydrodynamics parameters with monodisperse aerosol from 20 nm to 900 nm injected in the DBD.

Table 1. Post DBD positive and negative ions mobilities at 3 lpm.

Electrode temperature (°C)	Positive ions mobilities ($cm^2.V^{-1}.s^{-1}$)	Negative ions mobility ($cm^2.V^{-1}.s^{-1}$)
30-90	0.96/1.41/1.79	1.78
90-160	1.41 / 1.79	0.83/0.9/1.03/ 1.15/1.36

Table 1 shows the peaks position of mobility spectra. Positive ions are independent of gas temperature whereas negative ions depend on the nature of gaseous species produced by the discharge. Indeed at low temperature ozone is the predominant species and above 90°C nitrogen oxides are predominant.
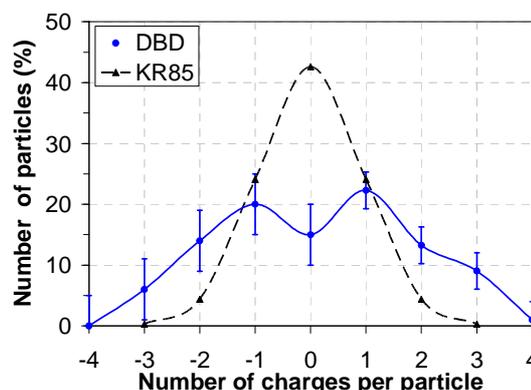

Figure 1. Charge distributions of 102 nm latex particles in Kr85 and 20 kHz DBD at 20 kV with a gas flow rate of 0.3 lpm with 0.6 s before analyses.

Figure 1 proves that particles are charged of both polarities due to ion persistence in the discharge gap induced by dielectric surface polarization. The net charge is slightly positive as a result of higher electrical mobility of negative charges (electrons and negative ions are better collected on the dielectric surfaces than positive ions). Though bipolar charging conditions, charge distributions differ from those obtained in radioactive neutralizer (KR[85]).

Final charge level of particles depends on the different positive and negative ion densities they cross. If charge level acquired by the particle inside the DBD could reach higher level than those measured, charge distributions tend to Boltzmann distribution due to homogeneous bipolar ions density downstream the charger.

As a conclusion, discharge filament can be considered as a local brief and confined ion/electron source, leading to transient charging conditions i.e. in varying electric field and charge densities.

At last, the frequency of the applied voltage controls the amplitude of the oscillating particle trajectory and can be adjust to limit electro-deposition in the DBD. DBD are thus an alternative to corona discharge, preventing the oxidation of metal electrodes inducing particle production and discharge evolution in time.

Petit M et al. (2002) *Review of scientific instruments* **73 (7)**, 2705-2712

Fuchs N A (1963) *Geofisica Pura e Applicata* **56 1,** 185-193

Borra JP (2005) *J. Phys. D : Appl. Phys* **39**, 19-54