J. Pharm. Pharmac., 1968, **20**, 54–57 Received June 19, 1967

A note on the determination of particle size by dielectric measurement

R. C. KAYE AND H. SEAGER

An incremental method for the determination of particle size distribution by dielectric constant measurement is described. The results obtained for griseofulvin and phenothiazine agree well with those obtained by Andreasen's method. The technique is suitable for the size-grading of low-conducting powder suspensions.

RECENTLY, Kaye & Seager (1967) described an incremental method for the determination of the droplet size distribution of emulsions by dielectric constant measurement. In this method, the proportion of dispersed phase in a narrow zone of emulsion was determined at suitable

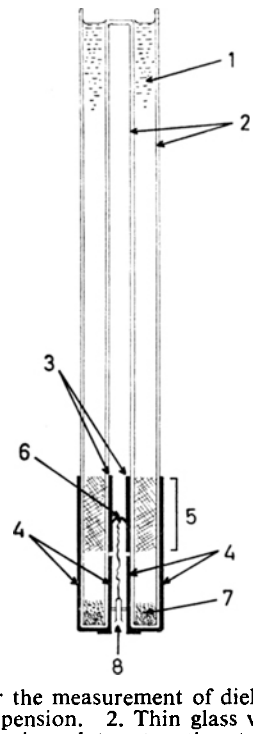

FIG. 1. Capacitance cell for the measurement of dielectric constant. 1. Annular space containing settling suspension. 2. Thin glass walls. 3. Capacitor plate at high R-F. potential. 4. Capacitor plates at earth potential. 5. Capacitance zone. 6. Copper contact. 7. Settled powder. 8. Coaxial socket.

time intervals, and by the application of Stokes' law, the droplet size distribution was calculated.

Using the same concept, this method has now been extended to the size grading of low conducting powder suspensions.

From the Division of Pharmacy, Department of Pharmacology, School of Medicine, Leeds, 2, England.

METHOD

Suspensions of powdered solid (2%) (phenothiazine and coarse graded griseofulvin) were prepared using 1% Brij 98 as the wetting agent. The components were accurately weighed and the systems were carefully dispersed, the powder being gently triturated in a mortar with the aqueous phase. The dielectric constants of the settling suspensions were then measured as follows.

A cell, provided with a pair of capacitor plates at its lower end (see Fig. 1) was filled with suspension. As the suspension gradually settled and the concentration of solid in the narrow zone decreased, the dielectric constant of the suspension in this region increased. The change in dielectric value resulted in an increase of cell capacitance and this was measured by the heterodyne beat method (see Kaye & Seager, 1965, 1966, 1967; Seager, 1966).

The readings of capacitance were converted into dielectric values using the equation

$$\Sigma = \frac{Cg + C\,(Cg/Co + 1)}{Cg - C\,(Co/Cg + 1)} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where Co = capacitance due to the air in the cell; Cg = capacitance due to the dielectric properties of the container walls; C = capacitance due to the dielectric properties of the suspension; Σ = dielectric constant of the suspension.

The composition of the suspension lying between the capacitor plates was calculated from the dielectric values employing the empirically derived equation

$$\%\ \text{Weight} = \frac{\Sigma - \Sigma_1}{d\Sigma/dC} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where Σ = the dielectric constant of the suspension; Σ_1 = the dielectric

TABLE 1. RESULTS FOR A SUSPENSION OF PHENOTHIAZINE IN WATER

Time		Zone capacitance in scale divisions	Dielectric constant of sample in zone	Composition of sample in zone		Diameter of particles (μ) leaving zone
min	sec			Weight %	Weight undersize %	
1	13	5,307	75·06	1·950	100	140
1	39	5,307·5	75·10	1·910	97·9	120
2	23	5,308·25	75·16	1·848	94·8	100
3	43	5,309·5	75·26	1·746	89·5	80
4	51	5,310·5	75·34	1·661	85·15	70
6	37	5,311·5	75·425	1·574	80·7	60
7	52	5,312	75·46	1·535	78·7	55
9	32	5,312·75	75·52	1·472	75·5	50
11	46	5,313·5	75·59	1·408	72·2	45
14	53	5,314·75	75·69	1·305	66·9	40
19	27	5,316	75·79	1·196	61·3	35
26	28	5,317·75	75·93	1·051	53·9	30
38	7	5,320	76·12	0·855	43·8	25
59	34	5,322·75	76·35	0·622	31·9	20
105	54	5,326	76·62	0·340	17·4	15
238	17	5,328	76·79	0·17	8·7	10

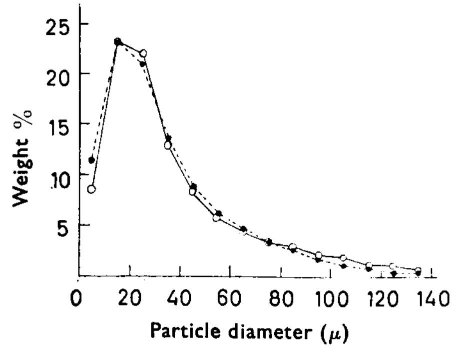

FIG. 2. Weight distribution polygons for phenothiazine suspended in water. ○—○, Dielectric methods; ●----●, Andreasen's method.

TABLE 2. RESULTS FOR A SUSPENSION OF GRISEOFULVIN (COARSE GRADE) IN WATER

Time		Zone capacitance in scale divisions	Dielectric constant of sample in zone	Composition of sample in zone		Diameter of particles (μ) leaving zone
min	sec			Weight %	Weight undersize %	
3	57	5,308·25	75·6	1·993	100	70
5	23	5,308·5	75·18	1·967	98·7	60
7	44	5,309·5	75·26	1·878	94·3	50
9	33	5,310·5	75·34	1·782	89·4	45
12	6	5,312	75·46	1·641	82·3	40
15	48	5,315·5	75·75	1·312	65·8	35
16	50	5,317	75·87	1·170	58·7	32·5
20	8	5,312·25	76·20	0·782	39·2	31
32	16	5,328·75	76·85	0·359	18	30
48	23	5,329	76·88	0	0	20
193	33	5,329	76·88	0	0	10

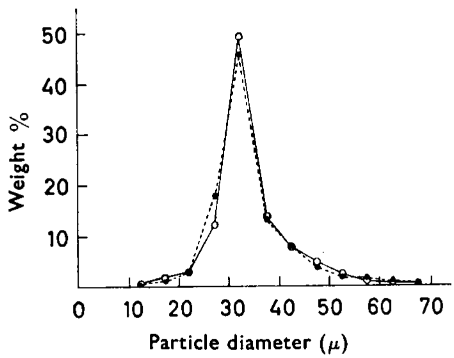

FIG. 3. Weight distribution polygons for griseofulvin suspended in water. ○—○, Dielectric method; ●—●, Andreasen's method.

constant of the continuous phase; $d\Sigma/dC$ = the rate of change of dielectric constant with suspension concentration.

The value of $d\Sigma/dC$ had been previously determined experimentally. The results of plotting dielectric constant against weight % for the suspensions of griseofulvin and phenothiazine gave straight lines of slopes 0·864 and 0·97 respectively.

The particle size distributions were then calculated from composition measurements using the modified form of Stokes' equation where d the diameter of the particles replaces r the radius of the particles.

Cumulative weight undersize curves were constructed from which weight distributions of particle size were obtained. Results for the cumulative weight undersize data for the two powdered suspensions are given in Tables 1 and 2. The weight distribution curves obtained for phenothiazine and griseofulvin suspensions, plotted alongside the size distributions obtained by the Andreasen's pipette method, are shown in Figs 2 and 3 respectively.

The agreement between the results obtained by the two methods is excellent, showing that the dielectric method offers a simple and rapid alternative method for the size grading of low conducting suspensions.

Acknowledgements. We are indebted to Glaxo Laboratories Limited for the generous supply of griseofulvin, and to the Imperial Chemical Industries for their sample of phenothiazine.

References

Kaye, R. C. & Seager, H. (1965). *J. Pharm. Pharmac.*, **17**, *Suppl.*, 92S–97S.
Kaye, R. C. & Seager, H. (1966). *Instrum. Pract.*, **20**, 733–738.
Kaye, R. C. & Seager, H. (1967). *J. Pharm. Pharmac.*, **19**, 78–86.
Seager, H. (1966). Ph.D. thesis, University of Leeds.