Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Chemistry

Elixir Appl. Chem. 46 (2012) 8167-8169

ISSN: 2229-712X

Wood Fibre reinforced polyethylene composites.

L Leke[1,3]*, B S Enoh[2], G O Igbum[3] and H T Dekaa[3]

[1]Surface Chemistry and Catalysis Research Group, University of Aberdeen, AB24 3UE, Aberdeen – UK.

[2]Department of Chemistry, University of Jos, P M B 2084, Jos, Nigeria.

[3]Department of Chemistry, Benue State University, P M B 102119, Makurdi, Nigeria.

ARTICLE INFO

Article history:

Received: 30 March 2012;

Received in revised form:

15 April 2012;

Accepted: 3 May 2012;

Keywords

Dracaena arborea,

Wood-plastic composites,

Polyethylene,

Fibre,

Biodegradation.

ABSTRACT

Low density polyethylene samples were reinforced with wood fibres from *Dracaena arborea*, the fibres were either bleached, unbleached, blended, unblended or in the acetylated form. Films formed after reinforcement of the polyethylene with the various forms of the fibres were tested to confirm their mechanical properties like tensile strength and tensile modulus. Moisture regains and water imbibitions were also determined. The reinforced samples were compared with a film formed from pure polyethylene. Mechanical properties of the wood fibre reinforced polyethylene composites were better than that of pure polyethylene. Pure polyethylene has a tensile strength of 20kN/m^2 and tensile modulus of 219kN/m^2 while the bleached and blended wood fibre reinforced polyethylene had a tensile strength of 42kN/m^2 and tensile modulus of 3620kN/m^2. Therefore, the reinforced polyethylene is suitable for use as specially tailored light weight structural parts in reinforcement. Whereas pure polyethylene is stable and resistant to environmental decomposition, the wood fibre reinforced polyethylene is renewable due to its ability to absorb moisture and imbibe water. Also, the wood fibre treatment showed improved moisture absorption and water imbibition potentials. This offers the possibility of biodegradation thereby meeting environmental demands.

Introduction

There has been a clear objection to the use of ordinary plastic in industries. This objection is due to lack of confidence in plastics due to some physical characteristic limitations like creep, fatigue, dimensional stability, high temperature performance, poor degradability and recyclable properties. To eliminate or minimize this limitations, plastics that have been reinforced with fibres have replaced the use ordinary plastic in aerospace, building and automobile industries as well as in the field of sports and leisure due to their resultant better mechanical properties like strength, stiffness, low weight, etc. (Maxwell,1983 and Moses, 1992). The plastic industries traditionally used talc, calcium carbonate, mica and glass or carbon fibres to modify the performance of plastics (Clemons, 2002). In order to successfully achieve a means of making materials with desirable properties as well as biodegradable and recyclable, scientists have used the knowledge obtained from composite studies. By embedding natural fibres like flax, hemp, remie, etc. into bio-polymeric matrix, made from derivatives of cellulose, starch, lactic acid, citric acid, etc. now fibre reinforced materials were generated (Hanselka,1996).

Natural fibre reinforced composites is an emerging area in polymer science. These natural fibres are low cost fibres with low density and high specific properties. They are biodegradable and non-abrasive. The natural fibre composites offer specific properties comparable to those of conventional fibre composites. When added to thermoplastics, natural fibres represent renewable reinforcements that enhance mechanical properties such as stiffness, strength and heat deflection under load. Having low densities compared with conventional inorganic fillers and reinforcements, these fibres are often used in applications such as inferior automotive paneling where the relatively low density of the natural fibre is an advantage (Tesdemir, 2009 and Clemons, 2003).

Wood is a natural composite of cellulose fibres in a matrix of lignin (Hon .D. 2001). Wood had long been used by the plastic industry as inexpensive fillers to increase strength and stiffness of thermoplastics and to reduce raw material costs (Wolcott and Englund, 2005). Wood plastic composite (WPC) consist primarily of wood and thermoplastic polymers. WPCs are normally made from a mixture of wood fibre, thermoplastic and small amount of process and property modifiers through an extrusion process. These materials have been viewed as wood fibre or particle reinforcing a continuous thermoplastic matrix (Tesdmir, 2009 and Wolcott and Englund, 2005). Wood plastic composites exhibit hybrid properties of food and plastic.

Wood-plastic composites (WPC) are a relatively new class of materials and one of the fastest growing sectors in the wood composites industry. Composites of wood in a thermoplastic matrix are considered a low maintenance solution to using wood in outdoor applications (Tesdmir, 2009). However, the commercial success of these emerging materials has been primarily by the improved moisture performance, recycled and waste material utilization, efficiency in product and process design (Wolcott and Englund 2005). Because of the limited thermal stability of wood, only thermoplastics that melt or can be processed at temperatures below 200 ^{0}C are commonly used in WCPs. Most WPCs are made with polyethylene, both recycled and virgin, for use in exterior building components. However, WPCs made with wood-poly ethylene are typically

Tele:

E-mail addresses: luterleke@gmail.com

used in automotive applications and consumer products, and these composites have recently been investigated for use in building profiles. Wood-PVC composites typically used in window manufacture are now being used in decking as well (Walcott and Addock, 2000).

When compared to solid thermoplastics, WPCs exhibit different mechanical and physical properties. Strength and stiffness are generally influenced with increase levels of wood fillers dependent on the materials and processing methods. Higher concentrations of wood fillers impact a natural resistance to ultraviolet degradation. Under some conditions, wood fillers can also increase the melt or softening temperature of the thermoplastic which allows for expanded serviceability. Wood thermoplastic composites have many processing advantages when compared with synthetic and mineral filled thermoplastics. Adding wood to a thermoplastic matrix will inevitably cause an increase in moisture uptake (Wolcott and Englund, 2005). Because WPCs absorb les moisture and do so more slowly than solid wood they have better fungal resistance and dimensional stability when exposed to moisture. Unfilled plastics absorb little, if any moisture, are very resistant of fungal attack and have good dimensional stability when exposed to moisture therefore are non-biodegradable (Clemons, 2002). The moisture content of the wood filler during processing is generally below 1 percent; therefore any filler exposed on the surface will absorb the surrounding water vapour and obtain equilibrium moisture content (EMC) (Wolcott and Englund, 2005). The goal of this research is to investigate the use of wood fibres to improve the mechanical properties, biodegradability and recyclability of polyethylene (thermoplastics).

Experimental

Results:

Samples Definitions:

Film A	Pure polyethylene films (PE)
Film B	PE + Blended, bleached fibre
Film C	PE + Blended, unbleached fibre
Film D	PE + Unblended, bleached fibre
Film E	PE + Unblended, unbleached fibre
Film F	PE + Acetylated fibre.

Materials

The wood fibre was obtained from the plant *Dracaena arborea* from the family *Agavaceae*. This plant is commonly found in the forest zone of Nigeria. The polymer used is polyethylene due to its availability, very high theoretical modulus and strength (Chantrasukul, 2007). The low density polyethylene (LDPE) sample was obtained from NASCO PACK (NIG). Ltd, Jos, North Central Nigeria.

Method

The fibres were bleached using Cl_2 and then acetylated. Some of the bleached and unbleached fibres were blended using a blending machine while some were not. The wood fibre reinforced polyethylene film was formed using a hydraulic press machine. Tensile strength and modulus were determined using Testremetric 220D. Moisture regain was determined using a Gallenkamp vacuum oven, by weighing, drying to constant weight, and then exposing the films to the atmosphere, allowing them to absorb moisture, and then weighing. Water imbibitions were also determined by drying to constant weight, then allowed to soak in water, then weighed.

Discussion

As shown in table 1, the fibre reinforced polyethylene films (Films B, C and D) exhibited better mechanical properties i.e tensile strength and tensile modulus as compared to the pure polyethylene film (Film A). The better mechanical properties exhibited by the fibre reinforced polyethylene over the pure polyethylene could be due to the presence of plasticizers (Bueche, 1959). Improved tensile properties of the bleached fibre reinforced composites over pure polyethylene could be attributed to the method of preparation. The properties of fibres as well as the method of preparation greatly affect the mechanical properties of composites (Nickel, 1998). Hence, the bleached fibre (Film B) performed better than the unbleached fibre films. This is likely due to the fact that the residual lignin was not removed, films containing blended fibres (Films B and C) exhibited better properties than the unblended fibre(Films D and E) having improved surface area, allowing for better fibre-matrix bonding and forming isotropic structures in the matrix as opposed to anisotropic structures in the unbleached fibres. The low elongation of the wood fibres reinforced composites (Films B C D and E) when compared to pure polyethylene (Film A) is because natural fibres are generally not extensible and due to the poor interaction between the fibres and polyethylene.

It can also be deduced from table 2 that the pure polyethylene (Film A) does not absorb moisture nor imbibe water. This is because polyethylene is hydrophobic. Since moisture absorption and water imbibitions are a function if biodegradability of any material, it implies that pure polyethylene is resistant to biodegradation. Amongst the reinforced polyethylene films, acetylated cellulose (Film F) showed the least in water and stability to chemical attack. It was also observed that those with bleached fibres (Film B and D) absorbed moisture and imbibed water more than the unbleached. This is due to better interaction between water and the delignified cellulose. Polyethylene films with blended fibres (Film B and C) also absorbed moisture and imbibed water better than the films with unblended fibres. This is attributed to the increase in surface area of the blended fibre, thereby giving room for better interaction between the fibre and moisture in the film.

Table 3 showing the water imbibition of the various films, also gave results that were of the same trend with that of moisture regain in table 2. This also tells of the biodegradability of the various films as earlier discussed.

Conclusion

This study shows that fibre reinforced polyethylene composites (wood-plastic composites) perform better in terms of mechanical properties, moisture and water regain as compared to pure polyethylene. Thus natural fibre reinforced composites are biodegradable which makes them environmentally friendly This is a favorable result, as it presents a possible solution to the problem of producing plastic materials that are not environmentally friendly after use.

Acknowledgement

The following are acknowledged for the success of this work, Department of Chemistry, University of Jos, Chemistry Department, Ahmadu Bello University, Zaria, and Chemistry Department Abubakar Tafawa Balewa University, Bauchi all in Nigeria.

References

Bueche, F. Rubber chemical technology 32:1269. 1959.

Chantrasukul, S. and Smornsakchai, T. "High strength polyethylene fibres from high density polyethylene/organo-clay composites". Polymer Engineering and science. 2007

Clemons, C. "Wood-plastic composite in the United State of America in the United states. The interfacing of two industries". Forest products journal 52 (6) 10-18. 2007.

Clemons, C., Caulfield, D. and Giacomin, A.J. "Impact Toughness cellulose-fibre Reinforced polypropylene: influence of microstructure in Laminates and injection moulded composites". In: Proc seventh international conference on wood fibre-plastic composites. Forest. prod SOC; Modison, WI pp 119-125. 2003

Hanselka, H. Herman, A.S., Nickel, T and Ridel, U. "Biodegradable fibre reinforced plastics based upon renewable resources". TECNITEX Totino- Lingotto. 1996

Hon. D and Shiraishi, N. (Eds). Wood and cellulose Chemistry. 2nd ed. New York: Marcel Dekker, pp.5. 2001

Maxwell, J. "The drive for plastic: competing in performance". Plastic and rubber international 8(2): 45-49. 1983

Moses, K. Kunstoff – varbund VDI-verlag Düsseldorf. 1992

Nickel, R., Reidel, U and Herman, A S. "Biocomposites-New construction materials derived from Biomass. Biomass for energy and industry". In tenth European Conference and Technology exhibition, Germany. 1998

Tesdemir, M, Biltekin, H and Caneba, D.T. "Preparation and characterization of LDPE and pp-wood fibre composites". J.Appl. polymer Sc. 112(5): 3090-3123. 2009

Walcott, P.M. and Adock, T. "New advances in wood fibre-polymer formulations. In Proc.Wood-plastic conference". Plastic Technology Magazine and polymer process communications. pp. 107-144. 2000.

Wolcott, P.M. and Englund, K. A."Technology review of wood-plastic composites".

In Proc. 33 International practice board/composite materials symposium. Pulman, Washington pp 103-109.2005

Table 1: Tensile strength and modulus

sample	Measurement $x10^{-2}$(m)	Force Applied (N)	Elongation $x10^{-3}$(m)	Elongation (%)	Tensile strength $x10^{-3}N/m^2$	Tensile modulus $x10^{-3}N/m^2$
A	8.0x2.0	32.00	7.29	09.11	20	0219.00
B	5.0x1.5	38.00	0.70	01.17	42	3620.00
C	3.0x1.0	23.00	0.84	02.80	76	2740.00
D	4.0x1,0	13.00	0.84	02.10	32	1550.00
E	2.5x1.0	02.00	2.76	11.04	9	0072.50
F	6.0x2.0	04.00	1.24	02.06	3	0001.61

Table 2: Moisture Regain %

Sample	Moisture gain film weight (g)	Moisture Dry film weight (g)	Weight Difference (g)	Moisture Regain (%)
A	0.3550	0.3550	0.0000	0.0000
B	0.3099	0.3095	0.0004	0.1291
C	0.2797	0.2795	0.0002	0.0716
D	0.3007	0.3005	0.0002	0.0665
E	0.1934	0.1933	0.0001	0.0517
F	0.2458	0.2457	0.0001	0.0407

Table 3: Water Imbibitions %

Sample	Water Imbibed film weight (g)	Water Dry film weight (g)	Weight Difference (g)	Water imbibitions (%)
A	0.3550	0.3550	0.0000	0.0000
B	0.3420	0.3095	0.0325	10.50
C	0.3277	0.2795	0.0201	07.19
D	0.3459	0.3005	0.0219	07.29
E	0.3023	0.1933	0.0123	06.36
F	0.2486	0.2457	0.0029	01.81