RELATIONSHIP BETWEEN ELECTROSTATIC CHARGE AND POWDER FLOW

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Several factors including particle size have been shown to influence powder flow (Jones & Pilpel, 1966) although interparticle forces such as electrostatic charge interactions have not been studied previously.

Three free-flowing direct compression tableting excipients were used: Emdex (E), Dipac (D) and Elcema G250 (EG). Additionally an excipient exhibiting cohesive flow properties was selected, Avicel PH101 (A). The flow properties of each excipient were quantified using a glass hopper with a 10mm diameter orifice mounted over an electronic flow balance connected to a chart recorder. Flow rates were measured on powders stored under ambient conditions and also following passage through an air cyclone (Staniforth 1980) where they acquired a frictional electrostatic charge. The charge magnitude on the particles was measured using a Faraday Well connected to an electrometer. The charged powder was fed into the hopper and the flow rates were again determined. Each powder acquired a frictional charge even when flowing out of the hopper (table 1) although the charge increased by a factor of between 30 and 100 following triboelectrification (table 1). The cyclone was used as an efficient method of frictional charging although similar effects could be produced by passing powders down chutes or long cylinders.

There was a very marked decrease in the flow rates of the three coarse excipient powders E, D and EG following frictional electrification (table 1). E and D had similar particle size distributions and the theoretical flow values calculated using the expression of Jones and Pilpel (1966) were similar to the observed flow rates prior to charging. Following charging the observed flow rates were much lower than calculated and had values normally associated with cohesive fine powders. A reduction in flow rate and a poor flow pattern were also found in EG following charging (table 1). A, showed only a small reduction in flow rate, probably due to the initial rate being close to the minimum flow value.

The results show that an increase in electrostatic charge can cause a normally free-flowing powder to exhibit 'cohesive' properties. This effect may occur by increased electrostatic attractions between the strongly electronegative powder particles and the electropositive hopper wall. These interactions increase the particle-wall friction and reduce the effective orifice diameter facilitating bridging over the hopper outlet (table 1).

Table 1. Electrostatic and flow properties of powders before and after triboelectrification.

	Charge after flow through hopper ($\times 10^{-9}$ C g^{-1})	Charge after triboelectrification ($\times 10^{-9}$ C g^{-1})	Flow before charging		Flow after charging	
			Flow Rate ($g\ s^{-1}$)	Description	Flow Rate ($g\ s^{-1}$)	Description
E	-0.566 ± 0.11	-329	3.123	Very Free Flowing	0.717	Initial Bridging
D	-0.93 ± 0.04	-98.9	3.011	Very Free Flowing	0.971	Initial Bridging
EG	-3.47 ± 1.61	-248	1.330	Free Flowing	0.216	Intermittent Flow
A	-7.23 ± 0.70	-385	0.315*	Very Cohesive	0.250*	Very Cohesive

* Vibration-assisted flow

Jones, T.M. and Pilpel, N. (1966) J.Pharm.Pharmacol. 18: 429-442.
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