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EFFECT OF NANOFILLER NanoBent® ZW1 ON MECHANICAL PROPERTIES OF COMPOSITES CONTAINING GLASS REINFORCED POLYESTER WASTE

The influence of the amount of nanofiller on the mechanical properties of composites containing glass reinforced polyester waste have been tested. The earliest studies showed that using more than 10 wt.% recyclate in polyester composites significantly decreases the compressive and flexural strengths. In this work a preparation based on the polyester resin Polimal 109-32K (product of Organica - Sarzyna Chemical Works) and the nanofiller NanoBent® ZW1 - organophilized montmorillonite (product of ZG-M "Zębiec" S.A.) has been obtained. The filler was introduced to the compositions in the amounts of 1, 2, 3 wt.% of all the components. The mechanical properties of the composites have been investigated at room temperature.

It was observed that an addition of 1 or 2 wt.% nanofiller NanoBent® to composites with 10 or 12 wt.% recyclate causes a increase in the strength. Styrene diffuses into the galleries of the organoclay montmorillonite easily resulting in a decrease in the amount of styrene available for crosslinking in the medium. This decreases the chain length between the crosslink sites leading to higher strength. The addition of 2 wt.% nanofiller to the composite with 10 wt.% recyclate significantly influences the mechanical properties compared to the properties of the composite without the nanofiller. Glass reinforced polyester waste may be used in 10 wt.% to polyester composites with 2 wt.% nanofiller NanoBent® ZW1 to obtain building materials like window sills.

Keywords: material recycling, nanofiller, NanoBent®, glass reinforced polyester waste, mechanical properties

WPŁYW NANONAPEŁNIACZA NanoBentu® ZW1 NA WŁAŚCIWOŚCI KOMPOZYTÓW Z RECYKLATEM POLIESTROWO-SZKLANYM

Zbadano wpływ nanonapełniacza na właściwości mechaniczne kompozytów z recyklatem poliestrowo-szklanym. Wcześniejsze badania wykazały, że dodatek recyklatu powyżej 10% wag. obniża znacząco wytrzymałość na zginanie i ściskanie kompozytów. W pracy zastosowano recyklat z laminatów poliestrowo-szklanych i żywicę poliestrową Polimal 109-32K (produkt Zakładów Chemicznych Organica - Sarzyna) oraz jako nanonapełniacz: NanoBent® ZW1- organofilizowany montmorylonit (produkt Zakładów Górniczo-Metalowych „Zębiec" S.A.). Nanonapełniacz dodawany był w ilości 1, 2 i 3% wag. do całej kompozycji. Badano właściwości mechaniczne kompozytów poliestrowych w temperaturze pokojowej.

Zaobserwowano, że dodatek 1 lub 2% wag. nanonapełniacza NanoBent® ZW1 do kompozytów zawierających 10 lub 12% wag. recyklatu poliestrowo-szklanego powoduje wzrost wytrzymałości. Styren dyfunduje bardzo łatwo do galerii organofilizowanego montmorylonitu, a w związku z tym znajduje się go mniej w mieszaninie, co powoduje powstawanie krótszych łańcuchów polimerowych o lepszych właściwościach wytrzymałościowych.

Dodatek 2% wag. nanonapełniacza do kompozytów z 10% wag. recyklatem poliestrowo-szklanym wpłynął znacząco na poprawę właściwości mechanicznych w porównaniu do właściwości kompozycji nienapełnionej. Odpady laminatów poliestrowo-szklanych mogą być użyte w ilości 10% wag. jako napełniacze do kompozytów poliestrowych z 2% wag. nanonapełnaicza NanoBent® ZW1 do produkcji materiałów budowlanych, np. parapetów.

Słowa kluczowe: recykling materiałowy, nanonapełniacz, NanoBent®, odpady poliestrowo-szklane, właściwości mechaniczne

INTRODUCTION

Polymer/clay nanocomposites have been the subject of extensive research for the last 15 years. A great deal of research has been carried out on different polymer systems like epoxy, polyurethane, however, very little has been published on the clay - unsaturated polyester system [1-4]. Kornmann et al [1] reported that even at a low concentration (1.5 wt.%) of montmorillonite activated by sodium ions, the fracture energy of polyester nanoncomposites could be doubled. Suh et al [2] studied the mechanism of mixing unsaturated polyester with organophilic - treated montmorillonite. The styrene monomer moves more easily than uncured polyester chains. This may generate a higher styrene monomer concentration in the montmorillone gallery than in any other part in a simultaneous mixing system. If polymerization occurs in these conditions, the total crosslinking density of the sample decreases due to low concentration of the styrene in the uncured polyester

linear chains. Hence, the styrene monomers, which act as a curing agent, are much more dispersed inside and outside of the silicate layers as the mixing time increases. Therefore, the crosslinking reaction takes place homogeneously inside and outside of the silicate layers, and the crosslinking density reaches the degree of crosslinking density of cured pure polyester.

The objective of this study is to enhance the performance of polyester composites with a glass reinforced polyester recyclate. The earliest of our studies showed that glass reinforced recyclates may be used as fillers in new polyester composites, but increasing the amount of recyclate to 15 wt.% decreases the mechanical properties of the composites [5-7]. In this work polyester composites with different amounts of organic modified montmorillonite NanoBent® ZW1 were prepared and the mechanical properties have been studied.

EXPERIMENTAL

Materials

The wastes of glass fibre reinforced cold-cured polyester laminates were ground in a shredder manufactured in Kubala Sp. z o.o. The recyclate was a mixture of cured polyester resin particles and glass fibre.

TABLE 1. **Contents of particular components in composites**
TABELA 1. **Udział poszczególnych składników w kompozytach**

Formulation	Recyclate %	Nanobent %	Resin %	Dolomite dust, %
10 0	10	0	20	70
10 1	10	1	20	69
10 2	10	2	20	68
10 3	10	3	20	67
12 0	12	0	20	68
12 1	12	1	20	67
12 2	12	2	20	66
12 3	12	3	20	65
15 0	15	0	20	65
15 1	15	1	20	64
15 2	15	2	20	63
15 3	15	3	20	62
18 0	18	0	20	62
18 1	18	1	20	61
18 2	18	2	20	60
18 3	18	3	20	59

The materials used for the composites with glass reinforced polyester waste were:
- nanofiller NanoBent® ZW1 manufactured in ZGM Zębiec S.A., organophilized montmorillonite,
- unsaturated ortophthalic polyester resin Polimal 109-32 K - manufactured in "Organika-Sarzyna" Chemical Works S.A. (Poland),
- initiator (metyl ethyl ketone peroxide),
- accelerator (cobalt naphthenate),
- dolomite dust manufactured in Kambud Sp. z o.o.

The components in the composites used in this research are presented in Table 1.

The compositions were mixed with the initiator (in the amount of 0.01 wt.%) and the accelerator (in the amount of 1 wt.%) at 22°C in our laboratory. Specimens of 40x40x160 mm were made.

Mechanical tests

The mechanical properties (compressive strength and flexural strength) of the composites were measured by using a Universal Testing Machine EDB-60 according to PN-EN 12372:2007 and PN-EN 1926:2007 standards. In the flexural test, the gauge length was 100 mm.

Results

The flexural strengths and the compressive strengths of the composites with different amounts (10, 12, 15 i 18 wt.%) of recyclate without and with nanofiller are given in Figures 1 and 2.

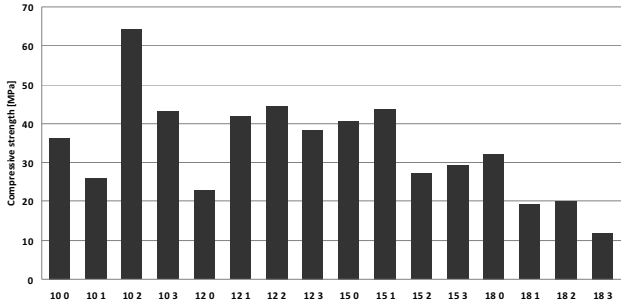

Fig. 1. Results of compressive strengths of composites with recyclate without and with nanofiller

Rys. 1. Wyniki badań wytrzymałości na ściskanie kompozytów z dodatkiem recyklatu bez i z nanonapełniaczem

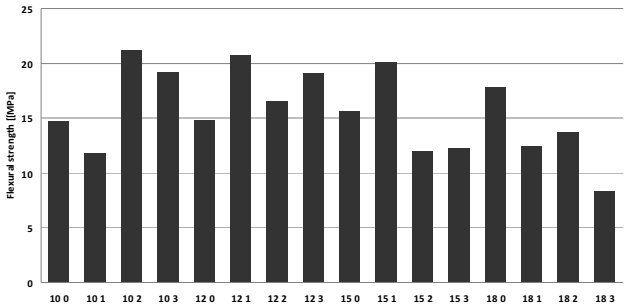

Fig. 2. Results of flexural strengths of composites with recyclate without and with nonofiller

Rys. 2. Wyniki badań wytrzymałości na zginanie kompozytów z recyklatem bez i z nanonapaełniaczem

The addition of 1 wt.% nanofiller to the composites with 10 wt.% glass reinforced polyester recyclate resulted in a reduction in compressive and flexural strengths. When the amount of nanofiller was increased to 2 wt.%, the compressive strength increased by up to

70% and the flexural strength - by up to 40% compared to the properties of the sample without the nanofiller. The values of the compressive strength and the flexural strength are near the standard recommendation for window sills [8]. This is a result of the high surface area attained by adding nanofiller to the polyester with recyclates. The polyester interacts with the filler surface forming an interphase of absorbed polymer and the overall polymer-filler adhesion increases due to the high surface area and thereby improves the strength. However, the addition of 3 wt.% nanofiller to this composite only slightly improves the mechanical properties. The decreasing trend of the strength above the filler amount of 2 wt.% can be attributed to the agglomeration of the filler at higher contents and decreasing the surface area available for the polymer-filler interaction.

The addition of 1 wt.% nanofiller to composites with a 12 wt.% recyclate increases the compressive strength (by 80%) and the flexural strength (by 40%) while the addition of 2 wt.% nanofiller increases the compressive strength (by 96%) and the flexural strength (by 11%) but further addition of 3 wt.% nanofiller increase the compressive strength (by 68%) and the flexural strength (by 29%) compared to the properties of the sample without the filler.

The addition of nanofiller to composites with 15 and 18 wt.% recyclates does not improve the mechanical properties of the composites. At a higher recyclate amount, the positive effects of the nanofiller are not observed because a high amount of recyclate can create a restriction to obtaining high crosslinking density, thus leading to lower strength.

CONCLUSIONS

The results of this work brought about the following conclusions:

1. Nanofiller NanoBent®ZW1 can either decrease or increase the compressive strength and the flexural strength compared to the unfilled composite with a glass reinforced polyester. The positive effect the nanofiller has on the mechanical properties is observed when the composites contain only 10 or 12 wt.% recyclate. This is because styrene diffuses through the galleries of the organoclay more easily owing to its smaller molecular structure than the polymer. This reduces the styrene amount available for crosslinking in the medium which is reason for the lower molecular weight between the crosslinking site, leading to restrictions for chain mobility and increasing the strength.
2. Nanocomposites comprising of 2 wt.% of NanoBent® ZW1 in the polyester composites with 10 wt.% glass reinforced polyester recyclate exhibited optimal mechanical properties.
3. Introduction of 1 wt.% nanofiller to the composites with 12 wt.% recyclate improves the compressive strength and the flexural strength.
4. Addition of the nanofiller to composites with 15 and 18 wt.% recyclated does not increase the mechanical properties.
5. Glass reinforced polyester waste can be applied only in the amount of 10 wt.% as a filler in building materials like window sills. By applying 2 wt.% nanofiller, improvements in all the mechanical properties are possible.

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