COMMUNICATIONS

The prediction of compatibility/incompatibility in blends of ethyl cellulose with hydroxypropyl methylcellulose or hydroxypropyl cellulose using 2-dimensional solubility parameter maps

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Typical two dimensional solubility parameter maps for ethyl cellulose, hydroxypropyl methylcellulose and hydroxypropyl cellulose have been constructed using literature data. The maps of the polymers showed some degree of overlap indicating some mutual compatibility. Compatibility between ethyl cellulose and hydroxypropyl cellulose was greater than between ethyl cellulose and hydroxypropyl methylcellulose. The maps may also be used to predict the effect of added plasticizers.

Blends of ethyl cellulose with either hydroxypropyl methylcellulose or hydroxypropyl cellulose are widely used in the formulation of delayed or sustained release films (Shah & Sheth 1972; Donbrow & Samuelov 1980, Rowe 1985). Knowledge of the mutual compatibility/incompatibility of these polymers together with their compatibility/incompatibility with added plasticizers is necessary to understand the morphology or microstructure of the films, especially the nature of the movement of substances through them. Since compatibility and solubility are closely related phenomena and the principles of solubility are already well defined, a study of the solubility characteristics of the three polymers alone and with plasticizers should have predictive value.

The solubility of polymers has attracted attention over the past two decades, and invariably the solubility parameter (δ) based on the regular solution theory of Hildebrand & Scott (1950) has been used. However, the concept, as originally proposed, proved only partially successful in predicting the solubility of polymers especially in those solvents with a tendency to hydrogen bond. To overcome this, the concept was extended by Hansen (1967a), who proposed a three component solubility parameter where δ_d is the dispersion or van der Waals' component, δ_p is the polar component and δ_h the hydrogen bonding component. Such an approach predicts that, when the data is plotted on a three dimensional projection, each polymer will be characterized by a volume formed by all the solvents which dissolve it, and that the degree of overlap between projections for blends of polymers and the relative positions of any added plasticizers will provide information on their compatibility (Hansen 1967b). However, since such projections are difficult to apply practically, the simpler approach based on the δ_h and δ_p components is more generally used. This concept has been applied in the present study.

Method

The three polymers examined were ethyl cellulose (Grade N50, Hercules Inc. USA), hydroxypropyl methylcellulose (Pharmacoat 606, Shin Etsu Chemical Co., Japan) and hydroxypropyl cellulose (Klucel LF, Hercules Inc. USA). Solubility parameter maps were constructed using data obtained from manufacturers' literature and that generated 'in-house' (Kent & Rowe 1978; Entwistle & Rowe 1979). The δ_p and δ_h values used were those generated by Hansen & Beerbower (1971) as recently compiled by Barton (1983).

Results and discussion

The solubility maps of the three polymers together with the position of the plasticizers, glycerol, diethyl phthalate and hexaethylene glycol (the main constituent of polyethylene glycol 300) are shown in Fig. 1. It was not possible to complete the maps for the two water-soluble polymers since the δ_p and δ_h values for water are uncertain (Barton 1983). A feature of the map for the ethyl cellulose is that it clearly shows the increased solubility profile of the 'N grade' of ethyl cellulose (ethoxyl content 48–49.5% w/w, degree of substitution 2.45) especially in solvents both with low values of δ_p and δ_h (i.e. the hydrocarbons and chlorinated hydrocarbons) and with moderately high values of δ_p and δ_h (i.e. the alcohols) compared with that of the 'K grade' with its lower ethoxyl content (46.1–47.2% w/w, degree of substitution 2.35) as used by Klein et al (1975).

These maps have practical implications in the prediction of both their mutual compatibility and their compatibility with plasticizers. It can be seen that there is a significant degree of overlap in the maps for the two water soluble polymers, indicating high mutual compatibility and that the maps for both polymers partially
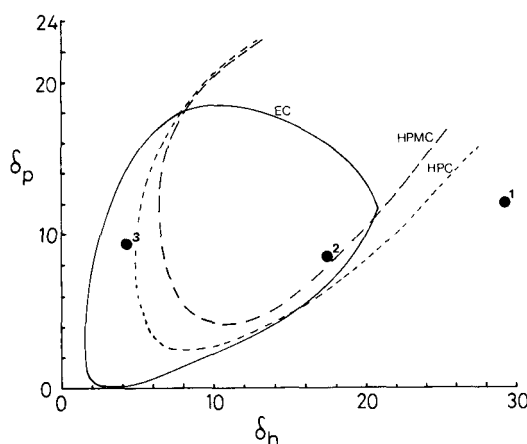
FIG. 1. Solubility parameter maps for ethyl cellulose (—EC) hydroxypropyl methylcellulose (— — HPMC) and hydroxypropyl cellulose (- - - - HPC). Positions of the plasticizers (●), glycerol (1), hexaethylene glycol (2) and diethyl phthalate (3).

first case the plasticizer will have no effect on either polymer and will probably form a separate phase; in the second case the plasticizer will partially interact with both polymers lowering their glass transition temperatures to a degree dependent on its partitioning between the two polymer phases; and in the third case the plasticizer will only interact with one polymer (in the example given, this would be the ethyl cellulose) lowering its glass transition temperature. While there are no literature reports to confirm the first case, the second and third cases have been recently confirmed for the examples given (Sakellariou 1982, 1984).

While at best solubility parameter maps of the type discussed are only a useful guide to predicting compatibility/incompatibility in polymer/polymer and polymer/polymer/plasticizer blends, the results clearly illustrate the potential of this kind of approach. Data on other polymers used in the film coating of solid dosage forms would be invaluable to the formulator in the optimization of formulations.

overlap that for the ethyl cellulose, indicating some degree of mutual compatibility but also incompatibility. The slightly increased overlap for the hydroxypropyl cellulose would suggest a slightly enhanced compatibility with ethyl cellulose compared with hydroxypropyl methylcellulose. However, in both cases, phase-separated systems will be formed. This has recently been confirmed by a detailed study of the thermomechanical properties of blends of these polymers (Sakellariou 1984).

The relative position of the three plasticizers (Fig. 1) clearly illustrates the three general positions to which added plasticizers conform when added to a two component polymer blend; firstly, falling outwith either of the two polymers (e.g. glycerol in a blend of ethyl cellulose and hydroxypropyl cellulose); secondly, falling within the overlapping region of the maps of the two polymers (e.g. hexaethylene glycol in a blend of ethyl cellulose and hydroxypropyl methylcellulose), and thirdly, falling within the map of only one of the polymers (e.g. diethyl phthalate in a blend of ethyl cellulose and hydroxypropyl methylcellulose). In the

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