EFFECTS OF NATURAL WEATHERING ON TENSILE STRENGTH AND EMBRITTLEMENT TIME OF BLENDS OF RECYCLED POLYPROPYLENE WITH POLYSTYRENE, POLYVINYL CHLORIDE AND VIRGIN POLYPROPYLENE

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Abstract: Natural weathering degradation of the blends of recycled polypropylene (PPr) with Polystyrene (PS), Polyvinyl chloride (PVC) and Virgin Polypropylene (PPv) was studied. Samples of PS, PVC and PPv were blended with PPr for the purpose of improving its Tensile strength and the embrittlement time which are some of the mechanical properties of polymer. While no particular blends had over all good result of the mechanical Properties tested, however, PS/PPr produced the best result of Tensile strength, followed by the blends of PPv/PPr and PVC/PPr. Also PS blend resist embrittlement more than PPv and PVC blends.

Keywords: Ageing, degradation, ductability, elongation, embrittlement, tensile-strength

Introduction

There are environmental problems and challenges associated with the management of plastic wastes in Nigeria as well as in many developing countries. Due to their non-biodegradability and diverse applications, plastic wastes from petrochemical source are prevalent in the environmental and causes health hazard, chocking of fertile soils, flooding due to blockage of drainage, breeding grounds for mosquitoes, death of livestock due to ingestions, food hazards, pollution (dioxin and furan) from burning of plastics. According to the study carried out by the federal ministry of environment, Nigeria generated more than 2.260 million tonnes of plastic wastes annually.

Among the waste generated is Polypropylene (PP) which is considered the most important material among polyolefins due to three main reasons. First, great properties of PP such as low density, high melting temperature and chemical inertness with low cost making PP optimum for long-life applications. Second, polypropylene is a highly versatile material meaning that diversity in structural designs and mechanical properties are achievable. Third, different morphological structures of PP are possible by using fillers or reinforcing agents and blending PP with other polymers which yield to have superior characteristics (Rajakumar *et al*., 2009). The deleterious effects of weathering on polymers generally has been ascribed to a complex set of processes in which the combined action of UV light and oxygen. The overall light-initiated process in the presence of oxygen generally is referred to as oxidative photo degradation or photo-oxidation. We can never have a pure thermal effect because oxygen is present and so the process is a thermal–oxidative degradation (Feidman, 2002).

Polymer blend could be defined as a mixture of at least two macro molecular substances, polymers or copolymers, in which the ingredient content is higher than 2 wt%. The blending of polymers provides a means of producing new materials which combine the useful properties of all of the constituents (Utracki, 1998). The ability to combine existing polymers into new compositions with commercial utilities offers the advantage of reduced research and development expense compared to the development of new monomers and polymers to yield a similar property profile.

Most pairs of polymers are immiscible with each other, and have less compatibility than would be required in order to obtain the desired level of properties and performance from their blends. Compatibilizers are often used as additives to improve the compatibility of immiscible or partially miscible polymers and thus improve the morphology and resulting properties of the blend.

In the present work, in order to encourage the use of recycle PP which in effect reduce environmental pollution and to produce a new materials through blending, the effect of weathering on mechanical properties (Tenacity and embrittlement time) of blends of recycle Polypropylene (PPr) with virgin Polypropylene (PPv), Polystyrene (PS) and Polyvinylchloride (PVC) without the use of comptibiliser were investigated.

Materials and Methods

Materials

Polypropylene (virgin), Polypropylene (recycled), Polyvinyl Chloride chips, Polystyrene chips.

Equipment

Triple beam balance (700series), Aglomerator (Model no 4600), Palletizer, Two roll-mill (Model No 5185), Mechanical heat press. (Model no D288), Particle board, Hundsfield Tensometer.

Preparation of sample

All the materials used were purchased from the local market, while the recycled polypropylene were collected from the waste bins, road sides, drainage, etc, it was sorted washed, shredded and makes it in chips form.

Formulation of samples

Twenty three samples were prepared in the following percentages, using three different polymers; Polystyrene (PS), Polyvinyl Chloride (PVC) and Polypropylene virgin (PPv) to the recycled polypropylene (PPr). The samples were processed on two a roll-mill machine at the Federal Institute of Chemical and Leather Technology, (CHELTECH). Zaria (M/C No 5185).The machine produced homogenous mixture of virgin and recycle material as formulated above. The machine is made up of two rollers and a collection tray. The temperature of the machine was set at 160-165^{0}C

Production of films

The films were produced using the heat press machine (Moore Birmingham S/No D 288) at the Polymer laboratory in the Department of chemistry, Ahmadu Bello University, Zaria. For each formulated samples, ten samples of 1 gramme each were heat pressed to produce a thin film of 7 & 7 cm of about 20 microns

Environmental exposure

The prepared film was cut into equal dimension of 5 x 5 cm and mounted on a neatly prepared particle board. The outdoor weathering of the films was carried out by exposing the films in an open air at the Fire Service Training School field from May-August, 2010. The field station is situated at Dakata, 10 km north of Kano, on latitude 9^{0}21 N and longitude 8^{0} 3 E.

The positions of the film were rotated so that they face the direction of the sun always. The daily temperature between this period varied between 23 – 40^{0}C in May – August. The average relative humidity was 60% R.H during the period of exposure.

Method of monitoring degradation

a) Embrittlement time: The polymer films were tested at 24 h interval for embrittlement, the test samples were bent through an angle of 180^0, the time taken for respective polymer to show a sign of crumbling and flaking was recorded as the embrittlement time for the respective samples (Kolawole and Olugbemi, 1985).

b) Tensile test: The tensile tests were carried out by using a Hundsfield Tensometer (S/No 3179)., in Strength of Materials and Heat Treatment Laboratory, Department of Mechanical Engineering, Ahmadu Bello University, Zaria. The film sample for the test was 6 cm long and 1.5 cm wide, neatly cut with scissors from the film. The sample was placed between two claws of the machine with the guage length of 2.5 cm long & 1.5 cm width and force was applied gently in both directions with the aid of tension winder until the sample breaks. The force and extension were read from the machine and also on the graph paper provided.

Results and Discussion

Tensile strength

The tensile-strength measures the steady force required to break a specimen. The tensile test is used to produce a load – elongation curve, which was used to determine the ultimate tensile strength, breaking elongation, Young's Modulus and toughness.

Figures 1 – 6 show that as the exposure time increases, the tensile-strength decreases. This is due to degradation by chain scission undergone during continuous exposure, which leads to decrease in molecular weight and the quantity of entanglements that gives strength to the polymer. Also as the percentages of the virgin polymers increases in the blends, the tensile strength increases this is due to the incorporations of virgin polymers in the recycled which improve some of the properties due to long chain of the virgin polymer. However, out of the three polymers blend studied, PS/PPr has the highest tensile strength irrespective of the percentage composition, followed by the blends of PPv and PVC (Tables 1 and 2).

Though the PS/PPr blends systems were considered partially miscible, because PS contains aromatic rings, while PP contains-straight carbon chains of aliphatic kinds.

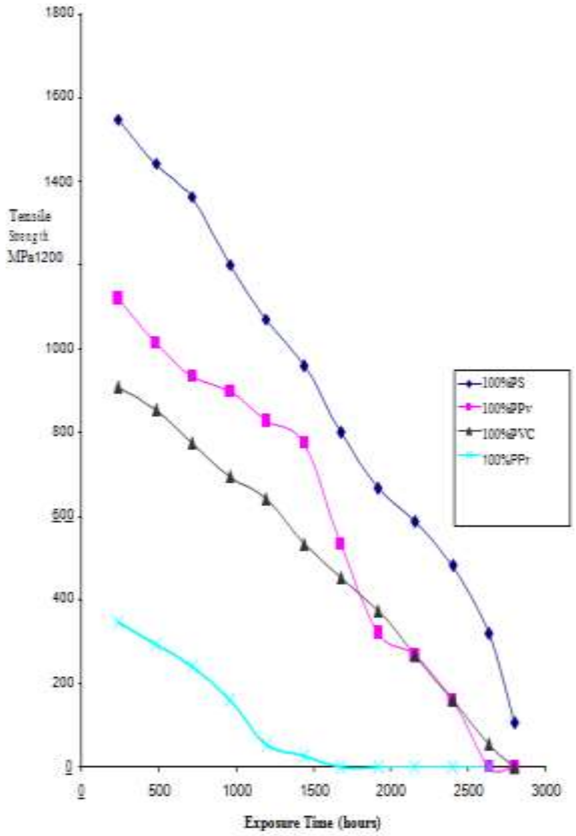

Fig. 1: Natural weathering on the tensile-strength of various polymers

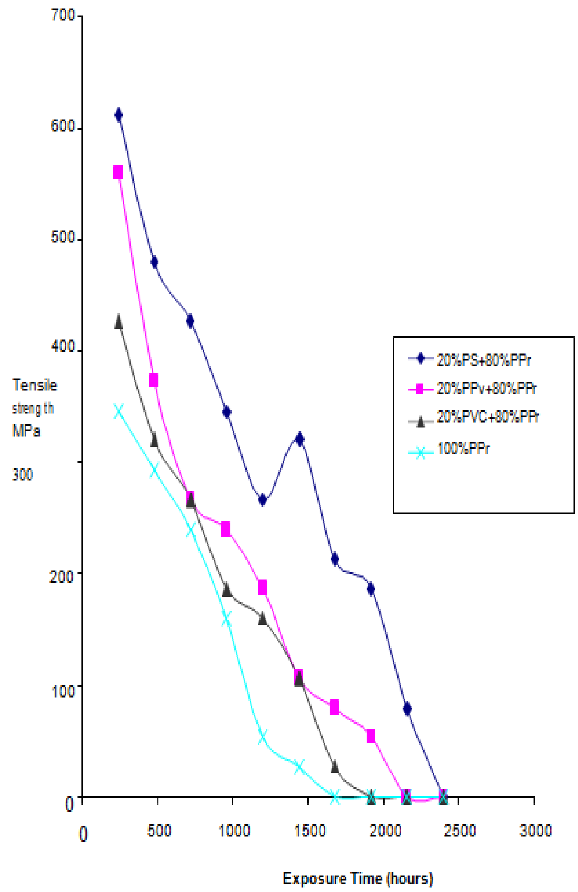

Fig. 2: Natural weathering on the tensile strength of various polymers

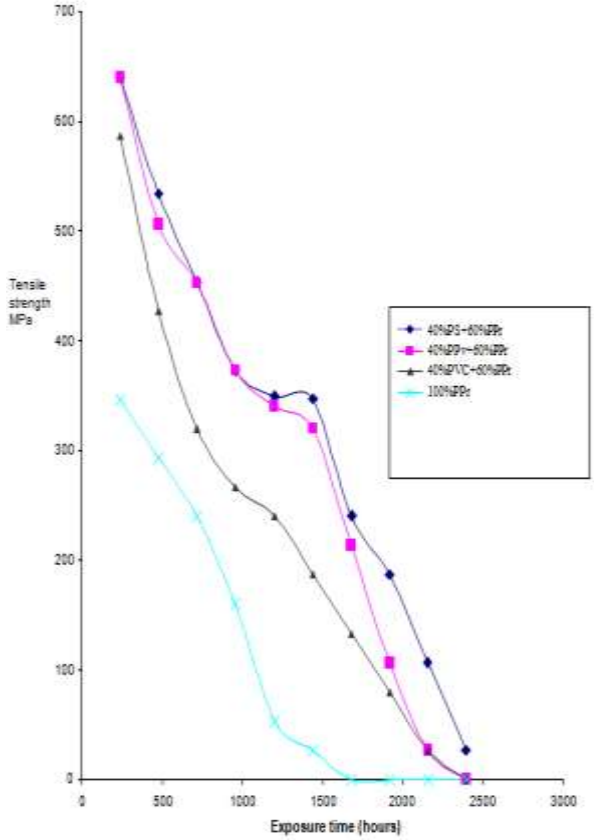

Fig. 3: Natural weathering on the tensile strength of various polymers

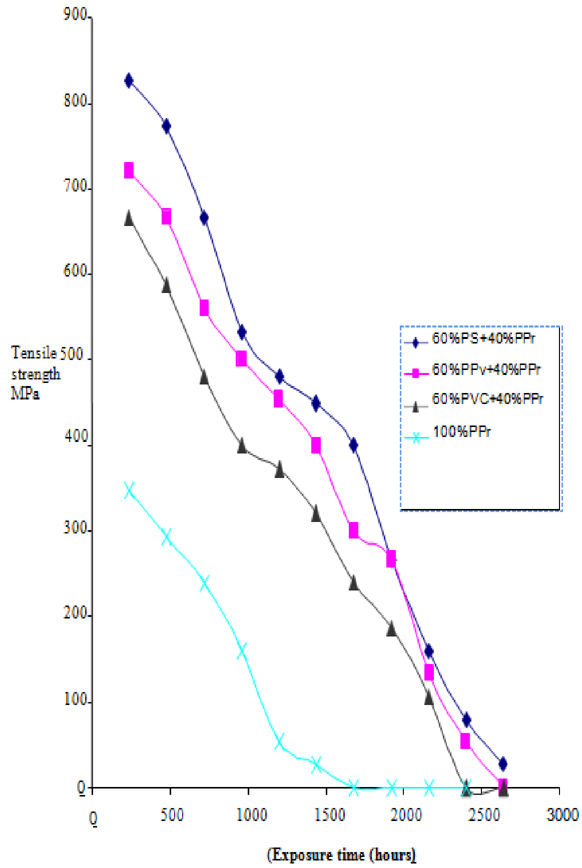

Fig. 5: Natural weathering on the tensile strength of various polymers

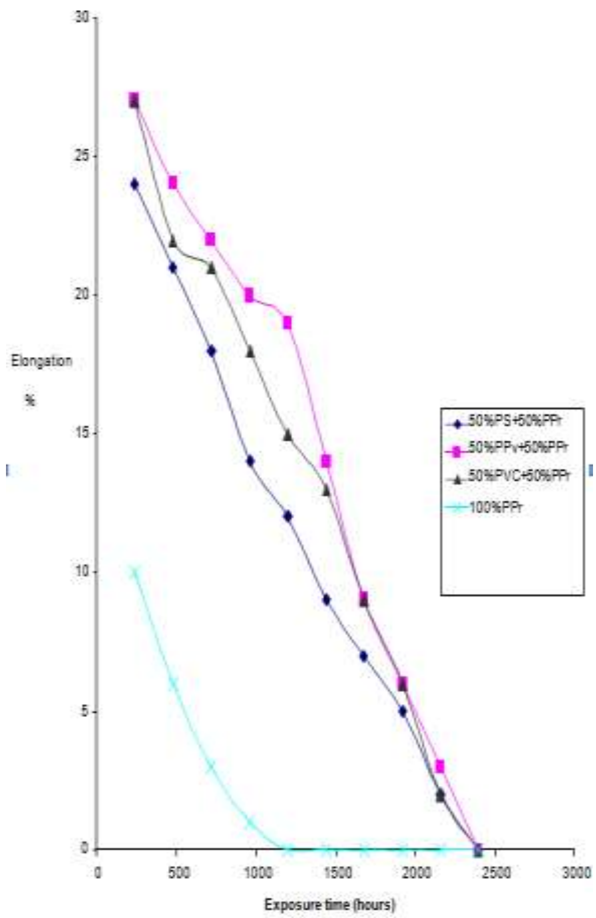

Fig. 4: Natural weathering on elongation of various polymers

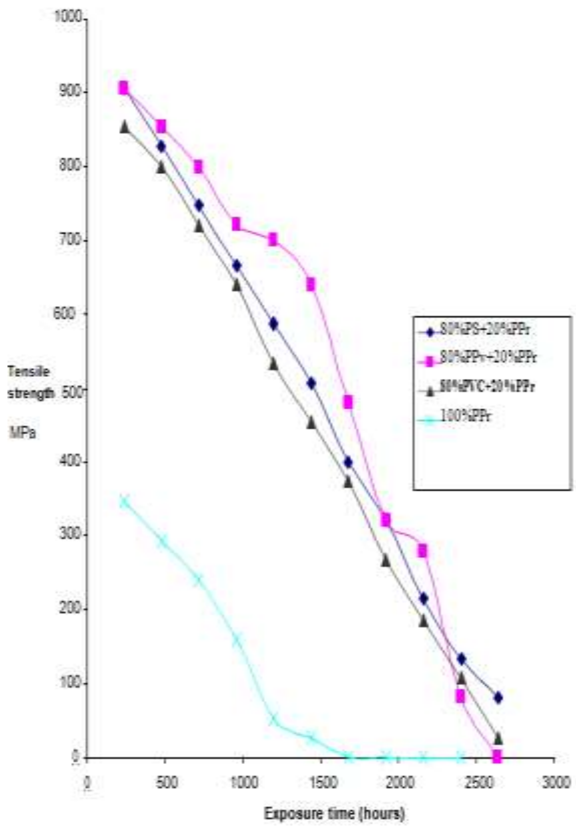

Fig. 6: Natural weathering on the tensile-strength of various polymers

Table 1: Percentage compositions of blends of recycle polypropylene (PPr) and virgin polypropylene (PPv)

PPr	PPv
0	100
10	90
20	80
30	70
40	60
50	50
60	40
70	30
80	20
90	10
100	0

Table 2: Percentage compositions of blends of recycle polypropylene with polyvinyl chloride (PVC) and polystyrene (PS)

PPr	PVC, PS
0	100
20	80
40	60
50	50
80	20
100	0

Past studies by Wantine *et al*. (2007), shows that at 20% or more of the PS in the PP blends shows a distinct and fine disperse morphology, which will produce high tensile-strength as good disperse morphology increase the molecular weight and high cross linking. The low tensile strength of PPr/PVC may be due to Immiscibility of the polymers which may require comptabilizers. However, Jianzhi *et al* (2006) in one of their works compared the mechanical properties of PP/PVC blends and PP/PVC/HBP (compatibilizer) the results shows that the tensile strength of the later is a little better than the former. This means that the blends of PP/PVC without comptabilizer canproducea reasonable good tensile-strength.

Embrittlement

Generally, when polymeric materials are exposed to weathering, such polymer will be attacked by heat, humidity etc. The molecular structure of such polymer will be altered (especially with u.v) thereby change its mechanical properties, the effects on molecular structure are; chain scission (breaking of the polymer molecule) and cross linking (connecting of two polymer molecule). Chain scission results in lower molecular weight causing loss of ductility; this is observed by reduction of elongation and stress at rupture (Fig. 7). The effects of cross linking are high yield strength and young modulus (Fig. 7). In most polymers both chain scission and cross linking occur, but the former usually prevails after some time and the main effect of photo degradation in solid polymer is weathering.

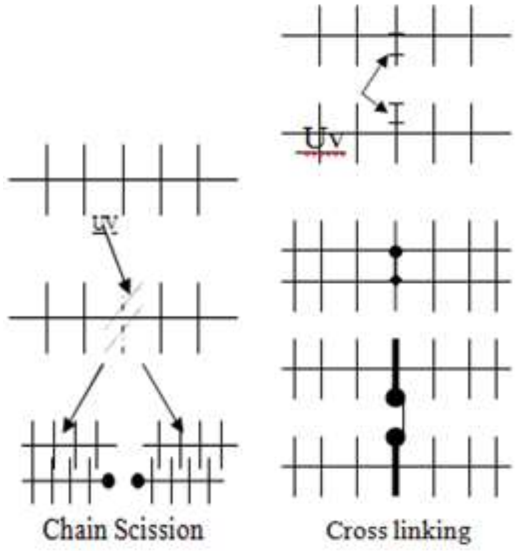

Fig. 7: Chain scission and cross linking in polymer molecule

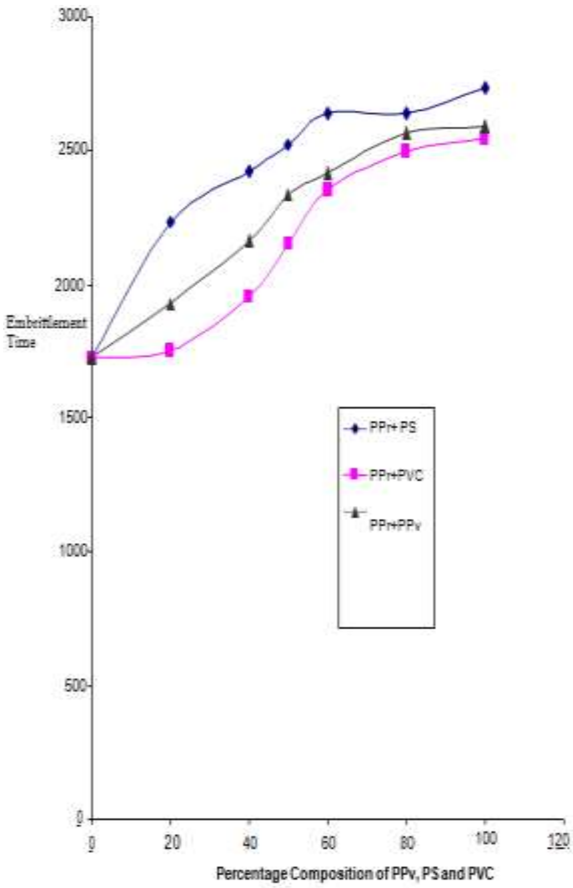

Fig. 8: Natural weathering on embritlement time of various polymers

Figure 8 shows the graph of Natural weathering on embrittlement time of various polymers. As the percentage of the virgin polymers in the blends increases so is the embrittlement time increasing. This is because incorporation of virgin polymers in the recycled ameliorates to a reasonable extent the damaging effect of degradation. The figure also shows that the blends of PS have high embrittlement time than other two blends of PPr and PVC.

Conclusion

The work revealed that some of the mechanical properties of recycled polypropylene can be improved by blending with polystyrene, polyvinylchloride and virgin polypropylene. Blending in the right proportion or percentages can produce a better material (polymers) that has peculiar characteristics. Between 20 – 30% the blend of PPv and PPr produce a remarkable improvement on tensile strength (Fig. 8). The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. When considering embrittlement, the PS blend resists embrittlement more than the other two polymers (PVC and PPv.). Embrittlement is due to oxidative ageing resulting from the loss of polymer capacity to undergo plastic deformation or toughness, which is one of the mechanical properties of polymers. PPr and PVC produces the worst results, are not encouraged to blend without comptibiliser. Due to their different polarity, poor adhesion, and high interfacial tension, they are incompatible. Thus, the corresponding blend possessing useful properties could not be obtained by direct blending of the two polymers (Xanthos, 1998; Byong and James, 2004; Tang *et al*., 1994).

Conflict of Interest

Author declares that there is no conflict of interest related to this study.

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