

Triboelectrification of Polymers

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Abstract—Triboelectrification accompanied by a significant accumulation of charge is typical for insulator powders that are often of industrial importance (polymers, pigments, flour, medicaments). In our study, we focus mainly on the triboelectric charging of polymer powders manufactured in fluidized-bed polymerization reactors that can typically encounter problems with agglomeration or fouling due to the excess electrostatic charge.

Specifically, we performed a systematic series of experiments regarding triboelectric charging of polyethylene (PE) particles accompanied by mathematical models based on discrete element method (DEM) in the cases where experiments were difficult to perform or where further explanation of experimental results was required. We particularly utilized our DEM model in order to predict the charging of PE particles due to particle-particle collisions, including the effect of electrostatic forces. The detailed model of particle charging also predicts the variation of charge at different spots on particle surfaces in dependence on particle shape.

Our set of experiments performed in a shaking box apparatus with removable inner walls suggests that particle agglomeration appears preferably in systems with frequent particle-particle collisions, whereas fouling is more likely to take place in systems with most of the charge generated due to particle-wall collisions. This is caused by a different nature of the two types of charging; particle-wall collisions produce rather homogeneously charged particles that repel each other but are attracted to a metal wall, whereas particle-particle collisions produce charged particles with a significant variation of charge among the particles, leading to inter-particle attraction.

The results of charging at various humidities suggest that unlike in the case of polar polymers, where water adsorbed on the surface of a polymer reduces the charging, in the case of nonpolar polymers like PE the concentration of water molecules in the boundary gas layer has a significant effect on the charging.

Additionally, we compared charging results of shaking box apparatus to those of our cascade method apparatus. The results indicate that not only charging dynamics, but also the saturation charge are proportional to particle-wall collision energy. This dependence can be explained by differences in accessible contact area: the particle's apexes sag at higher energies thus increasing the contact area that would be otherwise unreachable. Such hypothesis is in agreement with our measurements of surface roughness dependent charging.

We also performed charging experiments in an autoclave that enabled us to simulate reactor conditions (presence of sorbent, high pressure and temperature) and compared it to the

charging at standard conditions. Our experimental and modeling study of triboelectric charging can improve the understanding of the charging processes. Better knowledge of PE charging (or polymer charging in general) can help the industry to avoid agglomeration or fouling without the need of using additives (antistatic agents), leading thus to cost saving and product quality improvement.