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MODIFICATION OF EPOXY RESIN SYSTEM WITH DIFFERENT ELASTOMERS

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ABSTRACT

Polymer composites were produced on the basis of a defined epoxy system filled with rubber crumbs and a SBS elastomer in variable ratios.

The rubber crumbs were introduced directly in the composites. The other elastomer (butadiene styrene copolymer) was dissolved in toluene in advance. One more series was carried out with the butadiene styrene copolymer (SBS-elastomer) dissolved in the active thinner used in the epoxy composition. The dissolving of this filler in the active thinner was proved.

The established physical-mechanical properties of the test samples, prepared from the investigated composites proved that they can be used in the preparation anticorrosion films with very good adhesion, impact strength and elasticity.

Keywords: Polymer composites, epoxy system, organic fillers, rubber crumbs, SBS elastomer.

INTRODUCTION

For many years it was considered that by mixing two or more polymers it would be possible to obtain materials with similar or improved properties. Basically such polymer materials have principally new properties which makes possible their use in a wider range of applications. The epoxy resin has a number of positive properties and the systems based on it have a wide range of applications. In order to improve certain specific properties like better tensile strength and bending elasticity, it is necessary to introduce some special additives.

The modification of the epoxy resins with elastomers is an alternative to improve the physical-mechanical properties and many authors have chosen such a modification to obtain very good results. The elastomers that can be used have to undergo in advance a particular surface processing.

Most often the use of the elastomers as modification agents aims at improving properties like impact strength [2, 3], tensile strength [4-6] and elasticity by the bond test. The density of the epoxy systems' network modified with rubber is also an object of interest too. Elastomers on a polyurethane base can also be used in the modification of epoxy systems achieving very good strength characteristics [9]. The modification of different materials with rubber crumbs is of interest depending of their use, for example: for roofing materials [11], thermoplastic products [12] and anticorrosion coatings [13]. Usually the rubber crumbs are made from scrap tires. The number of the scrap tires is huge – only in the USA each year an estimated 250 billions are piled up. So, the utilization of rubber crumbs system can have an ecological effect.

EXPERIMENTAL

The basic epoxy system to be modified was obtained from an epoxy resin (Epilox T 19- 38/500, produced by "Leuna Harze") and cured with a modified polyamin as a hardener (Epilox- Harter H 10- 30, produced by "Leuna Harze"). As a active thinner (Epilox P 13-18, produced by "Leuna Harze") was used. As modifiers two different elastomers were used. One of them was grinded rubber (scrap rubber crumbs from tires) and the other one was a butadiene styrene copolymer (SBS). The rubber crumbs were introduced in the epoxy system only as a phase modifier without being processed because they do not dissolve but only swell in the thinner. The SBS elastomer was introduced in two series - as a toluene solution and as a solution in active the thinner. The composites obtained were tested for the degree of cure by using standard method of extraction by acetone. The produced test samples were evaluated for physical and mechanical properties like tensile strength, permanent and relative elongation using a dynamometer according to BDS ISO 37:2002, elasticity at bending Dinstat, according BDS EN ISO 178:1996, Shore A hardness according to BDS EN ISO 868:2003, pendulous hardness according to BDS EN ISO 2039-2:2003 and adhesion according to EN ISO 2409.

Table 2. Data for the degree of cure of the composites from Table 1.

№ of sample (Table.1)	1	2	3	4	5	6	7	8	9
Degree of cure %	86.8	86.4	85.1	85.9	87.8	82.3	80.8	80.9	82.5

RESULTS AND DISCUSSION

Two types of modifiers – grinded rubber (rubber crumbs of scrap tires) and a thermoplastic elastomer SBS in different quantities were introduced in the defined composition to achieve the desired goals. The composition's components used i.e. epoxy resin-hardener-active thinner were in the following proportions given in Table 1. These proportions were established experimentally in a previous work [10].

Table 1. Composition of the produced samples.

№ of sample	Epoxy resin, g	Hardener, g	Thinner, g	Rubber crumbs, g	SBS Elastomer, g
0	3	0.75	1.711	-	
1	3	0.75	1.711	1.2	-
2	3	0.75	1.711	1.8	-
3	3	0.75	1.711	2.4	-
4	3	0.75	1.711	3	-
5	3	0.75	1.711	-	1.2
6	3	0.75	1.711	-	1.8
7	3	0.75	1.711	-	2.4
8	3	0.75	1.711	-	3
9	3	0.75	1.711	-	1.2
10	3	0.75	1.711	-	1.8
11	3	0.75	1.711	-	2.4
12	3	0.75	1.711	-	3

The obtained results for the degree of cure are given in Table 2. They show that the maximum degree of cure of all compositions is around 86 % and that the degree of cure in case of the modifier of grinded rubber is a somewhat bit higher than in the case of the filler of the thermoplastic elastomer SBS. Probably this is due to the fact that as far as the SBS rubber is well dissolvable in toluene it is also solvable in the active thinner as established in [10]. The physical and mechanical characteristics of the obtained compounds were determined by the standard methods. The results can be seen in Tables 3 and 4.

It is obvious that in the case of grinded rubber's filling the tensile strength value decreases on increasing the filler as modifier, which is due to the relative decrease of the basic binding component. Evidently, the optimum filling of the epoxy system for this component is between 40 % and 60 % as far as this component is concerned.

The observed for same the hardness according to Shore A. Logically, the higher degree of Shore A hardness in the composites is due to the higher content of epoxy resin in the system. The decrease of this index is not as drastic in comparison to the decrease of the tensile strength.

The determined values of the relative and permanent elongation obviously are influenced to a considerable degree by the component causing the elasticity, i.e. the grinded rubber. The highest degree at the lowest content of grinded material is due to

Table 3. Physical-mechanical properties of the composites filled with rubber crumb.

№ of sample (Table.1)	Tensile strength MPa	Elongation at break, %	Residual elongation, %	Hardness Shore A
0	9.8	45	5.5	75
1.	9.12	40	5.3	70
2.	8.62	28.6	4.3	41
3.	6.16	27.0	6.1	36
4.	1.96	38.6	7.6	32

Table 4. Physical-mechanical properties of the composites filled with thermoplastic elastomer SBS.

№ of sample (Table.1)	Tensile strenght MPa	Elongation at break , %	Residual elongation, %	Hardness Shore A
5.	3.9	30	6	66
6.	4.1	29	7	67
7.	4.7	30	7	70
8.	4.04	45	8.33	49

Table 5. Physical-mechanical properties of coatings with toluene.

№ of sample (Table.1)	Adhesion (B)	Elasticity of bending, mm	Impact resistance, cm	Hardness
5	1	1	50	0.643
6	1	1	50	0.61
7	1	1	50	0.55
8	1	1	50	0.50

Table 6. Physical-mechanical properties of coatings without toluene.

№ of sample (Table.1)	Adhesion (B)	Elasticity of bend, mm	Impact resistance, sm	Hardness
9.	1	1	50	0.455
10.	1	1	50	0.45
11.	1	1	50	0.41
12.	1	1	50	0.39

a synergism of the two basic components - the resin system and the filler.

The results obtained in the case of the SBS filler as a modifier can be interpreted in a similar way. In this case the change of the results for the relative elongation and the Shore A hardness is identical as in the case of the grinded rubber as modifier, but the value of the permanent elongation differs. The values of the tensile strength in the two cases are merely equal which is due to the above mentioned solving of the filler in the active thinner that makes the obtained composition more homogeneous. In this case, the values of the tensile strength depend to a greater degree on the presence of the SBS rubber in the system and that is why they are two times lower than the optimum values in the case of the grinded rubber.

The dependence between the changes of the bending strength and the concentration of the filler (grinded rubber and SBS respectively) are shown on the Fig. 1 and Fig. 2.

Both figures show how the bending strength according Dinstat decreases with the increase of the filler's quantity. At this relationship, the determined tendency that the physical-mechanical indices become worse when the quantity of the basic binding component decreases is preserved.

It was decided, in view to the nature of the SBS filler and its possibility to be solved in the active thinner as well, to investigate the possibility of producing surface coatings on the base of the compositions shown in tables 5 and 6. Two types of lacquer material were worked out - one containing toluene as solvent and one without it, only dissolving SBS in active thinner. In both cases the coatings have good physical-mechanical properties (Tables 5 and 6)

In case of the active thinner the advantage of the obtained films is in their ecological effect - they have no organic solvents.

In the case of presence of toluene it is easier to spread the lacquer and the coatings obtained are more homogeneous. There is a possibility to obtain thick layer surface coatings up to 100 μm. Referring the results of the physical-mechanical tests of the films given in tables

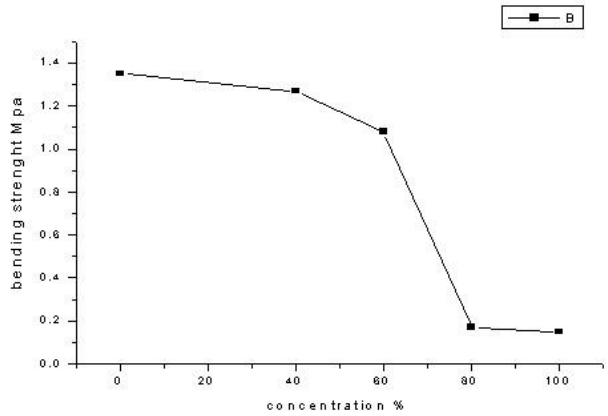

Fig. 1. Dependence of the bending strength on the quantity of the rubber crumb in sample.

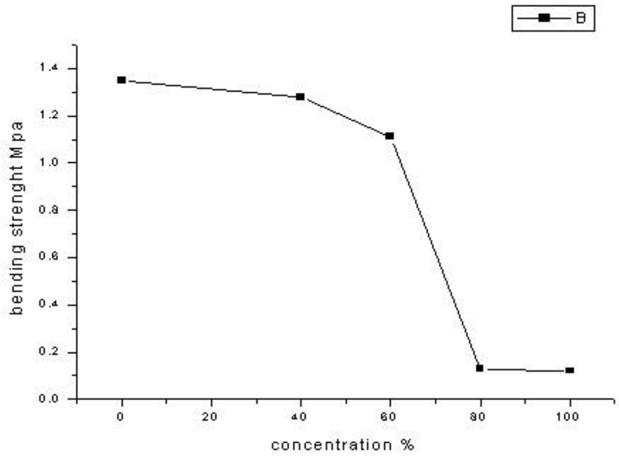

Fig. 2. Dependence of the bending strength regarding the quantity of the SBS elastomer in sample.

5 and 6, where the compositions differ on SBS content, it is evident that they can be used as anticorrosion coatings with very good adhesion, impact resistance and elasticity.

Regardless of the elastic character of the coatings especially those containing toluene, these coatings have satisfactory hardness. A decreased value of a film's hardness is due to an increase of the content of the active thinner, which makes lower the degree of cure.

CONCLUSIONS

The possibility to obtain epoxy composites with good elasticity, adhesion and hardness, suitable for flooring surfaces, was established.

The optimum quantitative proportions of the components in obtained epoxy composites were determined.

The possibility to obtain thick layer surface coatings on the base of developed epoxy composites was found.

REFERENCES

1. A. Vasilev, E. Djagarova, E. Levenson, Modifikacia na polimerite, Tehnika, Sofia, 1979.
2. V.D. Ramos, H.M.Costa, V.P. Soares, R.V. Nascimento, European Polymer Journal, **41,** 2005, 1043-1052.
3. M. Ochi, S. Shimaoka, Polymer, **36**, 1995, 1617-1675.
4. M. Ochi, T. Morishita, S. Kokufo, M. Harada, **40**, 1999, 1305-1312.
5. B. Pukanszku, F. Mauer, Europen Polymer Journal, **28**, 1992, 573-581.
6. T. Ijima, T. Horiba, M. Tomoi, European Polymer Journal, **27**, 1991, 851-858.
7. C. Kayanak, A. Arikan, T. Tincer, Polymer, **42**, 2001, 9687-9695.
8. T. Ijima, N. Yoshioka, M. Tomoi, European Polymer Journal, **28**, 1992, 573-581.
9. H. Tsung, S. Chun, Polymer, **37**, 1996, 2733-2742.
10. Z. Siemeonov, Diplomna rabota, UCTM, Sofia, 2005.
11. US Pat. 379229.
12. US Pat. 886646.
13. US Pat. 160016.