Short Communication

PLASTIC WASTE RECYCLING

*DALEN, M. B. & NASIR, T.

Department of Pure and Industrial Chemistry
University of Jos, Nigeria
*scitechno2003@yahoo.com

Plastics have become an indispensable part of our everyday life since their introduction over 100 years ago. Their versatility in application also brings associated disposability problem especially those that are used for packaging. Consequently, with growing public concern about environmental issues, plastic waste recycling offers a top shot solution.

The recycling of plastics that used to end up only at city landfills or incinerators is increasing around the world. Discarded plastic products and packaging make up a growing portion of municipal solid waste (MSW). The United States Environment Protection Agency (EPA) estimated that the amount of plastics throw away is 50 % greater in the twenties than at the beginning of the 1990s and that plastic waste accounts for about 20 % of all wastes discharged into the streams. Fortunately, over the past two decades, recycling of plastics has dramatically increased (Modern Plastic Encyclopedia Oct. 1990).

The present research aims to exploit blending of waste and virgin plastics as a method to reduce cost to the manufacturer and control environmental pollution.

Sample collection: The plastic waste of PVC, PET, LDPE and HDPE were collected from dumpsites within Jos. The virgin samples were obtained from Lela Agro Plastic Food Kano, Nigeria.

The waste plastics were identified using the Society of the Plastic Industry (SPI) method and sorted manually based on colour and type. They were washed in soapy water and rinsed and allowed to dry in a fume cupboard. The waste plastic samples were then mashed manually into smaller sizes (pellet).

Blending of virgin and waste plastic sample was done in the ratio shown in Table 1. The aluminum pot was heated for about 4-7 min before the introduction of the blended plastic sample. Melt was obtained with a strong, continuous agitation during the process. The time taken for each melt to form differs since the melt temperature for different polymers varies. The melt was quickly transferred into 15 x 10 cm mould as soon as it's formed and pressed with a flat, smooth surface 1 kg load for 24 hrs, after which the mould was opened to remove the caste film. The operation was repeated for all the rest of the samples.

TABLE 1. PERCENTAGE SAMPLES BLENDED.

Samples	Virgin (g)	Waste (g)
1	100	0
2	80	20
3	60	40
4	40	60
5	20	80
6	0	100

Cast film types were cut in sample sizes of 50 mm by 20. The thickness of each film was measured using a thickness gauge and the average was taken for each film type. The films were clamped on an automated Stable Micro system (Tensometer) 5011 one after the other and the load and extension of each film was determined at a speed of 0.20 mm/second.

The results of the tensile strengths testing of the blends for the different plastics are presented in Tables 2-5

DISCUSSION

The virgin PVC has the highest tensile strength (3106 Nm^{-2}) when compared to the other five blended samples; this is due to the fact that it has not been subjected to any form of pressure or heat before. The 100 % waste PVC has the lowest tensile strength (208 Nm^{-2}) which is due to the nature of the molecular structure as it has been subjected to different loads of pressure during usage and also to processing conditions before, thereby losing some mechanical properties. As shown on Table 2, the change in tensile strength between the 100 % virgin sample and that of 80 % virgin. 20 % waste plastic sample is not large (534) this indicates that, in recycling, the 80 % virgin: 20 % waste is the best blend that can be used.

The 100 % PET virgin sample has the highest tensile strength (6710 Nm^{-2}) compared to other five blended samples. Generally, the PET sample shows a brittle characteristic which can be seen from the degree of each tensile strain column (Table 3). The PET can be recycled at the ratio of 80 % (V) : 20 % (W) in a control manner. It can be converted into a polymer product of less tensile strength requirement. For instance, the food packaging PET containers can be converted to fuzz on tennis balls, (Braun, 1982).

At 100 % virgin LDPE, the maximum load exerted before breaking was 18.54 N, with an extension of 0.01 mm the tensile strength was 31930, showing the highest tensile strength when compared to

TABLE 2. RESULTS OF TENSILE STRENGTHS FOR PVC BLENDS

Weight of samples %	Samples thickness (mm)	Load (N)	Extension (mm)	Tensile Stress (Nm^{-2})	Tensile Strain	Tensile Strength (Nm^{-2})	Change in tensile strength
P = 100 W = 0	6.60 ± 0.01	34.52	0.191	11.805	0.0038	3106	3106
P = 80 W = 20	6.70 ± 0.01	30.23	0.200	10.289	0.0040	2572	534
P = 60 W = 40	6.70 ±0.01	21.23	0.215	7.226	0.0043	1680	1426
P = 40 W = 60	6.50 ± 0.01	11.20	0.211	3.854	0.0042	917	2189
P = 20 W = 80	6.80 ± 0.02	5.19	0.401	1.758	0.0080	219	2887
P = 0 W = 100	6.60 ± 0.01	5.13	0.424	1.754	0.0084	208	2898

TABLE 3. RESULTS OF TENSILE STRENGTH FOR PET BLENDES

Description of samples %	Samples thickness (mm)	Load (N)	Extension (mm)	Tensile Stress (Nm^{-2})	Tensile Strain	Tensile Strength (Nm^{-2})	Change in tensile strength
P = 100 W = 0	5.30 ± 0.01	33.12	0.091	12.078	0.0018	6710	6710
P = 80 W = 20	5.20 ± 0.01	24.52	0.091	8.988	0.0018	4993	1717
P = 60 W = 40	5.20 ± 0.01	15.13	0.120	5.546	0.0024	2310	4400
P = 40 W = 60	5.10 ± 0.02	10.12	0.122	3.709	0.0024	1545	5164
P = 20 W = 80	5.40 ± 0.01	4.03	0.130	1.463	0.0026	609	6100
P = 0 W = 100	5.50 ± 0.01	4.01	0.131	1.447	0.0026	602	6107

TABLE 4. RESULTS OF TENSILE STRENGTH FOR LDPE BLENDS

Description of samples %	Samples thickness (mm)	Load (N)	Extension (mm)	Tensile Stress (Nm^{-2})	Tensile Strain	Tensile Strength (Nm^{-2})	Change in tensile strength
P = 100 W = 0	6.45 ± 0.01	18.54	0.01	6.386	0.0002	31930	31920
P = 80 W = 20	6.32 ± 0.01	12.67	0.051	4.391	0.0010	4391	27539
P = 60 W = 40	6.90 ± 0.01	5.08	0.108	1.712	0.0020	856	31074
P = 40 W = 60	6.60 ± 0.01	4.98	0.142	1.703	0.0028	608	31322
P = 20 W = 80	6.54 ± 0.01	4.25	0.150	1.454	0.0030	484	31446
P = 0 W = 100	6.71 ± 0.01	2.99	0.199	1.017	0.0039	260	31670

TABLE 5. RESULTS OF TENSILE STRENGTH FOR HDPE BLENDS

Description of samples %	Samples thickness (mm)	Load (N)	Extension (mm)	Tensile Stress (Nm^{-2})	Tensile Strain	Tensile Strength (Nm^{-2})	Change in tensile strength
P = 100 W = 0	4.20 + 0.01	15.61	0.063	6.031	0.0012	5025	5025
P = 80 W = 20	4.50 + 0.02	10.14	0.090	6.855	0.0018	2141	2884
P = 60 W = 40	4.60 + 0.02	4.29	0.147	1.811	0.0029	624	4401
P = 40 W = 60	4.40 + 0.02	4.11	0.164	1.571	0.0032	490	4535
P = 20 W = 80	4.40 + 0.01	3.56	0.191	1.360	0.00356	377	4648
P = 0 W = 100	4.10 + 0.01	2.96	0.195	1.149	0.0039	294	4731

other five blended samples. The large difference in the change in tensile strength (275390) between the 100 % (V) and that of the 80 % (V) : 20 % (W) plastic samples indicates that, the waste plastic sample used for the recycling has been subjected to a varieties of stress during usage. This made it to lose its mechanical properties almost completely. The trend is repeated for other blended samples.

Such recycled polymer has to be converted to another polymer in which tensile strength is not a determining factor. e. g. conversion of frozen bags into grocery bags or garbage can liners (Liu & Waskom, 1992).

The HDPE followed the same trend as the LDPE (Table 5). The 100 % virgin has the highest tensile strength (5025 Nm^{-2}) when compared with that of the other five blended samples. The 100 % waste plastic sample has the lowest tensile strength due to lose this recycled regime as shown.

From the blends (60 % (V): 40 % (W), 0 % (V) :100 % (W), the change in tensile strength between each blended sample is more pronounced. This suggests that the recycled polymer is better converted into a product in which a lesser tensile strength is required. For instance, a plastic chair made of this polymer is better converted into a golf bag liners or toys.

According to Olabisi *et al*., (1979), (Not listed in ref) the presence of fillers in polymers increases the mechanical (tensile strength) properties of such polymers. It can be observed from the stress – strain plots that, PVC which is known to be the most plasticized polymer has the highest extension (strain) for each blends and melt at a higher temperature of (220 ^{0}C) but lower than the melt temperature for PET at (260 ^{0}C).

The trends generally show that, the highest tensile strength for 100 % virgin plastics is due to the nature of its molecular structure and the lowest mechanical properties of the 100 % waste is due to different kinds of stress it has been subjected to during its previous usage (Liu & Waskom, 1992).

The high extension for 100 % waste is due to the amount of plasticizing effect of the adjectives initial present. However, it was observed that the melting temperature for each plastic type decreases with increase in the percentage of waste material.

The PET blended samples show highest tensile strength variations but a lower extension, which may due to lack of plasticizing effect of its waste. It has been shown that the percentage of waste material to be blended with virgin materials play a vital role in the properties of the resulting product (s). This is evident in the individual samples. For example, 100 % pure (virgin) showed the highest tensile strength properties when compared with blended samples. The trend indicates that, the higher the percentage of waste plastic materials, the lower the tensile strength and the greater the extension due to the plasticizing effects of the waste (Tanko, 2002).

In conclusion, a blending ratio of 80 (V) to 20 (W) is strongly suggested for these plastic types, since this offers the highest tensile strength for each type and this will go a long way at reducing manufacturers cost.

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