

ESTIMATED SURFACE TENSIONS OF ATOMISED DROPLETS IN AQUEOUS FILM COATING

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The surface tension of atomised film coating solutions is one of the factors which influences the adhesion and spreading behaviour of droplets on a tablet surface. It has been reported previously (Aulton et al. 1986) that the surface tension of bulk aqueous HPMC solutions varies little ($44.5\text{--}46.2\text{mNm}^{-1}$) over a range of concentrations (5–12% w/w) commonly encountered in practice and therefore would not be expected to be a variable in the spreading process on the tablet surface. However during spraying there is a very large increase in solution surface area; typically 40m^2 is generated from 100ml of solution during atomisation (data from Malvern droplet sizer, Model 2200). This generation of new surface may be sufficient to produce droplet surfaces which are unsaturated with HPMC and thus exhibit a greater surface tension than that of bulk solutions. The relationship between surface tension and concentration for aqueous HPMC solutions has been determined at 20°C using a torsion balance. The data shows a surface tension-concentration profile similar to that exhibited by other non-ionic surface active agents. There is a decrease in surface tension from 72.8mNm^{-1} at 0% w/w to 55.4mNm^{-1} at 2×10^{-5} % w/w. At this point there is a sharp change in gradient, the surface tension falling less steeply to 44.5mNm^{-1} at a concentration of 12% w/w.

The surface excess concentration of HPMC at concentrations below 2×10^{-5} % w/w can be calculated from the Gibbs adsorption equation. If HPMC is assigned a weight average molecular weight of 3×10^5 (Rowe 1980) and the solution density is known, then the number of molecules in each size of droplet for a particular concentration can be calculated. Similarly the surface area of the droplets can be obtained and therefore the number of HPMC molecules available per m^2 of generated surface can be elucidated for any droplet size. This value can then be compared with the surface excess concentrations calculated from the surface tension-concentration profile and hence the droplet diameter below which the droplet surface tension increases markedly above that of the bulk solution can be calculated, as can the surface tension of different droplet sizes below this diameter. For example for this data, if a 9% w/w HPMC solution (density = 1021kgm^{-3}) is atomised, all droplets smaller than $143\mu\text{m}$ would exhibit surface tensions above the inflection at 55.4mNm^{-1} . Earlier work (Aulton et al. 1986) has shown that in a typical commercial spray between 90 and 100 wt.% of droplets are below this size. The calculated droplet surface tension (γ_{dr}) for a 9% w/w aqueous HPMC solution at 20°C increases linearly with decreasing individual droplet diameter (D_{dr}) for droplets below $143\mu\text{m}$ as defined in the equation below:

$$\gamma_{\text{dr}} (\text{mNm}^{-1}) = 72.8 - 0.121D_{\text{dr}} (\mu\text{m})$$

A time-dependent reduction in the surface tension of bulk HPMC solutions has also been observed. For example, at a concentration of 2×10^{-5} % w/w approximately 10 hours was required before the equilibrium surface tension was reached.

The above observations lead to the conclusion that the surface tension of droplets hitting a tablet surface may be considerably greater than that predicted from measuring the bulk surface tension, this effect being more pronounced with smaller droplets and less concentrated solutions and possibly potentiated by the time taken for HPMC molecules to reach the surface. Spreading of film coating solutions on tablet surfaces may therefore not follow expected trends. Factors such as solvent evaporation during travel to the tablet, polymer polydispersity and the inclusion of formulation additives may also influence this phenomenon.

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