

The compaction of magnesium carbonate

N. A. ARMSTRONG AND R. F. HAINES-NUTT

Welsh School of Pharmacy, University of Wales Institute of Science and Technology, Cardiff, Wales, U.K.

Compaction is essentially a two-stage process. As pressure is applied, re-arrangement of powder particles takes place within the die, so that large voids are filled and interparticulate friction may be sufficient to cause fragmentation of the weaker particles. Further increase in pressure is believed to cause elastic and plastic deformation of the particles, which results in the particles being brought into close physical contact; this in turn may permit interparticulate bonding by a "cold welding" mechanism (cf. Higuchi, Rao & others, 1953; Armstrong & Griffiths, 1970).

We have observed that compacts of magnesium carbonate, when placed in water, disintegrated rapidly into their component particles, presumably due to breakdown of interparticulate bonds by a liquid of high dielectric constant. We therefore considered that if particles of known size were compressed and then allowed to disintegrate, evidence of fragmentation or interparticulate bonding might be obtained.

Experimental

Material. Heavy magnesium carbonate, B.P. grade, dried at 70° to constant weight.

Particle size analyses were made using a Coulter Counter, model A Industrial, fitted with a 200 μm orifice tube. A mixture of 0.9% sodium chloride and 0.1% Dispersol T was used as electrolyte.

The compacts of magnesium carbonate, weighing 0.8 g, were prepared in a 1.27 cm stainless steel die, using an Apex model A 14 hydraulic press. The surface area of the compacts was determined by low temperature nitrogen adsorption using a Perkin-Elmer-Shell, model 212D Sorptometer, surface contamination being removed by degassing in a stream of helium (2 ml min^{-1}) for 18 h at 60°. Compacts were disintegrated by adding them to water (approximately 20 ml) and allowing the mixture to stand overnight. The resultant suspension was diluted and particle size analyses were again made; because of the low solubility of magnesium carbonate, size changes due to dissolution were ignored.

Results and discussion

The increase and subsequent decrease of surface area of magnesium carbonate with increase in compaction pressure described by earlier workers was noted, a maximum value of surface area being obtained at about 125 MNm^{-2} . A plot of the geometric mean diameter against compaction pressure indicated that size reduction takes place at low compaction pressures (i.e. up to about 140 MNm^{-2}), but further increase in pressure causes a rise in geometric mean diameter. This is emphasized by calculating the fraction of particles before and after compression which fall into two arbitrarily chosen particle size ranges, namely 20–30 μm and 90–100 μm . The percent weight fraction of the powder falling into each of these size ranges plotted against compaction pressure is shown in Fig. 1. This indicates that at pressures up to approximately 125 MNm^{-2} , the number of large particles shows a gradual reduction, while the

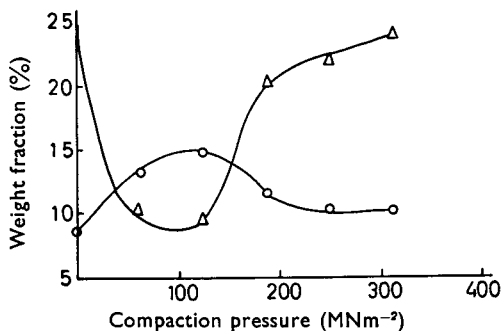


FIG. 1. Percent weight fraction—compaction pressure profile of two size fractions of magnesium carbonate; ○, 20-30; △, 90-100 μm.

number of small particles shows an increase, indicative of fragmentation. Above 125 MNm⁻² a further increase in compression pressure reverses these trends, giving strong evidence that at such pressures, particle aggregation is the predominant process. The maxima and minima of the mean diameter—compression pressure curves were found to occur at approximately the same compression pressure as the maximum value of the surface area—compression pressure curve.

In an attempt to obtain further correlation between compaction pressure, surface area and particle diameter, magnesium carbonate was sifted on an Alpine Airjet sieve, laboratory model into the following fractions: 33-45, 53-63, 75-89, 104-124 μm. The particle size distribution of each fraction was determined by Coulter counter and the geometric mean diameter calculated. Each fraction was then compressed at 62.5 MN m⁻² and the surface area and mean particle size of the resultant compact measured. The mean particle diameter of all fractions is reduced after compression at 62.5 MNm⁻².

Mean particle diameter before compression (μm)	..	39.5	61.5	87.0	121.8
Mean particle diameter after compression (μm)	..	32.2	52.0	64.5	89
Surface area (m ² g ⁻¹)	10.35 9.97 9.73 9.34

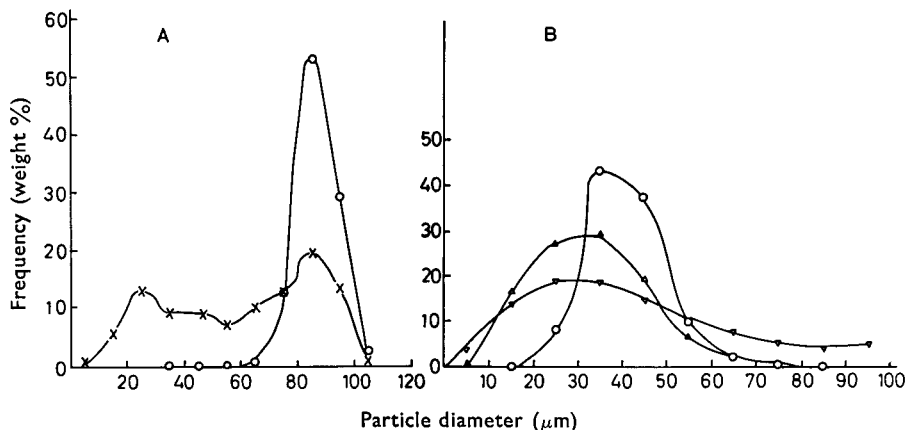


FIG. 2. Particle size distribution of (A) a nominal 75-89 μm fraction (B) a nominal 33-45 μm fraction of magnesium carbonate; ○, before compression; ×, ▲ after compression at 62.5 MNm⁻²; ▼, after compression at 250 MNm⁻².

As at low pressures, surface area increases with compression pressure, fragmentation is probably the only significant factor affecting particle size. Particle size reduction is especially notable with the larger particle sizes, this being emphasized by Fig. 2A which shows the particle size distribution within a nominal 75–89 μm fraction before and after compression at 62.5 MNm^{-2} .

Samples of the 33–45 μm fraction were also compressed at 250 MNm^{-2} and the mean particle diameter after compression determined. Fig. 2B demonstrates that in this case, as with the 75–89 μm fraction, fragmentation occurs at low compression pressures, the geometric mean diameter decreasing from 39.5 to 32 μm . At higher compression pressures, both fragmentation and aggregation probably occur, thereby rendering meaningful results more difficult to obtain. Nevertheless, Fig. 2B shows a significant increase in the number of large particles, the geometric mean diameter rising to 38.5 μm .

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REFERENCES

- ARMSTRONG, N. A. & GRIFFITHS, R. V. (1970). *Pharm. Acta Helv.* In the press.
HIGUCHI, T., RAO, A. N., BUSSE, L. W., SWINTOSKY, J. V. (1953). *J. Am. pharm. Ass. (Sci. Edn)*, **42**, 194–200.