Vol. 3, No. 4, 2009 Chemistry

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COMPOSITES ON THE BASIS OF DISCRETE WOVEN FILLER AND POLYPROPYLENE

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Received: January 15, 2009

Abstract. Possibility of fabrication by the method of extrusion of composite on the basis of polypropylene and discrete filler in the form of the grinded fabric is studied. Influence on physical-mechanical properties and water absorption of obtained materials for the fillers of various chemical nature - fabrics on the basis of synthetic or/and natural fibers, their filling degree in polypropylene, as well as dependences of these properties on pre-award dressing of filler is estimated.

Keywords: composite polymeric material, polypropylene, grinded fabric, dressing, extrusion, physical-mechanical properties, water absorption.

1. Introduction

Composite polymeric materials are widely used in various branches of human activity. The significant role among them is played by materials on the basis of the reinforced thermoplastics containing filler in the fibrous form or in the form of sheet. Such combination of components allows to improve mechanical, electrotechnical, tribo-technical, and other properties [1]. Besides introduction of significant amounts of cheap fillers the price of the composites reduces.

Analysis of scientific and technical literature produced no mentioning on application of the grinded fabrics as fibrous filler [1, 2]. In this connection studying of the possibility of fabrication of composites of this type and an estimation of level of their properties (the possibility of using scrap (a waste of the textile industry and utilized clothes) for filling) is of considerable interest.

2. Experimental

2.1. Materials and Methods of their Processing

Different components have been considered as a starting material for discrete woven fillers. In large quantities manufactured fabrics containing various chemical fibers and their mixes – 100 % polyester (P), 100 % cotton (C), 65 % polyester - 35 % cotton (PC), 38 % polyester + 62 % viscose (PV) – were investigated. In brackets the filler code number is provided.

In the part of the work, connected with pre-award dressing of filler, polymethilsilicone liquid PMS 400 was used as dressing being entered in 0.5 mas % of the filler. Preliminarily a dressing shot was dissolved in toluene in quantity which provides full wetting of the filler. The holding stage of wetting woven filler (grinded to fragments (5x10 mm) was carried out for 24 h, and then the grinded fabric was distributed in a shallow layer on the pallet and seated in a furnace at the temperature of 393 K. Dwell time in a furnace was 8–12 h – till full solvent release, that was estimated by the weighting method. The filler processed thereby was further used for obtaining of composites.

For dressing fabric consisting of 65 % polyester + 35 % cotton has been used. For comparison a series of compositions with dressing (PCa) and undressing (PC) filler of the same nature has been obtained and tested. In brackets the filler code number is provided. A highest possible degree of filling in polymeric composition has been reached for PC – 15 mas % and for PCa – 20 mas %.

The general technological approach in obtaining of composites consisted in preparation of a mixture of granules of initial isotactic polypropylene of mark H-3781 and preliminarily grinded to 5x10 mm fragments of woven filler in a melting-plate screw extruder [3], following which granulation of the extrudate and obtaining of the samples for the subsequent tests by a method of injection moulding was done.

Mechanical mix of polypropylene and discrete woven filler (from 3 to 20 mas %) was manufactured in an extruder with the following parameters of the process: working backlash between a disk and a case 2 mm; velocity rotation of a disk 100 rpm, temperature 473–193 K, diameter of a spinneret on extruder exit 10 mm. An extrudate in the form of a strand was granulated in a granulator, obtaining cylindrical granules 10 x 5–10 mm in size.

Processing of the compositions by injection was carried out on moulding machine “KUASY” with shot volume of 25 smi. At pressure 100 MPa and temperature 473–483 K the following kinds of test pieces were obtained: shovels (150 ± 5 x 4 ± 0.3 x 10 ± 0.2 mm), small bars (50 ± 1 x 6 ± 0.2 x 4 ± 0.2 mm), big bars (150 ± 5 x 14 ± 0.5 x 10 ± 0.3 mm), disks (60 ± 0.1 x 2 mm). Before the tests the samples were conditioned at ambient temperature for 48 hours.

2.2. Test Methods

Breaking strength σ_b, extension strain ε, residual strain ε_r, Charpy impact strength (notched samples σ_{im} or unnotched samples $\sigma_{im}{}^{I}$), bending stress σ_f and water adsorption w of the composites and initial materials have been estimated.

Stretching tests were made on a tension testing machine FP-10 at ambient temperature (293 K) and clips traveling speed of 20 mm/min in accordance with GOST 11262-76 on specimens of type A.

Static bending tests for 1.5 thickness of the sample were made on tension testing machine FP-10 at ambient temperature (293 K) and clips traveling speed of 20 mm/min in accordance with GOST 4648-71 on specimens of type A.

Charpy impact test was run in accordance with GOST 4647-80 on small unnotched bars and on big notched bars on impact tester KM-4 (a hammer No.2) at ambient temperature (293 K).

Swelling value in an aqueous medium of specimens in the form of disks immersed in distilled water at ambient temperature (293 K) for 1, 3, 5, and 7 days was estimated by the change of their weight.

For all compositions a series of five samples were used in each kind of the tests. All obtained results are statistically processed with confidential probability of 95 %.

3. Results and Discussion

Experimental data regarding the influence of polypropylene filling degree by the discrete fillers on the properties of the obtained composites are presented in Figs. 1-7. Basic possibility of obtaining composites on the basis of the polypropylene filled to 10 mas % by the grinded fabrics of the various chemical nature (on the basis of synthetic, natural, or mixed type fibres) using the extrusion method is shown.

Breaking strength σ_b (Fig. 1) does not change essentially for all fillers at the filling degree from 0 to 10 mas %. At the same time extension strain ε (Fig. 2) and residual strain ε_r (Fig. 3) for all compositions sharply decrease, reaching values of some percent at maximum filling degree. Smoother character of the dependences of the above-mentioned properties can be noticed only for woven PC filler, whereas in other cases the 5-7 fold decrease of these indexes takes place already at admission degree of 3 mas %. Charpy impact strength decreases sharply for notched (Fig. 4) and unnotched (Fig. 5) specimens of all composites, *i.e.* introduction of a filler of the fibrous nature into a polymeric composition produces no reinforcing effect as it might be expected. Especially essential decrease of Charpy impact strength σ_{im} is observed at small filling degree (3 mas %), which could be explained by heterogeneity of the composition due to non-uniform filler distribution. The further gradual growth of impact strength with the increase in filling degree testifies to this assumption.

Only for bending stress σ_f (Fig. 6) monotonous growth from 6 MPa (for initial polypropylene) to maximum 8.3 MPa (in case of filler) is observed with the increase of all considered woven fillers content in polymeric composition.

Water adsorption of composites in an aqueous medium (Fig. 7) has showed expected results. With the increase of the hydrophobic filler (polyester fabric) in the composition this index decreases from 0.4 mas % for the initial polypropylene to 0.1 mas %, whereas increase of

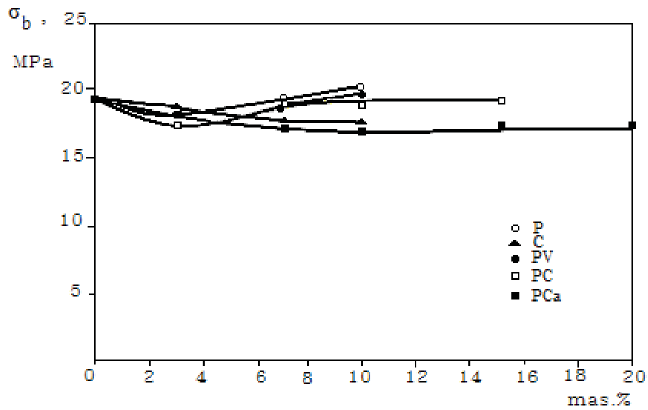

Fig. 1. Dependence of the breaking strength σ_b, of composite materials on the content, nature and dressing of the filler

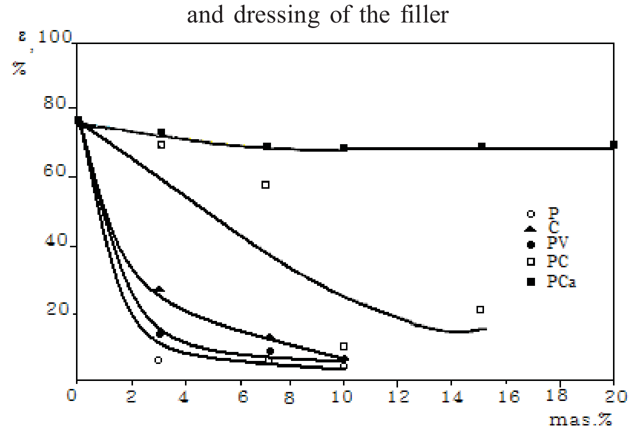

Fig. 2. Dependence of the extension strain ε of composite materials on the content, nature and dressing of the filler

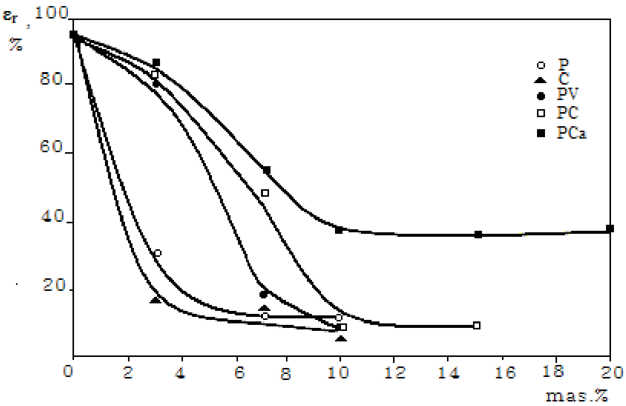

Fig. 3. Dependence of the residual strain ε_r of composite materials on the content, nature and dressing of the filler

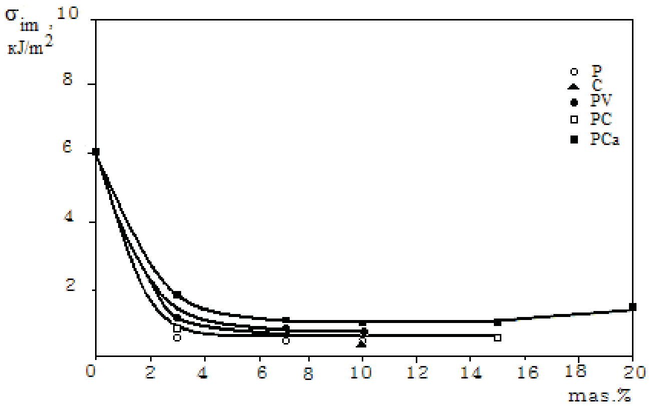

Fig. 4. Dependence of the Charpy impact strength (notched samples) σ_{im} of composite materials on the content, nature and dressing of the filler

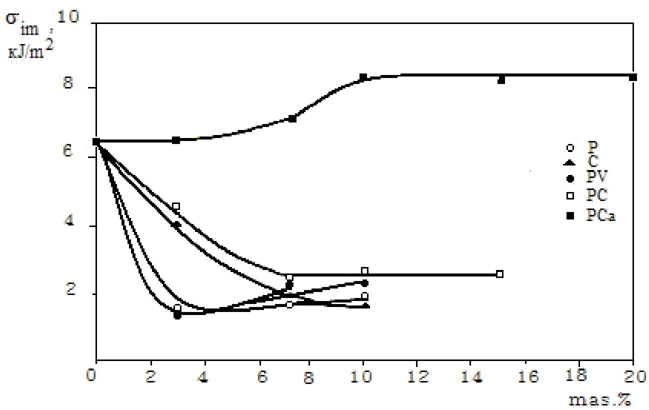

Fig. 5. Dependence of the Charpy impact strength (unnotched samples) $\sigma_{im}^{\prime}$ of composite materials on the content, nature and dressing of the filler

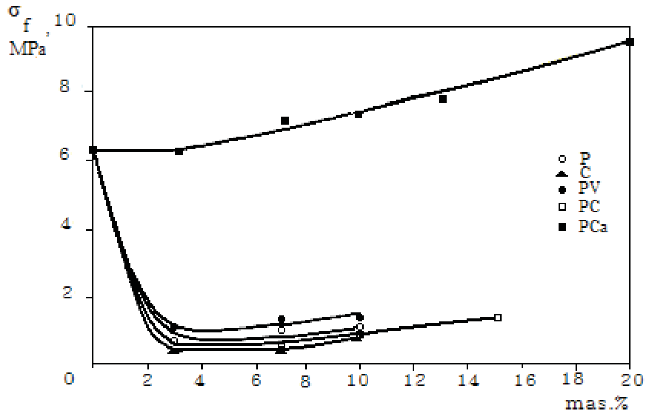

Fig. 6. Dependence of the bending stress σ_f of composite materials on the content, nature and dressing of the filler

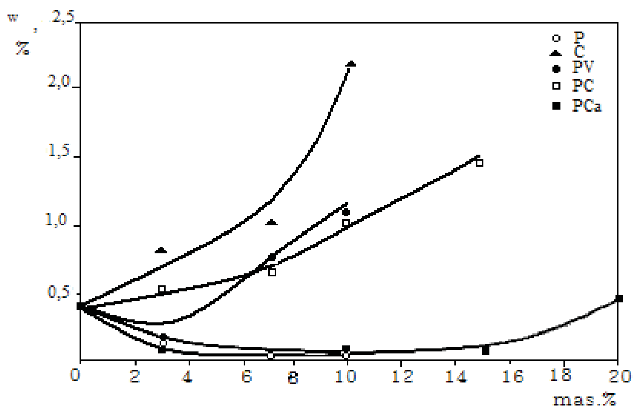

Fig. 7. Dependence of the water adsorption *w* of composite materials on the content, nature and dressing of the filler

hydrophilic fillers content (cotton fabrics) shows substantial growth of water adsorption – to 2.2 mas %. Increase of the mixed **PC** filler (containing cotton fibre) in the composition also resulted in water absorption increase, but to a lesser degree (to 1 mas %).

As one can see the obtained materials have quite satisfactory physico-mechanical properties though still are inferior to the initial polypropylene. As the positive aspect it is necessary to note the possibility of price reduction of the composites at the expense of introduction of significant amounts of cheap fillers like the woven fabrics which are subject to utilization.

Within the scope of this paper it was of interest to study the possibility to increase the filling degree of the composites on the basis of polypropylene and considered before grinded fabrics for the purpose of their price reduction and increase of their strength characteristics. This fact might be expected while adding of the grinded fabric scraps to thermoplastic polymer (it can be considered at the first approximation as a composite polymeric material with chaotically distributed discrete fibres) resulting in the increase of material stability under the conditions of static loading at stretching, compression, bending and impact load [3-5].

The data presented in Figs.1-7 for the considered polymer–filler system show that the obtained composite with low filling degree (3–5 mas %) has high heterogeneity. It is caused by non-uniform distribution of large particles of fabric in polymeric matrix, which results, as it is noted in [6], in the sharp decrease of such hardness indexes as impact strength, breaking, stretching and bending stress in comparison with the initial polypropylene. The growth of the filling degree leads to the increase of the composite uniformity and, as a consequence, to gradual growth of the above indexes, which is the general tendency for all considered woven fillers irrespective of the chemical nature of the fibres they consist of.

From the aforesaid it is expedient to consider the properties of polypropylene–woven filler system with higher filling degree. However the technological approach based on the using of undresses filler, has provided the maximum filling degree at 10 mas %. With significant technological difficulties due to extremely low flow of a composition at extruding it was possible to reach 15 mas % of the filling.

Preliminary dressing of the grinded fabric has been considered for increasing of the flow of compositions (mechanical mix of polypropylene with filler) at extrusion and raising the filling degree.

In Figs. 1-7 influence of dressing of discrete filler and its content in polypropylene composite on a number of properties is shown.

Breaking strength σ_b (Fig. 1) remains approximately at the level of the initial polypropylene for dressed and undressed filler in the interval from 3 to 20 mas % of filler. Extension strain ε, (Fig. 2) as well as residual strain ε_r (Fig. 3), considerably decreases, which is natural for the filled polymeric systems, but for compositions with dressed filler growth of this index (to 50 %) at high degrees of filling is observed, *i.e.* the obtained materials possess high plastic properties.

Charpy impact strength σ_{im} (notched specimens) for the filled compositions is substantially lower, than for the initial polypropylene; only at high filling degree small growth of this index is observed (Fig. 4). On the other hand, the increase of filler content to 15 mas % in case of its dressing leads to approximately 1.5 times growth of Charpy impact strength σ_{im}^{1} (unnotched specimens, Fig. 5) in comparison with the initial polypropylene. In case of undressed filler the increase of this index only to 2 кJ/m^2 is observed.

Bending stress σ_f (Fig. 6) monotonously increases with filler content growth, reaching 8.7 MPa at 20 mas % of woven filler, and 6 MPa for the initial polypropylene.

Dressing is also advantageous for water adsorption w index (Fig. 7) of the considered system. Deterioration of this index for the compositions including filler with 35 mas % content of hydrophilic fibres (cotton), is natural. However, dressing of the hydrophobic fibres surface results approximately in 3 time decrease of this index at maximum filling degree compared with the initial polypropylene.

4. Conclusions

The analysis of the results of the researches obtained at the first stage has allowed to conclude about the possibility of fabrication of the various composites on the basis of polypropylene and discrete woven fillers by the melting-plate screw extruder method and their subsequent processing by injection moulding in products with satisfactory physico-mechanical properties.

The further researches show that for the studied composites preliminary dressing of filler allows to considerably increase the filling degree and to provide essential improvement of such properties as Charpy impact strength (unnotched spacimens), bending stress and water adsorption.

Considering the opportunity of utilizing large quantities (up to 20 mas %) of cheap woven fillers, it has been shown that such composites can find wide range of application as construction materials.

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КОМПОЗИЦІЙНІ МАТЕРІАЛИ НА ОСНОВІ ДИСКРЕТНОГО ТКАНОГО НАПОВНЮВАЧА Й ПОЛІПРОПІЛЕНУ

Анотація. *Вивчено можливість одержання методом екструзії композиційного матеріалу на основі поліпропілену й дискретного наповнювача у вигляді здрібненої тканини. Оцінено вплив на фізико-механічні властивості й водопоглинання одержуваних матеріалів наповнювачів різної хімічної природи – тканин на основі синтетичних і натуральних волокон, ступеня наповнення ними поліпропілену, а також залежності цих властивостей від попереднього апретування наповнювача.*

Ключові слова: *композиційний полімерний матеріал, поліпропілен, здрібнена тканина, апретування, екструзія, фізико-механічні властивості, водопоглинання.*