BREAKING STRENGTH OF SUPPOSITORIES WITH SPECIAL RESPECT TO BRANDS ON SEMISYNTHETIC BASE

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Abstract

For solving fracture problems a suitable survey of the mechanical strength is needed. Two new measuring devices have been developed to determine the static and impact bending strength, resp. The two new methods and the known Erweka method provide information on three different strength types. Some representative data are given illustrating the strength of suppository bases, of their mixtures and the non-parallelism between the three types of strength.

Introduction

The basic materials of the suppositories have to meet numerous requirements with respect to their manufacturing, storage and their pharmaceutical efficaciousness. These requirements concern physical, chemical and biochemical properties.

Considering only physical properties we have to deal with melting and solidification points, solidification velocity, the number of crystal modifications, viscosity, the contraction accompanying solidification, adhesion to the casting mould, breaking strength, liquid incorporation capacity, etc.

A single substance can obviously not meet so many requirements. For a long time, cocoa butter had been dominantly used as suppository base due to its overall good properties. Around 1950 [1], a new family of substances was found, called Imhausen mass then manufactured under the trade name of Witepsol. These substances contain fatty acid triglycerides and varying amounts of di- and monoglycerides.

The Witepsols showed several advantages compared to cocoa butter: they solidify and separate from the mould more easily, have only one modification, emulsify and incorporate liquids better. On the other hand, the introduction of a new technology may give rise to problems, e.g. with breaking strength. To solve strength problems one needs first a suitable strength testing method.

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The subject of the present paper is the investigation of the mechanical strength of suppositories.

For the evaluation of suppository strength only Erweka method has found wide-spread application [2]. In the Erweka device the suppository is placed in vertical position between two horizontal jaws, then it is loaded by weights of 200 g till it crushes. In this way the axial compressive strength (C) can be characterized (Fig. 1).

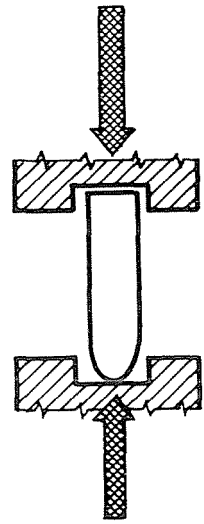

Fig. 1. Breaking force in the Erweka method (compressive loading in axial direction)

Fracture of suppositories on falling is, however, due to forces that are pulse-like and act in non-axial direction, hence the Erweka method is obviously not suitable to characterize this type of strength.

Test of static and impact bending strength

Two methods have been developed for testing static and impact strength, respectively. In both of them, suppositories are loaded perpendicularly to their axis.

In the static test the sample is loaded by gradually increasing weights (Fig. 2) quite similarly to the Erweka method. Static bending strength can be calculated from the dimensions of the sample, the moment arm and the final force causing break but, in case of standard conditions, strength may be characterized by the final load itself.

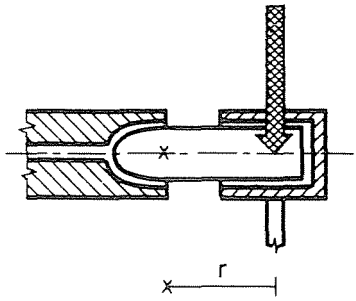

Fig. 2. Breaking by static bending
x: rotational axis
r: arm of the moment

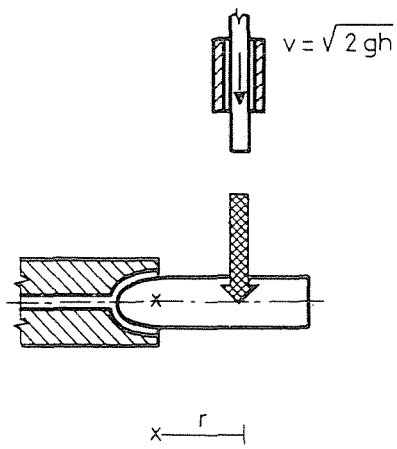

Fig. 3. Breaking by impact bending
v: final velocity of the falling body (see text)

Impact bending strength (*IB*) is tested in the following way: the suppository is held at one end and a variable mass is dropped on the other end (Fig. 3).

The $\vec{L}$ moment of the impact on the sample is determined by the m mass of the falling body, the vectors $\vec{v}$ of its final velocity and $\vec{r}$ of the arm of the moment:

$$\vec{L}\mathrm{m} = m \cdot \vec{r} x \vec{v}. \tag{1}$$

Counting with free fall the final velocity will be proportional to the square root of the fall height h:

$$v = \sqrt{2gh}. \tag{2}$$

where g is the gravitational acceleration. If v and r are perpendicular to each other the moment is given by

$$\vec{L} = m \cdot r \sqrt{2gh}. \tag{3}$$

Keeping r and h constant the impact strength is proportional to the mass and, consequently, the mass can be used as a measure of the strength IB.

As Eq. 3 shows the contribution of the error in the fall height h to the overall error of the moment is less than that of the error in the arm length r. In fact, unfortunately, it is just h that can be determined more accurately. If $h = 30$ mm, its uncertainty is about 1.5%.

The uncertainty of the arm length, on the other hand, may reach 1 mm which means 10% if $r = 10$ mm. This uncertainty in the arm length can hardly be diminished for several reasons:

1) The fastening of the sample demands a length of at least 15 mm.

2) It is not advisable to hit the sample near to its other end for its strength here is in most cases less than in the middle zone. This difference can be explained by the solidification process. In the mould it is this final zone that solidifies at last being in contact with the air and not with the cooled mould.

In order to obtain a right estimation of the mechanical behaviour of the main mass of the sample we have to blow at a point at least as far as 12 mm from the end. So, for 38 mm long samples we have only a length of

$$38 - (15 + 12) = 11 \text{ mm}$$

to make use of as arm of the moment. Sometimes it may be worth collecting data on the reduced mechanical strength of the sample end, as well.

3) The impact point of the falling body can be reproduced within 0.5 mm. If the guide rails are too close, friction brakes the fall in an uncontrolled way, so the velocity will be uncertain.

4) The length of the arm is in fact influenced by superficial irregularities of the casting. On this account the suppository does not fit well the holder and so breaks not exactly at the end of the holder but a little farther in. This may cause an additional uncertainty of 0.5 mm.

An error of 1 mm on the whole, that makes about 10% of the above mentioned effective arm length of 11 mm, is quite reasonable. Deviations between individual samples are frequently higher, so a precision of 10% is sufficient to establish the effect of parameters or to qualify samples as good, satisfactory or bad.

Samples are thermostated in both devices.

Comparison of the three types of strength

As it was to be expected, compressive (*C*), static bending (*SB*) and impact bending (*IB*) strengths have not proved to be parallel properties.

In Table 1 the three strengths are summarized for seven samples. Strengths are expressed in arbitrary units. Comparing the data of the pairs W 25 – W 45, H 15 – E 85 or W 45 – M. Estarinum, it can be seen that the three different kinds of strength are not parallel properties, i.e. they do not show necessarily the same dependence on the composition of the sample.

Table 1

Compressive (C), static bending (SB) and impact bending (IB) strengths of suppository bases in arbitrary units
C at 25.0 °C
SB and IB at 23.0 °C

Sample	IB	SB	C
W 25	45±5	550±50	>6.4
W 45	45±5	450±50	5.0±0.2
H 15	40±10	300±50	5.0±0.2
E 85	40±10	370±70	>6.4
W 35	30±10	500±50	5.0±0.4
Massa Est.	20±10	300±70	4.0±0.4
cocoa butter	30±5	170±50	2.5±0.3

It is also apparent, that deviations between samples produced of the same substance and by the same method are strikingly high in certain cases. The deviations of strength indicated in Table 1 are mostly higher than the uncertainty of the method itself.

The fragility of the suppository does not depend only on the strength of the basic material. A suppository contains the drug and usually several additives as well, thus the strength of the product does depend on the quality and quantity of each of the components, it may depend on the manufacturing technology and obviously depends on the temperature.

The effect of the composition is illustrated in Table 2. It can be established that the strength of a mixture is not additive. The impact strength of a mixture may be much lower than that of the components (see e.g. the suppository produced of 70% W 35 + 30% E 85). On the contrary, the same mixture shows a higher static bending strength than the components. All these reveal once more the non-parallelism of the three types of strength.

The temperature dependence of the three types of strength is demonstrated in Figures 4–6 for some bases. At temperatures below 25 °C the compressive

Table 2

Strengths of mixtures of suppository bases
Notations as in Table 1
Middle numbers of triplets refer to mixtures, upper and lower numbers to the components

Sample	IB	SB	C
90% W 35	50	500	>5.0
	45	550	>6.4
10% E 85	50	350	>6.4
70% W 35	50	500	>5.0
	<25	670	>6.4
30% E 85	50	350	>6.4
80% W 25	45	500	>6.4
	30	450	5.0
20% H 15	50	300	4.0
50% W 25	45	500	>6.4
	<25	350	5.0
50% H 15	50	300	4.0
90% W 35	50	500	>5.0
	50	590	–
10% H 15	50	300	4.0

strength of Witepsol bases is in general too high to be measured by the Erweka apparatus. The components of the base melt gradually as the temperature rises, approaching the state of a complete melt, i.e. zero strength, asymptotically. Thus the compressive strength is usually investigated in the temperature interval of 25 – 31 °C.

In Figure 4 two sets of values of this strength are plotted; the data given by the manufacturer [3] and those measured in our laboratory. The considerable difference between the two sets of data can be probably explained by differences in manufacturing.

Figure 5 shows the static bending strength of three Witepsol mixtures. The temperature interval extends from 15 to 26 °C in this case, corresponding to our actual interest.

The temperature dependence of the impact strength is represented for two Witepsol mixtures in Fig. 6. The high relative deviation of this type of strength is apparent. This behaviour may be of importance in the investigation of the random fragility of suppositories.

Summarising the strength features hitherto observed it may be concluded that

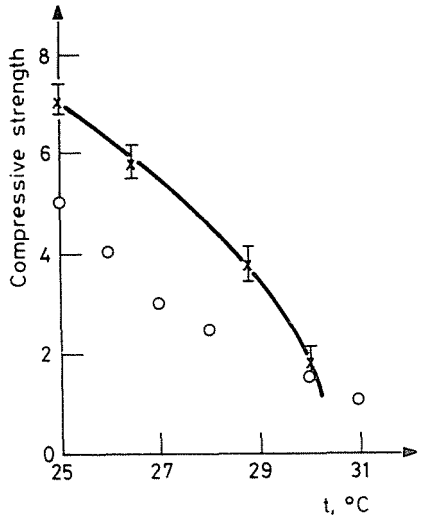

Fig. 4. Compressive strength of Witepsol W 25 vs. temperature; Erweka method
○: manufacturer's data
x: results of the present paper with their deviations

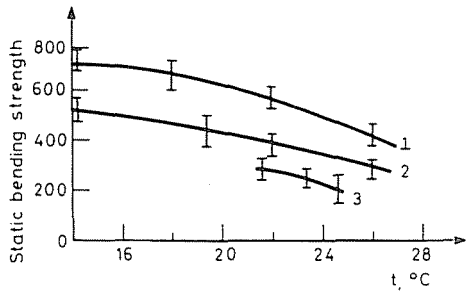

Fig. 5. Static bending strength of Witepsol base mixtures in arbitrary units vs. temperature
I: deviation range

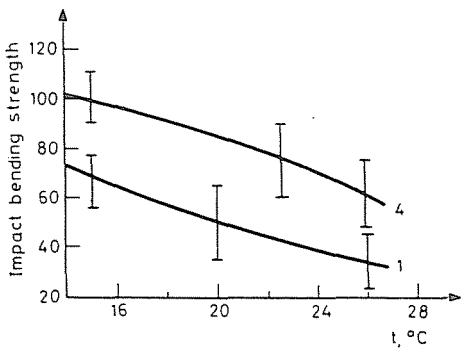

Fig. 6. Impact bending strength of Witepsol base mixtures in arbitrary units vs. temperature

1) The three types of strength are not necessarily parallel.
2) The strength of a mixture is in general not additive.
3) Deviations between individual suppositories of the same cast are the highest for impact strength and the lowest for compressive (Erweka) strength.

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