Experimental and Modelling Approach to Triboelectric Charging of Rough Polyolefin Particles

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Abstract:

The production of polyethylene (PE) in gas-phase fluidized bed reactors often results in significant electrostatic charge generation due to frequent particle collisions. This phenomenon can lead to operational challenges and economic losses. Understanding and mitigating the factors contributing to this charging is complex, particularly due to the interplay between catalyst type and reactor operating conditions, which influence the morphology of the final product.

In this study, we propose a method to standardize the interpretation of experimental measurements of triboelectric charging in rough polyolefin powders, aiming to isolate the effects of morphology. Traditional methods, such as using a Faraday cup connected to an electrometer, estimate the charge-to-mass ratio of powder samples. However, to validate models that account for real contact areas and surface roughness, it is essential to convert these measurements to charge-to-surface area ratios. Polyolefin particles typically exhibit non-spherical shapes, roughness, and porosity, complicating the recalculation of experimental data. We present experimental data on the morphology of various polyolefin samples and introduce a set of corrections to improve the accuracy of charging experiments, moving beyond the compact sphere approximation. Our approach involves characterizing particle morphology using MicroCT and determining mechanical properties with Atomic Force Microscopy. We simulate rough particle collisions using a Discrete Element Method (DEM) model with modified Hertzian mechanics, representing surface morphology through equivalent wave functions. This allows us to calculate particle behavior during impacts and the resulting charge transfer. Our findings indicate that particle-wall collisions (metal-insulator) are the primary source of charge generation, while particle-particle collisions (insulator-insulator) lead to uneven charge distribution, creating domains of both polarities on particle surfaces. We also demonstrate how variations in system setup - such as impact energy, system geometry, and particle quantity - affect charge distribution, resulting in different final charges despite identical electrostatic constants.

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