The application of an electrostatic powder flow (EPF) sensor for the dynamic electrostatic charge measurement of pharmaceutical powders

Hill-Izani, N.Y., Smith, G.*, Armitage, D.A., Polygalov E.
Pharmaceutical Technologies, School of Pharmacy, De Montfort University, Leicester LE1 9BH

ARTICLE INFO

*Professor Geoff Smith.
Tel.: +44 (0)116 250 6298
E-mail: gsmith02@dmu.ac.uk

KEYWORDS: (electrostatic, powder, flow, sensor)

SUMMARY

The aim of this work was to outline the basis of operation of the electrostatic powder flow sensor (EPF), including the dynamic charge measurement with respect to flow conditions and material characteristics. The RMS signals of five powders of varying cohesiveness processed through a twin-screw feeder were recorded. The mean $mV/g^{-1}s$ was dependant on the material characteristics of the powders (particle size, material chemistry etc.). It is hypothesised that the differences in powder electrification may result from inherent material characteristics, such as particle size and shape.

INTRODUCTION

Tribo-electrification of powders during a pharmaceutical process can lead to unwanted issues such as adhesion of powders to the processing equipment, Samiei, (2017). A rather simple instrument, known as a Faraday Cup, Shi (2017) is the method of choice for quantifying the electrostatic charge of a powder. However, the technique is limited to providing a single 'static' measurement while requiring a sampling method if incorporated on-line; whereas the mechanisms of electrostatic charging are dynamic and strongly dependent on powder flow rates and environmental conditions that prevail within the manufacturing process in question.

An electrostatic powder flow sensor (EPF), which measures the electrostatic fluctuation caused by the surface charges on moving particles, provides an alternative and dynamic measurement of electrostatic charge powder, one which captures not only the inherent charges but also those that originate under the active condition of flow.

The aim of this study was to develop a methodology for assessing dynamic charge on a variety of powders so that a risk rating might be developed in future which registers the propensity of powder accumulation as a direct result of tribo-electrification.

MATERIALS AND METHODS

Five powders of varying cohesiveness (Lactose 200M, Lactose #316 Fast-Flo, Maize Starch, Avicel PH101 and Avicel PH102) were conveyed through a volumetric twin-screw feeder (T20, K-Tron) at a screw speed of 100rpm. The EPF sensor and two decimal place solid-state balance were installed beneath the outlet of a twin-screw feeder such that the powder first passes through the EPF before arriving at the balance (Fig. 1).

The EPF sensor comprises a dual ring-electrode system. The two electrodes act as an electrometer, and are linked to a two-channel current to voltage (IVC) converter and a data acquisition module, acquiring measurements at 2 kHz, to produce an electrostatic 'noise' spectrum. The electronic balance captured the mass flow rate at a weighing rate of 20Hz and hence the rate of acquisition of the Root-Mean-Square (RMS) of the electrostatic 'noise' was set to the same frequency.

The RMS was measured by calculating the average deviation of the absolute electrostatic signal within a single time interval between two consecutive weights measurements over the course of the data set, illustrated in Fig. 2. A true RMS measurement requires significant processing power which renders it unsuitable for real-time measurement, whereas simply taking the absolute signal is >20 times faster. In the case of noise-like data, the average deviation and RMS should be equivalent. The term RMS was retained due to the familiarity of the term within electrostatics.

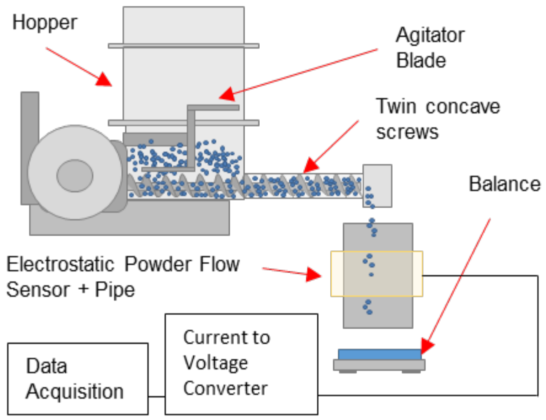

Fig. 1. *Experimental setup of volumetric twin-screw feeder, EPF and data measurement system.*

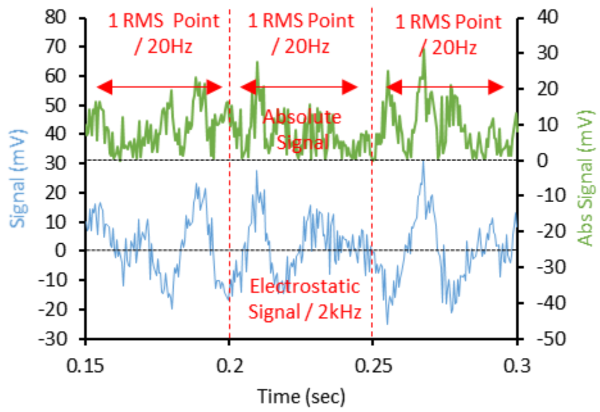

Fig. 2. *Signal and absolute signal as a function of time. RMS is calculated by taking the average deviation of the electrostatic data every 20Hz / 0.15sec time window.*

The RMS average was taken over a constant mass flow rate (dw/dt), where deviation was not greater than 1%. The RMS was then normalised against dw/dt and plotted as a function of time over the period of constant flow.

RESULTS AND DISCUSSION

The normalised RMS averages for all five materials are shown in (Fig. 3)

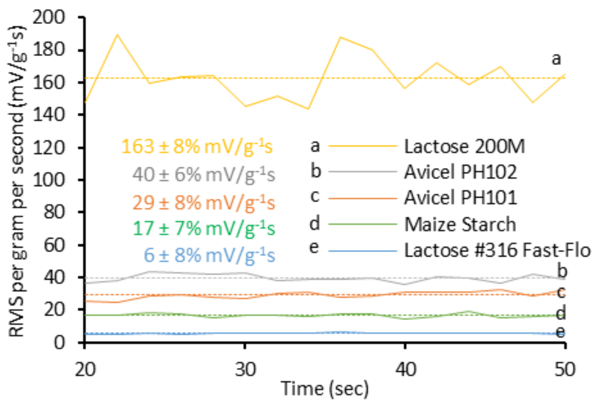

Fig. 3. *RMS normalised against dw/dt as a function of time within a 30s time window. Mean mVS/g^{-1}s for a material is indicated by dashed line and value of the same colour.*

The mean RMS/g^{-1}s values for Lactose #316 Fast-Flo and Maize Starch; were 5.6 mV/g^{-1}s and 16.8mV/g^{-1}s respectively. For Avicel PH101 and PH102 which differ in particle size distribution, the mean RMS/g^{-1}s was 29.2mV/g^{-1}s and 39.6mV/g^{-1}s respectively. Lactose 200M, a micronized grade, registered a mean RMS/g^{-1}s at 162.7mV, ~30 times greater than Lactose #316 Fast-Flo (a spray dried grade). The fluctuation in RMS/g^{-1}s for all materials were within ±6-8% deviation of the mean. The mVg^{-1} s values were shown to be dependent on material characteristics (e.g. particle size distribution).

CONCLUSIONS

In this study, the hypothesised that the differences in powder electrification may occur given the particle size and shape characteristics of these materials. For example, the only micronized material (Lactose 200 M) had the greatest dynamic charge, whereas the spray-dried spherical powder particles of Lactose 316 had the lowest dynamic charge.

REFERENCES

Samiei, L. et al., 2017. The influence of electrostatic properties on the punch sticking propensity of pharmaceutical blends. PowderTech, 305, 509-517

Shi, Q., et al., 2017. Simultaneous measurement of electrostatic charge and its effect on particle motions by electrostatic sensors array in gas-solid fluidized beds. PowderTech, 312, 29-37.