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# Ultraviolet Transmittance of Reinforced and Non - Reinforced High Density Polythylene Samples

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***Abstract:***
*In this study, reinforced and non – reinforced High-Density Polyethylene (HDPE) samples gave different ultraviolet transmittance rates. The reinforced composites were differently coloured and were prepared by mixing reinforces and HDPE samples in the ratios of 15:85 and 30:70 respectively. Reinforcers used include, Cassava flour, coconut husks flour and oak tree flour. Samples were rectangular. Two sets of HDPE samples were used to obtain the results presented in this paper. Samples used were of different thickness. The said materials are used to make containers used for storage of components like cooking oil, cosmetics among others. Less thick samples used were yellow (60.59 x12.24 x1.77 mm), white (61.64 x14.49x1.07 mm), transparent (59.65 x 11.95 x 0.93 mm) and black (59.44 x 13.03 x 1.24 mm) in colour and dimensions. The thicker samples were yellow (60.26 x 13.7 x 2.36 mm), white (61.16 x 11.36 x 1.90 mm), transparent (59.1 x 13.43 x 2.03 mm) and black (61.06 x15.35 x2.76 mm) in colour and dimensions. UV lamp (254 nm) used to illuminate the study samples was 20 cm from the aperture of the Spectro -320 where samples were placed. Optical Spectrum Analyzer (OSA) - 320 was used to study the UV transmittance of the samples. The transmittance difference in terms of percentage was represented using bar graphs. The results show that the reinforcers have a reducing effect on UV transmittance rate. As the reinforcer content increases, the UV transmittance rate decreases. This was verified by change in reinforcer - HDPE ratio from 0:100, 15:85 and 30:70.*

***Keywords:*** *Ultra violet, transmittance, reinforcement, high density polyethylene*

## 1. Introduction

The Electromagnetic (EM) spectrum consists of gamma rays, x-rays, ultra violet, visible light, infrared and radio waves, in the order of increasing wavelength. When EM radiations interact with matter, the material absorbs part of the rays and some of the rays are transmitted. Incident energy radiations are given in packets. The presence of ozone layer prevents high-energy rays from reaching the earth's surface directly. These rays include Cosmic, Gamma, X-rays and part of shorter wavelength ultraviolet (UV) rays. (Vesna, et al, 2010). Unfortunately, the alarming increase in depletion of ozone layer has caused great risks to man and his environs due to prolonged exposure to solar UV radiation (Bhupendra & Mangala, 2013). The weakening ozone layer allow ultraviolet rays to reach the earth's surface. UV radiations effects include sunburns on the human skin and high transmittance in materials like HDPE's. HDPE materials allow transmittance of UV radiation between 250 - 380 nm, which leads to penetration of the radiation through the material (Grigoriadon, et al, 2011, P. Kuria Kamweru et al, 2014).

In this study, I proposed that using coconut husks flour, oak tree flour and Cassava flour as reinforcers would also change the UV transmittance of virgin HDPE.Research done on how to cub UV transmission through HDPE materials showed that different methods can be employed. These methods include coating of HDPE, which is commonly used in plastic industries although it is an expensive approach. Again, Opaque pigmented coatings are done to prevent UV transmission through different HDPE materials. This technique although it reduces UV transmittance, it interferes with the aesthetic value of the HDPE material being used to design different containers for use. Blended samples absorb some UV light hence facilitates Ultraviolet weathering of HDPE (Laurent et al,2011). Therefore, this study proposes that blending of reinforcers and HDPE gives out a reinforced HDPE sample for use in designing required containers with a capability of arresting UV rays. This would reduce to a great extend UV transmittance hence its effect on substances stored in HDPE containers.

Much work has been done on blending ratios of polymers and different reinforcers. A study done by Yong Lei et al 2007, used a fiber to plastic ratio of 30:70 in studying preparation and properties of recycled HDPE/ natural fiber composites. Another study showed a variance of from 0-50% starch content variance in studying Mechanical, thermal and Morphological characterization of recycled LDPE/ corn starch blends (Pedroso & Rosa, 2005).In another study on Abrasive wear of HDPE/ UHMWPE blends, the substance of UHMWPE blended with HDPE were 0,10,20,30 wt% (Alessandra et al, 2011). Whenever a reinforcer is added to HDPE, it changes its properties. It increases impact strength, stiffness and composite odor among others. This therefore makes it necessary to limit the reinforcer/ HDPE blend ratio. The blending ratio should not be too high or too low. There is also need to limit blend ratio in order to reduce moisture intake by the new composite (Omar Faruk, et al, 2012).This study proposed a blending of reinforcers and HDPE at 0, 15, 30 wt %, which would cover the average value from the extreme ends of other studies done in the same field.

Studying the transmittance of reinforced and non-reinforced HDPE sample enables material designers and users to understand the different transmittance rates of various materials dimension and color wise. It would also help know the most appropriate material for use in different prevailing circumstances. In reference to the materials of study in this research paper, once the transmittance of each material sample is known, users will beat liberty to use what best suits them.

In this research work, results of UV transmittance of reinforced, non-reinforced and differently coloured HDPE materials are presented and discussed.

## 2. Experimental Procedure

### *2.1. Materials*

HDPE material was commercially obtained from Styroplast industry limited Kenya while reinforced HDPE was locally prepared in the laboratory at Egerton University. Reinforcers including Cassava, Oak tree bark and Coconut husks were obtained from Egerton University local market and ground to produce flour. The flour was sieved before use to ensure homogeneity in particle size of between 20 µm to 25 µm.

An electric coil was used to heat the samples for study contained in a cylindrical metallic heating vessel, which acted as a melting chamber in preparation of samples held in position by a pair of togs. A 600-rpm motor was used in driving a metallic stirrer while mixing of constitutes was in progress. Metallic chips (150mm by 100mm by 50mm) which acted as receiving plates to already prepared composite was available. A hacksaw was used to cut HDPE materials to required shapes (rectangular) and sizes for further analysis. A Vernier caliper was used to measure length, width and thickness of all the samples used in this study. A metallic cooling chamber made of brass was used to act as an enclosure for samples to allow efficient cooling rate.

### *2.2. Sample Preparation*

Pieces of HDPE were cut from commercially obtained HDPE materials. Sample dimensions were measured using a Verniercaliper and recorded. Respective reinforcers quantities were measured using formula 1: -

$$M_R = \frac{M_R\%}{M_{H\%}} X M_H \qquad (1) \text{ (Kamal B.A et al, 2008)}$$

*Where*

$M_R$ is the mass of respective reinforcer in grams represented by the % mass of reinforcer, $M_H$ is mass of HDPE in grams represented by the % mass of High-Density polyethylene, $M_R$ % is percentage mass of Reinforcer and $M_H$ % is percentage mass of HDPE

The Cut HDPE pieces were added to the heating vessel, which were heated until melting began at $150^oC\pm5^0C$.The molten HDPE was mixed up with a stirrer fixed on an electric motor. Heating continued until HDPE material was completely melted i.e. $190^oC \pm 0.5^0C$. Respective reinforcer ratios were added. The respective mixtures were further stirred to enhance homogeneity in the composite outcome. The molten HDPE composite was then poured into metallic receiving plate and allowed to cool. Desired study sample were therefore extracted for use.

### *2.3. Sample Transmittance Measurement*

Transmittance through HDPE samples was measured using Optical spectrum Analyzer (OSA) with Spectro-320, which has Specwin software as the user interface and for control.OSA 320 is an instrument that records transmittance spectrum within all spectral range programmed (P. Kuria Kamweru et al, 2014). Samples for study had different thickness, which contributed to the results of transmittance obtained. Spectro 320 runs samples for study, analyses studied samples and gives results in terms of transmission spectrum. Each sample for study was placed on the aperture of the Spectro-320. A UV lamp placed 20 cm from the aperture was used to illuminate the samples for study. The lamp irradiates at 254nm and 365 nm. For the current study, 254nm wavelength was used. UV Light was shone on such that it was incident at right angles to the sample (Yang- hsin Shih & Chun- Kang Wang, 2009). The first run was done without any sample in place (on aperture). This became the control scan for the experiment. Specwinsoftware sets a reference spectrum to 100%.All other scans that preceded the control scan were done in reference to it. In order to avoid direct radiations, transmission measurements were made with the long baffer, therefore collected transmitted radiation. The buffer blocks the view of incident flux, which has undergone at least two reflections from the source of radiation. It is positioned to prevent first reflections from entering the field of view for the photo detector. Sample transmission was measured using the integrating sphere with a short reflecting buffer.

## 3. Results and Discussion

### *3.1. Results*

Formula 2 was used to determine the values used to obtain table 2 for plotting of transmission bar graphs

$$\frac{x}{254} X\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where$x$– Is the respective transmission value in the transmission spectrum obtained and 254 is the radiation wavelength in nm

| Hdpe Material and Respective Reinforcement Ratios | | | |
|---|---|---|---|
| Colour | **0:100** | **15:85** | **30:70** |
| Yellow | 60.59 x 12.24 x 1.77 mm | 60.98 x12.27 x 1.80 mm | 61.00 x 12.34 x 1.88 mm |
| White | 61.64 x 14.49 x 1.07 mm | 61.74 x 14.66 x 1.58 mm | 61.98 x 14.78 x 1.88 mm |
| Black | 59.44 x 13.03 x 1.24 mm | 59.60 x 13.09 x 1.26 mm | 59.68 x 13.11 x 1.30 mm |
| Transparent | 59.65 x11.95 x 0.93 mm | 59.85 x 11.99 x 0.96 mm | 59.90 x 12.01 x 0.98 mm |

*Table 1: Samples Dimensions Before and After Reinforcement of HDPE Material*

The HDPE materials whose dimensions are given in table 1 were tested for transmission rate and gave an outcome as indicated in table 2

| | **Transparent** | | | **Yellow** | | | **White** | | | **black** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | 0:100 | 15:85 | 30:70 | 0:100 | 15:85 | 30:70 | 0:100 | 15:85 | 30:70 | 0:100 | 15:85 | 30:70 |
| Transmission rate (%) | 45 | 43 | 38 | 43 | 40 | 36 | 39 | 35 | 33 | 34 | 29 | 27 |

*Table 2: Transmission Rate for HDPE Material at 254 Nm*

| Hdpe Material and Respective Reinforcement Ratio | | | |
|---|---|---|---|
| Colour | **0:100** | **15:85** | **30:70** |
| Yellow | 60.26 x13.7 x2.36 mm | 57.66 x14.54x2.45 mm | 62.46x 13.16x2.9 mm |
| White | 61.16 x11.36 x1.90 mm | 60.4 x13.52x 2.65 mm | 64.13 x13.9x 4.96 mm |
| Black | 61.06 x 15.35 x2.76 mm | 59.2 x14.3 x4.2 mm | 56.98 x15.96 x4.11 mm |
| Transparent | 59.1 x13.43 x2.03 mm | 58.4 x12.87 x2.16 mm | 59.12 x12.95 x2.54 mm |

*Table 3: Samples Dimensions Before and After Reinforcement of HDPE Material*

The HDPE materials whose dimensions are given in table 3 were tested for transmission rate and gave an outcome as indicated in table 4

| | **Transparent** | | | **Yellow** | | | **White** | | | **Black** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | 0:100 | 15:85 | 30:70 | 0:100 | 15:85 | 30:70 | 0:100 | 15:85 | 30:70 | 0:100 | 15:85 | 30:70 |
| Transmission rate (%) | 27 | 25 | 23 | 26 | 21 | 18 | 12 | 10 | 8 | 20 | 18 | 15 |

*Table 4: Transmission Rate for HDPE Material at 254 Nm*

Using the values obtained in table 2, a graph of transmission rate against respective reinforcement ratios was plotted and gave a bar graph as indicated in Figure1 below.

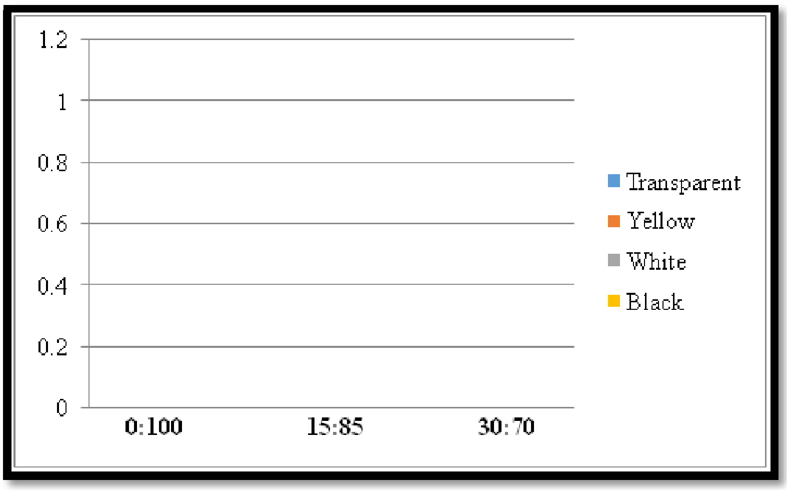


*Figure 1: Transmission Rate for HDPE Material at 254 Nm*

Again, using the values obtained in table 4. a graph of transmission rate against respective reinforcement ratios was plotted and gave a bar graph as indicated in Figure 2 below

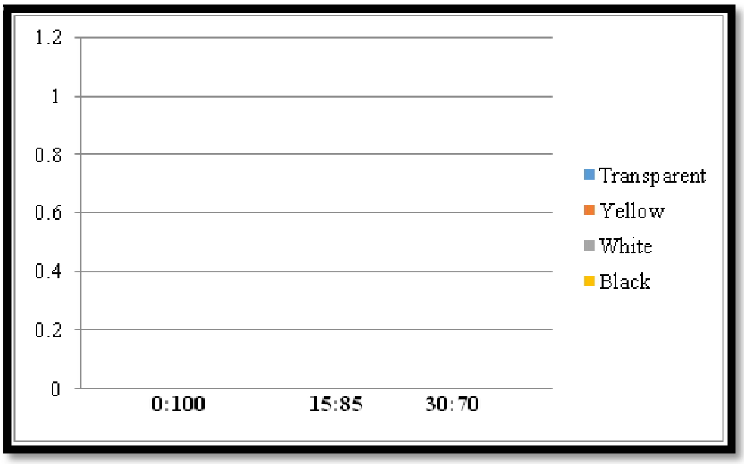


*Figure 2: Transmission Rate for HDPE Material at 254 Nm*

*3.2. Discussion*

As indicated in Figure1, non-reinforced samples had a higher transmittance compared to respective reinforced samples. This agrees with research work done by Alina Sionkowska, 2011 and Laurent et al, 2011. In their study, they realized that, blended HDPE samples are more photo – resistant than Virgin HDPE samples. When HDPE concentration is decreased through addition of a reinforcer, it leads to increase in positional planners in the forbidden energy gap hence decrease in transmittance (Majeed Ali Habeeb and Ahmed Hamza Abbas, 2015). For non-reinforced samples, transmittance was 45% for transparent HDPE material whose dimension is 59.65 x 11.95 x 0.93 mm and 43% for yellow HDPE material whose dimension is 60.59 x 12.24 x1.77 mm. Again, transmittance was 39% for white HDPE material whose dimension is 61.64 x 14.49 x1.07 mm and 34% for black HDPE material whose dimension is 59.44 x 13.03 x 1.24 mm.

The reinforced HDPE samples at 15: 85 ratio had a transmittance of, 43% for transparent HDPE material, whose dimension is 59.85 x 11.99 x 0.96 mm and 40% for yellow HDPE material, whose dimension is 60.98 x 12.27 x1.80 mm. Once more, transmittance was 35% for white HDPE material whose dimension is 61.74x 14.66 x 1.58 mm and 29% for black HDPE material whose dimension is 59.60 x 13.09 x 1.26mm.

The reinforced HDPE sample at 30:70 ratios had a transmittance of 38% for transparent HDPE sample whose dimension is 59.90 x12.01 x0.98 mm and 36% for yellow HDPE sample whose dimension is 61.00 x 12.34 x 1.88 mm. Again, the transmittance was 33% for white HDPE sample whose dimension is 61.98 x 14.78 x1.07mm and 27% for black HDPE sample whose dimension 59.68 x 13.11 x 1.30 mm.

UV transmittance alongside being affected by sample's composition, it is also affected by sample thickness. In this study, thickness increased as blending ratio changed from 0:100 to 30:70. Again, transmission rate decreased with increase in thickness. This is suggested to occur following the structure change of the affected study samples (Hiroyuki Sugimoto et al 2018). On the other hand, transmission rate decreased as reinforcement changed from 0:100, 15:85 and 30:70. This implies that, the reinforcers added to the virgin HDPE sample had harvested UV light and prevented some of the rays from going through it. These results are in accord with work done by S. Abdanan Mehdizadeh et al, 2015 whose results showed a decrease in transmission rate as sample thickness increased. This happened following the diminishing penetration of UV irradiation due to increasing thickness.

Transparent HDPE material had the highest transmission rate followed closely by the yellow HDPE material. The white HDPE sample had low transmission while the black sample had the lowest transmission rate. This trend repeated itself after reinforcement of HDPE samples at different reinforcement ratios.

From Figure 2, transmission rate was higher in non-reinforced samples compared to reinforced samples. The transmission rate for non-reinforced samples is 27% for transparent HDPE material, 26% for yellow HDPE material, 12% for white HDPE material and 20% for black HDPE.

For reinforced HDPE, materials whose blending ratio is 15:85 had a higher transmission rate compared to materials whose blending ratio was 30:70. For materials at 15:85, their transmission rate is, 25% for transparent HDPE material, 21% for yellow HDPE material, 10% for white HDPE material and 18 % for black HDPE material. For materials at 30:70, their transmission rate is, 23% for transparent HDPE material, 18% for yellow HDPE material 8% for white HDPE material and 15 % for black HDPE material

In respect to the colour of each sample, the materials in order of decreasing transmittance include transparent, yellow, black and white HDPE materials. Again, the transmission rate decreased with increase in thickness and reinforcement ratio.

## 4. Conclusion

From this study,

- Reinforcing HDPE samples, reduces UV transmittance
- UV transmission rate varies from one reinforced HDPE sample to another in terms of colour, reinforcer used and thickness

## 5. Acknowledgement

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