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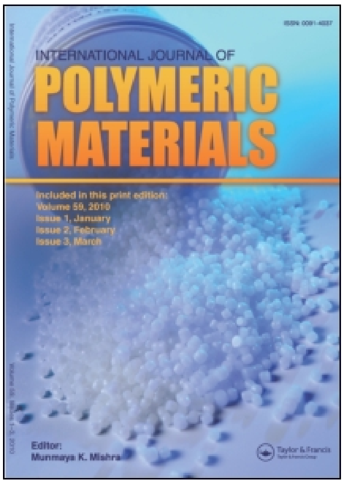

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The Effect of Mesomorphic Modifiers on the Mechanical and Protective Properties of Epoxy Composite Systems

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The Effect of Mesomorphic Modifiers on the Mechanical and Protective Properties of Epoxy Composite Systems

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This paper deals with the application of mesomorphic state compounds (MSC) as modifiers of epoxy compositions, which may have a significant influence on supermolecular level of epoxides and properties of coatings. The influence of MSC on the flow properties of epoxy oligomers, specific structural conversions and phisicomechanical properties of coatings has been studied. It has been shown that introducing MSC in amounts of 0.5–1% allowed the formation of coatings through the stage of thixotropical structurizing. It has been shown that selected MSC have polyfunctional properties and may work as relaxants of internal stresses, promoters of adhesion, inhibitors of corrosion and catalysts of film formation.

KEY WORDS Epoxy, composites, modifiers, mesomorphic.

Epoxy-resin based protective polymer coatings (PC) combine a wide range of valuable properties with low durability in biologically aggressive media, organic acids, etc.

By means of structural analysis methods the authors concluded[1] that these properties are caused by incomplete relaxation processes that result in the non-uniform defective structure in liquid and solid-state systems.

Oriented and ordered structures having some defects in polymer matrix and in surface layers of PC forming around the active fillers parcels as well as in substrate boundary layers.[2]

The aim of this work is to apply the mesomorphic state compounds as modifiers of epoxy compositions to regulate the supermolecular structure level of epoxides and the service life of PC.

Our decision to apply MSC as modifiers was taken because of their ability to create co-planar orientation in substrate boundary layers. By IR-spectra, MSC were shown to form chemical bonds with metal surfaces which have regular uniform distribution in the plane of the substrate.

Using high resolution nuclear magnetic resonance (NMR), it has been shown that incorporating some substitutes with donor-acceptor properties in MSC molecules allows the formation of a mesomorphic structure using the oriented molecules

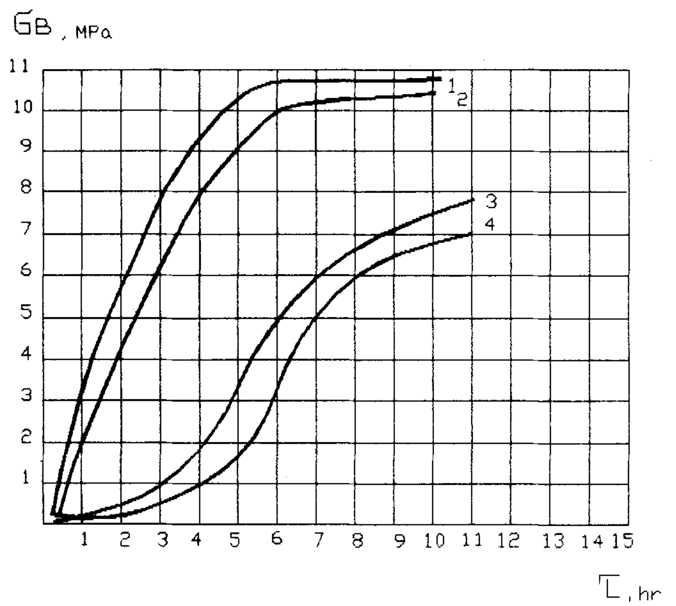

FIGURE 1 Kinetics of build-up of internal stresses in the formation of epoxy coatings at a temperature of 150°C (1), 120°C (2), 80°C (3), 20°C (4).

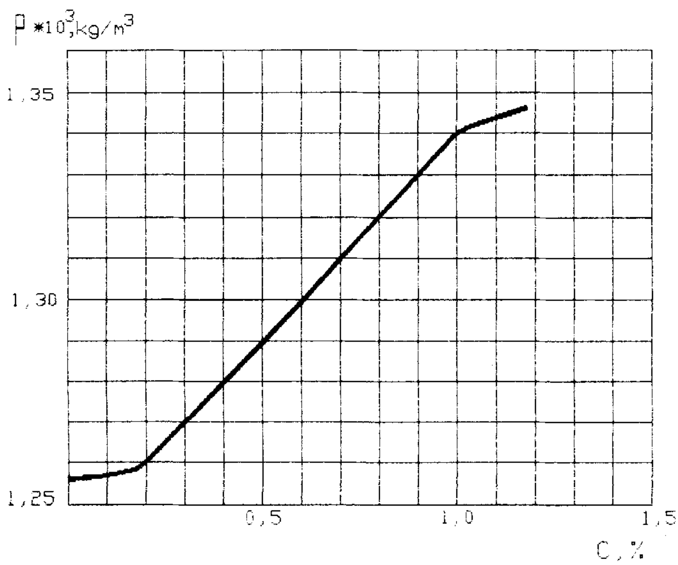

FIGURE 2 The effect of MSC content on the density of polymer coatings.

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TABLE I

The effect of additives on the mechanical properties of PC

Properties	MSC concentration, %			
	0	0,1	0,5	1,0
Adhesion strength, N/M	340	430	615	670
Elasticity (Young's) modulus, GPa	4,3	3,1	2,8	2,8
Breaking elongation, %	65	84	90	110
Tensile strength (σ_p), MPa	18,0	17,5	16,0	16,0
Internal stresses (σ_B), MPa	4,0	2,5	1,8	1,8
Hardness				
after 1 day	0,70	0,75	0,78	0,80
after 14 days	0,80	0,85	0,85	0,90

TABLE II

The effect of adding 1% MSC on the protective properties of PC

Media	Frequency capacitance coefficient	
	Amount of MSC, %	
	0	1
3% dairy acid		
after 1 day	0,76	0,95
after 14 days	0,63	0,93
1.5% caustic alcali		
after	0,96	0,95
Water		
after 1 day	0,95	0,94
after 14 days	0,95	0,94

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cause a noticeable increase in protective properties and the service life of PC. Such a mode of interface layers structurizing causes the internal stresses to drop while causing the adhesion strength in aggressive media to significantly increase.

Figure 1 illustrates the kinetics of developing internal stresses during the formation of epoxy-based coatings in various hardening conditions. It can be seen that the internal stresses in epoxy coatings are significant, with the largest being in the interface layers comparable with the adhesion and cohesion strength of PC.[3]

The structure defects cause comparably low protective properties of PC when exposed to model biochemical-active media such as organic and non-organic acids. The result is the increasingly selective electroosmosis of ions taking part in interfase corrosion processes.

The addition of not more than 1% of MSC results in optimizing the supermolecular organization and causes PC to undergo thixotropical structurizing.

From the data on the MSC effect on the rheological properties of epoxy composition, it was concluded that the original composition is a system with a low structure level. The addition of a modifier allows the creation of a thixotropic structure with a noticeable transition from upper to lower levels of a destroyed network in the narrow range of shear strength.

The creation of a mesomorphic structure in epoxide composition is confirmed by electronic microscopy as well as by increasing the density of reticulation following the concentration of MSC (Figure 2).

Table I shows the effect of MSC content on mechanical properties of epoxy-based PC. Adding MSC in small amounts of less than 1% results in a great increase in adhesion strength, elasticity, velocity of hardening, and reduces internal stresses without any noticeable changes in tensile strength.

The hardness of modified PC after one day was the same as for non-modified after 14 days.

The protective properties of PC were appreciated by changing the frequency of the capacitance coefficient (Kc) following the time of exposition in the aggressive model media such as 3% aqueous solution of dairy acid, 1.5% aqueous solution of caustic alcali and tap water. The closer Kc is to 1, the better the protective properties of PC.

It can be seen from Table II that MSC exhibits the properties of acid corrosion inhibitors. Additives-structurizers with mesomorphic structure have multi-functional properties and are capable of working as internal stress relaxators, adhesion promotors, corrosion inhibitors, and film formation catalysts. Depending on functional groups in macromolecular structure, MSC can play the role of PC colorants being added in small amounts (about 1%), resulting in a wide range of colors from blue to green.

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