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Thermoplastic elastomer blends based on waste rubber and low-density polyethylene

Summary — Materials based on waste rubber from discarded tires and low-density polyethylene (PE-LD) have been studied. The blends were prepared *via* compounding of molten PE-LD with ground rubber (average particle size 0.4 mm) in an internal mixer. The products behaved like thermoplastic elastomers. To improve mechanical properties of the blends, various compatibilisers (dicumyl peroxide, sulfur system) were added. The best materials had tensile strength 8.6 MPa and elongation at break 260 %.

Keywords: waste rubber, low-density polyethylene, blend, mastication, mechanical properties.

MIESZANKI ELASTOMERÓW TERMOPLASTYCZNYCH OTRZYMANE Z ODPADOWEJ GUMY I POLIETYLENU MAŁEJ GĘSTOŚCI

Streszczenie — W ramach pracy badano materiały wykonane z wykorzystaniem odpadów opon i polietylenu małej gęstości (PE-LD). Mieszanki sporządzano łącząc w mieszalniku stopiony PE-LD z rozdrobnioną gumą (średni rozmiar cząstek wynosił 0,4 mm) w temperaturze 150 °C, w przypadku mieszanek bez kompatybilizatora, a 180 °C w przypadku mieszanek z kompatybilizatorem. Uzyskany produkt miał cechy elastomeru termoplastycznego. Zbadano wpływ rodzaju i ilości użytego kompatybilizatora na właściwości mechaniczne otrzymanych mieszanek. Najlepszy materiał charakteryzował się wytrzymałością na rozciąganie o wartości 8,6 MPa i wydłużeniem przy zerwaniu 260 %.

Słowa kluczowe: guma odpadowa, polietylen małej gęstości, mieszanki, plastyfikacja mechaniczna, właściwości mechaniczne.

Waste treatment is one of the global problems of the mankind. Rubber, and mainly used tires present substantial part of the waste. 10 million of tires were discarded worldwide in 2001 [1]. Used tires can be recapped or retreaded supposing their carcasses are in good condition. Otherwise the tires have to be disposed of. The simplest way is to trash them to landfills. However, polymeric materials do not decompose easily. Tires discarded in landfills cause mosquito breeding and fire hazard. This poses a serious environmental problem. It is also not economically feasible because value added is zero or even negative. For these reasons, landfilling has been prohibited in many countries [1, 2].

Waste tires can be incinerated in cement kilns or special devices to obtain energy (electricity, steam *etc*.). Rubber serves as a fuel with caloric value higher than 30 MJ/kg [1, 2]. The energetic content of rubber and organic additives (including carbon black) can be exploited. To exploit the chemical content of rubber, pyrolysis can be carried out to produce oils and gases which can be transformed into various fuels or solvents. Carbonic residue is formed and it can be used as a low-grade filler for new rubber compounds, however the quality of this filler is inferior to the original carbon black. Nevertheless, the process is mostly commercially unprofitable [2]. Reclaiming of rubber is a common process which involves conversion of a crosslinked, thermoset polymer to a partially thermoplastic, processable and vulcanizable product possessing many of the properties of virgin rubber. Various physical and chemical reclaiming procedures have been developed. However, there is no way to obtain the original rubber and the additives. Along with increasing demand on rubber goods quality, the utilization of reclaimed rubber is limited [2].

Another branch of waste tire management is material recycling. Waste rubber is ground (at ambient temperature or cryogenically) and the product has wide application possibilities. It can be mixed with a binder (thermoset resin or liquid rubber) to form new material which can be used to construct playgrounds, parking lots, or produce railroad sleepers, bank stabilizers, noise barriers *etc.* [2]. Milled waste rubber can also serve as an additive to

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asphalt [3] or concrete [4]. Very fine powder from rubber waste can be used in compositions with virgin rubbers [5].

A route to a high level of quality is offered by blending rubber powder with thermoplastics to form materials similar to thermoplastic elastomers. Thermoplastic elastomers (TPEs) having characteristics of elastomers while retaining processing and recycling abilities of thermoplastics, have been of serious interest to scientists and manufacturers for many years [6]. Thermoplastic vulcanizates (TPVs), blends obtained by dynamic vulcanization of rubber in thermoplastic matrix are of particular interest [7]. Similar materials can be prepared by replacing a part or total amount of the virgin rubber by ground waste rubber (GR). Blends based on GR, mainly from used tires, and thermoplastics have been investigated by many researchers [8—21]. Their products were more or less similar to thermoplastic elastomers. Various thermoplastics have been investigated, either neat or scrap. Polyamides have been rarely used for this purpose [8]. However, for blending with common non-polar ground waste rubber, thermoplastics possessing also low polarity seem to be the most suitable. Egodage *et al*. [9] prepared blends of GR and isotactic polypropylene (iPP). Michael *et al*. [10] and Mennig *et al*. [11] also blended GR with iPP, however, good results comparable with commercial thermoplastic vulcanizates were only achieved when creating bonds between the rubber particles and the thermoplastic matrix, which was obtained by using sulfur, peroxides, polyfunctional monomers and reclaiming agents and adjusting a special regime of the most important processing parameters. Xin *et al*. [12] prepared expanded composites from GR/PP using a single-screw foam extrusion setup and chemical blowing agent. Sonnier and *co*-workers [13] investigated influence of γ-ray treatment on properties of blends of ground tire rubber and high-density polyethylene (PE-HD). The efficiency of such reactive compatibilization depends greatly on the chronology of γ-irradiation and injection-molding steps. Guo *et al*. [14] dealt with thermoplastic elastomers from scrap rubber powder and linear low-density polyethylene (PE-LLD) treated with dual compatibilizer consisting of PE-LLD grafted with maleic anhydride, methyl methacrylate and butyl acrylate and epoxidized natural rubber (ENR). The mechanical properties, especially elongation at break were improved significantly after compatibilization. Grigoryeva *et al*. [15] prepared thermoplastic elastomers based on recycled PE-HD, ethylene-propylene-diene terpolymer (EPDM) and ground tire rubber (GR) treated with bitumen. It was concluded that bitumen acts as an effective devulcanizing agent in the GR treatment stage. In the following steps of TPE production, bitumen acts simultaneously as a curing agent for the rubber components (EPDM/GR) and as a compatibilizer for the blend components. Li *et al*. [16, 17] synthesized PE-HD/ground rubber powder (GR) composites modified with various elastomers (ethylene-propylene copolymer, EPDM, ethy-

lene-octylene copolymer) and dicumyl peroxide and/or dimethyl silicon oil. The rheological behavior, dynamic mechanical properties, and morphology observation suggested that an enhanced adhesion between GR and polymer matrix formed in the modified PE-HD/GR composites. Naskar *et al*. [18] used rubber hydrocarbon of ground rubber tire (rGRT) as a partial substitute for EPDM in a dynamically vulcanized EPDM/acrylic-modified PE-HD blend. The 60:40 rubber/plastic blend was found to behave like a thermoplastic elastomer, and it was observed that 50 wt. % of EPDM can be replaced by rGRT without deterioration of properties.

Low-density polyethylene (PE-LD) can be used for blending with ground waste rubber as well. Radhesh Kumar and *co*-workers [19] investigated TPEs based on ground tire rubber (GTR, particle size 0.4—0.7 mm, untreated or thermomechanically decomposed), PE-LD and fresh rubber (natural rubber, styrene-butadiene rubber, EPDM) prepared with and without dynamic curing *via* sulfur or peroxide. The best performance was achieved by recipes containing decomposed GTR and EPDM after dynamic vulcanization with sulfur. This was attributed to dual compatibilizer effect of EPDM. Nevatia *et al*. [20] prepared thermoplastic elastomeric compositions from reclaimed rubber and scrap PE-LD. The 50:50 rubber/plastic ratio was found to be the best for processability and ultimate elongation. A sulfur-accelerator system was found to be better than a peroxide system for dynamic crosslinking. Grigoryeva *et al*. [21] chose a more complex procedure *via* pre-functionalization of waste PE-LD or PE-HD with maleic anhydride and GTR with maleic anhydride or acrylamide. The grafting was induced chemically or using γ-rays. High performance TPEs were prepared from these materials and EPDM.

The aim of our work is to study blends based on ground rubber from discarded tires and neat thermoplastic polymer. For this purpose, a thermoplastic with low melting temperature is suitable to prevent thermal degradation of rubber during processing. To be thermodynamically compatible with common non-polar types of rubber, a non-polar thermoplastic has to be used. For these reasons, low-density polyethylene (PE-LD) has been chosen.

EXPERIMENTAL

Materials

Ground waste rubber (GR) from discarded passenger tires prepared *via* mechanical grinding at ambient temperature was supplied by Montstav Cz (Czech Rep.), with average particle size 0.4 mm.

Low-density polyethylene (PE-LD) with trade name *Riblene FL 24* was supplied by Polimeri Europa SAS (France).

Ethylene-propylene-diene rubber (EPDM) with trade name *DUTRAL 4038* which contents of bound ethylene,

propylene and ethylidennorbornene of 68.5, 27 and 4.5 %, respectively, was supplied by Enichem (Italy).

Natural rubber (NR), SMR-20 grade, was supplied by Malaya Rubbers (Malaysia). A mixture of 40 % of dicumyl peroxide with 60 % of clay (DCP) named *Perkadox BC 40* was produced by Akzo (the Netherlands).

Three accelerators of sulfur vulcanization were used:

— tetramethylthiuram disulfide (TMTD, trade name *Vulkacit Thiuram*) manufactured by Bayer (Germany),

— 2-mercaptobenzothiazol (MBT, trade name *Pneumax MBT*) produced by Istrochem (Bratislava, Slovakia),

— TDDP (technical mixture of O-2-ethylhexyl- and O-isopropyl thiophosphoryl tetrasulfides, trade name *Sulfenax* TDDP) available from Istrochem (Bratislava, Slovakia).

Sulfur, zinc oxide, stearic acid were of standard grades for rubber industry. All the materials and chemicals were used as received.

Blend preparation

Blends contained 50 wt. % of thermoplastic phase and 50 wt. % of elastomer phase which was composed of either ground waste rubber solely or of 1:1 mixture of ground waste rubber and virgin one (EPDM or NR). To improve material properties, compatibilization system was added to some of the blends. The first compatibilization system — Perkadox BC 40 which is a mixture of dicumyl peroxide and clay was added in concentrations of 0.4, 0.8 or 1.5 weight parts per 100 weight parts of polymers. Sulfur compatibilization system contained: 5 parts of zinc oxide, 1 part of stearic acid, 0.5 part of MBT, 2 parts of sulfur and 1 part of common accelerator TMTD per 100 weight parts of polymers. In some blends TMTD was replaced by ecological nitrosamine-safe TDDP, the concentration of which had to be increased to 2.6 parts/100 weight parts of polymer due to its higher molecular weight compared with TMTD. The blends were labeled as follows: L stands for PE-LD, E for EPDM, N for NR, G for ground rubber, M for masticated ground rubber; thus LG means the blend consisting 50 wt. % of PE-LD and 50 wt. % of ground rubber, LEG is the blend consisting 50 wt. % of PE-LD, 25 wt. % of ground rubber and 25 wt. % of EPDM, *etc.* LEM blends were also prepared with PE-LD concentration different from 50 wt. %. Their compositions are reported in Table 1.

The blends were prepared using an internal mixer, Plasti-Corder Lab-station (Brabender, Germany) provided with 50 cm^3 mixing chamber. At the beginning of the mixing cycle, elastomer phase was heated and mixed in the chamber for 2 min. The mixing temperature was higher than the melting temperature of the thermoplastic matrix, namely 180 °C and 150 °C for blends with and without compatibilizer, respectively. After that, PE-LD and the compatibilizing system were added and mixed for 8 min under the same conditions. The rotor speed of 40 rpm was decreased to 20 rpm

during feeding the chamber. The optimum total weight of the batch was 46 g.

T a b l e 1. Compositions of LEM blends with different PE-LD concentration

Blend symbol	Concentration, wt. %		
	PE-LD	EPDM	masticated GR
LEM(25)	25.0	37.5	37.5
LEM(32)	32.0	34.0	34.0
LEM(37.5)	37.5	31.3	31.3
LEM(44)	44.0	28.0	28.0
LEM(50)	50.0	25.0	25.0

Ground Rubber Mastication

In particular cases, the ground rubber was masticated prior to use to obtain better compatibility of ground rubber with thermoplastic matrix. The process was performed in a laboratory two-roll mill (150 mm in diameter, 400 mm in length) at ambient temperature until the ground rubber formed a compact material, which took 10 to 15 min.

Methods of testing

All prepared materials underwent tensile tests. Other tests were performed only for the materials with both tensile strength higher than 7 MPa and elongation at break higher than 100 %.

Tensile tests

In order to do tensile tests, sheets (14.5 × 14.5 cm, 1.0 to 1.8 mm thick) were prepared by compression molding in a hydraulic press at 150 °C. At first, the blends were heated under slight pressure for 2 min. After that, the blends were pressed at 10 MPa for 3 min. Then, the mold was cooled in a water-cooled hydraulic press for 5 min. 10 dumbbell specimens for tensile tests 4 mm in width were cut from each sheet. Tensile testing was performed on Instron Universal Testing Machine, type 3365 (Instron, USA) according to ISO 37:2005 with one exception — due to partially thermoplastic nature of the product, the crosshead speed was lowered to 50 mm/min. Tensile strength (as stress at break) and elongation at break were evaluated.

Rebound resilience tests

For rebound resilience tests small cylinders (28 mm in diameter and 12 mm in height) were compression molded. The molding conditions were the same as mentioned above. Rebound resilience tests were performed according to ISO 4662:2009.

Hardness tests

The small cylinders from rebound resilience tests were used also for hardness tests. The data were obtained using manual durometer Shore D (Mitutoyo, Japan) according to ISO 7619-1:2004.

Test of recycling ability of the blends

The rests of films and broken tensile specimens were recycled by kneading in the mixer. Torque was recorded during mixing. The process was performed at chamber temperature 150 °C with rotor speed of 25 rpm and with kneading time 6 min. From the obtained recyclates new films were molded, tensile specimens were cut and tested under the same conditions as for the original materials.

RESULTS AND DISCUSSION

Tensile properties

Tensile properties of the prepared blends are shown in Figure 1 and 2. Figure 1 shows the positive effect of mastication of ground rubber on the tensile strength of the prepared materials. Tensile strength of LM is by 40 % higher
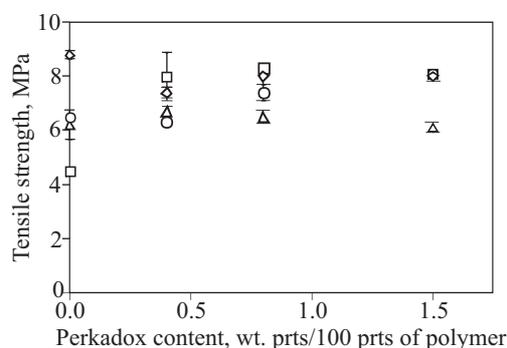
Fig. 1. Tensile strengths of the blends: ■ — LG, ▲ — LEG, ● — LM, ♦ — LEM(50); for description of blend symbols see text and Table 1
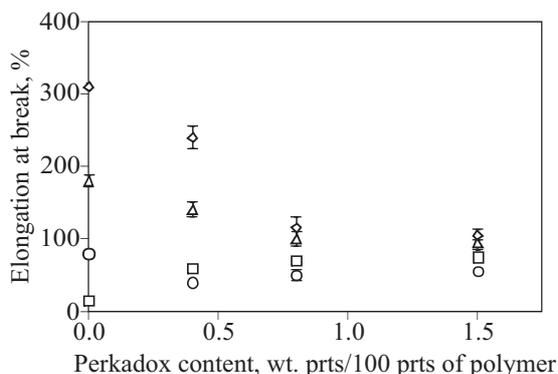
Fig. 2. Elongations at break of the blends: ■ — LG, ▲ — LEG, ● — LM, ♦ — LEM(50); for description of blend symbols see text and Table 1

than that of LG. The same change was observed comparing LEM(50) with LEG. Surface of ground rubber is expected to be activated by mastication. Replacement of half the amount of ground waste rubber by virgin EPDM caused tensile strength to rise by 35 % approximately for compounds containing either untreated or masticated ground rubber.

Contrary to the tensile strength, the elongation at break was greatly influenced by EPDM content (Figure 2). Elongation of LEM(50) was four times higher than the one of LM, that of LEG was even twelve times higher than the one of LG. The blend containing masticated GR had higher elongation at break than that containing untreated GR. The relative increase was 400 % and 70 % for LM *vs.* LG and LEM(50) *vs.* LEG, respectively. The above reported improvement of mechanical properties was probably caused by incorporation of fresh rubber having elasticity higher than crosslinked waste rubber.

LEM(50) blend had the best properties at all due to dual effect of the mastication of GR and presence of EPDM. For this reason, more LEM blends with different component ratio were prepared as well (their compositions are given in Table 1). We were looking for the component ratio at which the material would have the best mechanical properties. The results are presented in Table 2. The highest of obtained tensile strengths (8.8 MPa) was reached for LEM(50) blend. The best elongation at break (325 %) was reached for LEM(37.5). With increasing content of PE-LD and decreasing content of elastomer phase the tensile strength rose up while the elongation at break showed its maximum. Obviously, the higher the content of semicrystalline thermoplastic phase with high modulus and the lower the content of elastomeric phase containing a half of waste material, the higher the tensile strength and elongation at break, however the latter magnitude seems to be limited by low elasticity of the thermoplastic phase. Maximum of elongation at break might be observed for this reason. Mechanical properties of blends containing NR (LNG and LNM) were considerably worse than those with EPDM [LEG, LEM(50)] (Figure 3). Tensile strength and elongation at break of the blends containing NR did not exceed 4.0 MPa and 50 %, respectively. This
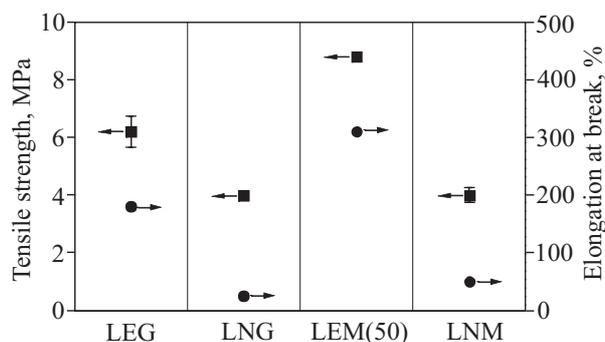
Fig. 3. Comparison of mechanical properties of the blends containing EPDM and NR: ■ — tensile strength, ● — elongation at break; for description of blend symbols see text and Table 1

was probably the consequence of lower thermodynamic compatibility of NR and PE-LD matrix compared with the one of EPDM and PE-LD which is higher due to presence of ethylene monomeric units in EPDM chains and similar polarity of EPDM and PE-LD.

T a b l e 2. Tensile properties of LEM blends (ternary blends of PE-LD, EPDM and masticated GR) with different PE-LD concentration, the composition of which is reported in Table 1

Blend symbol	Tensile strength, MPa	Elongation at break, %
LEM(25)	4.4	245
LEM(32)	7.0	300
LEM(37.5)	7.2	325
LEM(44)	7.3	270
LEM(50)	8.8	310

The main reason for addition of compatibilization system to blends was to form covalent bonds between PE-LD and ground rubber particles, eventually between EPDM and ground rubber or EPDM and PE-LD in order to improve product properties. Mechanical properties of such blends are shown also in Figures 1 and 2. Tensile strengths of peroxide-treated LG blends were almost twice higher than the value of that without peroxide. The maximum (8.3 MPa) was reached when 0.8 wt. parts of Perkadox BC 40 were added, compared with 4.5 MPa for the uncured blend. When changing the amount of peroxide, the tensile strength changed only in the range of experimental error. Similar conclusions can be made for elongation at break of LG. This was probably caused by a poor adhesion between ground rubber particles and PE-LD matrix in the uncured LG blend. Peroxides are typical initiators of radical reactions. We expect peroxide to induce curing of PE-LD matrix. Reactive radicals can be assumed to react also with rubber chains of GR particles which contain more reactive sites than PE-LD because the kinds of rubber mostly used for tire production (NR, SBR, BR) are unsaturated. Then, polyethylene network can be joined with rubber *via* these reactions resulting in better physical and mechanical properties of the compatibilized blends, however, no other proof of it has been done.

Tensile strength of the uncured blend containing EPDM (LEG) was higher by 38 % than that of the blend without virgin EPDM (LG). EPDM was expected to behave like a physical compatibilizer which could improve interfacial adhesion. Tensile strength of LEG did not depend on the Perkadox concentration. For a particular content of peroxide, every cured LEG blend had lower tensile strength compared with the one without EPDM (cured LG). This behavior might be the consequence of cohesive rupture in the EPDM layer at the rubber/PE-LD interface. On the contrary, elongations at break of all LEG blends were higher than those of LG blends. Elongation at break

of LEM blends decreased with increasing Perkadox content, showing that crosslinking of the material occurred.

T a b l e 3. Tensile properties of uncured blends and blends cured with sulfur system containing 2.6 wt. part of TMTD or TDDP; for description of blend symbols see text and Table 1

Blend symbol	Tensile strength, MPa			Elongation at break, %		
	un-cured	cured with TMTD	cured with TDDP	un-cured	cured with TMTD	cured with TDDP
LG	4.2 ± 0.2	5.2 ± 0.1	5.8 ± 0.1	15 ± 5	15 ± 2	15 ± 2
LEG	6.2 ± 1.1	4.6 ± 0.5	5.5 ± 0.9	180 ± 15	65 ± 10	80 ± 40
LM	6.5 ± 0.2	6.1 ± 0.1	5.7 ± 0.2	80 ± 5	15 ± 1	25 ± 2
LEM(50)	8.8 ± 0.3	5.9 ± 0.5	6.2 ± 0.9	310 ± 10	150 ± 25	130 ± 30

Sulfur curing system had a favorable effect in the basic combination of PE-LD/GR (*i.e.* LG) only (Table 3). Its tensile strength increased slightly (by 1 MPa approximately). Tensile strength of the other blends decreased and elongation at break fell down after sulfur curing, surprisingly even that of the blends containing EPDM [LEG and LEM(50)]. We expected sulfur atoms to support formation of bonds linking EPDM and GR resulting in improvement of mechanical properties of the product but this was not achieved. Furthermore, sulfur cannot cure PE-LD, and this can be also the reason of inferior properties of sulfur-cured blends.

Hardness and rebound resilience of the blends

Results of hardness and rebound resilience of the blends containing 50 wt. % of PE-LD are reported in Table 4. Hardness of the blends was lower by more than 13 °Sh D compared with neat polyethylene because the blends contained elastomeric part, the hardness of which is

T a b l e 4. Hardness and rebound resilience of selected blends; for description of blend symbols see text and Table 1

Blend symbol	Curing agent		Hard-ness °Sh D	Rebound resilience, %
	type	amount, wt. parts/100 parts of polymer		
neat PE-LD	—	—	46	19
LEG	—	—	31	18
LEG0.8	Perkadox BC40	0.8	31	19
LEG1.5	Perkadox BC40	1.5	32	19
LEM(50)	—	—	26	19
LEM(50)0.4	Perkadox BC40	0.4	28	19
LEM(50)0.8	Perkadox BC40	0.8	29	19
LEM(50)1.5	Perkadox BC40	1.5	29	19
LEM(50)TMTD	TMTD	1	27	18

generally lower. When changing the concentration of peroxide, hardness changed a little while rebound resilience was almost the same. Unfortunately, standard deviations of determined values are not available, thus these differences can be in the range of experimental error. With increasing PE-LD content, the hardness of the materials rose (Table 5), which is caused by a strong effect of hard thermoplastic matrix.

T a b l e 5. **Dependence of hardness and rebound resilience of LEM blends; for description of blend symbols see text and Table 1**

Blend symbol	Hardness, °Sh D	Rebound resilience, %
LEM(25)	15	23
LEM(32)	17	21
LEM(37.5)	18	19
LEM(44)	20	19
LEM(50)	26	19
neat PE-LD	46	19

Recycling ability of the blends

Torque on mixer rotors achieved at the end of recycling test did not exceed 41 Nm for any blend (Figure 4). Uncured LM blend had very low torque value near to neat PE-LD, therefore it possessed very good recycling
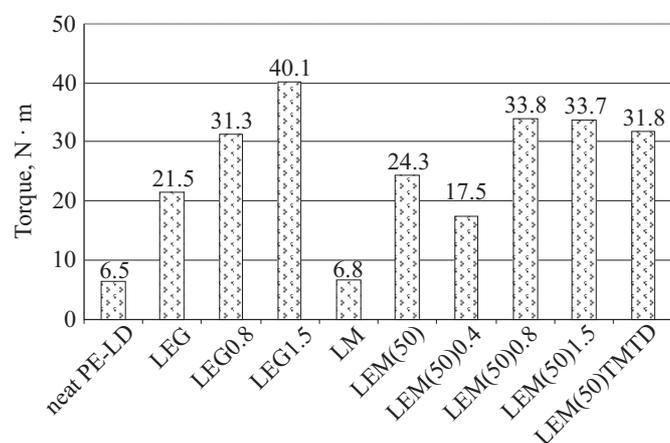
Fig. 4. Torque on mixer rotors achieved at the end of recycling (reprocessing) of the blends; for description of the blend symbols see text, Table 1 and Table 4

ability. As for LEG blends, torque rose with increasing amount of curing agent used. This can be explained by increasing extent of crosslinking obtained at preparation of particular blends.

Tensile properties of the recycled materials

The reprocessed materials were expected to have worse properties than the original ones (Table 6). Proper-

ties of uncured systems were not expected to change. Tensile strength of LEM blends cured with Perkadox BC 40 decreased after reprocessing (kneading). Unfortunately, standard deviations of determined values are not available, thus all other differences can be in the range of experimental error.

T a b l e 6. **Tensile properties of recycled materials; for description of blend symbols see text, Table 1 and Table 4**

Blend	Tensile strength, MPa		Elongation at break, %	
	original	recycled	original	recycled
LEG0.8	6.5	6.3	100	95
LEG1.5	6.1	6.0	95	95
LEM(50)0.4	7.4	5.7	240	215
LEM(50)0.8	8.0	6.6	115	145
LEM(50)1.5	8.0	6.2	105	100
LEM(50)/TMTD	5.9	5.7	150	145
neat PE-LD	14.4	—	580	—

CONCLUSIONS

Recycling of ground rubber from waste tires by mixing with molten low-density polyethylene (PE-LD) is a perspective branch of rubber recycling. The material obtained is assumed to contain particles of cured rubber dispersed in thermoplastic matrix. For this reason, the material is thermoplastic. If elastomer content is higher than 50 % the material is also soft enough at ambient temperature and has physical and mechanical properties similar to thermoplastic elastomers, although we have not studied its microstructure. Binary blends of ground rubber and polyethylene have inferior mechanical properties due to insufficient adhesion between the phases differing substantially in their modules. To improve their properties several additives have been tested.

The first method involves cold mastication of ground rubber in a two-roll mill before blending with PE-LD. Partial degradation of rubber network caused by shear load occurs. This modification results in improvement of tensile strength and elongation at break of the obtained material. The second modification lies in replacement of half the amount of ground rubber with virgin rubber. Of course, this solution has a drawback — only half the amount of waste rubber is utilized, nevertheless, if EPDM rubber is used, then the elongation at break improves a lot. NR is not suitable. Combination of both modifications, *i.e.* mastication of ground rubber prior to use and incorporation of EPDM for compatibilization, leads to the optimal properties of the product — tensile strength of 8.8 MPa and elongation at break of 310 %. These values together with that of hardness (26 °Sh D) placed in ranges typical for thermoplastic vulcanizates (tensile strength from 2 to 30 MPa, elongation at break from 200 to 600 %, hardness from 28 °Sh A to 65 °Sh D) [7]. When the content

of thermoplastic phase is decreased, tensile strength decreases.

Partial chemical crosslinking of the matrix is another method to improve blend properties. However, we found out that peroxide cure gives positive results only for basic blend of ground rubber and PE-LD (*i.e.* LG). Sulfur curing system fails. In addition, follow-up recycling of such materials gets more difficult after crosslinking. Properties of re-recycled materials are satisfactory.

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