

## Effect of the Lubricant Magnesium Stearate on Changes of Specific Surface Area of Directly Compressible Powders Under Compression

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### ABSTRACT

During compression, powders fragment, plastically deform, and/or may behave both ways. Different profiles of specific surface area changes have been shown in several studies for many powders. In this study, the effect of a lubricant on the specific surface area of a powder was studied during the consolidation process of the powder as an attempt to clarify the behavior of powders under compression. Changes in specific surface areas of Starch (Rice starch), cellulose (Avicel<sup>®</sup> PH102), spray dried lactose (Zeparox<sup>®</sup>), and dibasic calcium phosphate (Emcompress<sup>®</sup>) were studied using gas adsorption technique. Magnesium stearate was used as a lubricant. Specific surface area of plastically deforming materials; cellulose, and starch was clearly affected by the addition of lubricants. Spray dried lactose combined both fragmenting and plastically deforming behavior in its consolidation under compression and its specific surface area was slightly affected by the addition of lubricant. Specific surface area of fragmenting material; Dibasic calcium phosphate was not affected by the addition of a lubricant.

**Keywords:** Specific surface area; Magnesium Stearate Lubricant; Consolidation; Excipients; Gas adsorption.

### 1. INTRODUCTION

Tablet is the most commonly used dosage form, with more than 80% of the 200 most prescribed drugs in the United States<sup>1,2</sup>. A powder is a mix of a great number of individual particles; therefore it is not easy to predict the bulk powder behavior based on the exact properties of individual particles<sup>3</sup>. Excipients play a major role in determining powder properties and behavior. Lubricants are widely added excipients to many pharmaceutical tablet formulations. They minimize the friction between the tablet and the die metal surface that leads to the reduction of the ejection force and therefore, assists in tablet ejection<sup>1,2</sup>.

Consolidation of a powder bed under either

deformation or fragmentation will lead to some changes in surface area<sup>4</sup>. As particles assume an even closer relationship, this causes further surface area changes. Surface area studies may provide important information on the extent and mechanisms of particle consolidation. However, the relationship between surface area and pressure is complex. Several studies have obtained different shapes for the graph of surface area against compression pressure for the same solid<sup>5,6,7,8,9,10</sup>. Therefore, this study will attempt to clarify the behavior of powders under compression by studying the changes of specific surface area of selected solids and the effect of the addition of a lubricant.

Urwin<sup>11</sup> showed that degassing of samples of titanium dioxide at various temperatures and times caused variation in the surface area measured. Increase in the degassing temperature over the range 23°C-150°C caused an increase in the surface area values which was

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independent of the length of time of degassing. Between the temperatures of 150°C and 200°C, the temperature of pre-treatment became time-dependent. Stanley-wood and Johansson<sup>12</sup> determined the surface area of compacted and uncompacted magnesium trisilicate and found, similar to Urwin, that although the available surface area increased with temperature, the increase was not dependent on time in the range 18-40 hours. The time necessary to degas powders compressed over the range 17.5-250 MNm<sup>-2</sup> at a temperature of 24°C was, however, longer the higher the compaction pressure (17.5 MNm<sup>-2</sup> required 7 hours, 70 MNm<sup>-2</sup> required 14.5 hours, and 280 MNm<sup>-2</sup> required 18 hours).

Marshall and Sixsmith<sup>13</sup> also showed that the degassing time has an effect on surface area measurement. Using Avicel PH101, they showed that a constant surface area value was only reached after about 8 hours degassing. Morton<sup>14</sup> has shown, using heavy magnesium carbonate samples, that there was no significant difference in the specific surface area obtained on samples degassed for 12, 24 and 36 hours. Ball and Norwood<sup>15</sup>, who studied the surface areas and porosity changes of calcium sulphatedihydrate heated between 27°C and 362°C over a period of time between 10 min and 220 hours, found that at 79°C the surface area of calcium sulphatedihydrate reached a constant value after 100 hours. Heating at 147°C gave a maximum surface area after 240 hours. Although there was an increase in surface area this was not accompanied by changes in porosity. The increase in surface area without porosity changes was attributed to the variation in the surface energy of the adsorbent, because the  $C_{\text{BET}}$  values calculated from the isotherms increased.

## 2. MATERIALS AND METHODS

Four solids were chosen in this study whose consolidation mechanism is known. These were Zeparox<sup>®</sup> (Borculo Whey Products Ltd, Saltney), Avicel<sup>®</sup> PH102 (FMC International, Cork), Emcompress<sup>®</sup> (Mendell, Reigate) and rice starch (BDH, Poole). The effect of adding 0.5 or 1.0% magnesium stearate (Fisons Scientific Equipment, Loughborough) on

tablets properties was studied.

Manesty F3 (Manesty Machines Ltd, Liverpool) press was used to prepare tablets at range of pressures. A machine speed of 0.83 rev sec<sup>-1</sup>, i.e. 50 tablets.min<sup>-1</sup>, was kept constant in this study. The upper punch position of the Manesty F3 was controlled by a cam mounted on a gear and the position of the lower punch was controlled by an adjusting collar.

Powders were sieved and particle size range 355-425 micrometers was chosen. Five hundred grams for single component tablets were mixed in the Erweka UG cube mixer (Type KB 15, Copley Instruments Ltd, Nottingham) for 5 minutes at a rotational speed of 60 r.p.m. with magnesium stearate. Two concentrations of lubricant were used with every five hundred grams of powder; 0.5% (w/w) and 1.0% (w/w). Cellulose tablets were not lubricated. A 12.5 mm diameter flat faced punch and die system were used to prepare tablets from the different mixtures using the instrumented tablet press. Tablets average weight was 0.16 kg<sup>-3</sup>, and thickness varied according to the pressure applied. Each powder was fed manually into the feed hopper and tablets were prepared at wide range of compaction pressures to give tablets of different thickness (porosity). Force transducers were fitted to the upper punch and signals were displayed on a cathode ray oscillograph (Micromovements Ltd, Eversley). The pressure exerted by the upper punch was calculated by dividing the compaction force (kN) by the cross-sectional area of the punch. Thirty tablets were collected at each compaction pressure, the first six tablets being discarded. Tablets from each compaction pressure were appropriately labelled and stored in airtight containers under ambient conditions (18°C ± 2°C and 45% ± 5% relative humidity) for at least one week before testing.

All solid surfaces are contaminated by physically adsorbed gases and moisture which adhere to the surface. Therefore, before the surface area can be determined by a low temperature adsorption technique, these contaminants must be removed by heating the solid under vacuum for several hours. However it is essential that optimum conditions are selected so that the surface area is accessible to the adsorbing gas.

The NOVA-1000 apparatus is supplied with an aluminium oxide standard. After degassing this at the recommended temperature and time (6 hours at 350°C), a coefficient of variation among five replicates of 3.56% was obtained. So, in this work, conditions which produced the least coefficient of variation results with correlation coefficient higher than 0.99 were chosen to degas that powder. In this work, one gram of each sample of powder was inserted into a NOVA-1000's Pyrex-glass cell, the cell was placed in the degassing station in the

NOVA-1000 and the degassing process was loaded. Powders were degassed at 20°C, 40°C and 60°C in vacuo ( $10^{-3}$  torr) for 3 hours, 6 hours and 18 hours, and analysed 5 times each using 5 point BET method of partial pressure range 0.05-0.35, 1.00 being the saturation pressure for nitrogen. However, it is important to mention that the adsorption isotherm and desorption isotherm branches of the 6 types of isotherms in general separate at approximately just about the partial pressure of 0.35 and above, moreover, below this partial pressure all types of

**Table 1.1. Mean, standard deviation and coefficient of variation (%) of specific surface area (m<sup>2</sup>/g) for powders using different degassing times and temperatures (n = 5)**

Powder	No degassing (No treatment)	20 °C			40 °C			60 °C		
		3 hours	6 hours	18 hours	3 hours	6 hours	18 hours	3 hours	6 hours	18 hours
Starch	1.20 ± 0.14 (11.67)	0.89 ± 0.39 (43.82)	1.59 ± 1.20 (75.47)	1.39 ± 0.24 (17.26)	1.23 ± 0.15 (12.20)	1.54 ± 0.32 (20.78)	1.16 ± 0.26 (22.41)	1.36 ± 0.34 (25.00)	1.34 ± 0.37 (27.61)	1.13 ± 0.07 (6.19)
Cellulose	0.75 ± 0.11 (14.67)	0.73 ± 0.11 (15.07)	0.77 ± 0.08 (10.39)	0.79 ± 0.45 (56.96)	0.77 ± 0.08 (10.39)	0.74 ± 0.06 (8.11)	0.75 ± 0.06 (8.00)	0.71 ± 0.24 (33.80)	0.66 ± 0.15 (22.73)	0.78 ± 0.04 (5.13)
Spray-dried lactose	0.26 ± 0.09 (34.62)	0.36 ± 0.12 (33.33)	0.27 ± 0.07 (25.93)	0.16 ± 0.07 (43.75)	0.23 ± 0.10 (43.18)	0.17 ± 0.03 (17.65)	<b>0.21 ± 0.01</b> <b>(4.76)</b>	0.25 ± 0.11 (44.00)	0.47 ± 0.04 (8.51)	0.56 ± 0.09 (16.07)
Dibasic calcium phosphate®	0.95 ± 0.20 (21.05)	0.68 ± 0.20 (29.41)	0.75 ± 0.13 (17.33)	0.79 ± 0.05 (6.33)	0.87 ± 0.17 (19.54)	0.77 ± 0.21 (27.27)	0.89 ± 0.10 (11.24)	0.67 ± 0.21 (31.34)	0.70 ± 0.12 (17.14)	0.62 ± 0.47 (75.81)

isotherms have identical inclined straight line, thus, type of adsorption isotherm cannot be established. The conditions giving the smallest coefficient of variation with a correlation coefficient higher than 0.999 were chosen to degas that powder. From these experiments, the following conditions were selected: starch 18 hours at 60°C, Cellulose 18 hours at 60°C, Spray-Dried Lactose 18 hours at 40°C, and Dibasic calcium phosphate dihydrate 18 hours at 20°C (Table 1.1). The results were similar to those in a previous study<sup>16</sup>. However, it must be

mentioned that the surface area measurements reflect only surface area that is accessible to the adsorbing gas, which excludes surface area of pores that are no longer open to the surrounding porosity, i.e. their pore cross sectional area is less than the cross-sectional area of nitrogen molecule that is  $16.2 \times 10^{-20}$  m<sup>2</sup>. However, this technique suffers from the limitation of not being able to measure small pores and future work should be carried to measure it using other techniques such as Carbon Dioxide.

After degassing, cells were transferred from the degassing station to the analysis station in the NOVA-1000 and five points of partial pressure in range of 0.05-0.35 were applied to detect the adsorption of nitrogen gas on the surface of the powder according to BET method<sup>17</sup>. The nitrogen adsorption of 3 individual tablets was measured and the average and standard deviation were

calculated.

Each solid or mixture was subjected to the establishment of the relationships between compression pressure and tablet's specific surface area, and the effect of lubricant concentration on tablet properties was investigated. Tablets composition can be seen in table (1.2).

**Table 1.2. Tablets composition**

Tablet	Magnesium Stearate concentration (w/v%) in a 500 mg tablet	Magnesium Stearate concentration (w/v%) in a 500 mg tablet
	F - 1	F - 2
Starch	0.5%	1.0%
Cellulose	0.0%	0.0%
Spray-dried lactose	0.5%	1.0%
Dibasic calcium phosphate	0.5%	1.0%

**Table 1.3. Mean yield pressure (MPa) of different powders using Heckel plots lubricated with 0.5% magnesium stearate, except Avicel PH102 that was not lubricated.**

Powder	Y2 <sup>‡</sup>	Y1 <sup>‡</sup>	X2 <sup>†</sup> (MPa)	X1 <sup>†</sup> (MPa)	K (MPa <sup>-1</sup> )	Py (MPa)
Starch	1.78	1.43	200	100	0.0035	<b>286</b>
Cellulose *	2.20	1.68	200	100	0.0052	<b>192</b>
Spray-dried lactose	2.08	1.76	200	100	0.0032	<b>313</b>
Dibasic calcium phosphate	1.97	1.66	200	100	0.0031	<b>323</b>

<sup>†</sup> X1 and X2 are two points, chosen from the pressure axis (MPa).

<sup>‡</sup> Y1 and Y2 are the values of  $\ln 1/(1-D)$  corresponding to X1 and X2.

\* No lubricant is used

**Table 1.4. Mean yield pressure (MPa) of different powders using Heckel plots lubricated with 1.0% magnesium stearate, except Avicel PH102 that was not lubricated.**

Powder	Y2 <sup>‡</sup>	Y1 <sup>‡</sup>	X2 <sup>†</sup> (MPa)	X1 <sup>†</sup> (MPa)	K (MPa <sup>-1</sup> )	Py (MPa)
Starch	1.97	1.43	200	100	0.0054	<b>185</b>
Cellulose	—	—	—	—	—	—
Spray-dried lactose	2.05	1.74	200	100	0.0031	<b>323</b>
Dibasic calcium phosphate	1.91	1.60	200	100	0.0031	<b>323</b>

<sup>†</sup> X1 and X2 are two points, chosen from the pressure axis (MPa).

<sup>‡</sup> Y1 and Y2 are the values of  $\ln 1/(1-D)$  corresponding to X1 and X2.

Measurement of specific surface area at zero MPa indicates the average readings of the powder itself, prior

to being compressed into tablets.

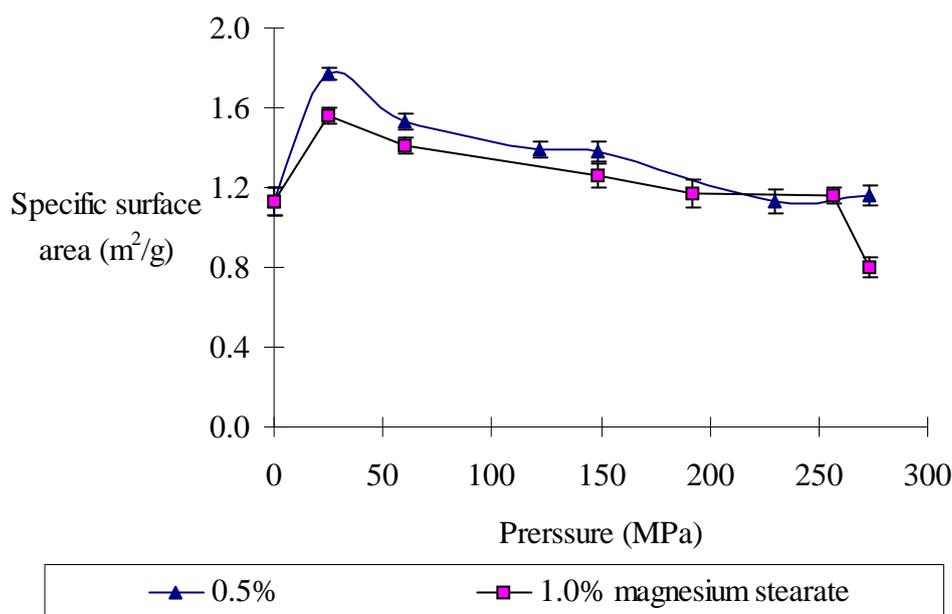
### 3. RESULTS AND DISCUSSION

#### 3.1 Rice starch

Figure 1.1 shows the Comparative plots of specific surface area versus pressure for tablets compressed from starch excipient used in this study, using 0.5% and 1.0% magnesium stearate.

Previous studies showed that starch consolidates

almost entirely by time-dependent plastic deformation<sup>18</sup>; researchers involved many areas including stress relaxation studies<sup>19,20</sup>, time dependent effects<sup>20,21</sup>, the weakening effect by magnesium stearate<sup>22,23</sup>, a low strength isotropy ratio, i.e. ratio of axial to radial tensile strength<sup>23</sup> and microscopical examination<sup>23</sup>.



**Figure 1.1: The variation of specific surface area (m<sup>2</sup>/g) with change in compression pressure (MPa) for tablets made from starch**

Starch tablets were degassed at 60°C for 18 hours, using 0.5% and 1.0% of magnesium stearate as a lubricant. Starch is a plastically deforming material and figure (1.1) shows that when pressure is applied there is an increase in the specific surface area of the powder at the beginning of the curve (at low pressure) that was due to the initial friction and attrition between the surfaces of the particles and hence the surface area would increase. Then the curve started to decline, showing a plastically deforming behavior of the particles very close to each other, and allowing less access of the nitrogen gas to the available surfaces. Hence, the surface area has decreased. However, upon increasing the lubricant concentration, only a slight difference in the specific surface area of

starch was seen. As pressure increases, more surfaces will slide against each other in the case of using more lubricant, and they will eventually come closer to each other, therefore the surface area was expected to be lower than in lower concentration of lubricant. On the contrary, the lubricant showed no difference in the surface area readings in the concentrations used, which indicates that, in the concentrations used, the lubricant did not affect the specific surface area in a plastically deforming material like starch. Duberg and Nyström<sup>23</sup>, using krypton adsorption method to measure the surface area of starch, found that under a compressive load, starch showed a very small increase in surface area after compaction compared to Dibasic calcium phosphate<sup>®</sup>, which is an

extensively fragmenting material, and they concluded that starch plastically deforms rather than fragments under compression.

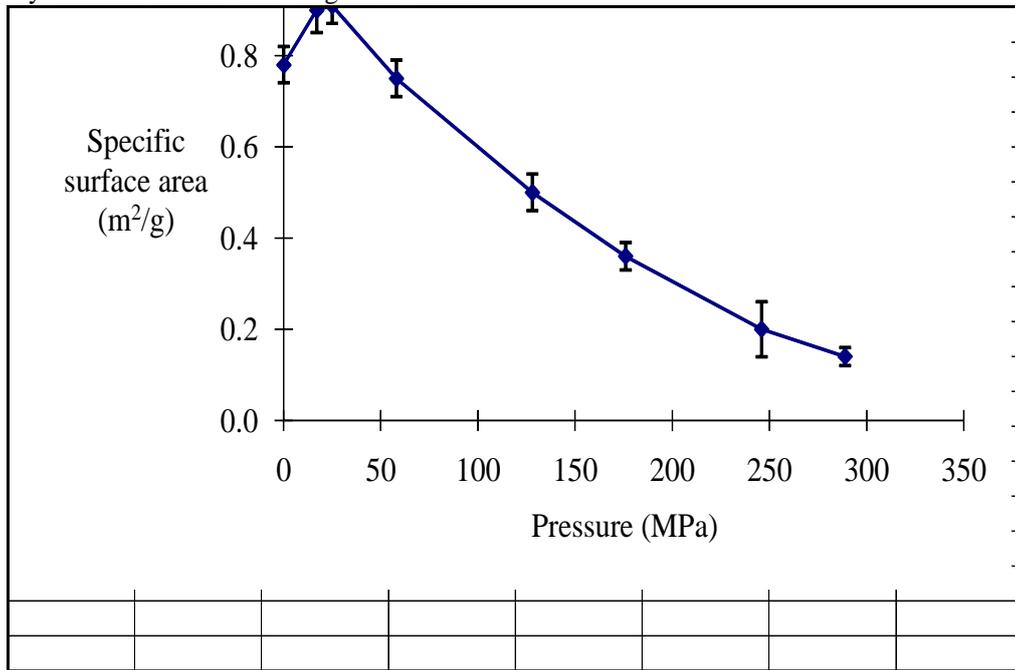


Figure 1.2: The variation of specific surface area (m<sup>2</sup>/g) with change in compression pressure (MPa) for tablets made from Cellulose

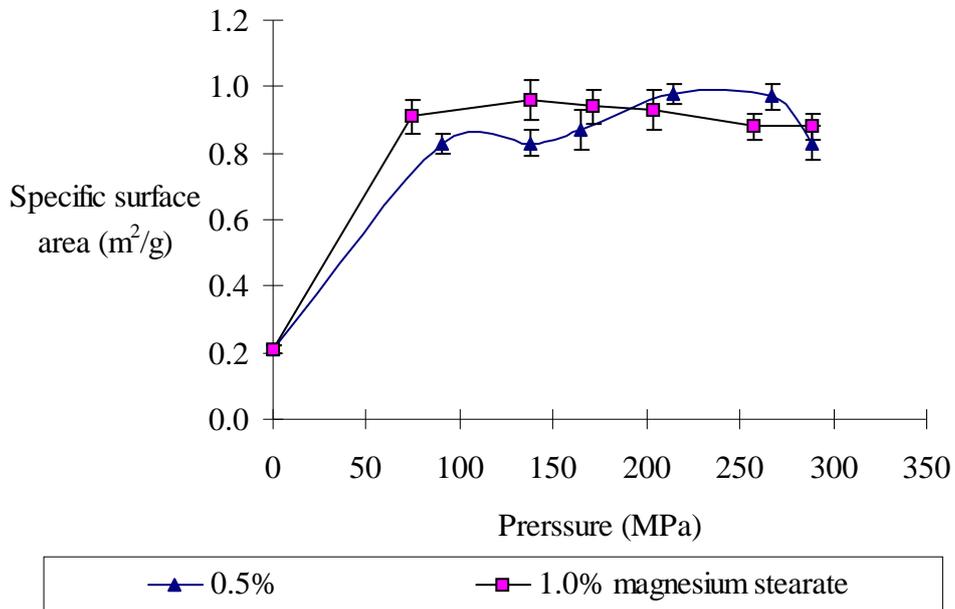


Figure 1.3: The variation of specific surface area (m<sup>2</sup>/g) with change in compression pressure (MPa) for tablets made from Spray-dried lactose

### 3.2 Microcrystalline cellulose (Avicel® PH102)

Previous studies showed that Avicel consolidates mainly by plastic deformation<sup>18,19,21,24,25,26,27</sup>. In this study, Cellulose was lubricated with 0.5% and 1.0% magnesium stearate. Upon using a lubricant, capping occurred at all used pressures. Capping occurs when the effect of the particles' elastic deformation exceeds the effect of the interparticular bonding forces. Tablets of Cellulose capped even when compressed at the lowest pressure used, namely 17 MPa. Reduction of the lubricant level to 0.25% also showed similar capping. Ritter and Sucker<sup>28</sup> showed that Cellulose produced hard tablets with no tendency to cap when compressed without additives. Therefore, Cellulose was investigated without adding lubricant. Tablets were degassed at 60°C for 18 hours before measuring the specific surface area.

It was expected that virtually all particles will undergo some fragmentation either as the result of the imposition of a compressive force or even, at low pressure, by abrasion as the particles slide over one another to give a less porous powder bed, but one which is still composed of discrete particles. This appears to have occurred with Cellulose (Fig. 1.2). As pressure started to increase, a slight increase in the specific surface area occurred presumably due to attrition or abrasion, and then the curve declined showing a plastically deforming behavior for microcrystalline cellulose powder. Upon increasing the pressure load and as the particles come adjacent to each other, attractive forces will develop between the particles. Due to capping of Cellulose with using a lubricant and due to its high initial porosity, this would exclude the solid bridges from being a mechanism of binding of particles of Cellulose. Compression at pressure above 176 MPa gave tablets the strength of which exceeded 40 kg, the maximum measurable on the CT40 tester.

Khan and Rhodes<sup>29</sup> showed that an increase in compression pressure caused some fragmentation of microcrystalline cellulose. Furthermore, they stated that the microcrystalline cellulose crystals were compacted close enough so that hydrogen bonding between them could occur. Fragmentation may increase the surface area of contacts between particles resulting in greater particulate bonding<sup>30</sup>. Ritter and Sucker<sup>28</sup> stated that

crystals are compacted close enough so that hydrogen bonding between them can occur.

### 3.3 Spray-Dried Lactose (Zeparox®)

Most previous studies have concluded that the consolidation mechanism of lactose occurs predominantly by fragmentation<sup>18</sup>. These findings included stress relaxation<sup>31</sup>, surface texture<sup>32</sup>, particle size<sup>28,33</sup>, susceptibility to magnesium stearate, high strength isotropy ratio and microscopical examination<sup>23</sup> and surface area changes<sup>8</sup>. However, some other studies have shown that lactose can undergo plastic deformation<sup>20,25</sup>. Directly compressible lactose containing amorphous lactose was shown to be capable of plastic flow<sup>8,34</sup>.

Spray-dried lactose, the lactose used in this study, is a spray-dried lactose built up of lactose monohydrate crystals, glued together with amorphous lactose, or lactose glass. Hence, it was expected to show both fragmenting and deforming properties<sup>8,34</sup>. In this study, lactose tablets were degassed at 40°C for 18 hours. Concentrations of 0.5% and 1.0% of magnesium stearate were used as a lubricant. Using pressure below 90 MPa with spray-dried lactose, produced tablets with low crushing strength values. Figure (1.3) shows that when pressure was applied to the powder containing 0.5% magnesium stearate, there was an increase in the specific surface area up to a pressure of 90 MPa. This can be attributed to the fragmentation and attrition between the surfaces of the particles. Beyond this pressure, the curve levels off indicating that the plastic deformation behavior has started to participate more in the consolidation of the particles, hence bringing particles' surface areas into closer proximity which allowed less access to the nitrogen gas. However, upon increasing the lubricant concentration, the specific surface area has also increased upto ~150 MPa of compression pressure, after which it started to level off, indicating also that the plastic deformation behavior has started to participate more in the consolidation of the particles. The plastic behavior could be related to the portion of amorphous lactose in the powder. In both concentrations of lubricant used, there was no significant difference in the data of specific

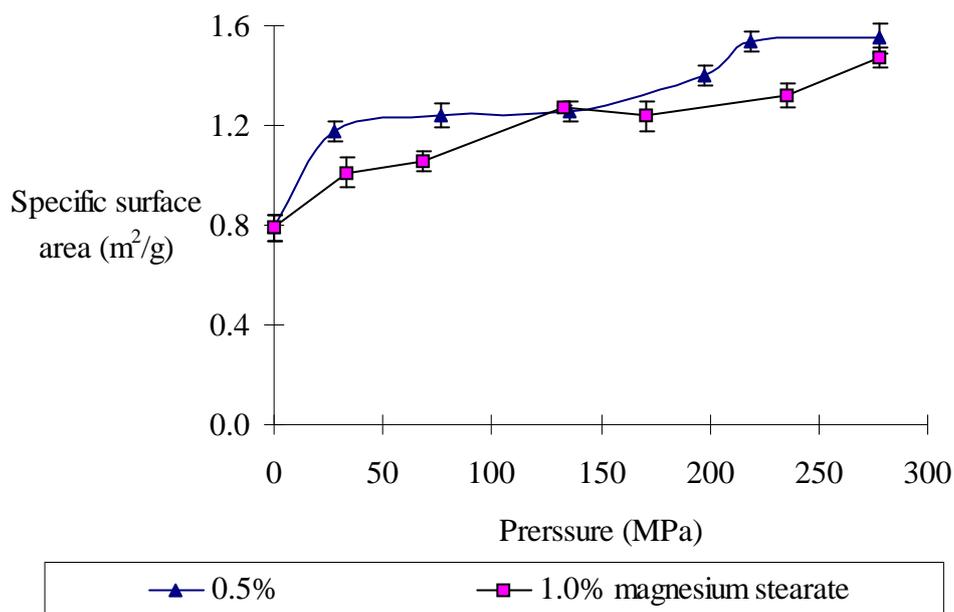
surface area of lactose. This indicates that the lubricant, in the concentrations used, has no effect on the specific surface area of directly compressible lactose which both fragments and plastically deforms.

Vromans and co-workers<sup>8</sup> suggested that a capillary condensation effect would limit the accessibility of the nitrogen to the surface area, and hence give poor reproducibility of the gas adsorption method. However, Vromans et al. gave no quantitative definition of "poor". However, in this study, there is a good linear relationship

between the specific surface area and the applied pressure up to ~70 MPa, after which the curve leveled off.

### 3.4 Dibasic calcium phosphate dihydrate (Emcompress<sup>®</sup>)

Dibasic calcium phosphate dihydrate undergoes extensive fragmentation during compression as demonstrated by large increase of surface area after compression<sup>35,23,7,18</sup>, a high strength isotropy ratio<sup>23</sup>, a very small effect of lubricants on tablets strength<sup>22,36,37,23</sup> and absence of time dependent effects<sup>20,25,38</sup>.



**Figure 1.4: The variation of specific surface area (m<sup>2</sup>/g) with change in compression pressure (MPa) for tablets made from Dibasic calcium phosphate**

In this study, Dibasic calcium phosphate<sup>®</sup> tablets were degassed at 20°C for 18 hours. Concentrations of 0.5% and 1.0% of magnesium stearate were used as lubricant. Figure (1.4) shows that when pressure was applied, there was an increase in the specific surface area of the powder up to the highest pressure used, which indicates that Dibasic calcium phosphate is an extensively fragmenting material. The increase in the specific surface area was because of continuous fragmentation and attrition between the surfaces of particles that resulted in many

new surfaces. However, with both concentrations of lubricant, there were slight differences in the specific surface area of Dibasic calcium phosphate; which indicates that the lubricant, in the concentrations used, has no significant effect on the specific surface area. This may be attributed to the new surfaces created that were not exposed to the lubricant. Duberg and Nyström<sup>23</sup> and Vromans et al.<sup>8</sup> found similar conclusion when used mercury porosimetry.

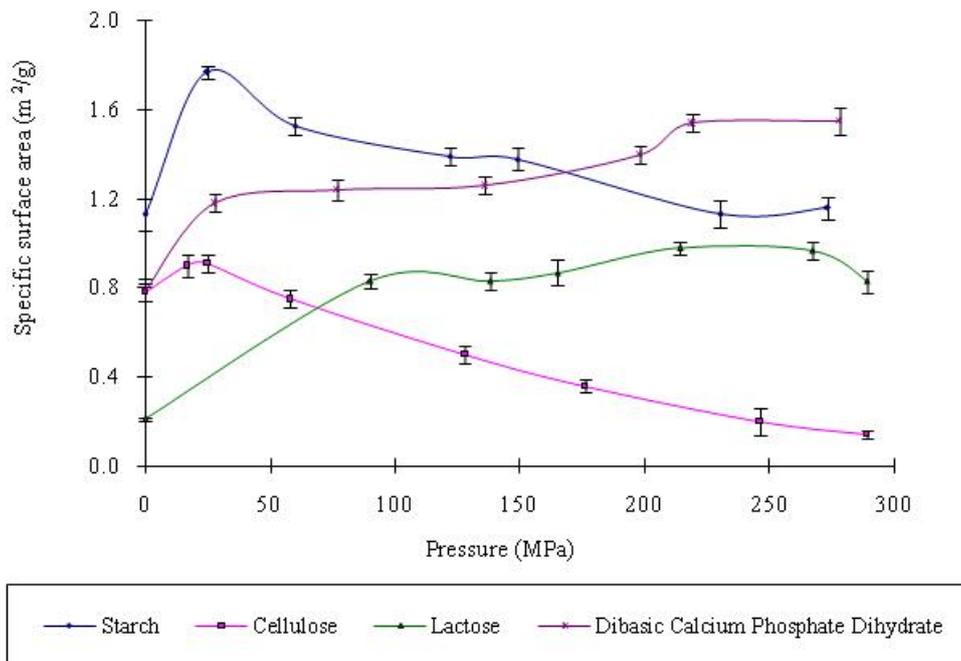


Figure 1.5: Comparative plots of specific surface area (m<sup>2</sup>/g) versus pressure (MPa) for tablets compressed from four excipients, using 0.5% magnesium stearate

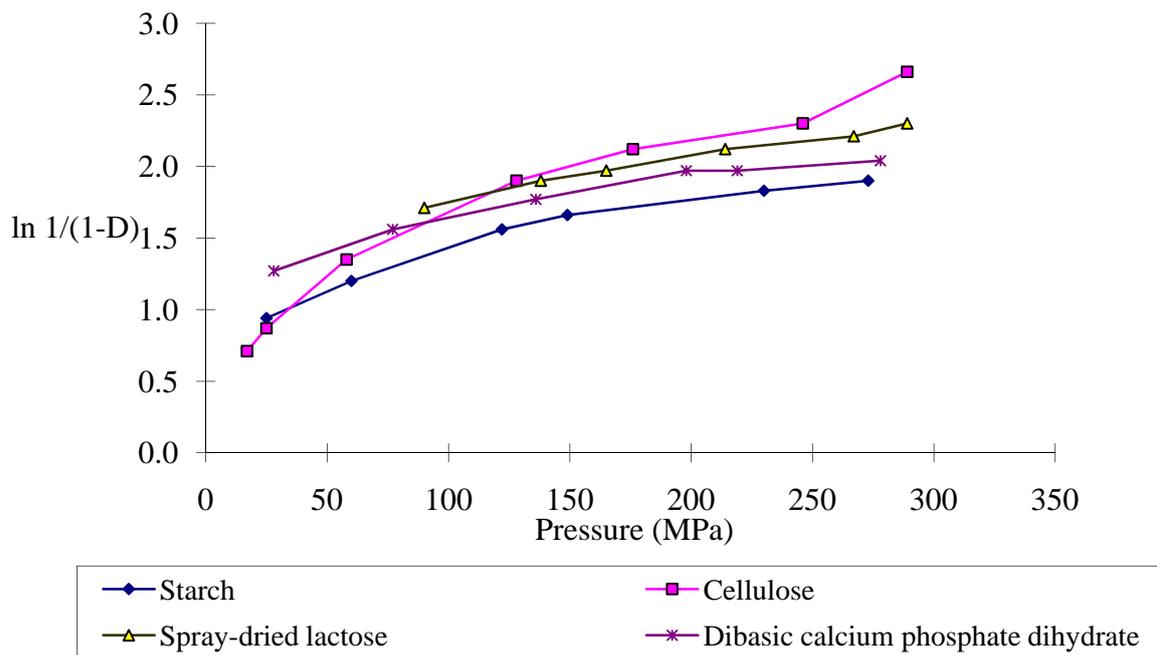


Figure 1.6: Comparative Heckel plots for tablets compressed from four excipients, using 0.5% magnesium stearate. No lubricant is used with cellulose

Figure (1.5) shows comparative plots between all the previously studied directly compressible excipients.

Tables (1.3 and 1.4) show that the yield pressure values in Heckel plot of starch in both concentrations of lubricant, are equal to 286 MPa and 185 MPa for 0.5% and 1.0% magnesium stearate respectively. An increase in the lubricant concentration has a profound effect on the yield pressure value of rice starch. Mitrevej et al.<sup>39</sup> showed, using Heckel analysis, that spray dried rice starch (SDRS) undergoes plastic deformation with low elasticity and that it has a very low fragmentation tendency.

The Heckel plot shows that cellulose has a yield pressure equals to 192 MPa (Table 1.3). The Heckel data for cellulose exhibits a small initial curved section indicating a little particle slippage, rearrangement, packing and fragmenting of individual particles (figure 1.6). Mitrevej et al.<sup>39</sup> studied Avicel PH102 using Heckel analysis and they showed that Avicel PH102 exhibits some fragmentation before undergoing plastic deformation.

Heckel plot for sprsy-dried lactose shows that the yield pressure values are high in both concentrations of lubricant, 313 MPa and 323 MPa for 0.5% and 1.0% magnesium stearate respectively (Tables 1.3 and 1.4) indicating that spray-dried lactose fragments and that the lubricant has almost no effect on its volume reduction.

With dibasic calcium phosphate dihydrate, Heckel plot shows that the yield pressure values of dibasic calcium phosphate dihydrate were high enough; 323 MPa for both 0.5% and 1.0% magnesium stearate (Tables 1.3

and 1.4), to indicate that dibasic calcium phosphate dihydrate fragments.

#### 4. CONCLUSION

The manner in which specific surface area changes with compression pressure varies dramatically between different materials. Tableting different excipients used in this study was done with the help of magnasiun stearate as a lubricant. Only Cellulose could be tabletted without a lubricant, while others could not be tabletted without the lubricant at even low compressional pressures.

With Dibasic calcium phosphate<sup>®</sup>, the specific surface area increased constantly over the whole pressure range, as Dibasic calcium phosphate is an extensively fragmenting powder. For directly compressible Spray-Dried Lactose, specific surface area increased up to 70 MPa due to the amorphous lactose monohydrate sited on the surface of the lactose monohydrate, then the plastic deformation behaviour starts to dominate. Both starch and Cellulose showed an increase in the specific surface area at low pressure. This is attributed to attrition between particles during rearrangement and packing. This increase is followed by a progressive reduction in specific surface area as the plastic deformation of the particles dominates under compression and consolidation.

Heckel plots (figure 1.6) and data shown in tables (1.3 and 1.4) show that the four excipients could be ranked, according to their yield pressure value, on the ductile-brittle scale (increase in brittleness) as follows: cellulose < starch < spray-dried lactose < dibasic calcium phosphate dehydrATE.

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## تأثير المشحم (مغنيسيوم ستيريت) على تغيرات المساحة السطحية الخاصة بالمساحيق القابلة للكبس أثناء عملية الكبس

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### ملخص

في أثناء الضغط، تنكسر المساحيق إلى شظايا أو تتحول إلى شكل آخر أو كلاهما. العديد من الدراسات أجريت على التغيرات التي تحصل على المساحة السطحية للمساحيق. في هذه الدراسة، تم البحث في تأثير مواد التشحيم على المساحة السطحية للمساحيق خلال عملية التقوية أو التدعيم للمساحيق في محاولة منا لتوضيح سلوك بعض المساحيق أثناء عملية الكبس. تمت دراسة التغيرات للمساحة السطحية لأربعة مساحيق مختلفة باستخدام طريقة الإدمصاص الغازي. ستيريت المغنيسيوم استخدمت كمادة التشحيم في هذه الدراسة.

المساحة السطحية للمساحيق التي تتحول بلاستيكا (السيليلوز والنشا) تأثرت بشكل واضح باستخدام مادة التشحيم. أما المساحة السطحية للاكتوز المنشف بالرداذ فقد تأثرت بشكل أقل عند إضافة مادة التشحيم.

أما عن المساحة السطحية للمادة التي تنكسر إلى شظايا خلال عملية التدعيم والكبس، فأشارت النتائج إلى أن هذه المادة لم تتأثر بإضافة مادة التشحيم.

**الكلمات الدالة:** المساحة السطحية، مواد التشحيم مغنيسيوم ستيريت، التدعيم، المواد المضافة (المسوغات)، الإدمصاص الغازي.