THE DETERMINATION OF THE COMPRESSIVE YOUNG'S MODULUS OF PHARMACEUTICAL MATERIALS

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The Young's Modulus is an important material property, being a measure of the stiffness, i.e. the resistance to strain of a material. The Modulus can be estimated by measurement of the slope of the stress-strain curve in the elastic region. Previously values have been determined for pharmaceutical materials by the flexure testing of compacted rectangular beams (Church & Kennerley 1983). For porous materials the Young's Modulus (E) can be described empirically by the Spriggs equation:

$$E_S = E \exp(-bp)$$

where E_S is the specimen Young's Modulus at porosity p, and b is a material constant (Spriggs 1961). A plot of $\ln(E_S)$ against p yields a straight line from which E can be found.

A technique for measuring E for cylindrical specimens has been described by Paddon & Wilson (1976). Cylindrical specimens of powders of various porosities were prepared on an Instron Physical Testing machine, using an 8.0 mm die and corresponding flat-faced punches (Manesty Type D), at a compaction rate of 0.5 cm/min. After 2 weeks' storage the specimens were weighed and measured, and the porosity was calculated using the apparent particle density of the material as determined by an air pycnometer.

The compressive Young's Modulus of the specimens was determined by straining the cylindrical test pieces between parallel platens on the Instron at a crosshead speed of 0.05 cm/min. The slope of the resultant stress-strain curve enabled E_S to be calculated from:

$$E_S = \frac{L}{(X-C)A}$$

where L is the length of the specimen (m), X is the slope (m/KN), C is the machine constant (determined by loading the machine without a specimen) (m/KN), and A is the cross-sectional area of the specimen (m^2).

Table 1 shows the values of E estimated for aspirin, Avicel PH102 and potassium chloride, from the relationship given by the Spriggs equation.

Table 1. Compressive Young's Modulus values

Material	Particle size (Microns)	Specimen wt (g)	$E(KN/m^2)\times10^6$
Aspirin	+ 180-250	0.7	2.5
Aspirin	+ 250-355	0.7	2.3
Aspirin	+ 250-355	0.5	2.2
Avicel PH102	+ 250-355	0.25	4.7
Potassium Chloride	* 250-355	0.5	9.2

The method clearly distinguishes between the above materials in their ability to resist deformation. The higher the Young's Modulus the greater the stress required to strain the inter-molecular bonds. Potassium chloride is composed of strong ionic bonds and has a higher modulus than the covalently bonded aspirin molecules. Such a fundamental material constant therefore allows a comparative measure of the elastic properties of materials under stress.

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