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Particle precipitation by bipolar corona discharge ion winds

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Abstract

The paper reports the development of a particle precipitation based aerosol sampler using bipolar corona discharge ion winds with collected particles of minimized net charge. For the new approach, neutralized particles move towards a sampler under the effect of electric field and dual ion winds. Since there is no electrode or sampling chip installed inside the air-flow channel, impediments to airborne particle flow or ion winds are removed along the flow direction. In addition, the isolation of ion winds, which generate circuit, allows using various materials for the sampling chip including non-conductors and also protecting collected particles from any discharge ignition on the chip. The device mechanism is numerically simulated in OpenFOAM to study the electrofluidodynamic interaction of charged particles and bipolar ion winds. The efficiency of the new approach has been investigated by experiment with a maximum efficiency of 94%. The effects of flow rate, discharge voltage and electrode distances on the method are also evaluated.

Keywords: Charged particles, ionic wind, particle simulation, corona discharge, OpenFOAM

1. Introduction

Research in the healthcare shows that the particulate matter (PM) causes up to 30% of the total burden of diseases [1]. The inhalation of PM could yield numerous lung diseases such as pulmonary fibrosis [2], pulmonary inflammation, pleural effusion, granuloma [3] and cancer risk [4]. Thus, the particle sampling in bio-technology has attracted significant effort to develop new techniques in various application areas, especially in the biomedical engineering. The main objective of the sampling is to collect a sample of airborne particles and then transport them to a detection unit. The active sampling devices are designed based on three major collection methods: the impaction, impingement and filtration [5]. For the impaction approach, the sampling is carried out by the collision of particles to a wall and called as the inertial impaction. Meanwhile in the impingement scheme, a flow of particles is channelled to a collection chamber through nozzles of an air jet. The number of collected particles depends on the air jet characteristics such as the nozzle geometry and the particles' diameter [6–8]. Several commercial devices using this technique include Coriolis® μ air sampler [9] and Bio-sampler [10]. For the filtration method, particles are collected by driving air through a membrane of high density [11–14]. Similar to the impaction technique, devices using the filtration scheme would be overloaded when working in highly contaminated environments [15]. Among sampling devices, the electrostatic precipitator (EP) is evaluated as an efficient technique to filter nanoparticles at low pressure drop [16–19]. This technique is usually applied in