



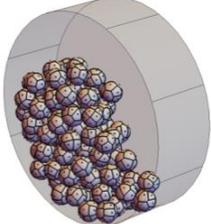
IFPRI PROJECT / REVIEW BRIEF TEMPLATE

1.0	(Working) Title	Contribution of tribo-electric charge to powder cohesiveness
1.1	Project or Review	Project
1.2	Technical Area ¹	Powder Flow / Dry systems
2.0	Submitted by	U. Zafar, P. Mort, F. Francqui
2.1	Member company/ies	Granutools
2.2	Idea creation date	13-June-2023
2.3	Last modification date	13-June-2023
3.0	Short goal description	Investigating both experimentally and numerically the distribution of charges created inside a powder during a flow and the contribution of these charges to powder cohesiveness. The study will be mainly fundamental in connection with original processes like tribo-agglomeration in a dry processing system.
3.1	Objectives	<p>The main motivation of the present project is to better understand the fundamental mechanisms leading to triboelectric charge build-up in powders during a flow. We will combine a fundamental experimental approach with an original set-up and a numerical approach with a customized DEM code.</p> <p>The spatial distribution of charges inside the packing will be investigated. Afterward, the influence of these charges on powder behavior will be analyzed. Indeed, the electrostatic charge accumulated on the grains contributes to cohesiveness through the electrostatic forces.</p> <p>GranuCharge instrument measures the net charge of a powder sample after flowing in contact with a selected material. This measurement predicts the chargeability of a powder inside a process. The experimental objective of the present project is to go one step further by investigating the distribution of charges inside the powder. For that, an electric field will be applied at the output of the V-tube charging the grains (before the faraday cup) and the motion of the grains will be analyzed with an ultrafast camera to estimate the charge present on each grain.</p>

		<p>Concerning the selection of the granular material, the focus will be on model and stable systems highly susceptible to charge in dry conditions (for example Z150 ceramic particles from St. Gobain), before considering more complex powders.</p> <p>This experimental approach will be combined with a numerical approach consisting in the simulation of the same process (grain tribo-charging in the V-tube and deviation in the electric field) with the customized DEM code described in the next section.</p> <p>Finally, the fundamental results will be used to improve the understanding of original processes like tribo-agglomeration in fluidized beds.</p>
3.2	Scope and Context	<p>When two materials are rubbed, electric charges are exchanged at the surfaces. This contact electrification called triboelectric effect is an old fundamental scientific subject. However, despite many studies dedicated to this subject, the fundamental mechanisms behind the triboelectric effect are not fully understood. Even the basic question related to the nature of the transferred charges (electrons, ions or material) is still debated. In the field of powder technology, the creation mechanism and the distribution of the charges inside a powder need deeper investigations.</p> <p>Practically, tribo-electrification in powders induces agglomeration, segregation or adhesion to surfaces due to the contribution of triboelectric charges to cohesiveness. In addition, electrostatic discharges might lead to fire and dramatic dust explosion. On the other hand, triboelectrification is used advantageously in electrophotography, powder coating and separation processes. Since the applications become more and more complex, a better understanding of the triboelectric mechanism is necessary to improve processes and to avoid problems.</p> <p>During the last decade, a series of fundamental studies were carried out giving new insights on the triboelectric effect. In particular, a mechanism of triboelectric charging based on patchy surfaces was proposed by Apodaca et al. [1]. The surfaces of both materials are made of sites that can accept charges (acceptors) at contact and sites that can</p>

give charges (donors) at contact under some probability. An experimental confirmation of this model has been shown by Baytekin et al. [2] with Kelvin force microscopy. Concerning the nature of those patches, water seems to be a good candidate as it is composed of H^+ and OH^- ions that could be transferred from wet to dry patches at the surface of the materials [3].

In the group of G. Lumay at ULiège, triboelectric powder properties have been the subject of both experimental and numerical investigations with a fundamental and also an applied approach [4,5]. The experimental investigations led to the development of GranuCharge instrument commercialized by GranuTools and used in many applications [6]. From a numerical perspective, an homemade DEM code has been adapted to create donor/acceptor sites on the grains using a Voronoi tessellation to apply the patches model to granular materials. During a flow, charges are exchanged between patches in contact and the patches are interacting by coulomb law, modifying the flow. These simulations already gave interesting results but an experimental validation is necessary.

	
<p>Customized DEM simulation with the tribo-patch-model</p>	<p>GranuCharge</p>

[1] M. M. Apodaca *et al.*, Contact electrification between identical materials, *Angewandte Chemie International Edition*, vol. 49, no. 5, pp. 946-949, 2010.

[2] H. T. Baytekin *et al.*, The mosaic of surface charge in contact electrification, *Science*, vol. 333, no. 6040, pp. 308-312, 2011.

[3] L. S. McCarty *et al.*, “Electrostatic charging due to separation of ions at interfaces: contact electrification of ionic electrets,” *Angewandte Chemie International Edition*, vol. 47, no. 12, pp. 2188-2207, 2008.

[4] A. Rescaglio *et al.*, Tribo-electrification of pharmaceutical powder blends, *Particulate Science and Technology* 37, 1020 (2019).

[5] G. Lumay *et al.*, Influence of mesoporous silica on powder flow and electrostatic properties on short and long term, *Journal of Drug Delivery Science and Technology* 53,101192 (2019)

		[6] G. Lumay et al. , Method to measure the ability of a flowing powder to electrostatically charge and measurement device, US Patent (US 10677753 B2) and European patent (EP 2 993 468 B1)
4.0	Contractor(s) with contact information	<p>Prof. Geoffroy Lumay, University of Liège, Belgium</p> <p>G. Lumay is a young professor head of the “Soft Matter Experimental Physics” group in the GRASP laboratory, part of CESAM research unit in the Science Faculty of ULiège. His research works articulate around two fields of Soft Matter Physics: granular material physics and colloid science. The common thread of his recent works in these two fields is the focus (i) on the effect of electromagnetic forces and (ii) on the influence of the surrounded fluid. He is conducting projects at the fundamental level with publications in renowned international journals (Physical Review Letter, Soft Matter, ...). Moreover, the results obtained at the fundamental level are also valorized in the framework of more applied projects resulting in publications in more specialized journals (Powder Technology, Int. j. of pharmaceutics, ...) and a patent. In this group, the strategy to study a physical phenomenon is based on the development of original experimental set-ups to obtain original experimental results. Afterward, physical models are proposed to describe the physical mechanisms and to extract the main parameters. If needed, numerical simulations are conducted in association with collaborators to investigate parameters which are difficult to control experimentally. This strategy will be followed for the present project.</p>
4.1	Comments / experiences	