function of pressure, but by inserting zero flow conditions at standard atmospheric pressure a non-pressure dependent permeability can be calculated, i.e.,

$$B^* = e(B + 0{\cdot}2268 \times 10^{-6}.CON.\sqrt{B}),$$

where CON is a constant dependent in part upon the Kozeny constant.

Table 1 compares values of B_0 and B* and the contribution of slip and viscous flow to B* at different flowrates and porosities for lactose tablets. The contribution of slip flow to the total flow is of the same order or greater than the contribution of viscous flow. This will lead to large errors in calculated values of S_0. The error in B_0 is sufficiently great at low porosities to require the computation of B*.

Table 1

e	$B_0.10^{15}(m^2)$	$B^*.10^{15}(m^2)$	Viscous flow	Slip flow
0·1035	0·1141	0·1285	0·0185	0·1100
0·1035	0·1324	0·1265		
0·1686	0·6078	0·6445	0·1924	0·4521
0·1686	0·6889	0·6416		
0·2809	5·667	5·731	3·310	2·421
0·2809	5·843	5·736		

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REFERENCE

CARMAN, P. C. & MALHERBE P. le R. (1950). *J. Soc. chem. Ind.*, **69**, 134–143.

The compaction properties of potassium bromide with particular reference to infrared spectroscopy

K. RIDGWAY AND M. E. AULTON

Department of Pharmaceutics, The School of Pharmacy (University of London), 29/39, Brunswick Square, London, WC1N 1AX, U.K.

Potassium bromide in a range of particle sizes has been compacted in a vacuum die at various applied pressures to produce flat discs. The infrared transmittance of the discs has been measured and related to the compaction mechanism.

The material used was potassium bromide (Analar grade: B.D.H. Ltd.). It was milled, and the following size ranges (μm) were prepared by sieving: 53–90 (mean 71), 90–140 (mean 110), 355–420 (mean 388) and 500–600 (mean 550). All of these fractions were then used to make flat discs or tablets, 13 mm diameter, in a vacuum die. Compaction pressure was applied and measured by a small calibrated hydraulic press; the pressure range covered was 100–1000 MN m^{-2}. The infrared transmittance of each disc was determined on a Pye SP100 spectrophotometer, and its tensile strength was measured by diametral compression using the apparatus of Shotton & Ganderton (1960).

Lambert's law was obeyed by all the discs: plots of log (absorbance) against thickness were straight lines, plotting at constant compaction pressure. All the lines had the same slope, with the exception of the thinnest tablets at the largest particle size, where the thickness was only one or two particle diameters.

Over practically the whole pressure range, the 110 μm material gave higher transmittance. The 71, 388 and 550 μm particle sizes all scattered a greater proportion of the incident radiation. At any one particle size, the transmittance increased fairly rapidly with increasing compaction pressure, usually reaching a maximum at or about 400 MN m^{-2}. Thereafter, there was a slight fall, followed by a less-pronounced rise in the region of 1000 MN m^{-2}. This behaviour reflects the fact that in the initial compaction stages the crystals are being forced into contact and welded together: the relative density reaches about 0·99 at 400 MN m^{-2}. Additional compaction force introduces flaws into the crystals which act as scattering centres for radiation and reduce the transmittance. At 1000 MN m^{-2} these tend to heal. This is confirmed by the behaviour of the tensile strength of the discs, which also rises, for 0·5 g

tablets made from the 71 μm material, from 3 MN m^{-2} at 100 MN m^{-2} compaction pressure to 7·6 at 800 MN m^{-2}, subsequently falling to 6·9 at 1000 MN m^{-2}. Thicker tablets, weighing 1·0 g of the same material, had lower tensile strengths. So also did tablets made from the larger particle size material.

It thus seems that at about 110 μm particle size, the initial crystal size is such that intergranular scattering and flaw scattering are minimized over the whole pressure range at the 13 mm die diameter used here.

REFERENCE

SHOTTON, E. & GANDERTON, D. (1960). *J. Pharm. Pharmac.*, **12**, *Suppl.*, 87T–92T.

A stable free radical for the investigation of hydrogen abstraction reactions in aqueous solution

J. C. DEARDEN AND A. O. ODUSINA

School of Pharmacy, Liverpool Polytechnic, Byrom Street, Liverpool L3 3AF, U.K.

A large number of biological and pharmaceutical reactions involve the abstraction of hydrogen, often as a primary step in the reaction sequence. An established method of examining hydrogen abstraction reactions is by use of a hydrogen-deficient, stable free radical, such as α,α-diphenyl-β-picrylhydrazyl (DPPH) (Dearden, 1971). However, the characteristics that bestow stability on a free radical generally tend also to bestow water-insolubility; whilst certain of the nitroxides are reasonably soluble in water, they are poor hydrogen abstractors.

In a search for a stable water-soluble free radical, we examined a number of ionic derivatives of DPPH, and found that the potassium salt of α,α-diphenyl-β-2,4-dinitro-6-sulphophenylhydrazyl (DDSH), first prepared by Ikrina & Matevosyan (1962), is reasonably stable in aqueous solution, and abstracts hydrogen readily from –OH, $-NH_2$ and >NH groups, but not in general from –COOH. We prepared the radical by sulphonation and subsequent nitration of *p*-chloronitrobenzene, followed by reaction with 2,2-diphenylhydrazine; treatment with lead dioxide then gave the free radical, which is deep purple in solution. The stability of DDSH in Clark and Lubs phosphate buffer is as follows:

pH	% decrease in absorbance (525 nm) in 1 h
5·6	0·7
6·5	0·6
7·4	0·8
8·6	1·1
9·8	1·9

These stabilities can be increased appreciably by de-gassing. The radical appears to be stable indefinitely in the solid form. The kinetics of hydrogen abstraction may be followed by either u.v. or e.s.r. spectroscopy. In the former case, a correction must be applied for absorption by the corresponding hydrazine formed as hydrogen abstraction proceeds, and a computer program has been written for this purpose.

We have so far investigated hydrogen abstraction from amino-acids and dipeptides in Clark and Lubs phosphate buffer (pH 7·4), and have obtained the following results: Glycine, $k = 0{\cdot}0048$ l $mol^{-1}s^{-1}$; L-alanine, $k = 0{\cdot}0025$ l $mol^{-1}s^{-1}$; L-proline, $k = 0{\cdot}015$ l $mol^{-1}s^{-1}$; glycylglycine, $k = 0{\cdot}031$ l^2 $mol^{-2}s^{-1}$; L-alanylglycine, $k = 0{\cdot}011$ l^2 $mol^{-2}s^{-1}$; glycyl-L-alanine, $k = 0{\cdot}024$ l^2 $mol^{-2}s^{-1}$; glycyl-L-proline, 0·023 l.$mol^{-1}s^{-1}$; L-alanyl-L-proline, 0·013 l $mol^{-1}s^{-1}$. The rate constants are clearly sensitive to changes in molecular structure, and may thus be explained in terms of electronic and steric effects within a molecule. In addition to its role in studies of reaction mechanisms, DDSH can also be used in quantitative analysis of pharmaceuticals (Papariello & Janish, 1965).

REFERENCES

DEARDEN, J. C. (1971). *J. chem. Soc.* In the press.
IKRINA, M. A. & MATEVOSYAN, R. O. (1962). *Zhur. Obs. Khim.*, **32**, 3952–3957.
PAPARIELLO, G. J. & JANISH, M. A. M. (1965). *Analyt. Chem.*, **37**, 899–902.