Chapter 50
Effect of the Filler on the Physico-Mechanical Properties of the Polyimide Composite Materials

A. D. Muradov, G. S. Suyundikova and A. G. Kunsafina

Abstract Studied the effect of content of the polyethylene terephthalate (PET) in the polyimide (PI) on the physical and mechanical properties of the polymer compositions. Found that an increase concentration of PET leads to changes in the morphology of polymer films. At the same time, the morphology of the polymer film compositions is more or less mesoporous.

Keywords Polyethyleneterephthalate · Polyimide · IR spectra · Polymer · Amidoacid

50.1 Introduction

One of the priorities of modern condensed matter physics is the study of patterns of composite materials structure formation. The main direction of macromolecular chemistry development at the present time is to create a polymer with a given structure. A promising direction is now towards getting different functional composite micro-and nano-structured macromolecular materials with controlled electro (dielectric-conductive), magnetic, optical (reflecting-absorbing) properties. The most important polymers in the successful solution of this problem are the polyimide (PI), including alicyclic structure. Chemical modification that allows purposefully regulate the processes of formation of the structure of the material is widely used [1–3]. In the creation of new polymer systems promising approach is to obtain mixtures of polymers belonging to the same or different classes, but the differing structure of macromolecules. In such mixtures, stiff polymers can stimulate the orientation of macromolecules with a more flexible chain and, on the

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H.-K. Jung et al. (eds.), *Future Information Communication Technology and Applications*,
Lecture Notes in Electrical Engineering 235, DOI: 10.1007/978-94-007-6516-0_50,

contrary, amorphous flexible chain polymers—lead to disordering of crystalline polymers and create new opportunities for controlling their properties [4, 5].

50.2 Experimental Part and Discussion

This paper is devoted to study the influence of the percentage of polyethyleneterephthalate (PET) in the PI on the physical and mechanical properties of the polymer compositions. Measuring the viscosity of polymer solutions was carried out in m-cresol at Ubbelohd viscometer at 20 °C, the concentration of a solution is 0.5 dl/g. Were identified as described, and the intrinsic viscosity of the individual polymers and mixtures thereof. IR spectra were taken with the standard method of thin membranes at room temperature on a spectrophotometer "Jasco IR-810" (Japan) in the range of 400–4000 cm^{-1}. Micrographs of the surface of samples obtained from thin membranes cast from 7 %-s cresol solutions.

Figure 50.1 presents data on the effect of the ratio of polymers on the reduced viscosity (η_{pr}) composite. As it can be seen, the studied dependence of all the weight percent ratio of PET in the PI has a similar shape of the curves.

According to the research shows that the additive dependence of the viscosity of the composition of the components due to the fact that between the PI and PET is no formation of any links, as well as conformational changes are not observed.

In order to obtain information about the size and structure of the thin domain optical microscopy membrane surface was studied. The general picture of the morphology of blends is a clear, homogeneous Polyimide matrix with uniformly distributed in the particles of the dispersed phase P2 with dimensions in the range of 1–50 μm. Figure 50.2 is a photomicrograph of the membrane solutions of mixtures of 90 % PI–10 % PET on the photomicrograph visible domains, i.e., hexagonal structure.

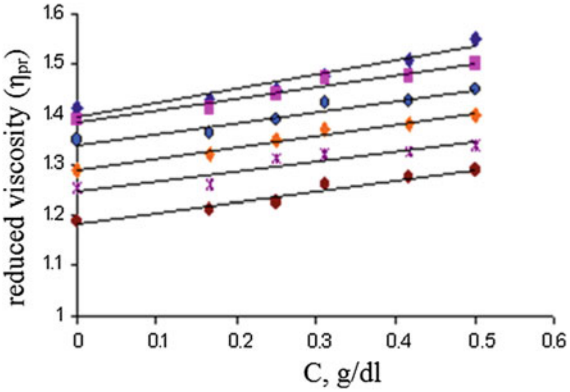

Fig. 50.1 The dependence of the viscosity of the solution concentration PI/PET blends with different ratios of the components. 95/5 (à), 90/10 (□), 85/15 (○), 80/20 (7), 75/25 (*), and 70/30 (●)

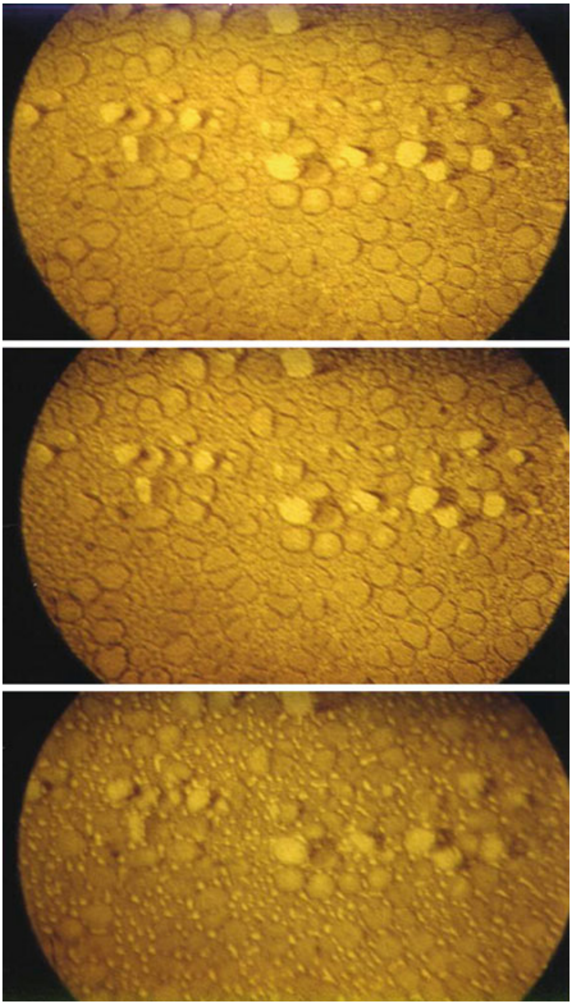

Fig. 50.2 Photomicrograph of the membrane blends PI/PET 90 %: 10 %

Furthermore, the addition of the second polymer alters the morphology of polymer membranes. In this case, the morphology of thin membrane materials is more or less mesoporous.

With the increasing content of the final structure of the PET membrane becomes more porous with pore sizes up to 40 nm at 10 wt.% PET (Fig. 50.3). The increase of PET above 10–12.5 wt.% causes symptoms thermodynamic incompatibility of polymers in the form of formation of opaque membrane samples.

TGA data analysis indicates the composition of the produced membranes, corresponding to the polymer in the initial solution (Table 50.1).

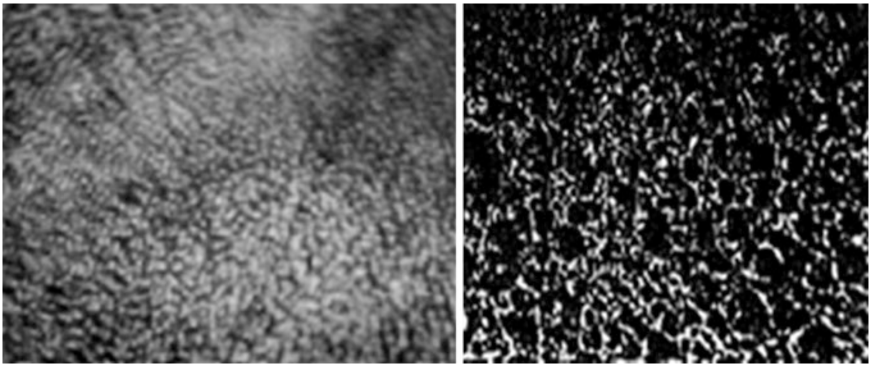

Fig. 50.3 Microscopic structure of polyimide composite membranes containing PET 1 (*left*) and 10 wt.% (*Right*)

Table 50.1 Composition of polyimide blends

Type of mixture	Imides content, wt.%	The content of amidoacid masses. %	PET content, wt.%	
			Gravimetrically	According to TGA
Gomopoliimid	89.8	10.2	–	–
PI-PET 1 %	86.1	12.4	1.05	1.15
PI-PET 2 %	83.8	12.0	2.1	2.25
PI-PET 5 %	80.5	11.8	5.1	7.7
PI-PET 10 %	77.9	11.4	10.2	10.3
PI-PET 15 %	74.2	10.9	15.3	14.9
PI-PET 20 %	65.7	10.6	20.4	24.3
PET	–	–	–	94.9

The table shows that with increasing PET content decreases imides with content amidoacid grow at low concentrations of PET (at 1–2 wt.%) and reaches up to 12 wt.%.

To confirm the results obtained by viscometry held infrared spectroscopic study of polymers. There is a direct proportional dependence of the growth intensity of the band in 1100, relating to the bending vibrations of the *C–O* bond of the ester to the increase of PET in the blend. From the analysis of the IR spectra of the individual polymers and their mixtures that do not observe the appearance of new or noticeable shift of the absorption bands characteristic of the original polymers, i.e., there is no formation of new connections between the components to be mixed UI, and PET (Fig. 50.4).

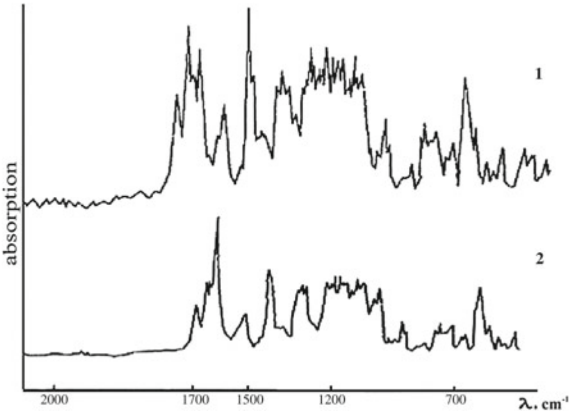

Fig. 50.4 IR spectra of the polymer composition PI/PET. *1* PI/PET (90 %: 10 %), *2* PI/PET (80 %: 20 %)

50.3 Conclusion

According to the research shows that the additive dependence of the viscosity of the composition of the components due to the fact that between the PI and PET is no formation of any links, as well as conformational changes are not observed.

The addition of a second polymer alters the morphology of polymer membranes. In this case, the morphology of thin membrane materials is more or less mesoporous.

With the increasing content of the final structure of the PET membrane becomes more porous with pore sizes up to 40 nm at 10 wt.% PET (Fig. 50.3). The increase of PET above 10–12.5 wt.% causes symptoms thermodynamic incompatibility of polymers in the form of formation of opaque membrane samples.

From the analysis of the IR spectra of the individual polymers and their mixtures that do not observe the appearance of new or noticeable shift of the absorption bands characteristic of the original polymers, i.e., there is no formation of new connections between the components to be mixed UI, and PET.

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