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STUDIES ON THE SWELLING OF COMPOSITE DISINTEGRANT - METHYLCELLULOSE FILMS

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ABSTRACT

Methylcellulose (MC) films swell rapidly on contact with water. Swelling rate decreases with increase in the viscosity of the MC. Disintegrants such as Polyplasdone (PVPP) and Ac-Di-Sol when present in the MC film buffer the swelling action of MC. The order of swelling for various viscosity MC in PVPP/MC composite films is similar to that of plain MC films but in the case of Ac-Di-Sol/MC composite films the swelling order is reversed. Swelling of MC films is related to the disintegration time of the tablets containing the MC.

INTRODUCTION

Methylcellulose (MC) is a hydrophilic colloid used as a binder in tablet formulations. It has properties such as film formation, thickening ability, adhesion and thermal gelation (1). Kryoer et al (2) have suggested that binder film formation has a significant effect on granule and tablet strengths. The mechanical properties of films of polymers used as solution binders have also been studied (3,4). Film formation by MC and its distribution in wet granulation has been reported to account for differences observed in water penetration and tablet disintegration time (5).

In an earlier publication (6), the authors reported a technique for measuring the swelling of MC films upon wetting. Swelling properties of MC films have also been correlated to the disintegration and dissolution of granules and tablets containing MC (7). In the present study, the effect of viscosity of MC as well as the presence of disintegrants on the swelling properties of MC films is investigated.

EXPERIMENTAL

Material

Sulphanilamide, in fine powder and of B.P. grade was chosen as a model drug. Methylcellulose of various viscosity grades, 20-30, 80-120, 350-550, 800-1200, 4000 and 7000-10,000 cp (Tokyo Kasei, Japan) was used to prepare the films and as a binder in tablets. The disintegrants used were cross-linked sodium carboxymethylcellulose (Ac-Di-Sol, FMC Corp., USA) and Crospovidone NF XV (Polyplasdone XL, GAF, USA).

Preparation of Tablets and Films

Tablets were prepared as described earlier (8). The method used to cast free films of MC was the same as that described in a previous study (6). A solution of 1% w/w of MC was poured onto glass petri plates to form films, 1.410 mg/cm^2. These films were dried at 60°C for 4 hrs. To make composite films, the appropriate amount of the disintegrant was suspended in the MC solution and the suspension poured into petri plates. The dried films were peeled off and cut into 1cm x 1cm squares which were then used for the swelling studies.

Disintegration of Tablets

The disintegartion time of individual tablets at 37 °C was determined according to the procedure described earlier (8).

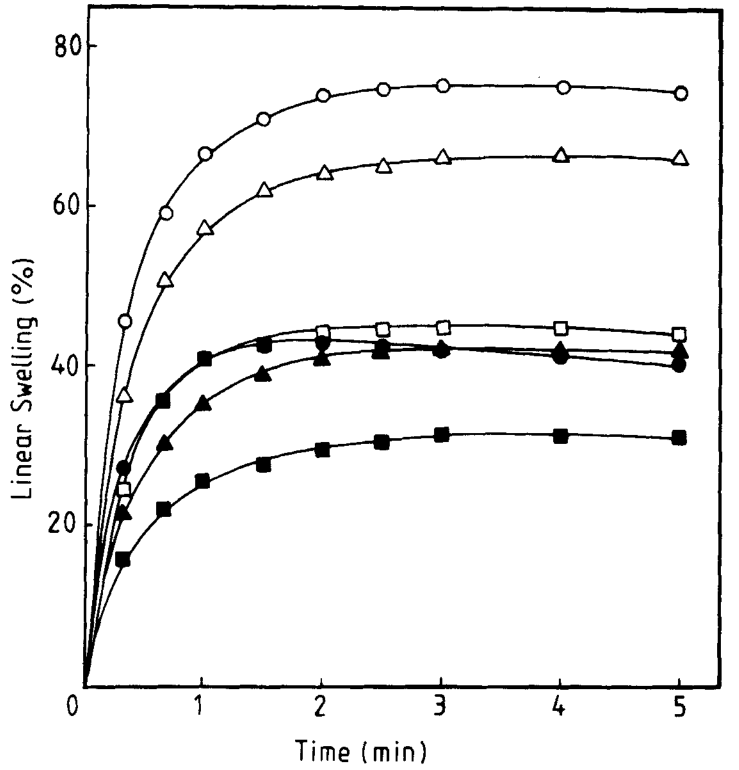

FIGURE 1

Swelling of films of different viscosity MC (1.410 mg/cm^2) at 37 °C : ○ , MC 20-30; △ , MC 80-120; □ , MC 350-550; ● , MC 800-1200; ▲ , MC 4000; ■ , MC 7000-10,000.

Swelling of Films in Water

The apparatus and method for studying the swelling phenomena of films involves the measurement of the linear expansion of MC films with time by projecting an image of the film on a screen (6).

Viscosity of Solutions/Dispersions

The viscosity of aqueous solutions of MC with/without the disintegrants was compared with that of water at 37± 0.5°C using a U-tube viscometer.

TABLE 1

Swelling of composite films of different viscosity MC (1.410 mg cm^{-2}) and disintegrants (0.353 mg cm^{-2}) at 37°C

	Maximum Swelling - E_{max} (%)					
	MC 20-30	MC 80-120	MC 350-550	MC 800-1200	MC 4000	MC 7000-10000
Without Disintegrant	74.95 ±0.86	66.47 ±1.81	44.84 ±1.53	43.03 ±2.21	42.42 ±2.14	31.51 ±1.81
+ Ac-Di-Sol	27.67 ±1.53	29.49 ±1.81	34.54 ±1.32	38.99 ±2.73	37.37 ±1.24	47.67 ±2.41
+ PVPP	37.37 ±2.26	32.52 ±1.11	31.51 ±1.94	33.94 ±3.24	30.10 ±1.94	25.05 ±1.11

RESULTS AND DISCUSSION

Effect of Viscosity of MC

From figure 1 it is seen that the swelling of the films at 37°C is rapid initially. Almost half the peak linear swelling percentage (E_{max}) is attained within the first 20 sec for each film formulation. A comparison of the E_{max} values (Table 1) shows that they decrease with an increase in the viscosity of the MC. Adhesive forces, which are of greater magnitude in the case of high viscosity MC are thought to bring about this behaviour.

On contact with water, films of MC spread smoothly followed by rapid swelling. Once the maximum swelling had occurred, the hydrated films remained afloat on the water surface. Some turned white in colour indicating a sol-gel transformation. Thermo-gelation is a typical physical characteristic of MC and is dependent on the concentration of the polymer and temperature of the water (9). MC could be present at a high concentration in the solution form at the water-film interface. This could lead to thermo-gelation occurring even at low temperatures as 37°C. Gel layer formation on the film prevents wetting of film interior and hinders swelling of film. A slight drop in the linear swelling values for some grades of MC films (Figure 1) after attaining E_{max} is due to dissolution of the film periphery. Apparently, swelling is not uniform throughout the length of the film. Portions of film towards the film edge swell to a greater degree than portions in the centre of the film. The two edges at right angles to each other, however, swell to the same extent as was shown statistically earlier (6).

A comparison of the swelling behaviour of different viscosity films shows that the two low viscosity grade MC (MC 20-30 and MC 80-120) form one group, having high E_{max} values and high rates of linear swelling (Figure 1 and Table 1). MC 350-550, MC 800-1200 and MC 4000 form another group while the high viscosity MC (MC 7000-10,000) forms a third group having very low linear swelling values. The adhesive and thickening properties of MC are dependent on the polymer chain length and the degree of substitution (1). These factors are reflected in the viscosity of the MC and a high viscosity MC has greater adhesive action.

<u>Effect of Disintegrants</u>

Swelling behaviour of PVPP/MC composite films containing 0.353 mg/cm^2 of PVPP is similar to that of plain films (Figures 1 and 2). Swelling decreases with increase in the viscosity of the MC but the magnitude of swelling is lower than that for plain MC films. The order of swelling in films containing Ac-Di-Sol (0.353 mg/cm^2) is opposite of that observed for PVPP/MC composite films and plain MC films (Figure 3). Swelling in this case increases with an increase in the viscosity of the MC. Again, the E_{max} values are lower than that for plain films (Table 1).

Ac-Di-Sol and PVPP cause an increase in the viscosity of MC solutions (Table 2). This increase is only marginally higher in case

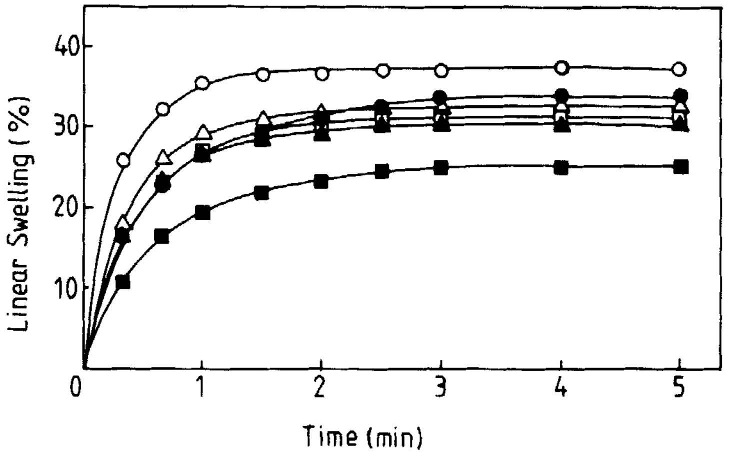

FIGURE 2

Swelling of PVPP/MC composite films of different viscosity MC (1.410 mg/cm^2) and PVPP (0.353 mg/cm^2) at 37 °C : ○ , MC 20-30; △ , MC 80-120; □ , MC 350-550; ● , MC 800-1200; ▲ , MC 4000; ■ , MC 7000-10,000.

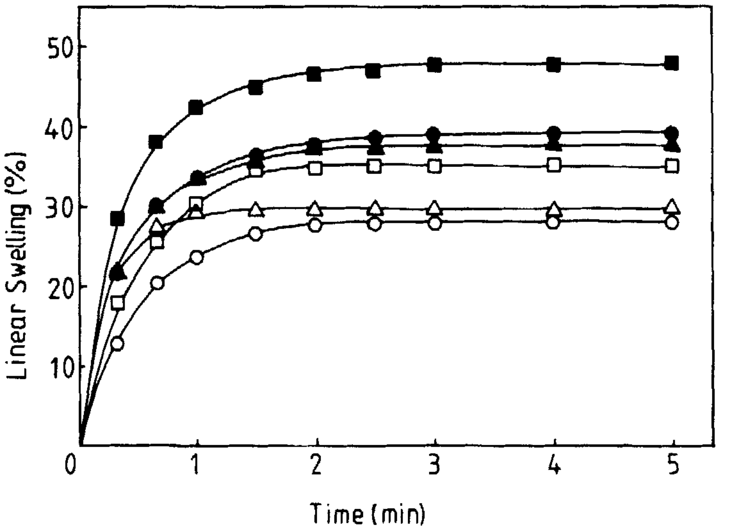

FIGURE 3

Swelling of Ac-Di-Sol/MC composite films of different viscosity MC (1.410 mg/cm^2) and Ac-Di-Sol (0.353 mg/cm^2) at 37 °C : ○ , MC 20-30; △ , MC 80-120; □ , MC 350-550; ● , MC 800-1200; ▲ , MC 4000; ■ , MC 7000-10000.

TABLE 2

Viscosity of MC solutions (0.5% W/W) containing various disintegrants (0.2% W/W) at 37°C. Flow time of distilled water - 11.43 ± 0.02 sec

MC grade	Flow time (sec)		
	Without Disintegrant	Ac-Di-Sol	PVPP
MC 20-30	19.75 ± 0.04	23.83 ± 0.02	20.79 ± 0.02
MC 80-120	30.16 ± 0.08	36.92 ±0.07	30.72 ± 0.03
MC 350-550	46.14 ± 0.02	58.31 ±0.06	50.15 ± 0.03
MC 800-1200	59.25 ± 0.17	79.60 ± 0.10	65.24 ± 0.15
MC 4000	119.38 ± 0.03	154.51 ± 0.08	130.65 ± 0.09
MC 7000-10000	169.73 ± 0.09	195.23 ± 0.34	177.41 ± 0.12

of PVPP but much higher in case of Ac-Di-Sol. Since swelling of films made from high viscosity MC is less, any increase in the viscosity of a particular MC solution should result in a decreased swelling of the film made from that solution. Thus, the low swelling shown by Ac-Di-Sol/MC and PVPP/MC composite films in comparison to plain MC films could be attributed to the contribution to the enhancement of the viscosity of MC solutions by the disintegrants.

If swelling of films were dependent solely on the viscosity of MC with or without the disintegrants, Ac-Di-Sol/MC composite films should swell to a lesser degree compared to PVPP/MC composite films because Ac-Di-Sol increases the viscosity of MC solutions to a greater extent than PVPP (Table 2). But this was not so. Ac-Di-Sol/MC composite films have greater E_{max} values than PVPP/MC composite films (Table 1). The contribution of Ac-Di-Sol particles to the swelling of films is thought to account for this behaviour. A microscopic examination of the hydration of different viscosity MC particles in an earlier study (10) revealed that these particles dissolved within 4 sec of contact with water. Using a video recording technique (11), Ac-Di-Sol particles were shown to undergo about 68% increase in their projected area diameter upon hydration whilst for PVPP particles it was about 29% (10).

Ac-Di-Sol particles aid the swelling of MC films due to their greater swelling action. Higher viscosity MC have greater capacity to swell, provided hydration is rapid as is when Ac-Di-Sol is present. Slow hydration which occurs when PVPP is present probably allows viscous forces to exhibit their adhesive action and limit the swelling phenomena. The swelling of the films is actually a net effect of the balance between adhesive/viscous forces that retard swelling and MC/disintegrant individual particle swelling. Hydration causes the polymer strands in the film to stretch out and swell. The swelling force is transmitted from particle to particle and eventually to the periphery of the film. The presence, among MC, of particles that are less soluble and that have either limited or no swelling action can weaken the swelling forces due to improper transmission and a buffering effect. This could be the reason why composite films had a lower E_{max} value compared to plain MC films.

Swelling of MC could have a direct effect on the disintegration pattern of tablets. With Ac-Di-Sol (Table 3), a decrease in DT with increasing viscosity of MC is observed. The amount of water that penetrates into the tablets has been found to increase with the viscosity of MC (8). Ac-Di-Sol particles, which are mostly fibrous in shape, facilitate 'wicking' of water into the tablet interior. This disintegrant aids the rapid uptake of water by the tablets. MC of a higher viscosity has a greater capacity to hydrate and thus utilises the water transported by Ac-Di-Sol. The swelling action of Ac-Di-Sol complements that of MC and the tablet disintegrates. Disintegration is complete before the adhesive effects of MC can be demonstrated.

For tablets containing PVPP, DT increases and water penetration decreases with an increase in the viscosity of MC (12,13). Consumption

TABLE 3

Disintegration of sulphanilamide tablets containing 2.5% and 5% of Ac-Di-Sol/PVPP and 2% MC of varying viscosity

MC grade	Disintegration time (sec)			
	Ac-Di-Sol		PVPP	
	2.5%	5%	2.5%	5%
MC 20-30	118.00 ± 4.00	252.20 ± 7.16	24.00 ± 1.41	23.20 ± 1.92
MC 80-120	51.60 ± 1.14	159.20 ± 6.14	45.40 ± 1.67	27.60 ± 2.07
MC 350-550	36.40 ± 0.55	108.00 ± 1.58	129.00 ± 8.40	46.00 ± 1.22
MC 800-1200	32.20 ± 0.84	79.60 ± 1.52	239.20 ± 16.13	48.80 ± 4.83
MC 4000	24.00 ± 0.71	62.00 ± 2.24	331.20 ± 24.10	52.60 ± 18.20
MC 7000-10000	25.80 ± 0.45	47.80 ± 0.45	567.20 ± 17.96	141.40 ± 18.20

of water for wet massing was more when Ac-Di-Sol was used in place of PVPP (14). The slow hydration of PVPP particles combined with the low swelling capacity of individual PVPP particles could allow MC sufficient time to exhibit its adhesive effects. Adhesive action, which is greater for higher viscosity MC, thus holds the tablet together and delays DT.

There exists a correlation between tablet disintegration, tablet water uptake and Disintegrant/MC film swelling. Swelling of Ac-Di-Sol/MC composite films increases with the viscosity of MC and in tablets containing Ac-Di-Sol, water penetration increases and consequently DT decreases. PVPP/MC composite films on the other hand, show decreased swelling with increase in viscosity of MC and in tablets, water penetration decreases and DT increases.

In conclusion, MC films undergo rapid swelling when hydrated. Higher viscosity MC films have lower swelling rates and peak linear swelling values. The swelling action and water uptake properties of the disintegrant affect the swelling behaviour of composite films. Swelling action of PVPP/MC composite films is similar to that of plain MC films while that of Ac-Di-Sol/MC composite films is just the opposite. The order of swelling for disintegrant/MC composite films can be related to the DT of tablets formulated with these disintegrants and MC.

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