Quantifying Tablet Punch Adhesion Risk Using a Compaction Simulator.

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Introduction

Sticking and picking is a common tableting problem, occurring when particles of the tablet formulation adhere to the punch face and disrupt the integrity of the tablet surface. The sticking tendency of a new formulation has traditionally been difficult to predict during development due to short production runs and limited press data. A number of different methods have previously been used to attempt to quantify sticking; including, assay of adhered materials [1], weight adhered [2] and use of instrumented punches [3]

The aim was to develop a simple method to quantify sticking risk using a minimal amount of material, which could be used early in development. A Compaction Simulator and a novel instrumented punch were used to characterise the sticking behaviour of 5 formulations, some of which were known to adhere to tablet punches during compression.

Picking Index: The ratio of adhesion strength to tensile strength, to quantify the risk of undesirable adhesion.

Materials and methods

The formulations tested were Ibuprofen DC [54%w/w Ibuprofen with 1% Mg Stearate]; three development formulations (A, B and C) and one placebo blend. Testing was performed using a Phoenix hydraulic Compaction Simulator (Dudley, UK). The upper punch was replaced with an instrumented adhesion punch (Fig 1a.) The punch has a removable 10 mm diameter tip which is fixed to a transducer held in the punch body and records a signal when adhesion occurs (1b), relative to the strength of the adhesion between tip and compact.

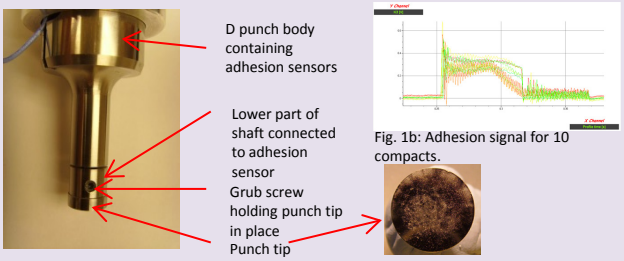


Fig. 1b: Adhesion signal for 10 compacts.

Fig. 1a: Photographs showing the new adhesion punch and removable tip with visually adhered formulation.

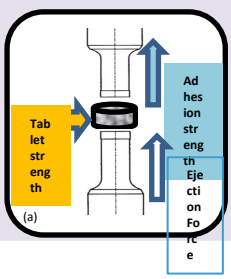
250 mg of formulation was filled into the die and compressed to compacts of 2 to 3 different target thicknesses. Depending upon material availability, 5-20 compacts were made at each setting. Compact dimensions were measured using callipers and the crushing strength was measured using a hardness tester. The adhesion signal and peak compression force were obtained from the compaction software. A calibration plot was used to convert the adhesion signal (v) to a corresponding adhesion force (N).

Adhesion force and Picking Risk

Measuring adhesion force alone does not indicate picking risk as it is a measure of interaction between the upper punch and the tablet surface. Therefore there are two factors important:
(1) Adhesion between punch face and compact
(2) Cohesion of the compact (tablet strength)

Previous investigations showed Ibuprofen to have a low adhesion force. However, this does not mean low sticking, as both punch faces were visually covered in a thick layer of adhered material. The adhered layer does not appear to be attracted to the adjoining material in the compact. Mannitol however had very high forces but excellent compact integrity.

Assessing the risk of sticking must therefore look at both adhesion and cohesion.



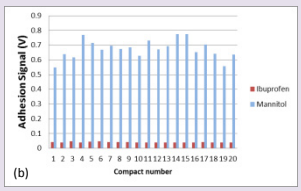


Fig. 2: (a) Schematic showing the adhesion forces involved in sticking and picking and (b) adhesion data for Mannitol and Ibuprofen.

Visual appearance:

Ibuprofen – gross sticking on both punch faces

Mannitol – punch faces clear

Calculations

$$Tensile\ strength = \frac{2P}{\pi dt}$$

P = Crushing strength (tablet hardness)
d= Compact diameter
T = Compact thickness

$$Adhesion\ strength = \frac{Adhesion\ force}{Punch\ surface\ area}$$

$$\boldsymbol{Picking\ Index = \frac{Tensile\ strength}{Adhesion\ strength}}$$

Results

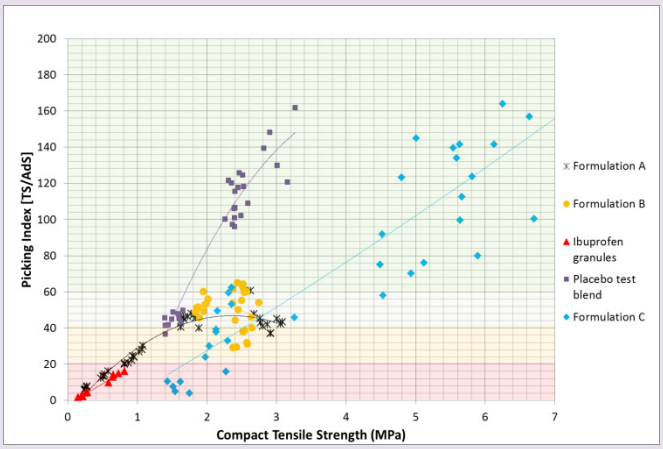


Fig. 3: The picking index results for the five batches tested.

Ibuprofen: Known high risk. Visual sticking after first compact. Although adhesion strength is low, tablets are extremely weak. The picking index was <20.

Formulation B: Is a formulation which is known to pick and stick in production if over-blending occurs and therefore can be considered a moderate risk. There was no visual evidence of sticking with this batch. The picking index was 30-65.

Formulation C: A development formulation with visual evidence of sticking during small-scale manufacture – high risk. The picking index is <20 at low tensile strengths. As compression force increases, both tensile strength and adhesion strength increase, however they increase at different rates. The results indicate force/tensile strength related picking risk.

Placebo blend: Known strength issues with capping and lamination at high speed but no sticking seen in manufacturing therefore considered low risk. Picking index was >40.

Formulation A: Unknown risk - A development formulation with no production experience. These results indicate that there should be a high risk of picking at low tensile strengths, but the risk decreases at higher forces/tensile strengths.

The picking index results appears to correspond well with the operator observations during tablet manufacturing. The results indicate that the picking index could be a useful tool to determine the risk of picking for new products. The data set is limited and therefore to generate a better model for prediction, further materials should be tested and included.

Conclusions

Picking and sticking occurs when material detaches from a tablet and sticks to the punch face and is a problem for manufacturers. The Picking Index gives the possibility of screening for picking risk early in the development process using only small amounts of sample. The following ranges are suggested for assessing risk of picking:

Picking Index:	>60 Low risk
	<40 Moderate risk
	<20 High risk

References

1. M. Roberts *et al*, Effects of surface roughness and chrome plating of punch tips on the sticking tendencies of model ibuprofen formulations, J. Pharm. Pharmacol., 2003, 55, 1223-1228.
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