Keyphrases □ Moisture content of granulations—relationship to particle size □ Granulations—moisture content as function of particle size

Sir:

In theoretical considerations relative to the drying of granulations, whether by stationary or fluid-bed techniques, it is customary to consider: (*a*) the granulate as uniform, and (*b*) a pooled, average moisture content as the experimental variable. However, granulations have a range of granule sizes and, in the strictest sense, it is not permissible to assume that the moisture is evenly distributed during and after drying. If a granule-sieve fraction has a particle diameter a, then the following relation can be obtained (1):

$$\frac{W - W_\infty}{W_0 - W_\infty} = \frac{6}{\pi^2}\sum_{j=1}^{\infty}\frac{1}{j^2}\exp[-j^2t/\kappa] \sim \frac{6}{\pi^2}\exp[-t/\kappa] \quad \text{(Eq. 1)}$$

where W is moisture content; the subscripts zero and infinity denote initial and final conditions, respectively; j is a running index; t is time; and $\kappa = a^2/(4\pi^2D)$, where D is a diffusion coefficient. Hence, W depends exponentially on a^{-2}, and the smaller granules are (as is intuitively obvious) drier than the larger ones after a certain drying time, t'.

In an experimental study of a continuous process, presently being conducted, sucrose granulations originally containing 7.0 ± 0.2% moisture were subjected to countercurrent drying[1]. The original moisture quoted is composite and theoretical and is not related to any sieve fraction, since wet sieving would be distortive at this point. In the case cited, a granulation was dried for 1 hr. The air inlet temperature was 149° (300° F.), the air outlet temperature was 45° (113° F.), and the dryer was operating at 3.5 r.p.m.

The dried granulation was sieved, and the various sieve fractions were subjected to toluene moisture analysis. The percent moisture was then plotted as a function of particle size (Fig. 1). Separate experimentation showed that $W_\infty = 0.42$, and plotting of ln [(W − 0.42)/6.58)] as a function of a^{-2} then produced a straight line (Fig. 2) with a slope of $-t'4\pi^2D$ cm.² [*i.e.*, the diffusion coefficient for the particular situation would be $-(\text{slope})/(4\pi^2t')$ cm.²/sec.] and an intercept of $\ln(6/\pi^2) = -0.5$; here t' is 3600 sec. It is seen from Fig. 2 that: (*a*) the data adhere fairly well to linearity and (*b*) the intercept is −0.56, in good agreement with the theoretical. These two facts substantiate the view that granules dry by a diffusional process and that, therefore, moisture content is a function of particle size. In cases where granules are not case hardened, the moisture levels equilibrate and the granulation is uniform when it reaches the tablet press. Most wet granulations, however, exhibit case hardening to a greater or lesser degree, and the above phenomena must be accounted for in processing.

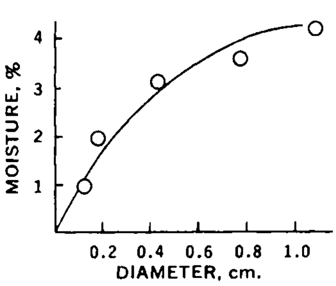

Figure 1—*Moisture content (percent) as a function of particle diameter. Diameters represent the average of the sieve fraction in question.*

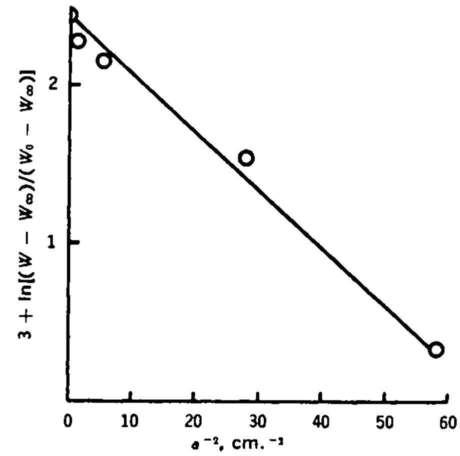

Figure 2—*Data from Fig. 1 plotted as shown in Eq. 1. The slope is* -3.68×10^{-2} *cm.², and the intercept is −0.56,* i.e., *2.44 − 3.*

The diffusion coefficient for the curve in Fig. 2 is $(3.68\ 10^{-2})/(4\pi^2 3600) = 3 \times 10^{-7}$ cm.²/sec., which is of the right order of magnitude for diffusion through capillary void space (2, 3).

(1) W. Jost, "Diffusion in Solids, Liquids and Gases," Academic, New York, N. Y., 1960, p. 46.

(2) J. T. Carstensen, "Theory of Pharmaceutical Systems, II, Heterogeneous Systems," Academic, New York, N. Y., 1973, p. 227.

(3) K. Ridgway and J. A. B. Callow, *J. Pharm. Pharmacol.*, **19**, 155S(1967).

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[1] Bartlett Snow Dryer Style J, 7.9 m. (26 ft.) long and 137.2 cm. (54 in.) in diameter.