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Tensile anisotropy of some pigmented tablet film coating systems

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The tensile properties of representative tablet film coating systems, containing hydroxypropyl methylcellulose alone and in combination with either polyvinyl alcohol, polyethylene glycol 400 and polyethylene glycol 1000 and pigmented with either talc or titanium dioxide, have been investigated. Tensile anisotropy was observed between film samples cut parallel to, and perpendicular to, the direction of rotation of the casting substrate and factors accounting for this phenomenon are presented.

It was reported previously (Okhamafe & York 1983) that films consisting of hydroxypropyl methylcellulose and a second polymer additive (cast using the rotating cylinder technique) exhibited some degree of anisotropy with respect to elongation properties, although the tensile strength and Young's modulus data did not show this phenomenon. The main consequence of tensile anisotropy is that the mechanical properties of a film would vary according to the direction of the applied stress. In the present study, this feature is considered for polymer systems pigmented with either talc or titanium dioxide.

Method

The polymer systems examined were hydroxypropyl methylcellulose (Pharmacoat 606, Shin-Etsu Chem. Co., Japan) alone, and in combination with 20% w/w of either polyvinyl alcohol (Poval PA-5, Shin-Etsu Chem. Co.), polyethylene glycol 400 or polyethylene glycol 1000 (BDH Chem. Ltd). The film formulations were prepared from 10% w/v aqueous solutions of the individual polymers. The main features of the pigment used—designated as talc A (coarse), talc B (fine), TiO_2A (anatase, untreated) and TiO_2B (rutile, organically treated)—as well as the methods employed to disperse the pigments in the film formulations, have been described in a recent paper (Okhamafe & York 1984). Free films were cast by the rotating cylinder technique and their tensile properties—tensile strength, Young's modulus, elongation—determined as previously detailed (Okhamafe & York 1983). For each film type, six samples were cut parallel to, and perpendicular to the direction of rotation of the casting substrate. Mean values of sets of data and associated standard deviations were calculated.

Results and discussion

As found previously for similar unfilled polymer systems (Okhamafe & York 1983), there was no significant difference (*t*-test at the 95% confidence level) between the tensile strength or Young's modulus of parallel and perpendicular samples for the pigmented films and these data are therefore not listed. However, the results for the mixed polymer systems in Tables 1 and 2 indicate that there was significant difference (95% confidence level) between the elongations of parallel and perpendicular samples at low pigment contents. The gap between these sets of values narrowed with increasing filler concentration.

Two major factors may account for the declining elongation anisotropy of the films with increase in pigment concentration. First, it seems possible that during the drying process the pigments or fillers hindered a uni-directional orientation of the polyvinyl alcohol, and polyethylene glycols 400 and 1000 which consequently became more randomly arranged, thus leading to a decrease in elongation anisotropy. This could have been achieved either as a result of the physical presence of the pigments or pigment-polymer interaction. Second, even if it is assumed that the alignment of the polymer additives in the films is not influenced by the presence of the pigments, the effect of molecular orientation of the polymer additives on film elongation is likely to decrease with increase in pigment levels. This is because the stress associated with the pigment particles as well as the effect of any pigment-polymer interaction would make the films more brittle. The direction of applied stress would therefore be increasingly less important as pigment concentration rises because the pigment particles are presumably

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Table 1. Elongation of parallel and perpendicular samples of filled hydroxypropyl methylcellulose (HPMC) films and HPMC films containing 20 wt% of polyvinyl alcohol (PVA) at 20 °C, 60% r.h. (standard deviation in parenthesis).

Filler content (wt%)	Elongation (%) HPMC Parallel	Perpendicular	HPMC/PVA Parallel	Perpendicular
Unfilled				
0	14·4 (1·3)	14·9 (1·0)	11·9 (1·74)	19·0 (2·4)
Talc A				
10	5·6 (0·6)	7·3 (0·5)	8·4 (1·0)	10·1 (1·2)
20	4·3 (0·3)	7·9 (0·9)	5·4 (0·3)	6·4 (0·7)
30	3·9 (0·6)	5·7 (0·2)	4·3 (0·7)	6·7 (0·6)
40	4·0 (0·5)	4·6 (0·6)	4·2 (0·3)	4·7 (0·6)
50	3·1 (0·3)	4·0 (0·5)	3·7 (0·3)	4·5 (0·7)
Talc B				
10	5·9 (0·6)	7·8 (0·9)	7·7 (0·6)	8·4 (0·6)
20	5·1 (0·7)	6·1 (0·8)	5·8 (0·7)	6·5 (0·5)
30	4·3 (0·5)	5·0 (0·3)	5·5 (0·4)	5·7 (0·3)
40	3·9 (0·5)	4·3 (0·7)	4·8 (0·4)	5·0 (0·9)
50	3·1 (0·6)	3·7 (0·8)	3·5 (0·2)	4·8 (0·5)
TiO_2A				
10	6·9 (0·5)	7·2 (1·0)	10·5 (0·6)	12·3 (0·9)
20	5·8 (0·8)	7·0 (1·1)	8·4 (0·7)	11·6 (0·6)
30	6·2 (0·7)	7·3 (0·6)	8·7 (0·9)	10·6 (0·4)
40	6·5 (1·0)	7·7 (0·5)	8·7 (0·7)	8·8 (0·8)
50	5·2 (0·6)	6·0 (1·0)	8·7 (1·1)	7·5 (0·9)
TiO_2B				
10	6·2 (0·2)	8·8 (0·3)	9·4 (0·9)	12·4 (1·3)
20	6·4 (0·5)	6·9 (0·7)	8·0 (1·3)	8·7 (0·9)
30	7·6 (0·7)	8·2 (1·2)	8·1 (1·1)	10·0 (1·1)
40	6·1 (0·5)	7·0 (0·5)	7·7 (1·1)	8·1 (1·0)
50	6·7 (0·9)	5·5 (0·5)	6·2 (0·4)	6·3 (0·8)

Table 2. Elongation of parallel and perpendicular samples of filled hydroxypropyl methylcellulose (HPMC) films containing 20 wt% of either polyethylene glycol (PEG) 400 or PEG 1000 at 20 °C, 60% r.h. (standard deviation in parenthesis).

Filler content (wt%)	Elongation (%) HPMC/PEG 400 Parallel	Perpendicular	HPMC/PEG 1000 Parallel	Perpendicular
Unfilled				
0	27·3 (2·9)	35·5 (2·8)	18·4 (2·1)	24·7 (2·2)
Talc A				
10	10·6 (1·5)	10·6 (0·8)	10·1 (1·2)	11·4 (1·5)
20	7·1 (1·1)	7·0 (1·1)	7·3 (0·8)	8·7 (1·1)
30	6·9 (0·7)	7·0 (0·8)	5·8 (0·3)	7·3 (0·7)
40	5·6 (0·6)	5·7 (0·4)	4·6 (0·9)	5·6 (0·8)
50	4·5 (0·2)	5·8 (1·1)	4·4 (0·6)	5·5 (0·9)
Talc B				
10	8·6 (0·5)	12·9 (1·2)	8·4 (0·6)	12·8 (1·4)
20	7·6 (0·8)	10·5 (1·3)	6·8 (0·7)	11·5 (1·8)
30	6·9 (0·8)	8·2 (0·9)	6·4 (0·3)	10·4 (1·0)
40	6·4 (0·9)	7·8 (1·2)	5·4 (0·7)	7·5 (1·9)
50	5·3 (0·6)	5·9 (0·7)	—	—
TiO_2A				
10	17·4 (2·0)	23·4 (3·7)	16·7 (1·8)	26·6 (1·8)
20	11·5 (1·4)	16·0 (1·3)	10·1 (1·0)	16·5 (2·9)
30	10·1 (0·4)	14·0 (1·5)	10·0 (0·7)	14·8 (2·1)
40	9·6 (0·7)	12·6 (1·3)	9·2 (1·4)	12·7 (1·5)
50	9·5 (1·0)	9·3 (1·3)	8·6 (0 6)	9·1 (0·8)
TiO_2B				
10	17·7 (1·8)	31·6 (3·1)	13·3 (1·0)	27·4 (3·2)
20	9·3 (0·6)	13·4 (0·6)	11·9 (1·2)	16·2 (2·0)
30	8·6 (1·0)	13·1 (1·1)	10·9 (0·9)	13·9 (1·1)
40	9·5 (0·7)	12·4 (1·8)	8·5 (0·8)	10·7 (1·0)
50	9·8 (1·1)	12·9 (1·3)	8·4 (1·2)	9·5 (1·3)

randomly orientated and crack propagation usually occurs in a direction perpendicular to the applied stress.

Elm (1953) has observed that acicular pigments in paint films prepared by brushing on a surface were aligned in the direction of the application of the brush. As a result, tensile strength, but not elongation, varied according to the direction of applied stress. Elm also noted that there was no pigment alignment in paint films cast by spraying. Thus the method of film preparation could influence the alignment of pigment particles in the polymer matrix, leading to tensile anisotropy. For the films examined in the present study, scanning electron microscopy did not show a specific orientation of either the plate-like talc or the spherical titanium dioxide. It is, therefore, unlikely that random orientation of the pigments had an anisotropic effect on the tensile properties of the films.

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