INDENTER TO EVALUATE THE VISCOELASTIC PROPERTIES OF TABLETS AND TABLET COATINGS

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A single pan balance has a spherical indenter (diameter 1.27 mm) suspended below the weights and a linear displacement transducer sited above the weights. The transducer receives an input of 5V and the output is fed to a chart recorder normally set at 20 mV sensitivity. The whole apparatus is mounted on a slate slab supported by partially-inflated, rubber tubes to damp down vibrations of the room. Weights are removed until the balance swings freely, after which 0.4 g is added to bring the indenter into contact with the test material. Then 100 g is added so that the indenter penetrates the surface of the test material and a creep curve is produced by the chart recorder. After 3 min, 100 g is removed to produce a recovery section of the creep curve. Instantaneous penetration and recovery distances are obtained from the creep curve and the balance scale readings. Each mg movement of the balance scale corresponds to 29.64 μm movement of the indenter. Creep functions may be calculated from the equation of Bland(1960):

$$a_{(t)}^{3} = \frac{3}{8} R \pi \left[\frac{1}{E} + \frac{1}{\eta} t + \psi_{(t)}\right] \qquad \text{Eq. 1}$$

where $a_{(t)}$ = radius of indentation = $(2Rh - h^2)^{\frac{1}{2}}$ at time t, R = radius of indenter, h = depth of indentation, π = force applied by indenter, E = elastic modulus, η = viscosity and $\psi_{(t)}$ = creep function, which can be evaluated by a "feathering" technique (Barry 1974).

Elastic moduli can be classified as penetration moduli, E_o and recovery moduli, E_r. E_o values are normally lower than E_r values, because of the microrugosities of the surfaces studied. However, if the indenter is reapplied to the site from which it has just been removed, the second E_o value is the same as the first E_r value. Therefore E_r values are a reliable measure of the elasticity of tablet surfaces.

When indentation is allowed to proceed for longer than 3 min, penetration of the surface will eventually cease as a result of build-up of compressed material. Hence 'plug flow' viscosities η, are calculated from penetrations which occur between 60s and 180s after the weight is applied.

Sometimes penetration of the surfaces of certain tablets and unplasticised tablet coatings ceases in less than 60s from application of the 100 g weight. In these cases 'plug flow' viscosities will be infinitely large and equation 1 reduces to

$$a_{(t)}^{3} = \frac{3}{8} R \pi \left[\frac{1}{E} + \psi_{(t)}\right] \qquad \text{Eq. 2}$$

Examples of elastic moduli and plug flow viscosities obtained from the surfaces of compressed materials, with Monsanto hardnesses of 4.0-4.2 kg, are given below.

Compressed Material	E_o (MPa)	E_r (MPa)	η (TPa s)
Alginic Acid	57	110	1.47
Maize Starch	63	203	1.49
Boric Acid	92	243	3.0
Sodium Chloride	208	495	5.3

Barry, B.W. (1974) in Recent Advances in Pharmaceutical Sciences Vol.4. Editors Bean, H.S., Beckett, A.H. & Carless, J.E., pp.33-35, Academic Press, London.

Bland, D.R. (1960). The Theory of Linear Viscoelasticity, p.91, Pergamon Press, Oxford.

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