TECHNICAL INFORMATION

Measuring the Disintegration Force Development of Tablets Containing Different Disintegrants

Introduction

The aim of this study was to investigate the disintegration behavior of croscarmellose sodium (CCS), sodium starch glycolate (SSG) and crospovidone (PVPP).
The tablets were tested for their disintegration time as well as the development of the disintegration force under confined and unconfined conditions.

Materials and Methods

Materials

A blend of **EMCOMPRESS®** dibasic calcium phosphate dihydrate (DCP) and **VIVAPUR® 101** microcrystalline cellulose (MCC) was used as an insoluble filler-binder. **LUBRITAB®** hydrogenated vegetable oil (HVO) served as a hydrophobic model API and **PRUV®** sodium stearyl fumarate (SSF) as a lubricant. The disintegrants used were: **VIVASOL®** croscarmellose sodium (CCS), **VIVAPHARM® PVPP XL** crospovidone (PVPP), or **EXPLOTAB®** sodium starch glycolate (SSG), respectively (all JRS PHARMA GmbH & Co KG, Germany).

Methods

Blending and Compaction

Three tablet formulations using different disintegrants namely CCS, SSG or PVPP were compacted on a rotary tablet press (PRESSIMA 13EU-D 2006, IMA Kilian). The formulations contained 68 % DCP, 10 % HVO, 17 % MCC, 4 % disintegrant and 1 % SSF. All ingredients, except for SSF, were mixed for 15 minutes in a free fall mixer (Brunimat Type Porta, Brunitec Suisse). Then, SSF was added and mixing continued for 3 min. The tablet press was equipped with 13 mm flat faced round punches and operated at 10 rpm. Tablets of 500 mg were pressed with a compaction force of 188 MPa.

Tablet Characterization

The tensile strength of the tablets was determined with a hardness tester (TBH 425 TD, ERWEKA). Disintegration time was measured with a disintegration tester (DT2, SOTAX) in water as well as in 0.1 M hydrochloric acid.

Disintegration Force

To measure the force developed by the tablets upon contact with water or hydrochloric acid, a Texture Analyser (TA.XTplus100, WINOPAL) was used (see Picture 1).
The tablets were placed between two sintered glass filter disks (Filter discs D20 Por 1, DURAN) (see Picture 2) in a vessel beneath the measuring punch of the Texture Analyser. The punch was lowered onto the upper glass filter disk until a force of 0.01 N was reached. Then, water or 0.1 M hydrochloric acid was added. The punch was kept in the same position during the measurement and the force exerted by the tablet was recorded.

The measurement was carried out on unconfined tablets as well as on tablets confined by a metal ring (see Picture 3), in order to detect the total axial force developed by the tablets. All measurements were repeated five times in water and in hydrochloric acid.

Pic 1 Texture Analyser TA.XTplus100

Pic 2 Tablet Between Two Sintered Glass Filter Disks

Pic 3 Tablet Confined by a Metal Ring

Results

Results and Discussion

The tensile strength of all three formulations is comparable and sufficient for further testing. All tablets disintegrated within 30 seconds both in water and in hydrochloric acid (Table 1).

Disintegrant	Tensile Strength [MPa]	Disintegration Time in Water [s]	Disintegration Time in 0.1M HCl [s]
CCS	0.71 ± 0.02	26 ± 4	19 ± 1
SSG	0.71 ± 0.02	28 ± 5	27 ± 2
PVPP	0.73 ± 0.01	20 ± 2	24 ± 8

Tab. 1 Tensile Strength and Disintegration Time of Tablets Tested in Water and 0.1 M Hydrochloric Acid

Figure 1 displays the disintegration force of unconfined tablets measured in water. Because tablets containing CCS and SSG disintegrated completely, the disintegration force reached a maximum and then dropped to zero, as the tablets fell apart (see Picture 4).

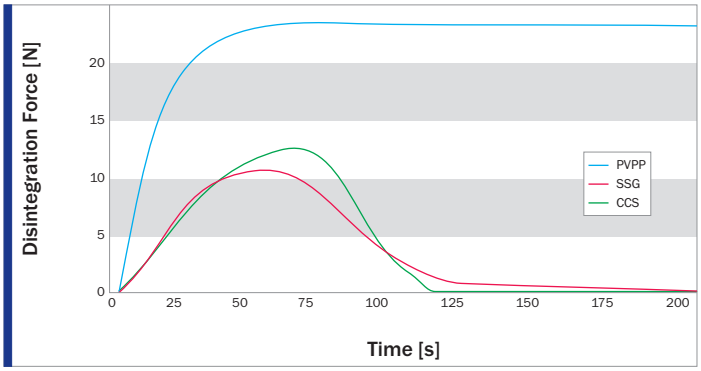
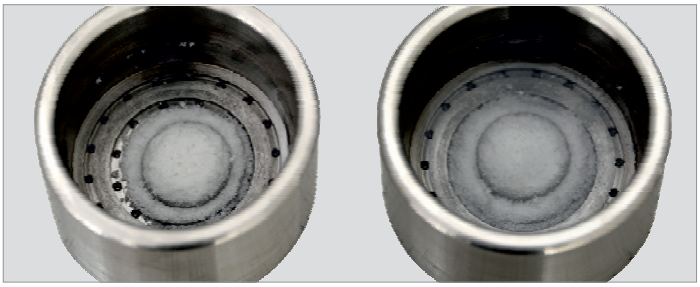
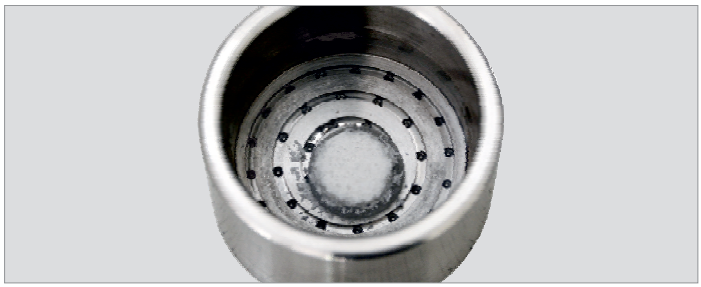


Fig. 1 Disintegration Force of Unconfined Tablets in Water



Pic 4 Tablets Containing CCS (left) and SSG (right) after Measurement in Water and Removing of the Upper Glass Filter Disk

The disintegration force of tablets containing PVPP was much higher and did not return to zero, because these tablets did not show any radial expansion or disintegration (see Picture 5) under the conditions of this test. This can be attributed to the shape recovery disintegration mechanism of PVPP, where the tablet expands against the direction of the applied compression force [1].



Pic 5 Tablet Containing PVPP after Measurement in Water and Removing of the Upper Glass Filter Disk

In hydrochloric acid, the disintegration force of the unconfined tablets containing CCS and SSG reached a plateau (Figure 2). This indicates that the tablets did not fall apart as in water. Due to the incomplete disintegration under the test conditions, the remaining matrix continued to exert a force onto the measuring punch. This result is consistent with the findings of other investigators who found that acidic media significantly reduces the liquid uptake rate and capacity of SSG and CCS [2,3]. The carboxylic groups of SSG and CCS can be protonated in acidic media, which leads to a loss of ionic charge in the molecule.

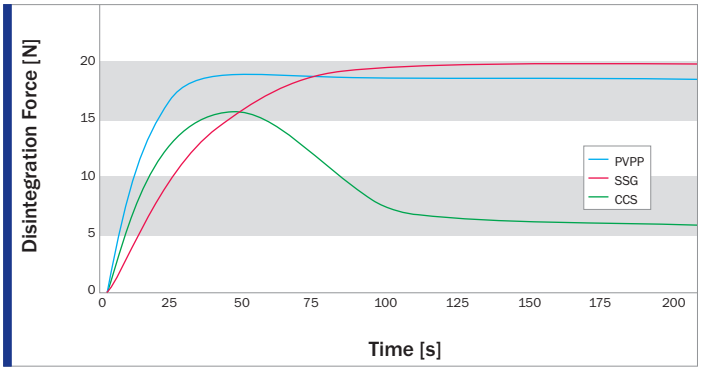


Fig. 2 Disintegration Force of Unconfined Tablets in 0.1 M Hydrochloric Acid

In the present study, the effect was more pronounced for SSG than for CCS. After a maximum the curve of CCS decreased again, which indicates that some parts of the tablets fall apart. It seems that CCS (wicking) is not as affected by acidic conditions as SSG (swelling). Also, the disintegration force of CCS in 0.1 M hydrochloric acid developed faster than for SSG. A possible explanation is, that wicking is mainly driven by capillary forces, whereas swelling depends on hydration of the polymer, which is affected by the loss of negative charge. As in water, PVPP showed shape recovery: The tablet expanded against the compression force without falling apart. The plateau was reached faster than in water but the force exerted to the punch was lower.

For the measurement of the total disintegration force, the tablets were inserted into metal rings to eliminate the effect of radial expansion and disintegration.
Figure 3 shows that tablets containing CCS have the highest total disintegration force and tablets containing PVPP have the lowest total disintegration force in both media. All disintegrants show a lower disintegration force in 0.1 M hydrochloric acid. Further investigations are necessary to find out why there is also a decrease of the total disintegration force for tablets containing the non-ionic disintegrant PVPP.

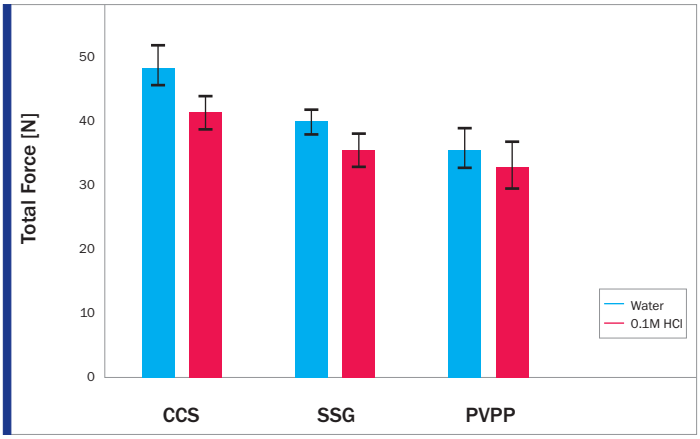


Fig. 3 Total Disintegration Force of Confined Tablets in Water and 0.1 M Hydrochloric Acid.

Conclusion

In this study, all tablet formulations tested exhibited rapid disintegration in a conventional disintegration tester. However, fundamental differences in their disintegration behavior were revealed, when measuring the time course of their disintegration force development using a Texture Analyser. Confining the radial expansion of the tablets by means of a metal ring allowed measurement of the total disintegration force. The HVO total disintegration force in water and 0.1 M hydrochloric acid was highest for tablets containing CCS and lowest for tablets containing PVPP. Hydrochloric acid was found to have a major impact on the disintegration behavior of SSG and –to some extent– CCS. PVPP was practically unaffected by the pH of the test medium.

References

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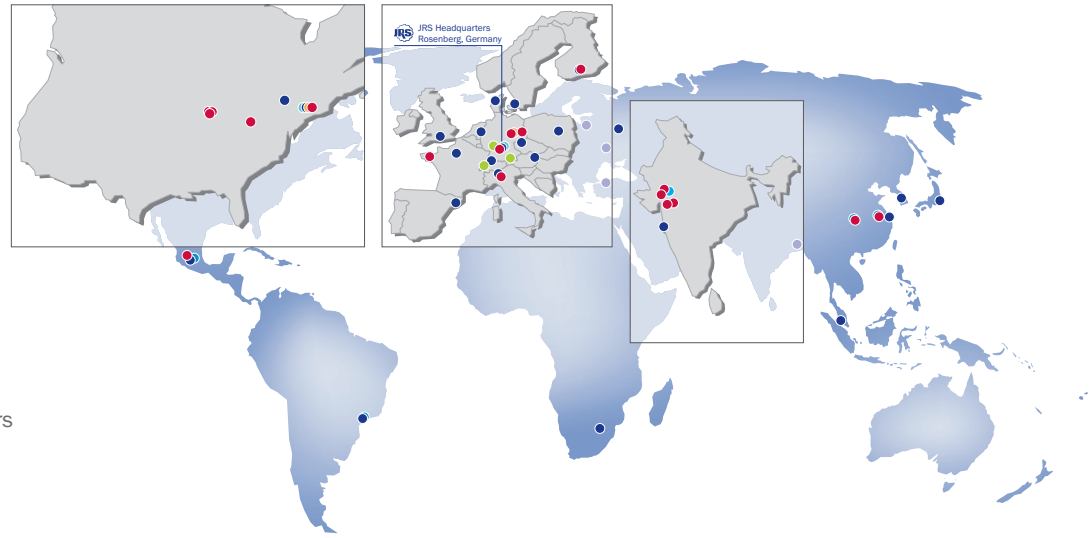

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