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PREPARATION AND CHARACTERIZATION OF ETHYLENE PROPYLENE DIENE MONOMER (EPDM) RUBBER MIXTURE FOR A HEAT RESISTANT CONVEYOR BELT COVER

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ABSTRACT

In this paper, the ethylene propylene diene monomer (EPDM) rubber-based dough recipe for a conveyor belt used in high temperature conditions was developed. As a first step, the silica loading effect on the mechanical and rheological properties was determined. After selecting the proper coating dough recipe, dough properties were investigated for filler mica, instead of silica, and the influence of paraffinic oil was tested for both silica and mica fillers. The properties of the EPDM rubber blend were investigated with rheometer tests on the semi-finished materials and with mechanical and physical tests (tensile strength, elongation at break, density, hardness, abrasion, heat ageing tests) on the finished coating materials after a vulcanization process. Thermal degradation behaviors of materials were analyzed by the thermal gravimetric analysis (TGA) system, and determination of chemical structure was analyzed by Fourier transform infrared spectroscopy (FTIR). The physico-mechanical characteristics of EPDM rubber blends were increased with silica loadings. EPDM rubber demonstrates thermal resistance in the temperature range of 150ºC – 160ºC under normal conditions. As a result of the studies conducted, the heat resistance of the coating rubber material was raised to 200ºC by adding silica and paraffinic oil with a higher flash point into the EPDM dough mixture formulae.

Keywords: EPDM, Filler, Mechanical properties, Heat-resistance, Characterization

1. INTRODUCTION

Today, the conveyor belt is used for material transmission in many industries. When continuous horizontal or less inclined transmission of masonry materials over long distances is concerned, the conveyor belt is the most appropriate solution. All kinds of material, dry or wet, can be carried by this type of conveyor. The conveyor belt consists of two parts. The first is called the "carcass" and the second is the "rubber coating". The part that takes the load is the carcass while the rubber part gives the exterior appearance to the belt and is subject to external influences. The coating properties vary according to hardness, heat resistance (to flame and heat), oil resistance, fuel resistance, solvent resistance, chemical resistance and physical strength. Conveyor belts should be moisture and impact resistant [1, 2].

Ethylene Propylene Rubber (EPDM/EPM) is a copolymer of ethylene and propylene. If during the copolymerization of ethylene and propylene a third monomer, a diene, is added the resulting rubber will have unsaturation and it can then be vulcanized with sulphur. These rubbers are the so-called EPDMs. The main properties of EPDM are its outstanding heat, ozone and weather resistance. For these reasons this rubber is widely applied in many applications [3].

Rubber mixture is a kind of dough that can be vulcanized (cross-linkable) and consists of appropriate rubber (polymer), other raw materials and additives in order to ensure the desired properties in the finished product. The materials selected in accordance with the purpose and creation integrity are called the "Recipe" or "Formula." Rubbers are never used alone. All ingredients used except rubber(s) are mentioned in the recipe as PHR (parts per hun0dred rubbers), which means the amount needed for a

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hundred parts rubber. The substances used in the rubber mixture are used to control process properties, desired features in the final product and cost control. The most important among these is the vulcanization system that is necessary to crosslink the rubber. Filling materials are used to reinforce the mixture or to make it less costly. Plasticizers are necessary to give softness to the dough during processing and then to provide the desired flexibility. Stabilizers protect the mixture from degradation both during the process and when the part is being used. Other additives (lubricants, blowing agents, magnetic fillers, etc.) can be added when needed [4-6].

Considering the studies in the literature, it was found out that each substance used in the rubber dough mixture affected the process properties and the features desired from the finished product. It was also observed that besides the heat resistance feature, other chemical and mechanical properties of the manufactured belt should also be evaluated as a whole [7-10] Suzuki et al. (2004) investigated the rubber/filling material interaction on the tension-force behavior for silica-filled SBR vulcanizates with respect to the molecule movements of rubber during deformation. The chemical binding between the silica and rubber was to increase the chain strength during tensile deformation of silica filled SBR vulcanizates [11].

Pal et al. (1983) conducted a sectional study of silica and clay filled EPDM rubber in the presence of a silane coupling agent. The polymer-filler material interaction, the network structure and physical properties were investigated [12].

Haisheng et al. (2008) prepared and vulcanized silica-, nanoclay-, and carbon black (CB)- filled ethylene–propylene–diene terpolymer (EPDM) mixtures. Rheological properties and cure characteristics of the mixtures and mechanical properties of vulcanizates were measured. Rheological property measurements indicated that the storage modulus, loss modulus, and complex dynamic viscosity of silica-filled EPDM mixtures were much higher than those of CB-filled EPDM mixtures. With 30 phr silica filled EPDM vulcanizates, a tensile strength and elongation at break of 23.5 MPa and 1045% were achieved, respectively [13].

In the study conducted by Ismail et al. in 2012, the effects of mica and talc on the curing, tensile and thermal characteristics of EPDM composites were compared. EPDM/ mineral composites were mixed with double screw extruder, fed with filler at different rates (100/0, 100/10, 100/15, 100/30, 100/50, and 100/70), and their vulcanization characteristics were determined by rheometer at 160°C. Due to the stronger interfacial interaction between filler and matrix, the EPDM/mica composite showed better tensile features than the EPDM/talc composite [14].

Many investigations into EPDM blends have been carried out to study the effects of carbon black, silica, clay and white rice husk ash (WRHA) on the curing characteristics as well as the physical properties of the filled EPDM [15-23]. In addition, many researchers and industrialists are attempting to reduce the cost with alternative materials such as filler in the blending formulation without any computation for the performance and properties. Many others researchers are trying to optimize the mixture formulation to improve the end product and also to change to a suitable alternative method regarding the same matter.

Heat-resistant rubber mixtures for conveyor belts are already in existence but all of them have patents. Unfortunately, none of the patents is from Turkey, so all heat resistant conveyor band manufacturers have to buy or import material, which costs a lot of money. Besides the physical and mechanical properties of the material, cost enters both in the choice of material and in the way the material is processed. These are the main motivations that drive the search to lower costs.

This research is principally to develop the formulation of the EPDM blend to coat the conveyor belt that is heat resistant at high temperatures. The physico-mechanical properties, thermal properties and

chemical structure of all formulations of EPDM blends were determined. The effect of EPDM/filler composition and paraffinic oil type on the blend characteristics was investigated.

2. MATERIALS AND METHOD

2.1. Materials

Ingredients of the EPDM rubber blend used in this study are given in Table 1 by trade name, chemical names, functions and suppliers. EPDM rubber contains 64% ethylene.

2.2. Preparation of Dough Mixtures

EPDM rubber was passed through a laboratory-type open mill (HMO Mak San Tic.Ltd.Sti) that consists of twin counter- rotating rolls. Mixing was achieved by shearing action induced at the nip between the rolls. Additives were added in carefully weighed quantities during the mixing process. Mastication was performed at low temperatures in order for the chemicals and filling materials to mix with the rubber and for better mechanical features. After the mixing operation was complete, the dough mixture was removed from the mill in the form of a sheet. Four different EPDM rubber-based dough recipes (described as codes: 1A, 2A, 3A and 4A) were prepared.

Table 1. Short summary of the components in the mixture

Material trade name	Chemical name/Function-Intended purpose	Supplier
EPDM 740	Ethylene- Propylene-diene rubber/Matrix	Keltan
HAF N330	High Abrasion Furnace Black / Reinforcement fillers	Phillips Carbon Black Ltd.
PERKASİL KS-Series	Silica/White reinforcement filler	Dagalti Kaucuk ve Kimyevi Maddeler Sanayi veTicaret A.S.
Micron's Mica20	Mica/ White reinforcement fillers	Mikron's Mikronize Mineral End. Ticaret A.S.
Kettlitz-TAC50	Triallylcyanurat(%50) /co-agent for peroxide cured polymers	Kettlitz
Paraffinic process oil**:** **(**FP;230°C);(FP;250°C)	Softener, lubricant/improving the dispersion of fillers	Petroyag ve Kimyasallar San. A.S.
Peg4000	Polyethylene glycol 4000/Activator	Arak Petrochemical Company
TMQ	2,2,4-Trimethyl-1,2-Dihydroquioline/Antioxidant	Material VegyipariSzövetkezet
ZMBI	Zinc 2-mercaptobenzimidazole/ Synergistic antioxidant	Matoflex
ZnO (%99,8)	Zinc oxide/Activator for sulphur vulcanisation	Hepsen Kimya Ltd.Sti.
Perkodox14 40	40%Bis (tert-butylperoxyisopropyl) benzene /crosslinking of natural and synthetic rubbers	Akzo Nobel Polymer Chemicals B.V.
S-80	80 % sulfur / Curing and vulcanization agent	Akzo Nobel Polymer Chemicals B.V.

According to the test results, 4A was selected as the main recipe as it had better heat resistance than the others. At the second stage of dough mixture studies, recipes 5A, 6A and 7A were developed based on formula 4A. Mica was used as reinforcement filler instead of silica and paraffinic oil (F.P.250°C) was used instead of the paraffinic oil (F.P.230°C) that had been used in the first four recipes. Compositional blends of the dough recipes were identified and are given in Table 2. Following the compounding convention generally used in the USA, the amount of rubber was set to 100 parts. Other materials were added to rubber at specified phr concentrations.

Table 2. Designation ratio of mixture

Recipe Ingredients	Recipes codes and Parts Per Hundred Rubber (PHR)						
	1A	**2A**	**3A**	**4A**	**5A**	**6A**	**7A**
EPDM	100	100	100	100	100	100	100
HAF N 330	40	35	35	35	35	35	35
Peg4000	2	2	2	2	2	2	2
ZMBI	1.5	1.5	1.5	1.5	1.5	1.5	1.5
TMQ	1.5	1.5	1.5	1.5	1.5	1.5	1.5
ZnO	5	5	5	5	5	5	5
Perkadox 14-40	6	6	6	6	6	6	6
TAC 50	1.5	1.5	1.5	1.5	1.5	1.5	1.5
S-80	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Silica	8	12	16	20	20	-	-
Mica	-	-	-	-	-	20	20
Paraffinic Oil, (FP;230°C)	20	30	30	30	-	30	-
Paraffinic Oil, (FP;250°C)	-	-	-	-	30	-	30
TOTAL	186	195	199	203	203	203	203

The stage properties of the preparation dough mixtures are given in Table 3. Within the recipes codes from 1A to 7A, carbon black, other fillers and chemicals mentioned in the recipe, paraffinic oil (softener, plasticizer), and sulfur (vulcanization and curing agent) were added to EPDM rubber taking into consideration the temperatures and times specified and the homogeneous dough was prepared.

2.3. Tests and Analysis

2.3.1. Rheometer measurement

A rheometer test was carried out on every single batch of compound. The rheometer describes precisely and quickly the curing and processing characteristics of vulcanizable rubber compounds. Curing speeds and the optimal curing time of EPDM rubber dough were determined using a 60techM2000A MD Rheometer in accordance with ASTM D1646 standard [24]. A 5.8±0.1 g sample taken from the prepared semi-finished product was placed on the rheometer device and cured at 195°C.

Table 3. EPDM rubber mixture preparation procedures

Recipe codes	Mixing Procedure	Duration of mixing (min.)	Temperature(°C)
1A	Rubber	0	35
	Reinforcement filler+ white filler +Chemicals +Process oil	18	50-55
	Curing agent	11	61-62
2A	Rubber	0	32-33
	Reinforcement filler + white filler + Chemicals +Process oil	11	45-48
	Curing agent	8	55
3A	Rubber	0	45
	Reinforcement filler + white filler + Chemicals +Process oil	10	61-63
	Curing agent	30	67
4A	Rubber	0	45
	Reinforcement filler + white filler + Chemicals +Process oil	27	62
	Curing agent	7	67
5A	Rubber	0	32.3
	Reinforcement filler + white filler + Chemicals +Process oil	29.55	48.5
	Curing agent	7.23	55.3
6A	Rubber	0	35.2
	Reinforcement filler + white filler + Chemicals +Process oil	25;49	46.5
	Curing agent	8.08	52.7
7A	Rubber	0	40.6
	Reinforcement filler + white filler + Chemicals +Process oil	26	52.08
	Curing agent	6.08	53.3

The place from which the lowest torque (M_L) and the highest torque (M_H) values of the rheometer curve is the point combining the ninth point (from low to high) of the one hundred points, which were received by dividing the axis into equal parts, on the axis of strength (y) with its corresponding point on the axis of time (x) is "the optimal curing time". In other words the "t_{90}" value. Curing speeds and the optimal curing time of dough mixtures were determined using rheometer curves (M_L, M_H, t_{s2}, t_{90}).

2.3.2. Forming

Compression was applied to the compound with a DEVOTRANS DVT NP Y sample preparation press machine. The compound in the form of putty was placed into the lower half of the mold (see Figure 1.), which was first subjected to unpressurized preheating at 180°C for 10 minutes to be softened. Then the upper half of the mold moves downwards, pressing (at 50 kg/cm^2 for 5 min.) on the mold and forcing it to fill the mold cavity. The mold equipped with a heating system provides curing (cross-linking) of the compound.

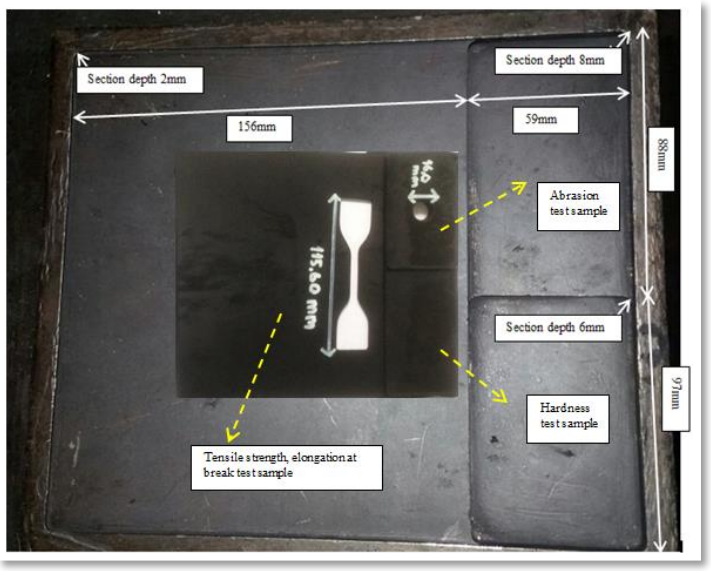

Figure 1. Photograph and scaling of the mold

2.3.3. Density

This experiment was conducted according to ASTM D297 standards [25]. The densities of the samples were determined by Archimedes Principle. This is the mass per unit volume and is measured by weighing the sample in air and in water. The samples were conditioned for three hours under laboratory conditions (23±2°C). Then, the samples that used at least 2.5 gram were weighed using a precision scale (PRECISE XB220). This gives an indication of whether the correct quantities of ingredients have been added.

2.3.4. Abrasion

Abrasion damage can occur when there is dynamic motion against an abrasive counter face. This test was conducted using a DEVOTANS DT 508 D4600 abrasion device according to ASTM D 5963 standards [26]. A test piece measuring 16 mm in diameter and 6-8 mm in thickness was pressed by 5 N constant forces against a rotating drum covered with an abrasive cloth. The loss in weight was measured after a certain number of revolutions of the 400mm rotating drum.

2.3.5. Hardness

Hardness represents the elasticity of the materials. The lower the hardness the more elastic the material is. The hardness test of cured rubber materials of all recipes was performed according to ASTM D 2240 standard [27] for Shore A hardness. A pointed conical indenter when pressed against a sample was pushed back into the case of the tester against a spring and this motion was translated into movement of the pointer on the dial. Five measurements from different locations at least 5 mm from each other were obtained. The hardness of the sample was calculated as the average of these measurements.

2.3.6. Tensile strength, elongation at break

Test specimens in the shape of a dog bone were prepared by die cutting from materials in the sheet. The test specimen consisted of a 15mm^2 cross-sectional area 50 mm in length and at least 2.0±0.2 mm in thickness. The test operating conditions were 23±2°C and 50±5% relative humidity. The testing machine, DEVOTRANS-Dvt BE, was equipped with a device for recording the tensile load and the amount of separation of the grips; both of these measuring systems were accurate to ±2%. The rates of

separation of the grips were accurate to ±0.1% and capable of adjustment from approximately 0 to 500 mm/min with a 50kN load cell or equivalent. The tensile strength was calculated by dividing the maximum load by the original cross-sectional area of the test specimen. The test was performed according to ASTM D 412 standards [28]. Elongation was the extension (change in length) between grips produced by a tensile force applied to the dog bone test piece and was expressed as a percentage of the original distance between the grips. Elongation at break was the elongation at the moment of rupture. The dog bone shaped rubber specimen was pulled in tension until rupture while loading was applied to the rubber sample. Test data were recorded on 100% tension set after break, peak and break load and elongation.

2.3.7. Differential scanning calorimeter (DSC) and thermogravimetric analysis (TGA) with thermogravimeter (TG)

Thermal decomposition behaviors of EPDM rubber based samples were analyzed using a SETARAM brand LABSYSEvo model thermal analysis system. Samples weighing 10-15 mg were heated from room temperature to 800ºC at a speed of 20°C min^{-1} in an aluminum crucible in a nitrogen atmosphere, and their thermal-oxidative degradation behaviors were determined.

2.3.8. Fourier transform infrared spectroscopy (FTIR) analysis

FTIR spectra were recorded in the range of 450 – 4400 cm^{-1} at room temperature in the ATR devices. The resolution was 4cm^{-1} and the number of scans to record IR spectra was 32.

3. RESULTS AND DISCUSSION

For comparison, the test results scorch time, t_{S2}, cure time, t_{90}, minimum rheometer torque (M_L) and maximum rheometer torque (M_H) are given in Table 4.

Table 4. Rheometer readings of different recipes

Sample Code	M_H(lb-in)	M_L(lb-in)	t_{s2}(min)	t_{90}(min)
1A	11.92±0.08	1.30±0.03	0.24±0.00	1.25±0.01
2A	12.90±0.18	1.58±0.06	0.24±0.00	1.24±0.00
3A	13.87±0.02	1.80±0.04	0.23±0.00	1.24±0.00
4A	**13.94±0.26**	**1.87±0.16**	**0.21±0.007**	**1.23±0.03**
5A	13.94±0.12	1.89±0.13	0.24±0.01	1.26±0.01
6A	9.72±0.17	1.08±0.12	0.26±0.00	1.32±0.03
7A	9.91±0.02	1.11±0.05	0.26±0.007	1.35±0.00

The effect of the reinforcement filler showed up especially in its ability to change the viscosity of a compound and also the vulcanized properties with increasing amounts of filler. In rheometer readings, M_L values of 1A, 2A, 3A and 4A samples were directly related to the viscosity of compound, and increased with the increasing amount of filler. M_H value, from which one can interpret the strength of vulcanization, also increases directly proportionally with increasing amounts of filler. The best results were obtained in the 4A sample. Paraffinic oil (F.P.250^{0}C) made the expected change to the viscosity of the compounds. Also, the optimal curing time t_{90} value increased for 5A and 7A code samples containing paraffinic oil (F.P.250^{0}C). Mica in EPDM composites (6A and 7A code samples) increased the curing time t_{90} [1, 4,19].

From the rheometer readings ultimate tensile stress and strain were obtained as the average of three samples. They are tabulated in Table 5. These stress values for different elongations are reported by rubber technologists as 100% modulus, 300% modulus, etc. However, these measures are not actually modulus values. For that reason, in this study rather than comparing Young Modulus of compounds, ultimate tensile strength and ultimate elongation values are used for comparison [19].

Table 5. Some mechanical and physical properties of EPDM rubber composite samples

Sample codes	Tensile Strength σ_{ZB} (N/mm^2)	Load at Breaking (N)	Elongation at Break Δl(mm)	Percent Elongation at Break σ_S(%)	Hardness	Abrasion (mm^3)	Density (g/cm^3)
1A	19	291	460.30	1213.0	53.00±0.00	105.5±1.06	1.01±0.001
2A	21.0	287.8	579.30	1159.0	53.67±1.53	100.0±48	1.01±0.001
3A	20.6	280.8	560.64	1149.6	53.50±0.35	107.0±0.71	1.02±0.002
4A	**22.5**	**336.0**	**578.51**	**1094.8**	**59.00±0.71**	**105.1±4.39**	**1.03±0.005**
5A	22.9	330.0	580.51	1100.7	58.25±0.53	114.5±0.35	1.04±0.00
6A	**16.3**	**205.6**	**511.47**	**1023.0**	**55.50±0.70**	**145.0±21.21**	**1.04±0.00**
7A	15.8	197.4	541.79	1084.0	54.75±0.18	185.0±14.85	1.05±0.00

Both the strength values and the hardness were generally increased with loading of silica filler but decreased with high flash point oil and mica filler. The ultimate elongation tended to decrease as filler loading increases. Process oils were added to the rubber compounds primarily to lower viscosity and to reduce both stress-strain resistance and the hardness of the finished samples. Mica and process oil tended to affect such properties as viscosity, hardness, modulus, and elongation in opposite directions. As can be seen from Table 5, using mica as filler (6A and 7A samples) and paraffinic oil (F.P.250^{0}C) (5A and 7A samples) instead of the paraffinic oil (F.P.230^{0}C) considerably decreased the hardness and increased the elongation at break and abrasion. These results indicated that silica and low flash point oil gave better processability than mica and high flash point oil in EPDM composites [11, 14].

Tensile strength and elongation at break are the only properties used to judge the resistance of a rubber compound. According to International Standards (ISO 188), tensile strength, elongation at break and abrasion of cover material for conveyor belts should be minimum 18 N/mm^2, 400% and maximum 150 mm^3, respectively. In this study, the tensile strength, elongation at break and abrasion of 4A and 5A samples were determined as 22.5; 22.9 N/mm^2, 1094.8%; 1100.7% and 105.1; 114.5 mm^3, respectively.

Thermogravimetric analysis (TGA) and thermal ageing have proven to be successful techniques in determining the thermal stability and the decomposition of polymer blends under a variety of conditions. The changing of mass, which is a characteristic of material, depended on experimental conditions. Weight loss (degradation) of pure EPDM began near 300°C and the curve declined gradually at first, decreasing sharply at around 400°C [29]. Thermal Gravimetric Analysis was also studied for compounds 4A and 6A samples. Figures 2, 3, 4 and 5 show the TGA and the DSC graphs of 4A and 6A code samples containing silica and mica, respectively.

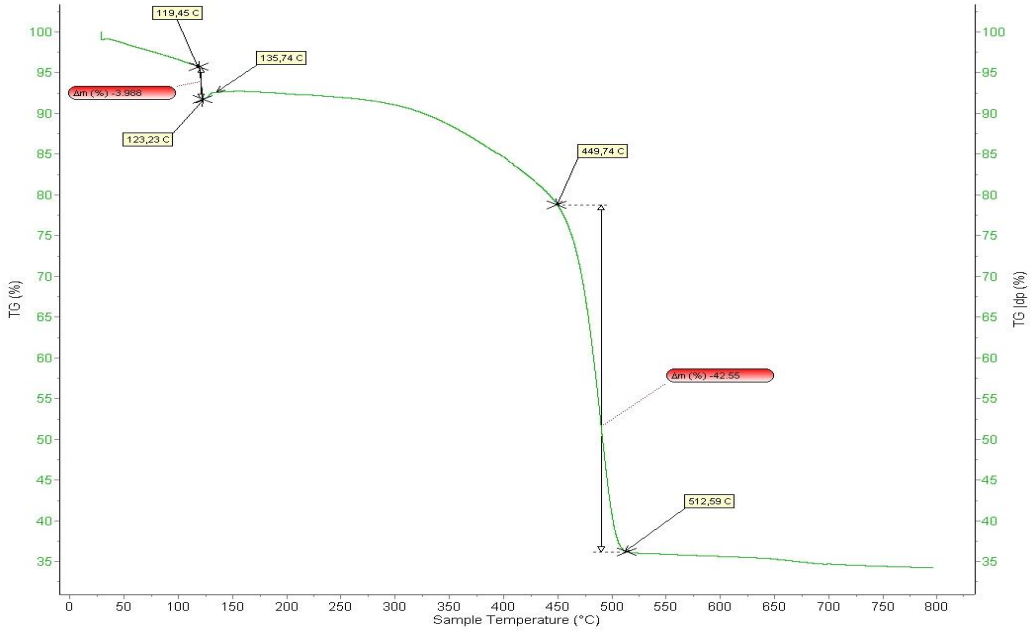

Figure 2. The schematic TG curve recorded for sample 4A

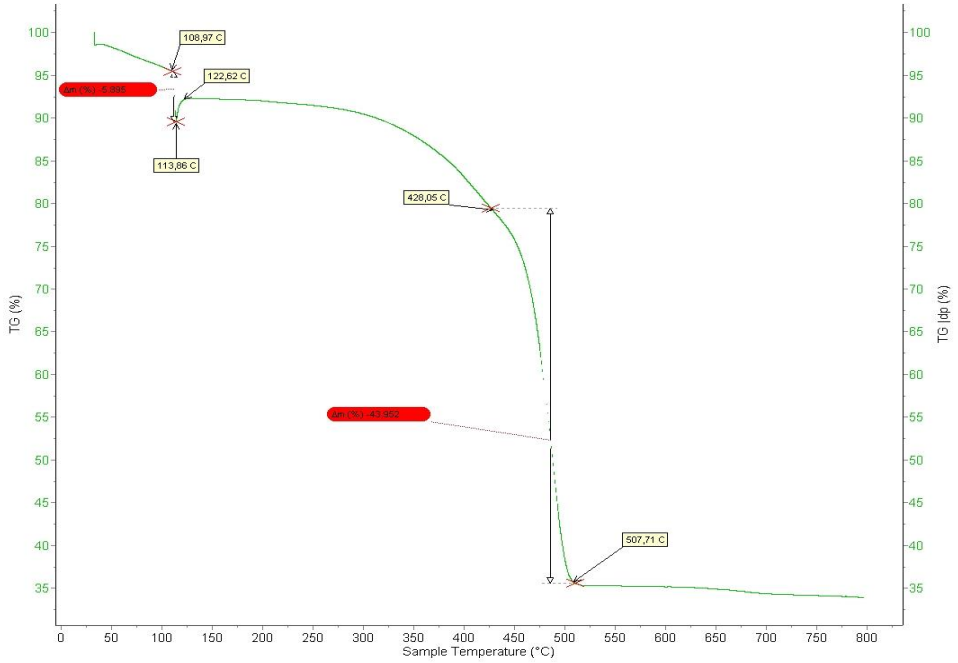

Figure 3. The schematic TG curve recorded for sample 6A

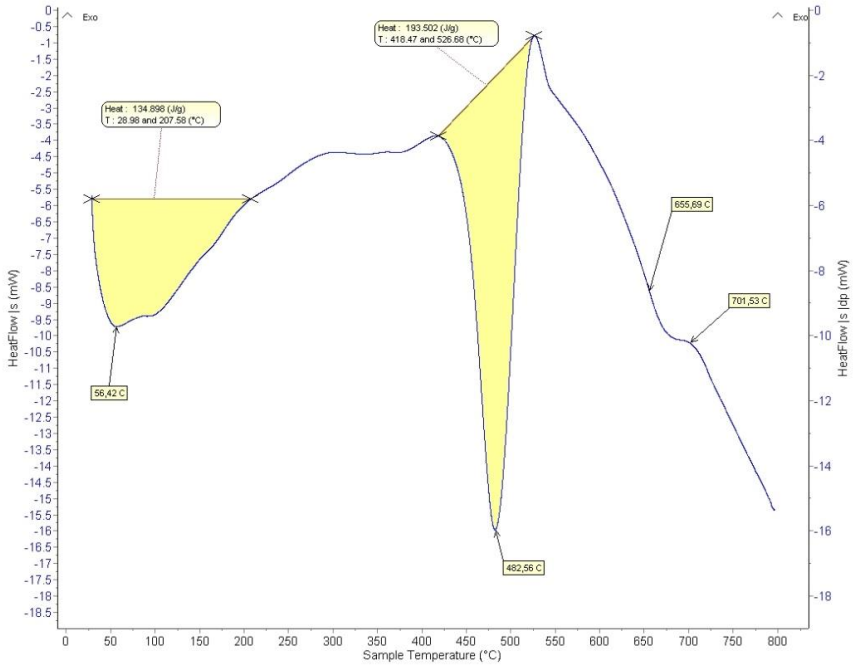

Figure 4. Schematic representation of DSC curve of sample 4A

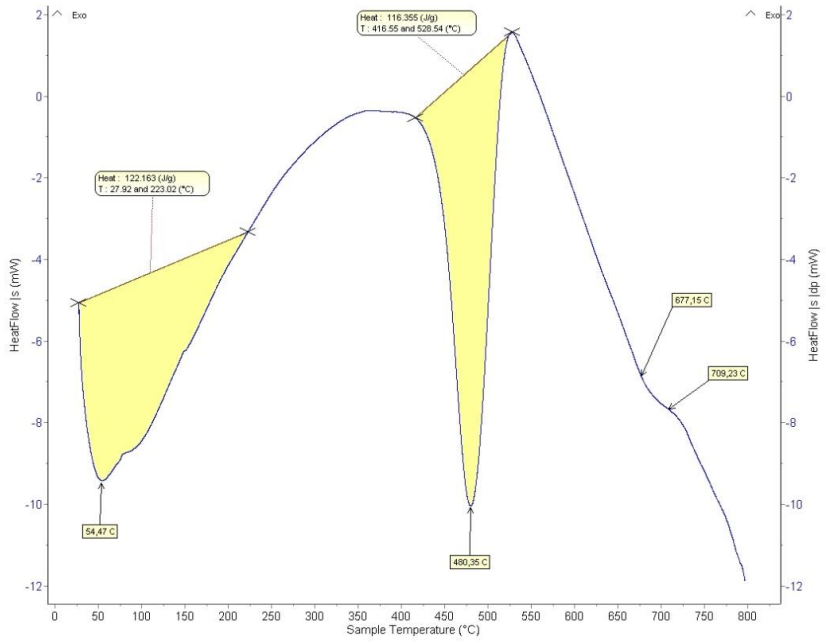

Figure 5. Schematic representation of DSC curve of sample 6A

For both samples, the first mass loss was observed at 100^0C, due to a loss of water, and the second mass loss at around 400–510^0C was related to the main degradation of EPDM rubber chains or segments. The mass loss observed during the first and second stages were 3.99-5.89% and 64-66%, respectively. Table 6 gives the relevant data obtained and derived from the DSC measurements of 4A and 6A code samples. The peak point temperature was taken as the melting point (*T*m) and the midpoint of transition as the glass transition temperature (*T*g). The area of the melting endotherm has been used to find the heat of fusion (ΔH) [30].

Table 6. The relevant data obtained from the DSC measurements of 4A and 6A samples

Sample Code	T_g(^{0}C)	T_m(^{0}C)	ΔH_g(J/g)	ΔH_m(J/g)
4A	56.42	482.56	134.898	193.502
6A	54.47	480.35	122.163	116.355

The thermal decomposition of EPDM blends is an endothermic process, which can release water to decrease temperature.

Characterizing the prepared rubber blends for the presence of respective additives is an important step in material science. Presence of various functional groups within the matrices is ascertained by FT-IR spectroscopy [31]. Figure 6 shows the Fourier transform infrared (FTIR) spectra representing functional group compositional analysis of 4A, 5A, 6A and 7A that were carried out on thin films between KBr pellets.

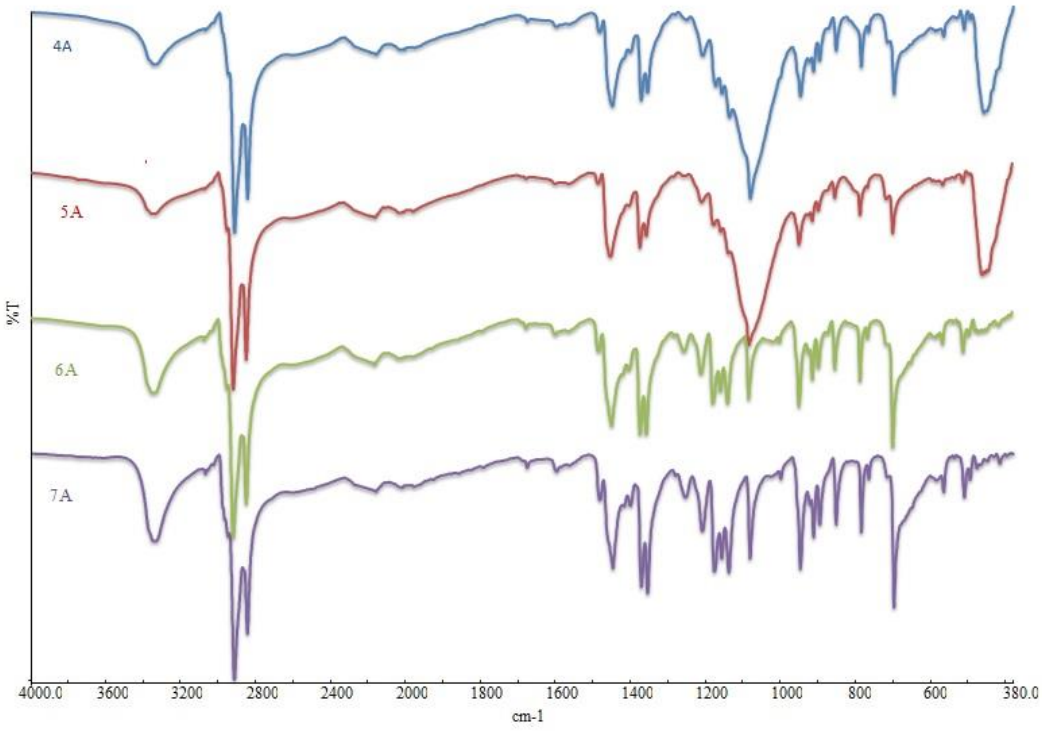

Figure 6. FTIR spectra of heat resistant EPDM rubber samples

Bands in 3346-3336 cm^{-1} are the peak of the OH hydroxyl groups. Bands within 2920 and 2849cm^{-1} area show the symmetric and asymmetric CH_2- stretching vibration in the EPDM chain. Bands around 1451 and 1374 cm^{-1} show respectively CH_2- scissoring vibration and symmetric C-H stretching of CH_3 in propylene units. The 1236 cm^{-1} peak belongs to the OH hydroxyl groups. Peaks in 1000-1200 cm^{-1} range give absorption of vibration caused by in-plane deformation of a hydrogen atom in the aromatic ring. The significant decrease in the peak intensity at 950 and 949 cm^{-1} wave number shows that the samples largely cured at room temperature. In the samples to which mica was added, the decrease in the peak intensity at 914 $cm^{-1}$and curing at room temperature continued. 898-854 cm^{-1} shows the post-second

curing in the decrease in the peak intensity. (CH_2)n coming from the ethylene unit in the EPDM chain in the band range at 786-699 cm^{-1} shows n≥5 rocking vibrations. Bands in 512-511 cm^{-1} range are predicted to belong to the C-S strain. The peak at 460cm^{-1} is caused by the crystal structure of the silica [32].

4. CONCLUSIONS AND RECOMMENDATIONS

In this study, the EPDM rubber-based dough recipe for a conveyor belt used in high temperature conditions was developed. The change in M_L,ts_2, t_{90} and M_H, which are the most commonly used parameters in process control in the rubber industry, were employed. From the results of this experimental investigation, the following conclusions can be drawn:

Increasing the amount of silica in an EPDM compound increases viscosity, rate constant of vulcanization reaction, strength, hardness and deflection under compression, however, increasing the amount of filler decreases elongation. Paraffinic oil (F.P.250^{0}C) in EPDM compound decreases viscosity, strength, deflection under compression, and increases elongation, while it does not considerably affect the rate constant of vulcanization. EPDM rubber coated conveyor belt shows thermal resistance in the 150^{o}C – 160^{o}C temperature range under normal conditions. Thanks to these studies, the thermal resistance of the samples prepared according to recipes 4A and 5A was increased to over 200^{0}C by adding various chemical materials at certain ratios into EPDM dough mixture recipes.

As a result, it was determined that the most suitable mechanical and rheological properties were in recipe mixtures 4A and 5A.

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