Influence of poly(vinyl chloride) and polymer-silicate fillers on the properties of polyester resin

Diana Katruk, Volodymyr Levytskyi

Department of Chemical Technology of Plastics,
Lviv Polytechnic National University, UKRAINE, Lviv,
S. Bandery street 12, E-mail: SamoiliukD@gmail.com

Abstract – The influence of polymer modifier poly(vinyl chloride) (PVC) and polymer-silicate fillers on the physico-chemical regularities of structuring of unsaturated polyester resin have been investigated. It has been ascertained that addition of Zn-silicate fillers in polyester composition leads to slower curing speed, and the introduction of Ni-silicate fillers and PVC leads to accelerate the process of curing polyester oligomers. Physical-mechanical and corrosion properties of polyester materials modified by polyvinyl chloride and polymer-silicate fillers have been determined.

Key words: polyester, compositions, modification, polymer-silicate fillers, poly(vinyl chloride).

I. Introduction

The introduction of poly(vinyl chloride) (PVC) as a polymer modifier and polymer-silicate fillers into polyester composition will enable regulating the process of structuring connector through the formation of boundary layer with a lower degree of cross-linking [1]. Thus, the formation of coherent boundary layer, which is capable of deformation will reduce tensions on the border "polymer – filler" resulting from shrinkage and thermal deformation, as well as changes in the morphology and properties of polyester composites. These changes of the properties, especially rheological and physical-mechanical, are related to the influence of the filler on the structure and properties of a near-boundary layer of the polymer and the interaction between the filler particles themselves [2].

II. Experimental

For research was used unsaturated polyester resin brand Estromal 11.LM-02. As modifiers was used PVC brand Lacovyl PB 1156 and polymer-silicate materials, which were previously obtained by compatible precipitation of water-soluble silicates and polymers under the influence of metal chlorides of different nature [3,4].

The influence of PVC and polymer-silicate fillers (PSF) on physical-chemical properties of unsaturated polyester resins was performed by determining surface hardness and hardness by pendulum. The surface hardness of the samples was determined on Consistometers Hepplera at 293 K in pushing the polymer sample steel cone angle sharpening 58^0 08' under the weight of 5.0 kg for 60 seconds. Determination of hardness by pendulum was performed under ISO 1522-73.

Protective properties of coatings based on modified polyester composites in corrosion-active medium determined through research components of the system impedance metal – coating.

III. Results and Discussion

The introduction of nickel-silicate structures and PVC into the reaction medium leads to acceleration of the curing process of polyester compositions and the introduction of zinc-silicate structures has the opposite effect. This is likely due to a different effect of metals on all stages of the process of resins curing, especially at the stage of activation and the different nature of functional surface-active groups of fine polymer-silicate structures, including acid-base surface balance.

At the same time, in the case of forming the polyester composite including Zn-containing silicate filler that slows resin curing, the possibility of increasing the strength characteristics of the composite is created. However, in composites with a Ni-containing silicate filler that accelerates the process of connector structuring the conditions for the formation of structures with high internal stresses occur.

The introduction of poly(vinyl chloride) and polymer-silicate fillers also affects the performance criteria of polyester composites.

It should be noted that the polyester compositions show changes in physical-mechanical properties over time, as complete curing of polyester oligomers occurs within 10-30 days depending on the brand of polyester [5].

The values of surface hardness after aging for 28 days determined by two methods (using the Hepler consistometer (F) and by the pendulum (without heat treatment (H) та with heat treatment (H_{th})) are presented in Fig. 1.

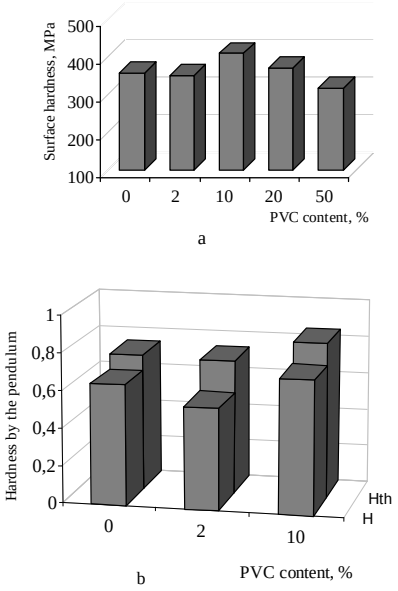

Fig. 1. Effect of PVC on surface hardness(a) and hardness by the pendulum (b) of polyester

As we can see, the hardness values defined by the two methods differing in the applied load vector are correlated with each other.

The introduction of PVC leads to the increase in surface hardness values by 10-50 MPa at its content in the composition about 10-20% by weight. Further increasing in the PVC content somewhat reduces the value of surface hardness, which is obviously due to a significant increase

in the heterogeneity of the system, the formation of interfacial areas where the density of a fluctuation mesh between structured polyester matrix and PVC macromolecules is reduced.

Heat treatment of polyester materials at 353-363 K leads to higher values for the pendulum hardness which is due to the additional structuring of polyester materials at the higher temperatures.

Composites containing some kind of metal-silicate formations have somewhat different patterns of changes in surface hardness compared to composites modified by PVC. The influence of the polymer-silicate filler and its composition on surface hardness of polyester resin is shown in Table. 1.

TABLE 1

EFFECT OF POLYMER-SILICATE FILLERS ON SURFACE HARDNESS OF POLYESTER COMPOSITES

№	Polymer-silicate filler*	F, MPa	Hardness by the pendulum	
			H	H_{th}
1	-	359,7	0,643	0,726
2	Ni	403,7	0,555	0,701
3	Zn	351,3	0,523	0,727
4	Co	375,2	0,656	0,767
5	Ba	436,4	-	-
6	Cu	446,1	-	-

* - a filler content of 2% by weight.

It is determined that the introduction of Ni-, Co-, Ba-, and Cu-containing silicate fillers leads to an increase of surface hardness values. However, in the case of the introduction of Zn-containing silicate filler the opposite effect is observed, that is surface hardness decreases slightly. These determined features are apparently caused by the varying impact depending on the nature of the cation of the polymer-silicate filler on the polymer matrix structuring processes, leading to the formation of polyester mesh with varying degrees of structuring and various interstitial molecular weight.

The influence of polymer-silicate fillers on the surface hardness of polyester composites modified by polyvinyl chloride is shown in Fig. 2.

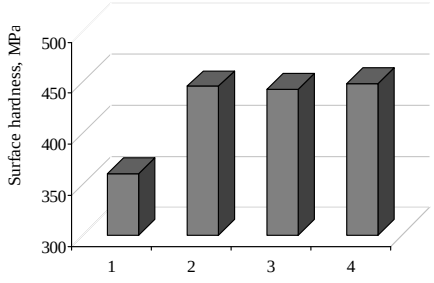

Fig. 2. Influence of PSF on surface hardness of the modified polyester resin (PVC content is 5% by weight; metal-containing silicate filler content is 2% by weight). Filler: 1- without filler; 2 – cobalt-silicate; 3 – cuprum-silicate; 4 – barium-silicate

Polyester composites modified by PVC which additionally contain metal-silicate fillers are characterized by high surface hardness values as opposed to a polyester resin modified by 5% PVC by weight. Thus, surface hardness values are almost identical.

To evaluate the protective properties of coatings based on modified polyester composites the impedance components of a system "metal – coating" were investigated in corrosion-active medium. This made it possible to estimate the changes of the dielectric properties of the polymer layer in the atmosphere and set the time when determining factor becomes the polarization resistance of electrode processes at the interface "steel – polymer coating" instead of the insulating properties of the coating itself.

It is revealed that the resistance of some modified polyester compositions, being high in the first days of research then dereased and approached the level of $1,5 \cdot 10^6$ Ohm·cm^2, indicating the penetration of aggressive environment to the steel substrate and loss of coating protective properties. After such a resistance reduction the appearance of the first points of corrosion can be observed on samples. The longest metal protection is provided by coverings on the basis of the modified polyester resin comprising poly(vinyl chloride) in an amount of 2% by weight and the nickel-silicate filler.

Conclusion

It is revealed that the process of resin curing and the properties of polyester composites modified by poly(vinyl chloride) is significantly impacted by the introduction both the polymer modifier and polymer-silicate fillers to the polyester composition. This allows adjusting the process of connector due to the structuring through the formation of coherent boundary layer with a lower degree of residual stresses.

It has been ascertained that modification of polyester composites by poly(vinyl chloride) allows adjusting the strength properties of the material. The introduction of PVC leads to the increase in surface hardness values by 10-50 MPa at its content in the composition of 10-20% by weight.

It was established that modified polyester materials containing PVC (in the amount of 2% wt.) and the nickel-silicate fillers have the highest corrosion resistance.

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