# ATMOSPHERIC PRESSURE PLASMAS FOR AEROSOLS PROCESSES IN MATERIALS AND ENVIRONMENT

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**Abstract**: To highlight applications of plasmas in Atmospheric Pressure Electrical Discharges to aerosol processes for Materials and Environment (filtration, diagnostics), respective properties of dc-corona, streamer and sparks and ac-Dielectric Barrier Discharges are first briefly reminded.

The production of vapor i.e. condensable gaseous species, leads to nano-sized particles by physical and chemical routes of nucleation in these AP Plasmas: (i) when dc streamer and spark filamentary discharges as well as ac filamentary Dielectric Barrier Discharges interact with metal or dielectric surfaces, and (ii) when Discharges induce reactions with gaseous precursors in volume. It is shown how composition, size and structure of primary nano-particles are related to plasma parameters (energy, number per unit surface and time and thermal gradients).

Then the growth by coagulation controls the final size of agglomerates versus plasma parameters and transit time in and after the plasma. Charging and electro-thermal collection are depicted to account for the related potential applications of controlled kinematics of charged aerosol.

## 1. INTRODUCTION

*Aerosol*, defined as suspended liquid/solid particles (drop/powder) in gases, presents a large interfacial surface per unit volume used for heat exchanges, filtration and heterogeneous chemistry. More recently, nano-particles (1D min < 100nm) have been synthesized for their physical properties (e.g. for tribological and mechanical properties of inorganic and carbon fullerenes) and for their chemical and bio-functionalities (e.g. for lower melting temperature, catalysis and drug delivery).

In gas phase, nano-sized aerosols are formed either by evaporation of liquid droplets leading to crystallized solute (spray drying and pyrolysis), or by gas-to-particle conversion (nucleation when the saturation vapour pressure is overcome (as for crystallization above a saturation solute concentration).

Gas-phase aerosol processes performed at atmospheric pressure provide an economic alternative for nano-technologies. They are cost-effective, environment friendly (no liquid by-products) and energy efficient. Since, high-purity nanometer particles, more easy to collect from gases than from liquids, are produced, some aerosol processes are scaled-up for daily production of hundreds of tons of tailored $TiO_2$ particles and others are integrated in chemistry, energy, environment and health processes.

Production processes control particle size, composition and structure. Indeed, if nano-powders are used to save raw materials, the size-dependant properties of nano-materials are reported for tailored nano-particles, smaller than 50 nm with standard deviation of the size distribution below 1,2 [1].

A post-production processing of particles (e.g. size selection, shaping of aggregates, mixing and homogeneous/focused deposition) leads to powders, composite materials, suspensions and coatings.

This paper focuses on the interest of dc to 100 kHz ac Atmospheric Pressure Electrical Discharges (hereafter referred as APED) for the production, the charging and the processing of aerosols. However, it does not cover neither the chemical nor the thermal processing of particles injected in Plasmas for functional surface coating by post-discharge reactivity [2] and for purification, spheroidisation, surface coatings [3].