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Experimental Study on Recycled HDPE and Waste Glass Powder Composite Material for Pipe Production

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Abstract*— In most pipe industries of Ethiopia, the scraps of the original pipes are simply collected and are being taken as wasted materials. Specially, in industries of HDPE (High-Density Polyethylene), it is observed that the scraps are mostly used for the protection of farming areas inside the companies. But further technological activates were not applied in recycling and reusing of such wastes. HDPE by nature is a type of flexible and easily recyclable plastic material which can be mostly used for production of pipes. Also, in most glass industries and easily crushable bottle glass users of the country, wastes of any cracked& crashed glasses are seen being dumped around road sides and garbage areas. Therefore, in this study, it is aimed and practiced that the waste HDPE's scrap are experimentally processed and then mixed with the waste powder glass and then a new composite material which is composed of waste HDPE matrix and glass powder reinforcement is produced. The experimental results obtained reflect recyclability of the wastes and capability of becoming best matrix as well as reinforcement material. For the experimental work, six(6) samples having 0 %, 2%, 4%, 6%, 8% and 10% of the reinforcement and 90% of the matrix(84.56% waste HDPE + 5.44% Additives/Dutrex oil), 92% of matrix (86.56% waste HDPE + 5.44% Additives/Dutrex oil), 94% of matrix (88.56% waste HDPE + 5.44% Additives/Dutrex oil), 96% of matrix (90.56% waste HDPE + 5.44% Additives/Dutrex oil), 98% of matrix (92.56% waste HDPE + 5.44% Additives/Dutrex oil) and 100% of matrix (94.56% waste HDPE + 5.44% Additives/Dutrex oil) were used. In order to obtain the required composite product, the composite raw was heated and pressed to form the required samples. As per the composite standards, mechanical properties of the samples such as hardness, tensile strength, tear strength, modulus, elongation and surface abrasion resistance were measured. And the main composite physical properties such as water absorption test, density, relative density, maximum pressure and heat resistance capability were measured. The compounding mechanism (consistency, compatibility, and sticky property of each sample material) is properly performed on each sample, Chemical reaction is properly performed on each sample, and Crosslinking between all chemicals, bonding agents, activators, facilitators, reinforcement materials of each sample is properly characterized. And also, theoretical density of samples was determined by using rule of mixture. After all experiments are conducted a composite sample having 27.645MPa of tensile strength, 22.061MPa of tear strength, increasing in hardness (54.37 to 58.93 shore A), average actual density of density of 1.1195 g/cm^3, average theoretical density of 1.001 g/cm^3 and with increasing abrasion resistance capability were selected.

Keywords: Wasted HDPE, wasted glass powder, property testing. Matrix, Reinforcement.

I. INTRODUCTION

In Ethiopia, Plastic and Glasswastes mainly including scrap High-Density Polyethylene and waste bottle glasses are among the frequently observing wastes being seen dumped along road sides and other garbage collecting areas.Knowingly or unknowingly even the quantities of such wastesis enormouslyincreases from day to day. It is observed that, the concern of the community and other concerned bodies regarding to the positive and negative impacts of such wastes is too less. The negative impact of the wastes is that if they are not properly disposed, they can leads to the environmental pollution. And their positive impact is that they can be recycled and then reused for other purpose. Many different studies were conducted in most developed countries in order to recycle and then reuse of plastic wastes in other forms applicable for various applications. But further studies were not conducted upon recycling waste HDPE by reinforcing it with a waste glass powderto make a new composite product.

Therefore, this study is focused mainly on exploring the possibility of recycling and then reusing a scrap waste High Density Polyethylene by reinforcing it with a glass powder resulted from waste glass for the purpose of producing new property composite products such as for making ground mat, car internal mat, car external mat (weather strip), roofing mat, etc. In this case, the wasted HDPE is used as a matrix and the wasted glass is used as a reinforcement material. And then, by properly applying the scientific concept of composite materials and mechanisms, the selected matrix material and reinforcement material are required suitably for adapting various applications. In this study thecomposite samples are fabricated by varying the amount of the raw materials including the necessary additives. The experimental setup for fabricating and testing the samples is made in various

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workshop and industries of the country Ethiopia.

Totally, six(6) samples are prepared by varying the amount of wasted glass powder (the reinforcement) and the waste HDPE (the matrix)and the required mechanical and physical property testing of composite products such as tensile strength testing, tear strength testing, hardness testing, modulus of elasticity at different percentages, elongation testing, density and specific gravity/relative density testing, surface abrasion resistance testing, temperature resistance testing and water absorption testing of each sample are performed. The compounding mechanism (consistency, compatibility, and sticky property of each sample material) is properly performed. Chemical reaction is also properly performed on each sample. Crosslinking between all chemicals, bonding agents, activators, facilitators, reinforcement materials of each sample is properly characterized.

The results gained from the property test of each sample are then recorded differently.After all the experimental works are accomplished, the sample materialwith an optimum pipe property is therefore selected.

II. METHODS AND MATERIALS

2.1. Raw material preparation:

2.1.1. Wasted HDPEraw material preparation methods and procedures

In this part, some steps have been followed to prepare the particles of a wasted HDPE material:

Step-1: Collecting different wasted HDPEand Preparation of the wasted HDPE for the simplicity of heating and mixing process: First and foremost, different wasted HDPE were collected from the disposal areasand from various HDPE industries alongside the region (as shown in figure 1). And in order to simply heat the raw HDPE, it is preferred to reduce the size of the raw materials manually to make them comfortable with the size of the two rollers of the mixing machine as shown in figure 2 below.

Fig.1: Collected Waste HDPE for study

Fig.2: Prepared waste HDPE plastic

Step-2: Cleaning and dust avoiding process fromthe waste HDPE and drying process

2.1.2. Glass powder preparation methods and procedures

In the preparation of reinforcement from the wasted flint bottle glass, the following steps were followed.

Step-1: Collecting the selected wastebeer bottle glasses from different areas.

Step-2: Cleaning and reducing the size of the glass bottles for powder preparation

Step-3: Manually washing the glass raw, drying, grindingthe broken glasses, sieving the glass powder and then selecting the minimum size (0.2mm) glass powder to be used as reinforcement.

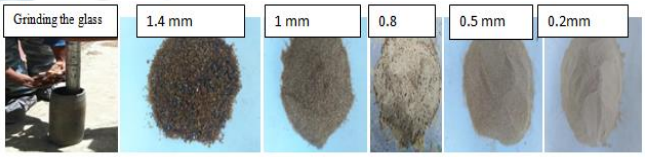

Fig.3: Prepared different sized glass powder/reinforcement

2.1.3: Machines and Equipment used on the study:

To conduct the experimental analysis setups like manual cutting setup, manual sieving setup, manual grinding setup, pressing setup, thickness measuring setup, hardness measuring setup, tensile and tear strength testing setup, mixing machine, Mooney line Viscometer, Rheometer (Rheo-line) moving die machine, density measuring set up and surface abrasion resistance testing setup was used.

2.2: Experimental investigation:

2.2.1. Sample preparation:

In a composite standard of plastics, one sample is aimed to have 500 gram of weight. And the additive material Dutrex oil (which adds a masticating property for the sample) should have 5.44% or 27.2 grams of the total weight for one sample [1]. Therefore, totally, six samples were prepared by varying the compositions of the matrix, the reinforcement and the additive material.

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1. 0 % of the reinforcement and 100% of matrix (94.56% waste HDPE + 5.44% Additives/Dutrex oil). And this sample is represented by “Sample A’.
2. 2 % of the reinforcement and 98% of matrix (92.56% waste HDPE + 5.44% Additives/Dutrex oil). And this sample is represented by “Sample B”.
3. 4 % of the reinforcement and 96% of matrix (90.56% waste HDPE + 5.44% Additives/Dutrex oil). And this sample is represented by “Sample C”.
4. 6 % of the reinforcement and 94% of matrix (88.56% waste HDPE + 5.44% Additives/Dutrex oil). And this sample is represented by “Sample D”.
5. 8 % of the reinforcement and 92% of matrix (86.56% waste HDPE + 5.44% Additives/Dutrex oil). And this sample is represented by “Sample E”.
6. 10 % of the reinforcement and 90% of matrix (84.56% waste HDPE + 5.44% Additives/Dutrex oil). And this sample is represented by “Sample F”.

- In this study the main aim was to prepare the samples with different weight percent and to consider applicability the resulting composite material. Therefore, by considering the difference in property of each sample, the sample material which results an optimum property is considered as best sample material.

2.2.2. Composition selection of raw materials and additives:

Step 1:Selecting composition of the raw materials: Table1 shows that composition each of the additive raw materials used on the study during preparing the sample.

Table 1. Composition of raw materials per 500 gram of composite sample preparation

Raw material	Amount per sample (in grams) and in %											
	A		B		C		D		E		F	
	g	%	G	%	G	%	G	%	G	%	G	%
Matrix	472.8	94.56%	462.8	92.56%	452.8	90.56%	442.8	88.56%	432.8	86.56%	422.8	84.56%
Reinforcement	0	0%	10	2%	20	4%	30	6%	40	8%	50	10%
Masticator / Additive	27.2	5.44%	27.2	5.44%	27.2	5.44%	27.2	5.44%	27.2	5.44%	27.2	5.44%
TOTAL	500	100%	500	100%	500	100%	500	100%	500	100%	500	100%

Step-2: Measurement the weight of each raw material: The weight of each raw material was measured based on the batch size.

Step-3: Mixing and Heating process: The raw materials wereheated and mixed together based on the above weight percent and then forced to heat separately based on the heating temperature of 100^{o}C.The Heating and mixing process were conducted using two rollcolander machine shown in figure 4 below.

Fig .4: Raw Materials heating and mixing process using two roll Colander machine

Step-4: Raw samples preparation: After heating and mixing processes, the resulting samples were finally produced as shown in Figure 5.

Fig.5: Prepared samples (before pressing)

Step-5: Pressingprocesses: In order to make such samples having known property, each sample were pressed by the help of curing press machine by the same pressing pressure of 1000 KPa and curing/pressing time of 60 seconds as shown in figure 6 below.The common sub-steps followed during pressingprocerssare described as follows:

- Adjusting the machine properly based on the assigned temperature, pressure and time values.
- Placing the sample inside the mold of the curing press machine.
- Loading the machine to connect the upper and the lower dies
- Loading the assigned temperature (100^{o}C) to heat the samples and waiting for 60 seconds at each sample material.

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- Loading the machine to separate the dies and then picking up the pressed and heated sample from the mold.
- Cooling the heated sample for 5 minutes.
- Pressing the samples at a pressure of 1000 KPaand then preparing specimens for testing based on the size and thickness criteria required for mechanic al and physical property testing. Figure below shows pressing process conducted during the experimental process.

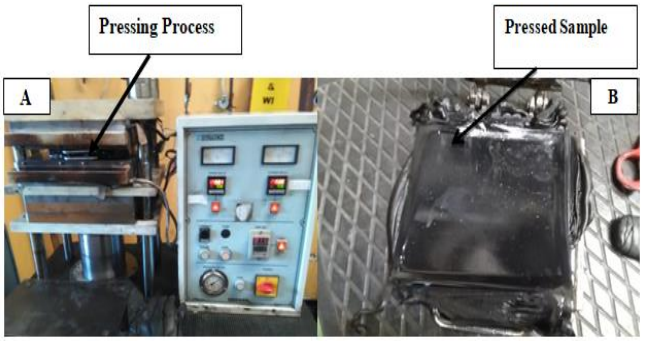

Fig. 6:Pressing process (Fig-A) and Pressed sample (Fig-B)g

Step-6: Preparation of specimens for testing: Based on the standardized sizeof the indenters of the mechanical and physical property testing setups which were used during the experimental work of this study,specimens having an average thickness of 2.5 mm (after measuring at three different parts of the specimens, that means at the top, at the bottom and at the middle)were prepared for each testing.

III. 3. RESULTS AND DISCUSSION

3.1. Results gained from mechanical property testing:

Results of Hardness Measurement:

The effect of weight difference of the reinforcement on the hardness of each sample is shown in Figure 7. The hardness value is measured in shore A hardness unit measurement. As observed from this Figure, the hardness value of each sample is increased with increasing the weight percent of the reinforcement. At this condition, this is not enough to select an optimum sample and it requires considering the other mechanical/physical properties discussed below.

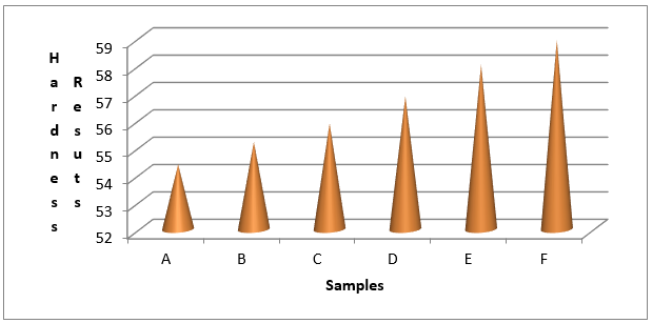

Fig.7: Hardness values of each sample

Results gained from tensile strength testing, modulus testing, and elongation testing:

To conduct the tensile strength testing, modulus and elongation testing experiments, the minimum, maximum and mean values of each test are obtained on each sample. But the mean values were taken for analysis.

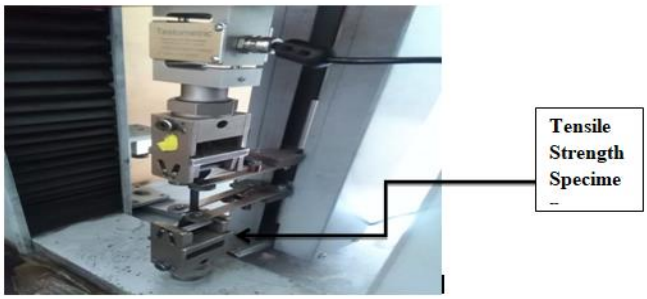

Fig.8: Tensile strength testingprocess using universal tensile strength testing machine

Table 2. Tensile strength, modules, elongation results of each specimen:

Sample	Testing amount	Tensile strength (MPa)	Modulus (MPa)	Elongation in %
A	Min	21.957	3.3679	682.45
	Mean	**22.529**	**3.5766**	**703.08**
	Max	23.529	3.7962	716.50
B	**Min**	22.695	3.3246	655.05
	Mean	**23.641**	**3.7060**	**771.92**
	Max	23.583	3.8590	884.62
C	**Min**	23.891	3.4844	746.15
	Mean	**25.443**	**3.5540**	**792.61**
	Max	26.922	3.6243	832.70
D	**Min**	25.083	3.0478	732.93
	Mean	**27.645**	**3.5156**	**805.77**
	Max	30.070	3.9253	847.55
E	**Min**	19.861	2.8868	631.23
	Mean	**22.030**	**3.5276**	**677.74**
	Max	24.643	4.0947	729.12
F	**Min**	18.468	3.2124	635.75
	Mean	**20.246**	**3.5366**	**650.82**
	Max	21.578	3.8510	665.40

As considered in Table 2, the averagetensile strength is increased as the amount of the reinforcement (glass powder) is increased in Samples A, B, C, D. But, in sample E, the tensile strength is starts to decrease. Therefore, this shows that the maximum amount of glass powder that can be mixed with thematrix material is 6% and is found in sample D.The tensile strength values found in samples A, B, C, D has generally satisfied the optimum property of composite

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products. This can also be assured by the graphof saturation point shown in Figure 9.

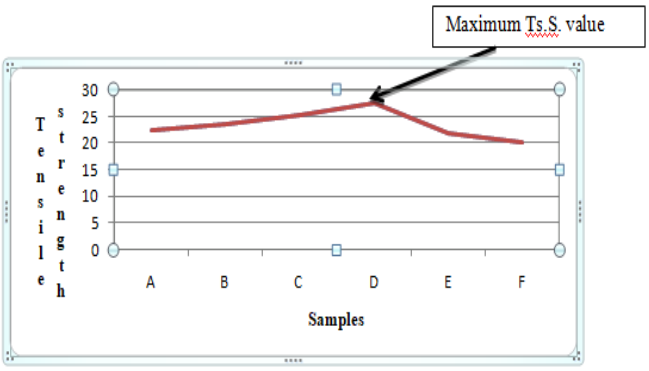

Fig.9: Maximum Ts.S (Tensile strength) value obtained from tensile strength testing

Also, as increasing the amount of the reinforcement from 0% to 6%, then the elongation of samples A to D is also averagely increased.But, when the amount of the reinforcement is excessively increased above 6%, the elongation value also decreased. Generally, sampleD have achieved the optimum property of composites.

❖ **Stress-Strain graph of each sample:**

The stress-strain graph of sample A, B, C, D, E and F resulted from testing the tensile strength using universal tensile stress testing set up are shown in Figures 10 to 15 respectively. As observed from each graph, after the maximum limit of reinforcement material, the saturation lines of each graph has stopped at the maximum saturation point (before the final deformation is occurred). After this point, the saturation line starts to deform randomly (starts to change its direction down ward as shown in Figures 10 to 15). Therefore, even by considering the stress-strain graph of each sample, it is possible to justify the optimum amount of the reinforcement (flint glass powder) to be added in to the waste HDPEmatrix.

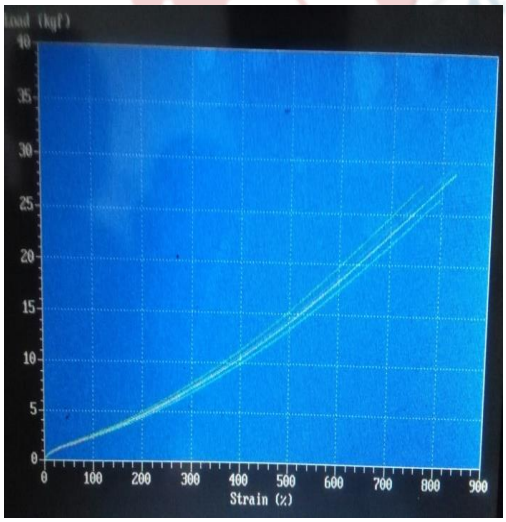

Fig.10: Stress-Strain graph of sample

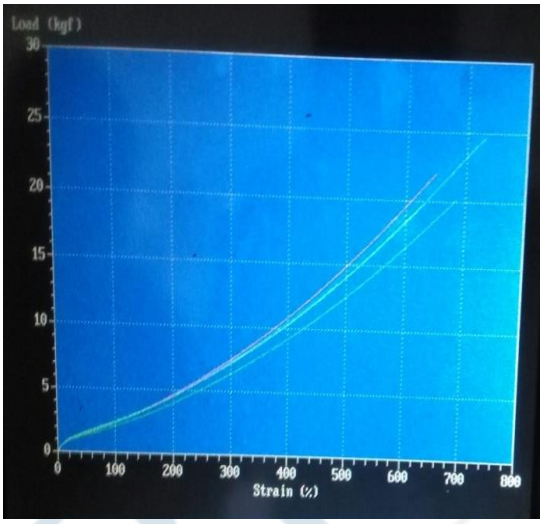

Fig.11: Stress-Strain graph of sample B

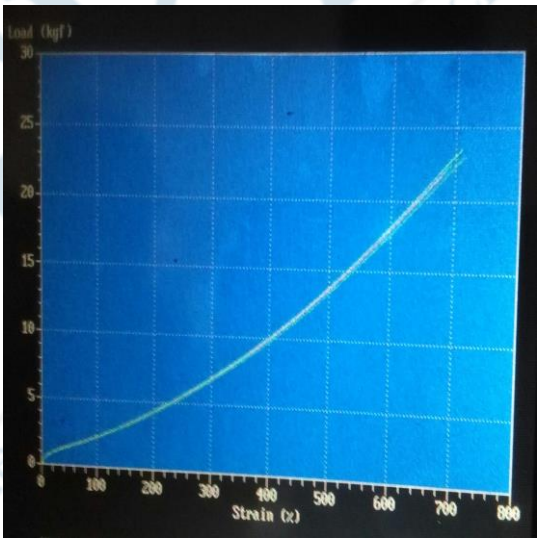

Fig.12: Stress-Strain graph of sample C

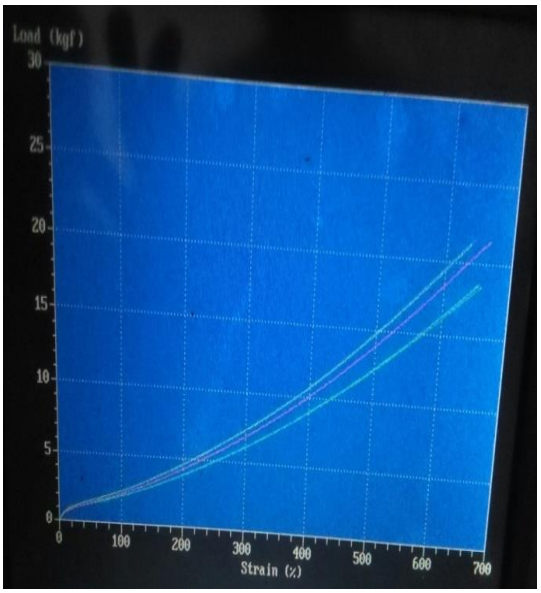

Fig.13: Stress-Strain graph of sampleD

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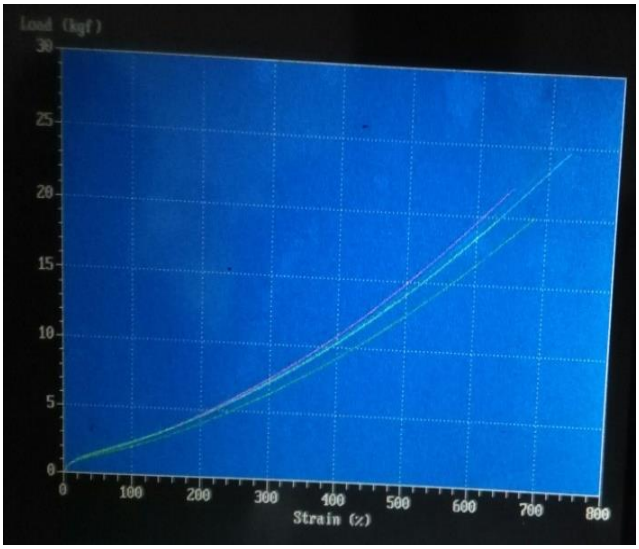

Fig.14: Stress-Strain graph of sample E

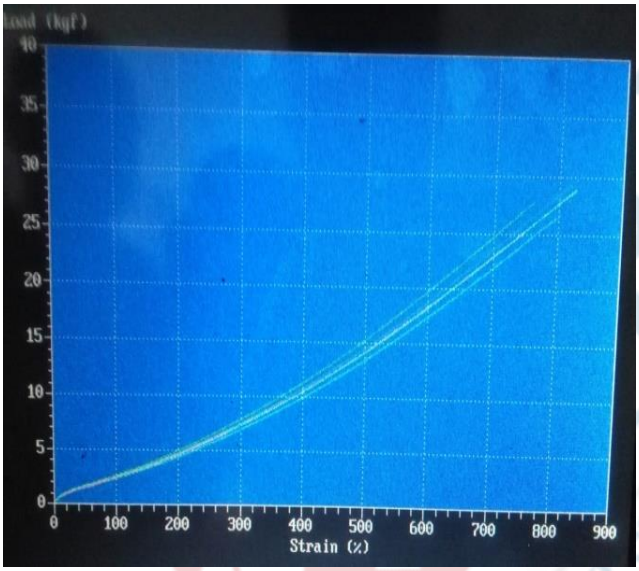

Fig.15: Stress-Strain graph of sample F

Results gained from tear strength testing

To conduct the tear strength also three specimens are prepared and tested respectively, and then the resulting average values of tear strength testing are listed in Table 3.

Fig.16: Tear strength testing process using universal tear strength testing machine

Table 3. Tear strength results of each specimen

Sample Type	Average tear strength (MPa)
A	20.40
B	21.337
C	21.934
D	22.061
E	18.597
F	13.668

✓ It is observed that, as the amount of the reinforcement material is increased, tear strength (Tr.S) is increased in samples A to D. But, in Sample E, the tear strength starts to decrease. Therefore, this shows that the maximum amount of the reinforcement that should be mixed with the matrix is 6% and it is found in sample D. This can be assured by the graph of as shown in Figure 17.

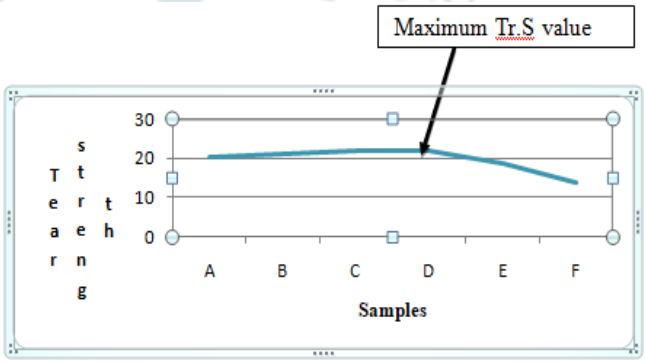

Fig.17: Maximum Tr.S(tear strength) results obtained from tear strength testing

Results gainedfrom surface abrasion resistance testing

The primary weight measured before abrasion and secondary weights measured after abrasion of each sample are listed in the Table 4. And the surface abrasion resistance was tested by using the surface abrasion testing set up as shown in figure 18. This testing set up was used for testing the capability of resisting a maximum abrasion on the sample. This set up was also used to measure the capability of resisting external load on each sample.

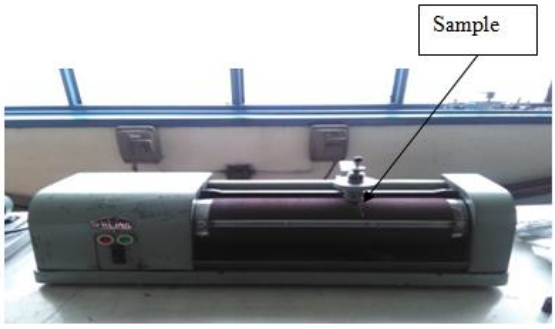

Fig.18 Surface abrasion testing process

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Table 4. Abrasion resistance results of each sample material

Sample material		A	B	C	D	E	F
Weight (gram)	Before abrasion	500	500	500	500	500	500
	After abrasion	492.31	495.87	497. 05	498.03	499.18	499.76

The results listed in Table 4shows that as the amount of the reinforcement is increased, the capability of the samples can also be increased. And the maximum surface abrasion resistance value is obtained in the last sample.This idea can also be supported graphically as in below.

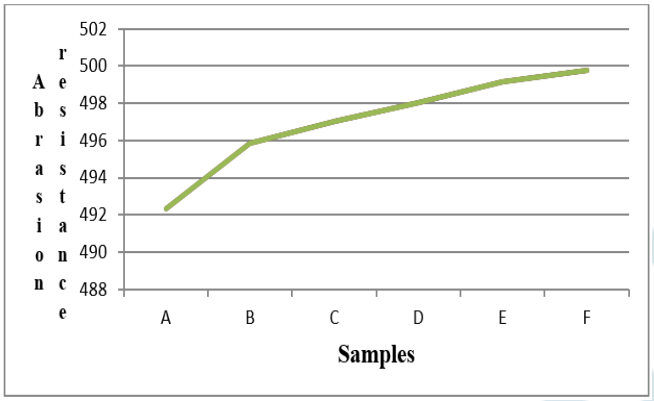

Fig. 19: Results of abrasion resistance testing

3.2. Results gained from physical property testing:

Physical property testing results are briefly explained as follows.

Results gained from actual/measured and theoretical / calculated density testing:

The actual or measured density values of each sample were measured using Bra-bender as shown in figure 20. And therefore the actual density of sample A is0.9101 g/cm^3, sample B is0.8730 g/cm^3, sample C is0.9391 g/cm^3, sample D is 0.9615 g/cm^3, sample E is1.003 g/cm^3, and sample F is 1.010 g/cm^3.

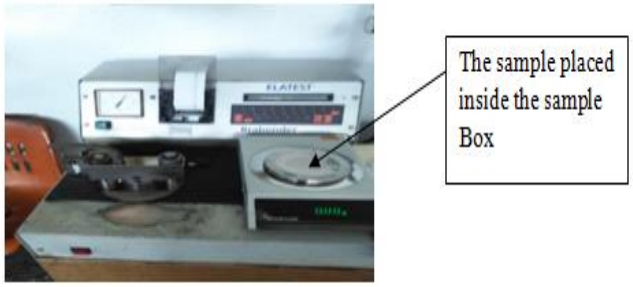

Fig.20: Measuring the actual density usingBra-bender

And according to ASTM standard C128 and based on the composite mixture rule formula of equation 2.1, the calculated/theoretical density of the samples is calculated as:

$$\rho_t = \rho_m V_{fm} + \rho_r V_{fr} + \rho_a V_{fa} \qquad (2.1)$$

Where, ρ_t = Theoretical density of the composite, ρ_m = density of the matrix, V_{fm} = volume fraction of the matrix, ρ_r = density of the reinforcement, V_{fr} = volume fraction of the reinforcement, ρ_a = density of the additives, V_{fa} = Volume fraction of the additives. The wasted HDPE is the matrix, wasted flint glass powder is the reinforcementand dutrex oil is the additive in this study. Therefore, the theoretical density of each sample is calculated as follows:

- For sample A= [(0.95) * (94.56/100) + (2.1) * (0/100) + (0.93) * (5.44/100)] = 0.9489 g/cm^3
- For sample B= [(0.95) * (92.56/100) + (2.1) * (2/100) + (0.93) * (5.44/100)] = 0.9394 g/cm3
- For sample C= [(0.95) * (90.56/100) + (2.1) * (4/100) + (0.93) * (5.44/100)] = 0.9949 g/cm^3
- For sample D= [(0.95) * (88.56/100) + (2.1) * (6/100) + (0.93) * (5.44/100)] = 1.0179 g/cm^3
- For sample E= [(0.95) * (86.56/100) + (2.1) * (8/100) + (0.93) * (5.44/100)] = 1.0409 g/cm^3
- For sample F= [(0.95) * (84.56/100) + (2.1) * (10/100) + (0.93) * (5.44/100)] = 1.0639 g/cm^3

Table 5. Comparison of measured (actual) density and calculated (theoretical density)

Sample	A	B	C	D	E	F
Actual/measured density (g/cm^3)	0.9101	0.8730	0.9391	0.9615	1.003	1.010
Theoretical/calculated density (g/cm^3)	0.9489	0.9394	0.9949	1.0179	1.0409	1.0639

- The density comparison of each sample can be expresses as follows in Figure 21.

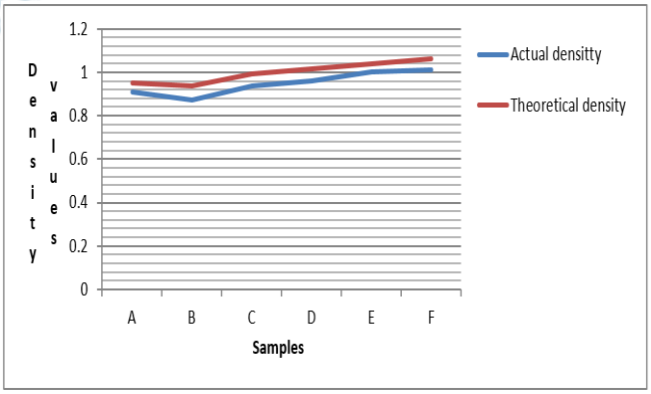

Fig. 21: Comparison between Actual and theoretical densities of each sample

Results gained from Rheometer and Viscometer testing

At this experimental stage, three (3) main testes are measured together. Thus are testing maximum heat (temperature) resistance capability of each sample, testing the curing temperature, pressure and time of each sample and finally assuring the tests by checking a rubber saturation line

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of each sample.The results obtained from the Rheometer tests are shown in Fig. 24 to 29.During the process, unnecessary dusts, excessive chemicals, moisture from the sample were avoided usingRheo line moving die machine. And it also used to facilitate compacting (properly mixing) the contents of the sample. The required compacting temperature, pressure and curing time for the particular composition of the sample is very important to produce the defect free components. The required curing temperature, pressure and time for a particular composition were predicted by using this machine. The maximum temperature/heat that the material can resist and convert the sample from plastic in to elastic was also measured as shown in figure 22.

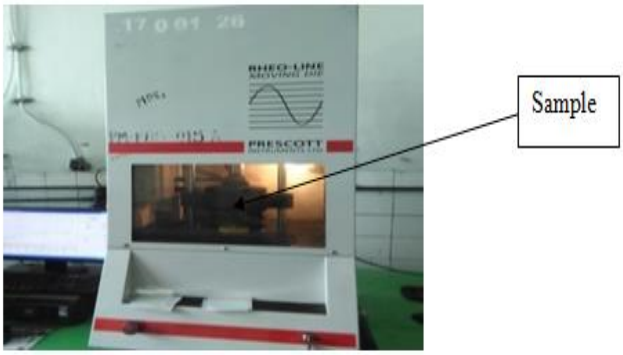

Fig.22: Measuring maximum heat resistance capability using Rheometer

- The consistency, compatibility, and sticky property of the sample material were tested by using the Mooney line viscometer. And the thermoplastic saturation line/point of each sample was checked by using this machine as shown in Figure 23.

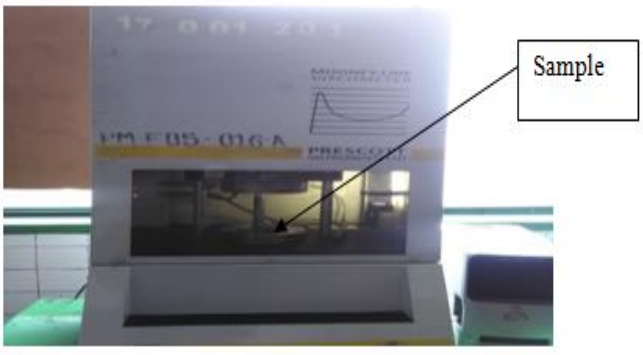

Fig.23: Testing the consistency, compatibility, and sticky property using Mooney line Viscometer

The results obtained from the Rheometer tests are shown in Fig. 24 to 29.

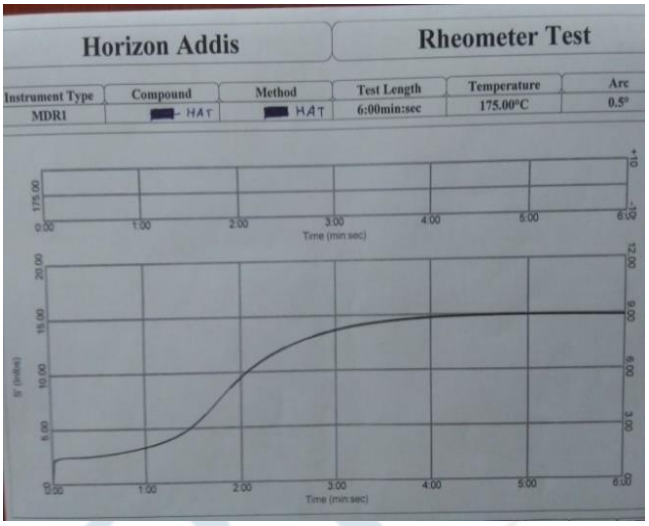

Fig.24: Rheometer test for sample A

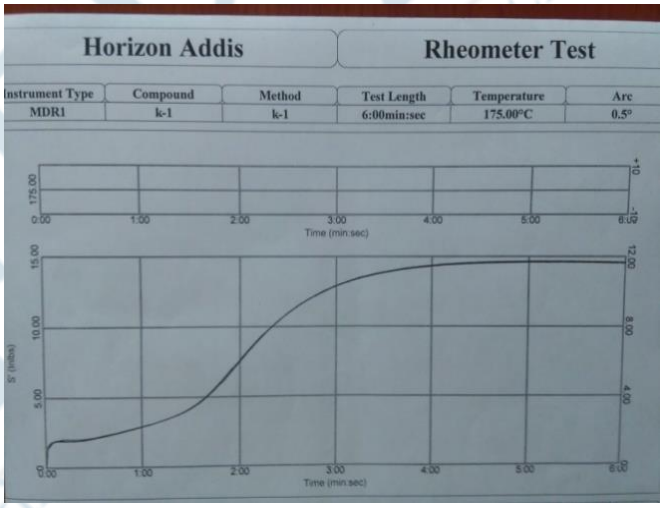

Fig.25: Rheometer test for sample B

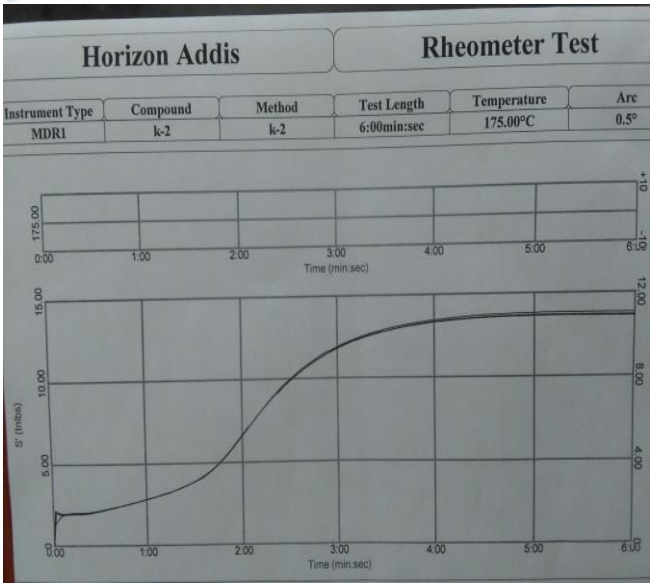

Fig.26: Rheometer test for sample C

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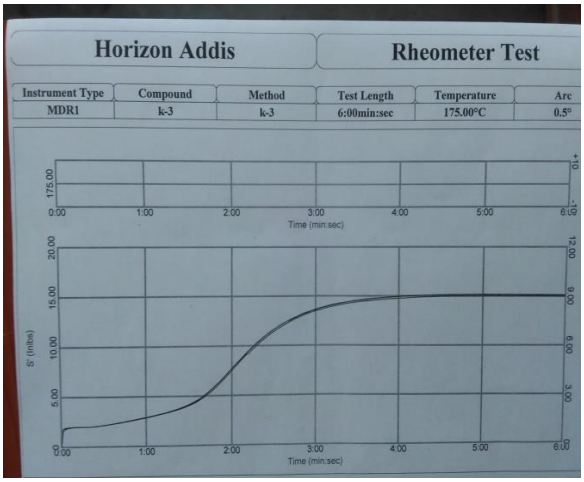

Fig.27: Rheometer test for sample D

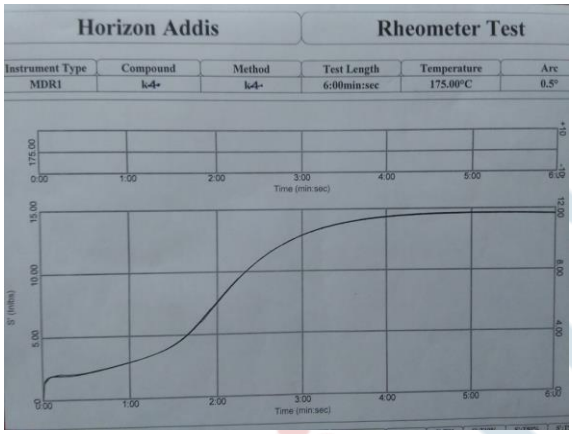

Fig.28: Rheometer test for sample E

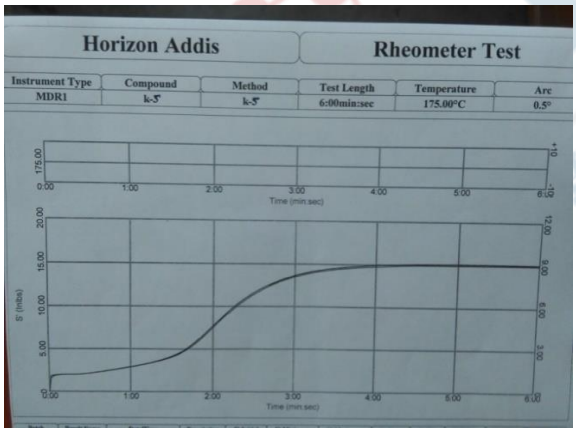

Fig.29: Rheometer test for sample F

As per the purpose of Rheometer and Viscometer tests, the following main points were observed. The maximum capability of resisting a temperature of all the samples is 175 ^{o}C which is the same amount with that of Sample A's temperature resisting capability (175 ^{o}C).

- ✓ The maximum curing time of each sample is 30 minute, the maximum curing temperature of each sample is 150 ^{o}C, the maximum curing pressure of each sample is 150 psi (1034.25 Kpa) and thus values are the same with that of sample A's curing values.
- ✓ All of the samples have achieved a saturation line rule. This line shows that:
  - The compounding mechanism (consistency, compatibility, and sticky property of each sample material) is properly performed on each sample.
  - Chemical reaction is properly performed on each sample.
  - Crosslinking between all chemicals, bonding agents, activators, facilitators, reinforcement materials of each sample is properly characterized.
  - Mixing process of all the contents on each sample is properly performed.
  - Unnecessary dusts, moisture, excessive oil, excessive chemicals and other excessive additives are properly avoided.

When any one of the above purposes is not achieved, the plastic saturation line can never been drawn like the shape shown in Figures 24 to 29 and theplastic saturation line of each sample cannot be checked.

Results gained from water absorption testing:

During the experimental work, each sample was immersed in to a water tank for 24 hours to observe their water absorption capacity. And their weight was measured using digital weight balance setup (before and after immersion). Therefore, as observed from the results gained from the test (as listed in Table 6), there is no any weight difference obtainedbefore and after immersion. Also, the percentage of water absorption of each sample is 0%.

The reason for this similarity in weight is that the composite sample prepared is already have dry thermoplastic property and whenever it is immersed in to water for days it can never absorb water. Andin order to make the wet sample dried, it is followed that, the sample material pulled out from the water is forced to be dried first for around 30 seconds and then putting it in the weight balance.In this case, even the sample has a dry thermoplastic property; it can be shaped by heating its surfacewhen it is needed to change its structure in to a pipe form.

Table 6. The weight difference of each sample (before and after immersing in water).

Number	Sample material	Dry Weight (Before Immersing) (gram)	Wet Weight (After Immersing) (gram)	Weight difference (kg) (Dry weight - Wet weight)
1	A	500	500	0
2	B	500	500	0
3	C	500	500	0
4	D	500	500	0
5	E	500	500	0
6	F	500	500	0

- ➢ Calculating the percent water absorption by using the formula given in equation 2.2:

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$P_{WA} = [(W_W - D_W) \div D_W]*100$ 2.2

Where, $P_{WA}$is percentage of waster absorption, W_W is wet weight of the sample and D_W is dry weight of the sample. Here, the words "dry and wet" refers to before and after the sample is immersed in water respectively.

Therefore, based on this formulation, percentage of waster absorption of each sample is calculated as follows.

For sample - A $P_{WA} = [(W_W - D_W) \div D_W]*100 =$ [(500-500)/500]*100% = 0%

For sample - B $P_{WA} = [(W_W - D_W) \div D_W]*100 =$ [(500-500)/.500]*100% = 0%

For sample - C: $P_{WA} = [(W_W - D_W) \div D_W]*100 =$ [(500-500)/500]*100% = 0%

For sample - D: $P_{WA} = [(W_W - D_W) \div D_W]*100 =$ [(500-500)/500]*100% = 0%

For sample - E: $P_{WA} = [(W_W - D_W) \div D_W]*100 =$ [(500-500)/500]*100% = 0%

For sample - F: $P_{WA} = [(W_W - D_W) \div D_W]*100 =$ [(500-500)/500]*100% = 0%

IV. CONCLUSION

This study has followed the concept of composite materials to produce the supposed polymer composite products by taking a wasted HDPE polymer as a matrix material and a wasted flint glass powder as a reinforcement including various additives. In this case, different experimental investigations were basically conducted to prepare the samples and to test the main mechanical properties such as tensile strength, tear strength, hardness, abrasion resistance, modulus and elongation. Moreover, physical properties of each sample such as water absorption test, actual as well as theoretical density test and abrasion resistance test are accomplished. To conduct the experiment totally six samples having 0 %, 2%, 4%, 6%, 8% and 10% of the reinforcement and 90% of the matrix (84.56% waste HDPE + 5.44% Additives/Dutrex oil), 92% of matrix (86.56% waste HDPE + 5.44% Additives/Dutrex oil), 94% of matrix (88.56% waste HDPE + 5.44% Additives/Dutrex oil), 96% of matrix (90.56% waste HDPE + 5.44% Additives/Dutrex oil), 98% of matrix (92.56% waste HDPE + 5.44% Additives/Dutrex oil) and 100% of matrix (94.56% waste HDPE + 5.44% Additives/Dutrex oil) were used. And therefore, a composite sample having 27.645 MPa of tensile strength, 22.061 MPa of tear strength, increasing in hardness (54.37 to 58.93 shore A), average actual density of density of 1.1195 g/cm^3, average theoretical density of 1.001 g/cm^3 and with increasing abrasion resistance capability were selected.The compounding mechanism (consistency, compatibility, and sticky property of each sample material) is properly performed on each sample. Chemical reaction is also properly performed on each sample.Crosslinking between all chemicals, bonding agents, activators, facilitators, reinforcement materials of each sample is properly characterized and then it is assured that this composite product have achieved the composite properties of water pipes.

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As per the accomplishment of this research project, it is better to raise great respect and thanking for Adigrat university research and community service, Horizon Addis Tire Industry found in Addis Ababa Ethiopia, Asko flint glass industry found in Addis Ababa Ethiopia for their financial support, andMekelle University Mechanical & Industrial Engineering Workshop assistants and Laboratory assistants for their generous help during the experimental work. I would like to thank for the community found around the sampled research areas of Ethiopiafor everything helped me during getting enough information about the data related to the investigation. And for others those who participated directly or indirectly on this study, I have a great respect.

REFERENCES:

[1] Ahmed, Rehan, Options for Improvement of Solid Waste Management System through Community Participation in Case Study areas of Ghousia Colony and Orangi Town, Karachi, Pakistan, (1992).

[2] Baud, Isa and Hans Schenk, Solid Waste Management, Modes, Assessments, Appraisals and Linkages, Tokyo, Japan23 April (1994),

[3] L. Piergiovanni and S. Limbo, Ceramic packing materials, New york, (2016).

[4] Mark HF, Bikales N, Overberger CG, Menges G, Kroschwitz, Encyclopedia of Polymer science and engineering. Wiley, New York, (1985)

[5] Carlos Rolando Rios-Soberanis, Manufacture of Partially Biodegradable Composite Materials Based on PLA-Tires Powder: Process and Characterization, Tokyo, Japan, April (2013).

[6] Hughes, C.S, Feasibility of Using Recycled Glass in Asphalt. Report VTRC 90- R3. Virginia Transportation Research Council, Charlottesville, VA, (1990).

[7] Cerbu, C. &Curtu, I, Mechanical characterization of the glass fibers resin composite material. MaterialePlastice 48(1), (2011), 93–97.

[8] PetrValasek, Recycling of waste rubber powder and micro-particles as filler of thermosets, Denmark, June(2014).

[9] Sinha V., Patel M., Patel J.2008PET waste management by chemical recycling: a review. J. Polym. Environ.

[10] Shaxson L.2009Structuring policy problems for plastics, the environment and human health: reflections from the UK. Phil. Trans. R. Soc. B 364, 2141–2151

[11] Swift G., Wiles D.2004Degradable polymers and plastics in landfill sites. Encyclopedia Polym. Sci. Technol. 9, 40–51

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 10, Issue 10, October 2023

[12] Ryan P. G., Moore C. J., van Franeker J. A., Moloney C. L.2009Monitoring the abundance of plastic debris in the marine environment. Phil. Trans. R. Soc. B 364, 1999–2012

[13] Perugini F., Mastellone M., Arena U.2005A life cycle assessment of mechanical and feedstock recycling options for management of plastic packaging wastes. Environ. Progr. 24, 137–1

[14] Park C.-H., Jeon H.-S., Park K.2007PVC removal from mixed plastics by triboelectrostatic separation. J. Hazard. Mater. 144, 470–476 .

[15] Fisher M.2003Plastics recycling. In Plastics and the environment (ed. Andrady A.), pp. 563–627 Hoboken, NJ: Wiley Interscience.

[16] British Plastics Federation. Oil consumption. 2008. (20 October 2008)

[17] Barnes D. K. A., Galgani F., Thompson R. C., Barlaz M.2009Accumulation and fragmentation of plastic debris in global environments. Phil. Trans. R. Soc. B 364, 1985–1998.