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Effect of Monoazo Dye on The Mechanical Properties of Low Density Polyethylene and Unplasticised Polyvinyl Chloride

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ABSTRACT: A red coloured monoazo dye (1-Phenylazo-2-naphthol) has been synthesized from aniline and 2-naphthol at a temperature of 5°C. UV spectrum of the dye showed the presence of azo group and naphthalene chromophores at wavelength of 285-400nm and 200nm respectively. The effect of the dye on the mechanical properties of UPVC film obtained by solvent casting and LDPE film obtained by compression moulding using standard hot melt compounding technique shows that the dye has no significant effect on the tensile properties of UPVC. However, addition of the dye to LDPE reduces the elongation – at – break, ultimate tensile strength and modulus properties. @ JASEM

The extension of the service life or service stability under variable conditions and in general the improvement and modification of the property of the polymer can be achieved by incorporating various additives in the polymeric material matrix (Driver, 1979), Dubois (1977). These include plasticizers, stabilizers, antioxidants, lubricants, antistatic agents, flame-retardants, absorbers, fillers, colourants etc. Colourants additive in the form of dyes, pigments and specialty colour compounds are ingredients to plastics to enhance appearance, beauty, attraction or appeal to consumers i.e. for aesthetic purposes.

Colouring additive although constituting only a very small proportion of polymer products, can result to various undesirable effects. It has been reported, for instance, that phthalocyamine pigment (Alfonso, *et al*, 1973, Turturro *et al*, 1973) which are widely used in the colouration of polyethylenes, show striking deformations in polyethylene injection mouldings immediately after extraction from the mould or during storage period. Evidence also exists to support the effect of the several organic and inorganic substances in the modification of morphology and mechanical properties of several polymers (Kargin *et al*, 1967). Ogbobe (1992) reported that a colourant additive containing a significant amount of ultramarine blue is photosensitive. In small amounts, they tend to mask the UV screening effect of added screeners during the early stage of photooxidation. Addition of ultramarine blue to HDPE promotes chain scission initially while favouring cross-linking on prolonged photo oxidation.

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Pigment master batches and diazo dyestuffs colourant have been given prominent attention and favoured whereas very little if any in industrial practice of colouring based on monoazo dye stuff is mentioned. Therefore, in this present work, we have synthesized monoazo dyestuff and examine its effect on the mechanical properties of LDPE and UPVC.

MATERIALS AND METHODS

Extrusion grade LDPE, density 0.92gcm^{-3} and melt flow index 2 was used. UPVC used in this work is a homopolymer labeled as 0500M 40722bg and supplied by Oxyvinyls, Dallas, Texas, USA through KGM Plastics Nigeria Ltd., Isolo, Lagos. All other chemicals and reagents used were of analytical grade or otherwise stated and were used without further purification. A 4.9ml of aniline was dissolved in a mixture of 16ml conc. HCl and 16ml distilled water. The solution was placed in an ice bath to reduce the temperature. 4.0g of $NaNO_2$ was dissolved in 20ml of distilled water and added to the cold solution of aniline hydrochloride to produce the dye intermediate (benzene diazonuim chloride). 7.8g of 2-napthol was dissolved in 45ml of 10% NaOH. The resulting solution was cooled to 5°C by immersion in an ice bath. The napthol solution was stirred vigorously and the cold benzene diazonuim chloride solution added very slowly to precipitate the desired monoazo dye (1-Phenylazo –2- napthol). The precipitate was filtered, washed to neutral and dried. (Vogel, 1978). All preparations were carried out in an ice bath to avoid the decomposition of the dye intermediate. The solubility of the dye in various solvents and its melting point was determined. Chromophores and functional groups present in the dye were determined by recording their UV and IR spectra respectively.

LDPE supplied as granules were further chipped and mixed with varying percentage (0, 1, 2, 3, 4, 5 wt %) of the dye using silicone oil as processing aid. Dumb-belled shaped composites were obtained using a 200m thick aluminum sheet moulds filled with LDPE dye mixture. Compression moulding using two steel blocks made the composites. The tensile properties were measured using an instron tensile testing machine (model 1041 system) with a full-scale deflection of 5000N. A guage length of 10cm was employed for all samples. A crosshead speed of 1000mm/min was used. All measurements were made at 65% relative humidity at 20°C. The variation of stress with strain, ultimate tensile strength and elongation-at-break were determined. Varying weight percent (0, 1, 2, 3, 4, 5 wt %) of the dye was added to UPVC. A film of 50μm thick was obtained by solvent casting in tetrahydrofuran (THF). Coloured films in each case were obtained in a one-pot process to avoid thickness variation. The tensile properties were determined using an instron tensile testing machine (model 1041 system) of full-scale deflection 5000N. A gauge length of 10cm was employed for all the samples. A crosshead speed of 200mm/min was used. All tests were carried out at 65% relative humidity at 20°C. The variation of stress with stain, ultimate tensile strength and elongation at break were evaluated.

RESULTS AND DISCUSSION

Results of the dye solubility test show that the dye is soluble in n-hexane, chloroform, benzene and THF and insoluble in methanol, ethanol, 10% NaOH solution, ethanioc acid and petroleum ether (40 - 60°C).

The dye had a melting point range of 80-120°C. UV and IR spectra of the dye are shown in figure 1 and 2 respectively.

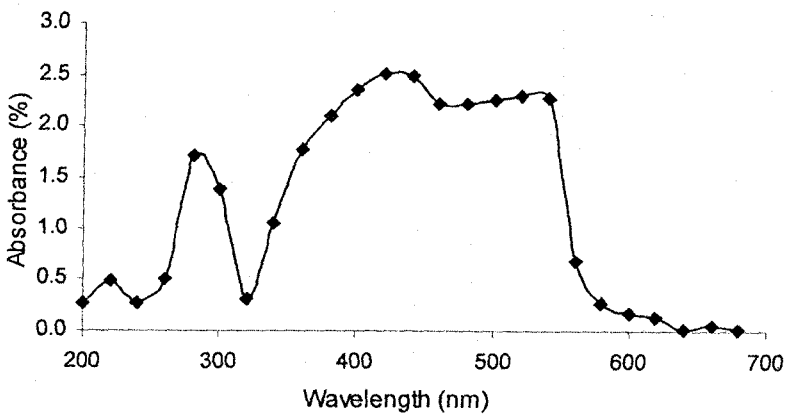

Figure 1: UV spectrum of 1-Phenylazo-2-naphthol

From the figure, it is observed that the chromophores present in the dye are naphthalene, which absorbs maximally at 200nm and azo group (-N=N-), which absorbs in the range 280 – 400nm. IR recordings show a major peak at 1493 cm^{-1} wave number corresponding to aromatic functional group, which may be from the aniline or naphthalene component of the dyestuff. The effect of the dye on elongation-at-break, ultimate tensile strength and modulus for both LDPE and UPVC are indicated in figures 3, 4, and 5 respectively.

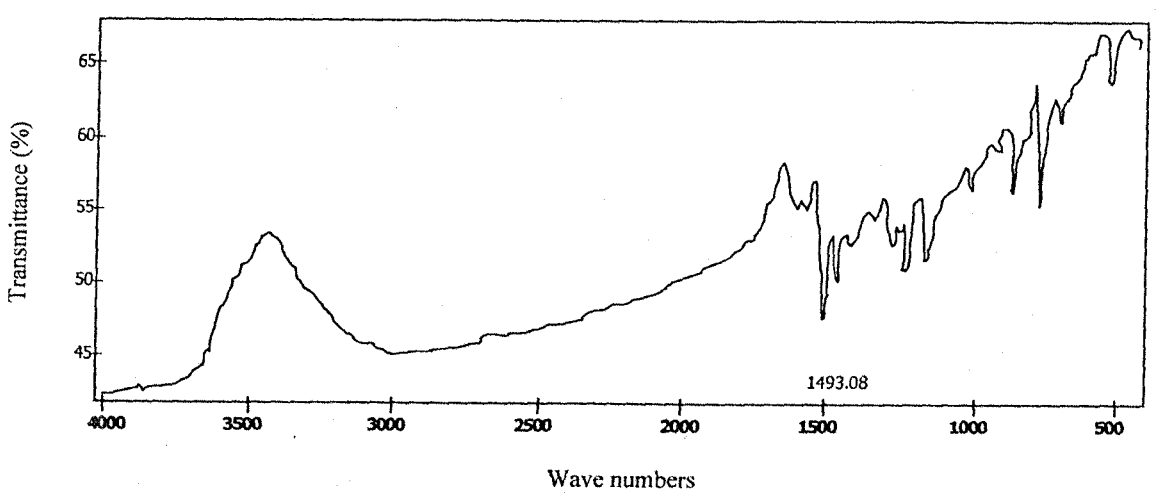

Figure 2: IR spectrum of 1-Phenylazo-2-naphthol

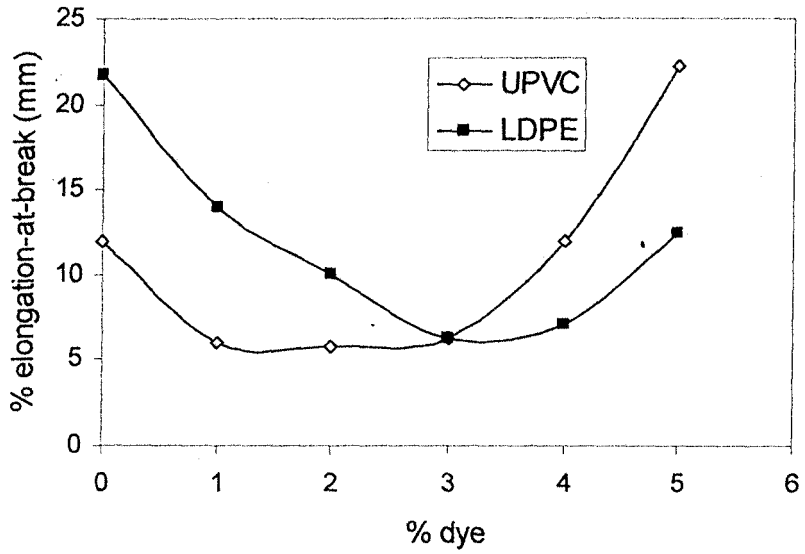

Figure 3: % Elongation-at-break as a function of % dye

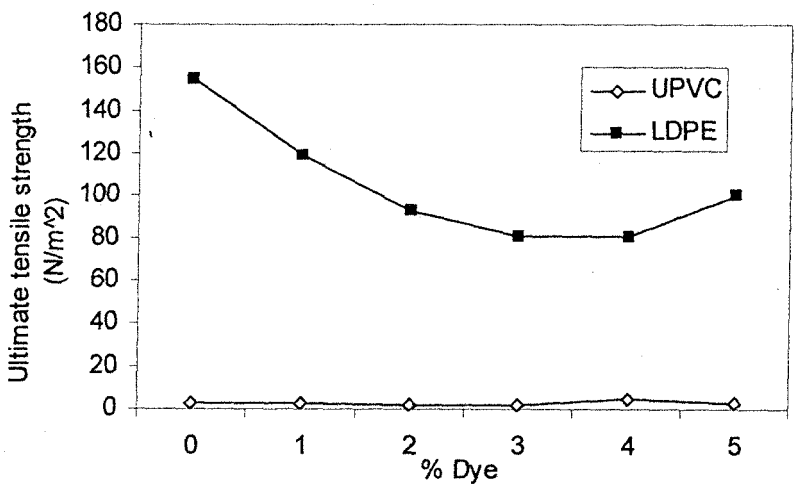

Figure 4: Ultimate tensile strength as a function of % dye

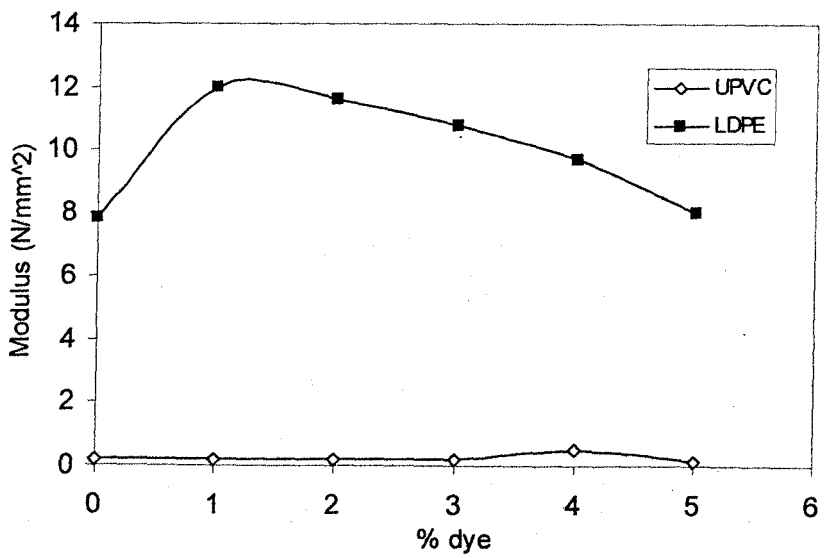

Figure 5: Modulus as a function of % dye

Fig. 3 shows that the elongation-at-break increases for coloured UPVC and decreases for coloured LDPE as the dye uptake increases. The increase in elongation-at-break may be an indication that the dye is exercising a plasticizing action. Although the mechanism through which this occur is not known, it may be due to the interaction between the solvent and the dye thus causing the latter to act as a lubricant to facilitate movement of UPVC macromolecules chain over each other and provides internal lubricity (Bower, 1979). This can be a significant advantage indicating that the dye can function as a dual purpose polymer ingredient. The possibilities being as a colourant and a plasticizer.

Figure 4 shows the effect of the monoazo dye on the ultimate tensile strength of both UPVC and LDPE. The dye has no significant effect on the ultimate tensile strength of UPVC while it downgrades the ultimate tensile strength of LPDE. From Figure 5, it can be seen that the dye has no appreciable effect on the modulus of UPVC. It is also observed that at 1% wt composition, the dye upgrade the modulus of LDPE. Between 2 – 5% wt composition, the dye downgrades the modulus of LDPE. The decrease in elongation-at-break, ultimate tensile strength and modulus especially at higher composition when the dye is incorporated into LDPE may be regarded as an impairment of the mechanical property of the polymer. The possible effect being that the addition of

the dye produces a resultant polymer that is soft and weak. The weakening may be due to the decrease in intermolecular forces between the polymer molecules due to the presence of low molar mass dye molecules which interfere with both the intermolecular attractive forces and the physical force of interlocking between the polymer molecules due to the coiled up structure.

Conclusion: It has been shown that 1-phenylazo-2-naphthol, a monoazo dye has no significant effect on the mechanical properties of UPVC indicating the possibility of using the dye for colouring of PVC for aesthetics purposes. Also on addition of the dye to LDPE, it is observed that there is a decrease in elongation-at-break, ultimate tensile strength and modulus. This suggest that dye molecules in LDPE should enhance degradability of LDPE.

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