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COMMUNICATION

The Effect of Temperature and Polymer Concentration on Dynamic Surface Tension and Wetting Ability of Hydroxypropylmethylcellulose Solutions

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ABSTRACT

The purpose of the present study was to evaluate quantitatively the changes of dynamic surface tension and contact angle of hydroxypropylmethylcellulose (HPMC) aqueous solutions as a function of temperature and polymer concentration of the examined solutions. HPMC aqueous solutions of different concentrations (1%, 2%, 3%, 4% w/w) were prepared without plasticizer and with 1% w/w Lutrol F127. Dynamic surface tension of the prepared solutions was determined by the Du Nouy ring method of the KSV Sigma 70 computer-controlled and programmable tensiometer. The dynamic contact angle of Avicel PH-101 tablets was measured against HPMC solutions of various concentrations by the plate method of the KSV Sigma 70 tensiometer. The obtained results indicate that dynamic surface tension measurement can be applied for the accurate determination of the thermal gelation temperature of the prepared HPMC solutions. With increasing concentration of HPMC, dynamic contact angle values of solutions also increased, thus decreasing the spreading behavior on the surface of Avicel tablets.

Key Words: *Contact angle; Dynamic surface tension; Hydroxypropylmethylcellulose (HPMC); Wetting ability.*

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INTRODUCTION

Film coatings using hydroxypropylmethylcellulose (HPMC) have become popular, taking the place of conventional sugar coating of tablets, because they give a superior appearance, act as protection for fragile tablets, and mask the unpleasant taste of drug substances.

The physical properties of film-coating solutions and suspensions can potentially exert an influence at many stages during the film-coating process. These stages include delivery to and droplet production at the atomizing device, travel to the tablet surface or multiparticulate core, and the wetting, spreading, penetration, evaporation, and adhesion of the atomized formulation at the substrate surface. When droplets of aqueous film-coating formulations contact a substrate surface, they will wet, spread over, and adhere to the substrate as well as penetrate to the surface. The extent to which these factors occur will depend on the properties of the substrate, the coating formulation, and the conditions being used to apply the coat (1,2). One way of assessing the potential behavior of a coating formulation on a substrate is by the measurement of the contact angle made by a drop of formulation on the substrate surface (3–6).

The purpose of the present study was to apply dynamic surface tension and contact angle measurements for determination of thermal gelation temperature and for the evaluation of the spreading behavior of HPMC coating solutions on the Avicel PH-101 tablet surface.

EXPERIMENTAL

Materials

HPMC (molecular weight 86,000, Aldrich), Lutrol F127 (BASF, Germany), microcrystalline cellulose (Avicel PH-101, BASF) were used. HPMC aqueous solutions of 1%, 2%, 3%, and 4% w/w concentrations were prepared without plasticizer and with 1% w/w Lutrol F127 (BASF) selected as the plasticizer.

Dynamic Surface Tension Measurements

The dynamic surface tension of different HPMC solutions was determined by the Du Nouy ring method using a computer-controlled and programmable tensiometer (KSV Sigma 70, RBM-R, Braumann GmbH, Germany) after equilibration at 20°C, 25°C, 30°C, 35°C, 40°C, and 45°C for 1 hr. Measuring parameters were as follows: minimum number of cycles, 5; minimum measuring time, 5 min; speed up, 2 mm/min.

Dynamic Contact Angle Measurements

Tablets were compressed from the Avicel PH-101 dry powder blend using a pressure of 10 MPa. The 10 MPa compressional pressure ensured samples of similar low porosities. The dynamic contact angle of the tablets was determined against HPMC solutions of various concentrations by the plate method of the KSV Sigma 70 tensiometer at 20°C ± 0.5°C. Round-shape tablets of 12 mm diameter and 0.5 mm thickness were compressed. Measuring parameters were as follows: minimum number of cycles, 3; upper limit, −1 mm; lower limit, −5 mm; speed up, 2.5 mm/min; speed down, 2.5 mm/min.

From the extrapolated bouyancy slope, it is possible to obtain the contact angle:

$$\cos \Theta = f/p\gamma_{LV} \tag{1}$$

where Θ is the contact angle, f is the force measured on the balance, p is the measured plate perimeter, and γ_{LV} is the surface tension of the polymer solution (7).

RESULTS AND DISCUSSION

Table 1 summarizes the dynamic surface tension values of HPMC solutions measured at different temperatures. The results indicate that there is a sudden increase in the dynamic surface tension values at 45°C, which refers to the thermal gelation of HPMC.

The applied plasticizer decreased the surface tension value of the HPMC solutions, referring to its interfacial structure modifying effect. The gel network, which could be observed visually, was also formed in the presence of plasticizer at the same temperature. The higher standard deviation of the surface tension values within the measur-

Table 1

Dynamic Surface Tension Values of 2% w/w HPMC Aqueous Solutions at Various Temperatures

Temperature (°C)	Surface Tension (mN/m) ± SD: Without Lutrol F127	With 1% w/w Lutrol F127
20	50.58 ± 0.763	42.41 ± 0.137
25	52.88 ± 1.401	40.38 ± 0.090
30	53.27 ± 0.762	40.72 ± 0.015
35	53.79 ± 0.635	41.13 ± 0.043
40	56.21 ± 0.537	41.44 ± 0.189
45	75.91 ± 0.566	41.58 ± 2.759
47	111.57 ± 1.237	42.64 ± 4.763

Table 2

Advancing Contact Angle Values of Avicel PH-101 Tablets in Hydroxypropylmethylcellulose Aqueous Solutions of Different Concentrations (n = 3; RSD < 10%, 20°C)

	Advancing Contact Angle	
Concentration (% w/w)	Without Lutrol F127	With 1% w/w Lutrol F127
1	85.30	23.0
2	91.60	62.5
3	94.30	67.7
4	113.80	100.9

ing cycles refers to the formation of a gel network. The reason for the measured difference in the dynamic surface tension values could be the formation of different three-dimensional gel structures caused by the applied plasticizer. The solvation of HPMC could be changed in the presence of Lutrol F127.

Table 2 summarizes the dynamic contact angle values of the prepared HPMC solutions. With increasing polymer concentration and increasing viscosity, the measured contact angle values slightly increased; consequently, spreading of the solutions on the Avicel surface decreased. The presence of plasticizer decreased the contact angle of solutions compared to that of the HPMC solutions without plasticizer. The applied hydrophilic-type plasticizer improved the spreading behavior of the coating solutions, thus improving the continuous film formation on the substrate surface.

CONCLUSIONS

Since the whole coating operation could come to a standstill as the coating suspension or solution would take the form of a firm gel, accurate determination of the thermal gelation temperature by dynamic surface tension measurement has a decisive impact from the point of formulation. Dynamic contact angle measurements give useful information concerning the spreading behavior of HPMC solutions. The results indicate that these measurements can be improved by the application of hydrophilic-type plasticizer.

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