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A relation between the incompatibility and the dipole moment of polymers

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SUMMARY

The incompatibility of different couples of polymers is correlated with the dipole moment of these polymers. It is shown that when the dipole moment of a polymer A is very close to the dipole moment of a polymer B the incompatibility of the mixture polymer A-polymer B is very low. In the contrary a mixture polymer A-polymer B presents a high incompatibility when the dipole moment of the polymer A is too different from the dipole moment of the polymer B.

PROCEDURE

The viscosimetric study of the ternary system polymer A-polymer B-solvent or of the corresponding copolymer A-B was many times used in order to determine the interaction parameter χ_{AB}, which characterises the incompatibility of the couple polymer A-polymer B(1-7). The viscosimetric study of the ternary systems polymer A-polymer B-solvent also leads to a method of estimation of the incompatibility of the polymers without been necessary to determine the χ_{AB} parameter (8) : this method will be used in this work.

According to this method the intrinsic viscosity of the polymer A, $[\eta]_{AB}$, is determined in a mixture of a solvent with a constant quantity of polymer B. In the same solvent, but without the polymer B, we also determine the intrinsic viscosity of the polymer A, $[\eta]_A$. The quantity $\Delta[\eta]_A = [\eta]_A - [\eta]_{AB}/[\eta]_A$ gives the decrease of the intrinsic viscosity of the polymer A by the presence of the polymer B in the solvent and this decrease is due to the incompatibility existing between polymer A-polymer B. In the following we determine the intrinsic viscosity $[\eta]_B$ of the polymer B in solution in the same pure solvent and the intrinsic viscosity $[\eta]_{BA}$ of the polymer B in solution in a mixture of the solvent with a constant quantity of polymer A. The quantity $\Delta[\eta]_B = [\eta]_B - [\eta]_{BA}/[\eta]_B$ gives the decrease of the intrinsic viscosity of polymer B due to presence of the polymer A in the solvent. The constant quantity of the polymer A or B in the mixture , solvent plus polymer, is always the same and equal to 0.125×10^{-2} gr/cm^3. Finally, the quantity $\Delta[\eta]_{AB} = \frac{1}{2} (\Delta[\eta]_A + \Delta[\eta]_B)\%$ expresses a measure of the incompatibility existing between the polymer A and polymer B as it was described in our previous work(8).

The measurements of the intrinsic viscosity for each couple of polymers have been conducted using polymer samples of relatively high molecular weights ($M_W > 50.000$) in order to avoid the relation existing between the incompatibility and the molecular weight of polymers. It was shown that the incompatibility increases when one of the polymer of the couple is of low molecular weight ($M_W < 10.000$)(9,10). In order to have comparable results for all the polymer couples studied in this work, the viscosimetric measurements of each couple has been conducted in a solvent which is a good one for the two polymers of the couple ; so the influence of the solvent on the incompatibility of the

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polymers is avoid(6,8,11).

According to the above remarks the quantity $\Delta[\eta]_{AB}$ must express an "intrinsic" value of the incompatibility which characterizes the couple polymer A-polymer B.

RESULTS AND DISCUSSION

We give in Table I the values of the quantity $\Delta[\eta]_{AB}$ for different couples of polymers. The viscosimetric measurements have been conducted using an automatic viscometer.

Table I : Values of the intrinsic viscosity variation $\Delta[\eta]_{AB} = \frac{1}{2}(\Delta[\eta]_A+\Delta[\eta]_B)\%$ and of the difference of dipole moment $\Delta\mu = |\mu_A-\mu_B|$ for six polymer couples (PVA:polyvinylacetate, PVC:polyvinylchloride).

couples of polymers	$\Delta[\eta]_{AB}$	$\Delta\mu$
PS - PMMA	7.00	0.99
PS - PVC	10.55	1.19
PS - PVA	11.20	1.34
PMMA- PVA	3.60	0.35
PMMA- PVC	3.15	0.20
PVC- PVA	3.30	0.15

In the following, we try to correlate the incompatibility of these couples of polymers with the dipole moment μ of the two polymers. As it is known (12-15) the value of the μ of each polymer is given per monomeric repeating unit and is given by the relation $\mu = (\bar{\mu}^2/N)^{1/2}$ where N is the number-average degree of polymerization and $\bar{\mu}^2$ is the mean-square dipole moment of the long chain molecule.

More precisely we correlate the incompatibility of each couple of polymers with the absolute value of the difference of dipole moment $|\mu_A-\mu_B| = \Delta\mu$ of these polymers. As we see in Table I there is a direct relation between the incompatibility of a couple of polymers and the difference of dipole moment of these two polymers. A couple of polymers with a high value of $\Delta\mu$ present a high value of incompatibility as it is expressed by the high value of $\Delta[\eta]_{AB}$, while for a couple of polymers with a low value of $\Delta\mu$ we have also a low value of $\Delta[\eta]_{AB}$.

In Figure I we present the relation between $\Delta\mu$ and $\Delta[\eta]_{AB}$. The curve is not very reliable since we have a small number of experimental points and the values of $\Delta\mu$ present a dispersion. The error bars in fig.I give this dispersion in the values of $\Delta\mu$, which we find from Polymer Handbook(15) (the values of $\Delta\mu$ in Table I are mean values).

Our measurements concern a relatively low number of couples of polymers because only for a low number of polymers the value of μ is determined(15). All our results given in Table I are obtained using only vinyl polymers. If we use the polyoxyethylene glycol with polystyrene or polymethyl-methacrylate we obtain points that do not fit on the curve of figure. Nevertheless this viscosimetric results can give a "guide" for the research of compatible couples of polymers or couples of polymers with very low incompatibility.

Our results also indicate that the compatibility between two polymers can't be attributed to specific interactions but as A.K.Nandi et al(16) claim the compatibility must be attributed to a lack of "complementary dissimilarity." This dissimilarity is expressed here by the difference in the dipole moment of polymers. For example, in the case of two polymers presenting a high

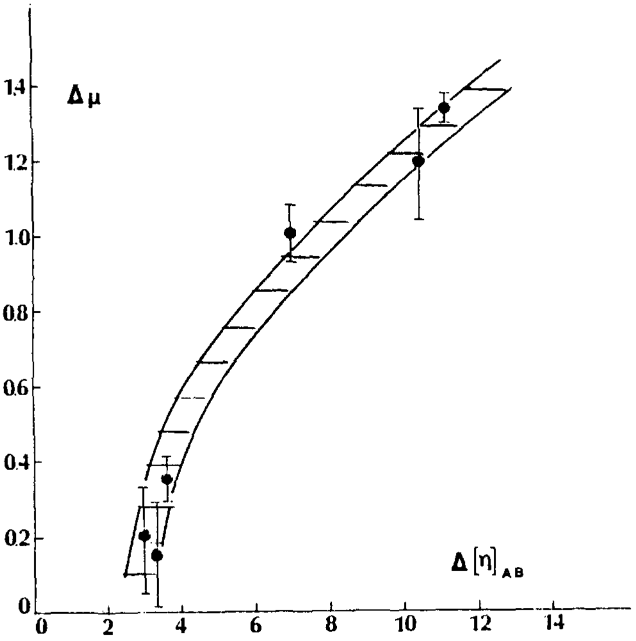

Fig.1. Relation between the incompatibility, expressed by the $\Delta[\eta]_{AB}$ value and the difference of dipole moment $\Delta\mu$ of polymer couples.

value of the difference $|\mu_A-\mu_B|$ the dissimilarity is high and the monomers of each polymer give interactions of the type δ^{-}-δ^{+} with other monomers which belong to the same polymer and this leads to the face separation. In the contrary, in the case of two polymers presenting a very low value of the difference $|\mu_A-\mu_B|$ the dissimilarity is low and the monomers of each polymer give interactions with other monomers which belong to the same or to the other polymer indifferently : hence the polymers are compatible.

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