PLASTO-ELASTIC BEHAVIOUR OF GLADIOLUS STARCH DERIVED PYRODEXTRIN (GSDD)-PVP COGRANULATES DURING COMPACTION

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ABSTRACT

The compaction behaviour of gladiolus starch derived pyrodextrins (GSDD) and their cogranulates with polyvinyl pyrrolidone (PVP) was studied. Purified starch was extracted from the corms of **Gladiolus actinomorphanthus** plant and later dextrinized at two conditions to produce two batches of pyrodextrins. The plastoelasticity of the pyrodextrins and their cogranulates with PVP was determined using standard procedures. Result of the study indicated that these pyrodextrins alone had high elastic recoveries, which were reduced on cogranulation with PVP. All the cogranulates showed predominant plastic behaviour.

Key words: Gladiolus starch; pyrodextrins, Avicel; cogranulates; plastoelasticity.

INTRODUCTION

As a powder or granule is compressed in a die, various stages of the process leading to compaction can be separated into four- rearrangement, deformation, compaction and relaxation [1,2]. In rearrangement, particles move within the die cavity to occupy void spaces that exist between particles. When particles can no longer rearrange themselves, the materials will start to deform elastically. On exceeding the elastic limit, the material deforms either elastically or destructively [3]. Either mechanism can occur and is dependent upon the material characteristics, compaction speed and particle size. Plastic deformation will aid bonding because it increases the contact area between particles and fragmentation produces newer surfaces, which also favour strong bonding [3]. In this study, the compaction behaviour of GSDD and its cogranulate with PVP a very common pharmaceutical excipient used as binder in tablets was explored. Gladiolus starch is obtained from the corms of the plant Gladiolus actinomorphanthus (Fam. Iridaceae). GSDD is a heat coversion product of gladiolus starch. Its physicochemical properties and use in paracetamol tablets have been evaluated [4,5]. Gladiolus actinomorphanthus starch has been shown to perform well in paracetamol tablets in the concentration range of 2-10%w/w both as binder and as intragranular disintegrant [4]. There was thus the need to ascertain the consolidation behaviour and the possible mechanism of tablet formation when this novel starch is used as an excipient. This research would create awareness with regards to this starch since the result could be extrapolated to other poorly compressible pharmaceutical powders.

MATERIALS AND METHODS

Materials

PVP (BASF Wyandotte Corp.) Avicel PH 101 (FMC), dimethyl sulphoxide, DMSO (Merck and dextrin (Matheson Coleman & Bell) were used as procured from their local suppliers without further purification. Gladiolus starch and the pyrodextrins used in this study were obtained from a batch processed and characterized in our laboratory. The properties of the pyrodextrins (GSDD1 and GSDD2) have earlier been published in this journal [5]. All other reagents and solvents were of analar grade and were used as such.

Methods

Preparation of cogranulates

Cogranulates of admixtures of GSDD and PVP were prepared by solvent granulation[6] in the following ratios: 0:1, 1:1, 2:1, 1:2 and 1:0. In each case, the calculated quantities of the two powders were weighed accurately on a weighing balance (Sauter, KGD 7470 Germany), mixed thoroughly in a mortar and wetted with water. The wet mass was dried at 40 °C for 1 h and then screened through a mesh of 1 mm and later dried at 60 °C for 1h and screened through 0.8 mm mesh.

Determination of plastic compression

A 500 mg quantity of the samples of each of the pyrodextrins or their cogranulates with PVP was tabletted in single punch tabletting machine (Manesty F3) fitted with 12.5 mm flat faced upper and lower punch adaptors at 50 units of force. The load was applied gradually to the granule mass so that maximum load was achieved after 30 sec. The load was maintained for 30 sec, released over 30 sec and the tablet ejected over 30 sec so that the whole cycle occupied 2 min. The plastic compression (PC) was calculated from the equation below [7,8]. The process was repeated five times for each ratio of GSDD and PVP, and Avicel PH 101.

$$PC(\%) = \frac{H_o - H_f}{H_f} X\ 100 \quad \ldots\ldots\ldots\ (1)$$

Where H_o and H_f are the thickness of the tablet after 30 sec when first formed and after the loading period respectively.

Determination of elastic compression

The elastic compression (EC) of the pyrodextrins or cogranulates was determined using equation 2 [10].

$$EC(\%) = \frac{H_e - H_o}{H_e} X\ 100 \quad \ldots\ldots\ldots\ (2)$$

where H_e is the thickness of the tablet after ejection from the die.

Plastoelasticity determination

The plastoelasticity of the pyrodextrins and their cogranulates were calculated from the relationship:

$$Plastoelasticity = \frac{EC}{PC} \quad \ldots\ldots\ldots\ (3)$$

RESULTS AND DISCUSSION

The result of the plastoelasticity studies

is presented in Table 1. The result indicated that the pyrodextrins and their cogranulates with PVP had varied plastic compression and elastic recovery values, hence, the ratio of elastic compression (EC) to plastic compression (PC) referred to as plastoelasticity (EC/PC) varied. It is known that powders or granules with very high elastic recoveries compared to plastic compression form tablets that have overall low hardness and tensile strengths [9]. This is true because when a powder is compressed in a die, interparticle bonds are formed resulting in a compact but on releasing the load from the compact, elastic forces come into play. When the elastic forces become greater than the interparticle bonds, the tablet integrity fails. The tablettability of a powder depends therefore, on its ability to form strong interparticle bond and to resist elastic forces operative after the removal of the applied load. The plastoelasticity values of GSDD1 (4.26 ±0.72) and GSDD2 (4.00 ± 0.87) alone compare well with the value for Avicel (4.13±1.11). High EC/PC value indicates that the material is predominantly elastic while low value indicates that plastic deformation plays a major role in tablet compact formation. Avicel PH 101 is a material known to deform plastically [10]. However, it has been shown that Avicel PH 101 when compacted at a maximum pressure of 5 Mpa, exhibit a high degree of elastic recovery [11]. Some of the test materials in this study had high elastic recoveries with overall low plastoelasticity values (Table 1). It is thoughtful therefore, to believe that GSDD1 and GSDD2 may deform by the same mechanism as Avicel PH 101, since their EC/PC values were about the same (Table 1). Cogranulates of GSDD1 with PVP in the ratio of 1:1,and 1:1 and 2:1 combinations of PVP and GSDD2 had high elastic recoveries and relatively low plastic compression values. However, their EC/PC values were lower than that of the standard, Avicel PH 101. It has been shown that pharmaceutical powders and their mixtures with EC/PC values less than 10 could be formed into satisfactory tablets [8,12]. Addition of PVP to GSDD reduced both PC and EC, with 1:2 ratio of PVP and GSDD2 producing the lowest reduction. This may have formed interpolymer complex with greater plastic tendency than others. The implication of this reduction is that pharmaceutical powders of low compressibility could be compressed with these cogranulates. The optimum combination was 1:2 ratio of PVP and GSDD2 which had EC/PC value of 0.23 ± 0.02. This shows that the combination is predominantly plastic and very weak elastic recovery force was present. Such combination would produce tablets of high tensile strengths.

CONCLUSION

Admixtures of GSDD1 (or GSDD2) and PVP produced cogranulates with reduced elastic recovery tendencies and could be good candidates for tabletting pharmaceutical powders of low compressibility. Their plastoelasticity values approximate that of Avicel PH 101 used as standard in this study.

Table 1: Plastoelasticity studies result

Batch	Ratio	PC (% ±SD)	EC (% ± SD)	EC/PC ± SD
PVP: GSDD1	0:1	7.17±1.22	30.56± 3.45	4.26 ±0.72
PVP: GSDD1	1:0	5.26±0.87	6.98±1.21	1.33±0.08
PVP: GSDD1	1:1	8.11±1.32	14.29±1.98	1.76±0.07
PVP: GSDD1	2:1	2.86±0.34	9.09±1.25	3.18±0.91
PVP: GSDD1	1:2	2.63±0.56	5.41±1.11	2.06±0.69
Avicel PH 101	-	9.08±1.12	37.48±3.79	4.13±1.11
PVP:GSDD2	0:1	8.33±1.21	33.33±3.67	4.00± 0.87
PVP:GSDD2	1:0	5.26±1.11	6.98±1.27	1.33±0.08
PVP:GSDD2	1:1	6.25±0.98	17.24± 2.31	2.76 ±0.99
PVP:GSDD2	2:1	9.83±1.34	16.67 ±2.17	1.78±0.10
PVP:GSDD2	1:2	5.88±0.89	1.37±0.21	0.23±0.02

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