DRUG DEVELOPMENT AND INDUSTRIAL PHARMACY, 20(5), 853-858 (1994)

EFFECT OF DEGASSING TEMPERATURE ON THE SPECIFIC SURFACE AREA AND OTHER PHYSICAL PROPERTIES OF MAGNESIUM STEARATE

Deepak S. Phadke[1] and Julie L. Collier[2]

[1]Marion Merrell Dow Inc., Kansas City, MO, 64137
[2]Current Address: Eli Lilly and Company, Indianapolis, IN 46285

ABSTRACT

The effect of degassing temperature on the magnitude of the BET specific surface area and other physical properties of magnesium stearate was investigated. Magnesium stearate samples from two manufacturers were degassed using helium at 23°, 30°, 40°, 50° and 60°C. The specific surface area of the degassed samples was measured using both single- and multi-point BET methods. The moisture content and thermal properties of the degassed magnesium stearate samples were also examined. The specific surface area values decreased with an increase in the degassing temperature. The Karl Fischer and thermogravimetric analysis results also showed a decrease in the moisture content with an increase in the degassing temperature. The differential scanning calorimetry thermograms of the degassed samples showed changes in the endotherm characteristics along with changes in the melting point and heat of fusion values. It is hypothesized that the lower specific surface area values obtained after degassing at higher temperatures may be due to a partial conversion of the magnesium stearate dihydrate crystals into a monohydrate, an anhydrate or a mixture of the two forms. These results suggest that magnesium stearate samples should be degassed only at room temperature prior to the BET surface area analysis. The results of this study also show that it is important to consider the degassing conditions used when comparing specific surface area data from different sources.

INTRODUCTION

Magnesium stearate is widely used as a lubricant in pharmaceutical tablet and capsule formulations. The specific surface area of magnesium stearate measured by the BET method(1) is commonly used as a parameter for evaluating batch-to-batch and manufacturer-to-manufacturer variability in its physical and lubricant properties. Both the single- and multi-point BET methods have been used for the measurement of the specific surface area of magnesium stearate. In these methods, samples are typically degassed at a certain temperature under a constant flow of helium or nitrogen to remove any adsorbed gases prior to the actual surface area measurement. In an earlier study, the single-point method gave lower specific surface area values for magnesium stearate samples than the muti-point method(2). Frattini and Simioni(3) measured the specific surface area of several magnesium stearate samples using the single-point method after degassing the samples at room temperature for 12 hours. Ertel and Carstensen(4) in their study, deaerated magnesium stearate samples at 60°C under a constant nitrogen flow for 12 hours prior to measuring the surface area using the multi-point method. Earlier work in our laboratory(5) indicated that the degassing temperature markedly affected the surface area values obtained for magnesium stearate.

The objective of this study was to investigate the effect of degassing temperature on the magnitude of the specific surface area values obtained by the single- and multi-point BET methods, and also on other physical properties such as moisture content and thermal behavior of magnesium stearate from Mallinckrodt Inc. and Witco Corp.

MATERIALS

Magnesium Stearate lots from Mallinckrodt Inc., St. Louis, MO, Batch No. 2255A8; and from Witco Corp., Chicago, IL, Batch No. EC53817 were used in this study.

METHODS

Approximately 200 mg samples were degassed at 23°, 30°, 40°, 50° and 60°C under a constant helium(6) flow for 24 hours using a Monotector apparatus(7). The degassed samples were reequilibrated to room temperature before performing the following tests.

The specific surface area of the degassed samples was measured by both single- and multi-point BET methods using a Quantasorb Jr. surface area analyzer(8). The single-point measurement was done using a commercially available 30% mixture of

TABLE 1 - Single- and Multi-Point BET Specific Surface Area Values

Manufacturer	Degas. Temp.(°C)	Single Point SSA m^2/g	Multi Point SSA m^2/g
Mallinckrodt Inc.	23	6.63	7.83
	30	6.36	7.53
	40	5.28	5.96
	50	5.10	5.76
	60	4.68	5.26
Witco Corp.	23	10.48	12.96
	30	9.73	11.82
	40	8.42	9.86
	50	7.28	8.18
	60	7.22	8.08

nitrogen in helium. The multi-point determination was done using 10, 20, and 30% mixtures of nitrogen in helium(9). All measurements were made in duplicate.

The Karl Fischer moisture determination was done using an EM Aquastar Model C2000 instrument(10). All samples were tested in duplicate.

A Perkin-Elmer model DSC-2(11) differential scanning calorimeter was used to evaluate the melting behavior. Samples were scanned from 50° to 200°C at a heating rate of 10°C per minute. A Perkin-Elmer model TGS-2 thermogravimetric system was used to determine the weight loss over a temperature range of ambient to 130°C at a scan rate of 5°C per minute.

RESULTS AND DISCUSSION

The single-and multi-point BET specific surface area values; the Karl Fischer moisture and TGA weight loss results; and the DSC melting point and heat of fusion data for the samples degassed at various temperatures are shown in Tables 1, 2 and 3, respectively.

The data shown in Table 1 indicate that for both the Mallinckrodt and Witco samples the specific surface area values decreased in magnitude with an increase in the degassing temperature. It is interesting to note that the rate of decrease in the magnitude

TABLE 2 - Karl Fischer Moisture and TGA Weight Loss Results

Manufacturer	Degas. Temp.(°C)	Karl Fischer (%W/W)	TGA Weight Loss (% W/W)
Mallinckrodt Inc.	23	4.80	4.23
	30	4.80	3.98
	40	4.68	3.60
	50	3.56	2.96
	60	2.25	2.41
Witco Corp.	23	5.24	4.07
	30	4.40	3.83
	40	4.13	3.61
	50	3.05	2.47
	60	1.95	1.79

TABLE 3 - DSC Melting Point and Heat of Fusion Data

Manufacturer	Degas. Temp.(°C)	Melting Point(°C) Max. Temp.	Heat of Fusion Cal/g
Mallinckrodt Inc.	23	126.73	47.46
	30	127.63	46.63
	40	128.33	44.85
	50	125.58	33.95
	60	131.32	13.60
Witco Corp.	23	125.72	40.33
	30	128.86	39.55
	40	124.39	37.71
	50	129.48	9.23
	60	128.90	9.88

of the specific surface area values with an increase in the degassing temperature was similar for the both the Mallinckrodt and Witco samples.

The Karl Fischer moisture and the TGA weight loss data shown in Table 2 exhibited a gradual decrease in the amount of moisture with an increase in the degassing temperature. The water of hydration associated with the monohydrate, dihydrate and trihydrate forms of pure magnesium stearate corresponds to approximately 2.95%, 5.74% and 8.57%, respectively(12). The Karl Fischer moisture content values for the samples degassed at room temperature approximately coincide with the water of hydration present in the dihydrate form. These results indicate that the dihydrate form upon degassing at higher temperatures partially converts into the monohydrate or anhydrous form or a mixture of the two forms.

The DSC melting point and heat of fusion data shown in Table 3 indicate that there was a small increase in the melting point of the degassed samples with an increase in the degassing temperature. The heat of fusion values showed a small decrease up to the degassing temperature of 40°C followed by a marked decrease for samples degassed at 50° and 60°C. Ertel and Carstensen(12) have reported melting points of 122.5°C and 125.1°C for the dihydrate and the anhydrous forms of pure magnesium stearate, respectively. Although the melting point values as shown in Table 3 are slightly higher than the reported values, they show a similar trend. At the scan rate of 10°C per minute used in this study, only one endotherm was observed. Ertel and Carstensen(12) observed two endotherms at a scan rate of 2°C per minute. They attributed the first endotherm to the loss of water of hydration and the second to the melting of magnesium stearate. It is likely that the faster scan rate used in our study failed to resolve the two endotherms. It is also probable that the heat of fusion values reported in Table 3 result from two components; one due to the loss of water and the other due to the melting of magnesium stearate. The heat of fusion values for both the Mallinckrodt and Witco samples degassed at 50° and 60°C were markedly lower, apparently because of the significantly lower amounts of water present in these samples.

CONCLUSION

The degassing temperature used prior to the BET surface area analysis has a marked effect on the magnitude of the single- and multi-point specific surface area values obtained for magnesium stearate. The Karl Fischer moisture values and the thermal analysis data on the degassed samples indicate that the dihydrate form of magnesium stearate undergoes partial conversion to the monohydrate and/or the anhydrous forms during degassing at 50° and 60°C. These results suggest that in order to prevent this change, magnesium stearate samples should be degassed only at room temperature prior to the BET surface area analysis. These results also show that it is important to consider the degassing temperature used when comparing the magnesium stearate specific surface area data from different sources.

ACKNOWLEDGMENT

The authors wish to thank Gary Eldridge Jr. for technical assistance on this project.

REFERENCES

1. S. Brunauer, P.H. Emmett and E. Teller, *J. Am. Chem. Soc.* 60, 309, (1938).
2. D.S. Phadke and J.L. Eichorst, *Drug Dev. and Ind. Pharm.* 17, 901, (1991).
3. C. Frattini and L. Simioni, *Drug Dev. and Ind. Pharm.* 10, 7, (1984).
4. K.D. Ertel and J.T. Carstensen, J. *Pharm. Sci.*, 77, 625, (1988).
5. D.S. Phadke and J.L. Eichorst, *Pharmaceutical Research,* Suppl., 6, S-59, (1989).
6. Acetylene Products Inc., Indianapolis, IN.
7. Quantachrome Inc., Syosset, NY.
8. Ibid.
9. Acetylene Products Inc., Indianapolis, IN.
10. EM Aquastar Company, Hiranuma, Sangyo, Japan.
11. Perkin-Elmer Company, Norwalk, CT.
12. K.D. Ertel and J.T. Carstensen, *Int. J. Pharm.*, 42, 171, (1988).