Miller, R., Horn, A., Iversen, L., Pinder, R. (1974) Nature 250: 238–241

Muller-Schweinitzer, E. (1980) J. Cardiovasc. Pharmacol. 2: 645–655

Pijnenburg, A. J. J., Honig, W. M. M., Struyker Boudier, H. A. J., Cools, A. R., Van der Heyden, J. A. M., van Rossum, J. M. (1976) Arch. Int. Pharmacodyn. Ther. 209: 429–436

Ruffolo, R. R. Jr, Rosing, E. L., Waddell, J. E. (1979) J. Pharmacol. Exp. Ther. 209: 429–436

Schmidt, M., Imbs, J. L., Giesen, E. M., Schwartz, J. (1982) Eur. J. Pharmacol. 84: 61–70

Starke, K., Spath, L., Lang, J. D., Adelung, C. (1983) Naunyn-Schmiedebergs Arch. Pharmacol. 323: 298–306

Struyker Boudier, H. A. J., Cools, A. R. (1984) J. Pharm. Pharmacol. 36: 859–860

Struyker Boudier, H., Teppema, L., Cools, A., van Rossum, J. (1975) Ibid. 27: 882–883

Van Oene, J. C. (1984) Pharmacological evaluation of some alpha-adrenoceptor and dopamine receptor agonists. Doctoral thesis, State University of Groningen, Groningen

Van Oene, J. C., Houwing, H. A., Horn, A. S. (1982a) Eur. J. Pharmacol. 81: 75–87

Van Oene, J. C., Houwing, H. A., Horn, A. S. (1982b) Ibid. 85: 69–77

Van Oene, J. C., Sminia, P., Mulder, A. H., Horn, A. S. (1983) J. Pharm. Pharmacol. 35: 786–792

Vizi, E. S., Harsing, L. G., Knoll, J. (1977) Neuroscience 2: 953–961

Walters, J. R., Roth, R. H. (1976) Naunyn-Schmiedeberg's Arch. Pharmacol. 296: 5–14

Woodruff, G. N. (1979) in: Horn, A. S., Korf, J., Westerink, B. H. C. (eds) The Neurobiology of Dopamine, Academic Press, London, pp 523–539

Woodruff, G. N., Sumners, C. (1979) in: Imbs, J. L., Schwartz, J. (eds) Advances in the Biosciences, vol. 20. Pergamon Press, New York, pp 57–70

J. Pharm. Pharmacol. 1985, 37: 847–848
Communicated April 5, 1985

The determination of yield values using a BP plate plastometer

JOHN D. TOPHAM, GARY P. MARTIN*, *Departments of Pharmacy, Portsmouth Polytechnic PO1 2DZ and *Brighton Polytechnic, Moulsecoomb, Brighton BN2 4GJ, UK*

The BP 1980 Appendix VJ, A79, describes a method determining the yield values of viscoelastic gels. The test relies upon four separate 0·1 g aliquots of the gel being compressed between two glass plates, the upper plate weighing 100 g. After allowing the plastometer to stand for 10 min, the resulting zone diameter of each of the four samples is measured. The Appendix states that a yield value (τ) in N m^{-2} can be calculated from the expression:

$$\tau = \frac{2{\cdot}943 \times 10^3}{d^3} \quad (1)$$

where d = the mean zone diameter in centimetres of the four samples.

The equation appears to be derived from that given by Voet & Brand (1950) for a single spread sample:

$$f = \frac{12PV}{\pi d^3} \quad (2)$$

where f is the yield value (interchangeable with the symbol τ of the BP), P is the force applied to the sample by the top plate of the plastometer in dynes, V is the volume of the sample in cm^3, d is the diameter of spread in cm.

When the BP plastometer specifications are inserted in equation 2, it becomes:

$$f = \frac{12 \times 100 \times 981 \times 0{\cdot}1}{4\pi d^3} = \frac{2{\cdot}943 \times 10^4}{\pi d^3}$$

This assumes a density for the gel of 1 g cm^{-3}. Conversion of the yield value from dynes cm^{-2} to N m^{-2}, results in equation 3 (d still being measured in cm):

$$f = \frac{2{\cdot}943 \times 10^3}{\pi d^3} \quad (3)$$

Equation 3 indicates that the BP equation (equation 1) has omitted division by π. In addition a dimensional analysis of the units of measurement of equation 2 casts doubt upon the validity of the whole equation.

Voet & Brand (1950) state that they derived equation 2 from the work of Howink (1934). His work contains equation 4 which relates the effective weight of the top plate (W), to the radius (r) of the zone and the distance (h) between the plates of the plastometer:

$$W = \frac{2\pi}{3} \cdot \frac{fr^3}{h} \quad (4)$$

This can be rearranged to give:

$$f = \frac{12Wh}{\pi d^3} \quad (5)$$

Assuming that spread occurs uniformly when the sample is compressed, then h can be expressed in terms of the volume of a cylinder, i.e. $h = (4V/\pi d^2)$. When this is substituted in equation 5 and W is replaced by the downward force, P, then the BP symbol τ will replace f for the yield value:

$$\tau = \frac{48PV}{\pi^2 d^5} \quad (6)$$

* Correspondence.

This equation for yield value was originally derived by Scott (1932) and expressed in the form:

$$\tau = \frac{3\pi^{1/2}\,Ph^{5/2}}{2V^{3/2}}$$

which reduces to equation 6, when h is expressed in terms of the volume of a cylinder, V.

Equation 6 was used by Wilson & Bachelor (1971) to characterize the plastic nature of dental cements.

When the BP Plastometer Test Values are inserted in equation 6 it becomes:

$$\tau = \frac{48 \times 0{\cdot}1 \times 9{\cdot}81 \times 0{\cdot}1 \times 10^{-6}}{4\pi^2 d^5} = \frac{1{\cdot}192 \times 10^{-7}}{d^5}\ \mathrm{N\,m^{-2}}$$

the diameter, d, being measured in metres and assuming, again, a sample density of 1 g cm^{-3};

or:
$$\tau = \frac{1{\cdot}192 \times 10^{3}}{d^5}\ \mathrm{N\,m^{-2}} \qquad (7)$$

when d is measured in centimetres.

Evidence suggests that the test is more accurate when a single 1 g sample is used (Brown et al 1984), in which case equation 7 becomes:

$$\tau = \frac{4{\cdot}77 \times 10^{4}}{d^5}\ \mathrm{N\,m^{-2}}$$

However equation 6 is probably the most appropriate form of presenting a yield value, since it allows flexibility to adjust sample volume, and upper plate weight depending upon the nature of the sample. It must, however, be remembered that for equation 6 to be valid the material under consideration must be plastic, i.e. actually possess a yield value. Flow between the plates must have ceased for this yield value to be determined and thus the 10 min experiment referred to in the BP Appendix will be inadequate for some plastic materials.

The theoretical analyses of equilibrium compression between parallel plates of cylindrical materials has been reviewed by Dukes (1968). Equation 6 is based upon a consideration of radial plug flow (Scott 1932). Whilst this may be valid for certain plastic materials, other theories and equations for yield value are thought to be more applicable (a) for the compression of rather hard materials which produce small axial deformations (Peek 1932), and (b) when it is more appropriate to consider the specimen as a plastic solid rather than a flowing liquid (Dukes 1968).

REFERENCES

Brown, D. G., Topham, J. D., Martin, G. P. (1984) J. Pharm. Pharmacol. 36: 20P

Dukes, W. A. (1968) in: Onogi, S. (ed.) Proceedings of the 5th International Congress on Rheology. Vol. 2. University Park Press, pp 315–325

Howink, R. (1934) Physikalische eigenschaften und feinbau von atur-und kinstharzen Pub. Akademische verlagsgesellschaft MBH, Leipzig, pp 33–36

Peek, R. L. (1932) J. Rheol. 3: 345–372

Scott, J. R. (1932) Trans. Inst. Rubb. Ind. 7: 169–186

Voet, A., Brand, J. S. (1950) American Ink Maker 9: 28–31, 59–61

Wilson, A. D., Bachelor, R. F. (1971) Br. Dent. J. 130: 437–441