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Poly Vinyl Alcohol and *Caesalpinia bonducella* Shell Green Composite for Packaging Application.

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ABSTRACT

A bio-based composites are currently has astonishing application. The properties of these bio-based composites reinforced with natural fibers are closely related to the nature of cellulose and its crystalinity properties. To instigate natural fibers in various diversified applications such as exterior parts of automobile, construction and chemical storage tanks, these fibers must possesses enough impact strength, water absorption and chemical resistance properties, various new investigation with new natural fillers had been tried(1-5). In this research a new approach had been tried with caesalpinia bonducella shell (CBS) and spent coffee ground (SCG) as reinforcement with PVA. The filler were powdered, dried and sieved before reinforcement. Various compositions were made by solvent casting method by mixing PVA with the natural filler (CBS and SCG) having five different filler percentage as 10wt%, 20wt%, 30wt%, 40wt% and 50wt% and glycerin (processing aid). The structure of PVA films, obtained from solution, was determined by using Infra Red Spectroscopy (IR). The influence of fillers in blend systems on the properties like tensile strength, chemical resistance and bio-degradation of the prepared films was investigated

Keywords: Poly Vinyl Alcohol, Bio composites, Bio Polymers, Natural fibers

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INTRODUCTION

Natural fiber are gaining the interest of researchers in past five decades, due to their ample properties like light-in-weight, corrosive resistance, bio-degradability and availability, in addition they are also eco-friendly and economical. Most of the composites available in the market today are produced with high durability ensuring high product life. Unfortunately, in order to make these products efficient, manufacturers have traditionally used non-biodegradable fibers made from non-renewable resources. The use of various natural reinforcing fillers and fibers in thermoplastics with the fibers such as hemp, jute, flax, sisal, banana, kapok, corn husk had gained acceptance in commodity plastics and applications of these materials during the past decade had been reported in the literature [5-12].The advantage of composite materials compared to that of conventional materials is mainly due to their higher specific strength, stiffness and fatigue characteristics, which enables structural designs to be more versatile. These composite materials are synthetic or naturally occurring materials made from two or more constituents materials with significantly different physical or chemical properties which remain separate and distinct at macroscopic and microscopic scale within the finished structure. These are materials that comprise strong load carrying material known as reinforcement which are embedded in weaker bulk material known as matrix. Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. The reinforcement may be particles, platelets or fibers and are usually added to improve mechanical property such as stiffness, strength and toughness of the matrix material. However, natural fibers have some disadvantages such as high moisture absorption, low modulus, alleviated chemical resistance and poor wettability. Few researchers figured out vast benefits of these natural fibers reinforced composites as having low specific weights, relatively high strengths, low density, high stiffness and resistance to corrosion, so they find applications in automotive, interior door panels of cars, decking, structural, packing and electrical and electronics industries, boats and sports [13, 14, 15].

The current requirement of biodegradable and disposable packaging or single use items or reducing the issue relevant to their post consume status is attracting increasing attention for the utilization of poly (vinyl alcohol) (PVA) in the production of environmentally friendly polymeric material. The good processability and the well known biodegradability of PVA have been the guidelines for the basis of the formulation of PVA-based water-soluble films and composites with fillers that do not affect PVA propensity to biodegradation in aqueous medium. It is expected that researchers continue to explore the new potentialities for such superior composites and increases their applications as a way to achieve long term environmental sustainability.

The present work is aimed at the following objectives.

- To prepare a new green composite by using of bio- material waste Caesalpinia Bonducella Shell powder (CBS) and Spent Coffee Ground (SCG) with eco- friendly material PVA
- To study the mechanical and chemical properties
- To find the suitability for application in packaging needs

MATERIAL DESCRIPTION

POLY VINYL ALOCHOL

PVA is a common and well-known polymer that possesses salient features such as water solubility, ease-of-use, film-forming property, and bio-degradability. Also (PVA) has been widely used for the preparation of many blends and composites with several natural, renewable polymers such as chitosan, starch as fillers, and applied them in the development of green composite technology to achieve ecological sustainability. Recently many innovative and environmentally conscious manufacturers, composite consists of PVA, a biopolymer, with natural fibers, are improve the biodegradability and physical properties of PVA, in order to choice it as eco-sustainable materials. Due to the presence of –OH active groups and their hydrophilic nature, PVA/ natural fiber composites gives high compatibility because of its good interaction between fibers resulting with good composite properties and satisfactory performance. Researchers in this fields found that compounding of PVA/natural fibers could be achieved at low temperatures (<170^{o}C) in the presence of a plasticizer.

Caesalpinia Bonducella Shell Powder And Spent Coffee Grounds

The seeds, leaves and roots of (CAESALPINIA BONDUCELLA) are used for the treatment of tachycardia, bradycardia, tuberculosis, tympanitis, pain in the abdomen, fever, cold and cough and liver fluke in ruminants. The outer shell of this caesalpinia bonducella is thrown off and is of no use had been taken as reinforcing filler along with PVA for the current research work.(Fig. 1)

Figure1: Caesalpinia Bonducella and Spent Coffee Grounds

Spent coffee ground (SCG) contains large amounts of organic compounds (i.e. fatty acids, amino acids, polyphenols, minerals and polysaccharides) that justify its valorization. Earlier innovation explored the extraction of specific components such as oil, flavor, terpenes, and alcohols as value-added products. However, by-products of coffee fruit and bean processing can also be considered as potential functional ingredients for the food industry. There is an urgent need for practical and innovative ideas to use this low cost SCG and exploit its full potential increasing the overall sustainability of the coffee agro-industry.

EXPERIMENTAL

Caesalpinia Bonducella Shell powder and Spent Coffee Grounds powder were used as such without any modification to compare the properties of the composite with respect to the weight percentage of the filler content with the virgin matrix material. Originally, the renewable filler were washed thoroughly with water to remove the impurities, dried in sunlight for 2days and oven dried at 80^{o}C for 24h, ground into powder using a food processor to get filler powder. The powdered filler are passed into the sieve shaker to get uniform particle size of 75 µm.

Mixing of PVA matrix material and the natural filler (CBS and SCG) was done by taking 100 g of PVA with varying percentage of powdered and sieved filler, CBS and SCG (10 wt%,20 wt%,30wt%,40 wt%,50wt%,) and glycerin (processing aid). Five different blends of polyvinyl alcohol, glycerol and natural fillers (CBS and SCG) along with neat PVA have been prepared by solvent casting (Table1). The influence of fillers in blend systems on the properties of the prepared films was investigated. The structure of PVA films, obtained from solution, was determined by using Infra Red Spectroscopy (IR).

Table: 1 Composition PVA/CBS and PVA/SCG composite film

S.No	Sample	Content
1.	Neat PVA	100% PVA
2.	PVA-CBS(10)	90% PVA and 10% CBS
3.	PVA-CBS(20)	80% PVA and 20% CBS
4.	PVA-CBS(30)	70% PVA and 30% CBS
5.	PVA-CBS(40)	60% PVA and 40% CBS
6.	PVA-CBS(50)	50% PVA and 50% CBS
7.	PVA-SCG (10)	90% PVA and 10% SCG
8.	PVA- SCG (20)	80% PVA and 20% SCG
9.	PVA- SCG 30)	70% PVA and 30% SCG
10.	PVA- SCG (40)	60% PVA and 40% SCG
11.	PVA- SCG (50)	50% PVA and 50% SCG

Universal testing machine is used for the determination of elongation at break and tensile strength of the prepared films. Chemical test was done in laboratory where a piece of each samples was cut and dipped in different solutions like HCl, CH_3COOH, NaOH for a weak and then differences were noted.

Laboratory-accelerated soil degradation tests had been carried out gravimetrically at 25±2^{0}C in the microbial active garden soil as described at [16].

RESULTS AND DISCUSSION

Changes observed in IR absorption bands of the PVA films formed by incorporating CBS and SCG revealed the possibility of liberation of –H and –OH groups as well as scission of the main chain. Careful consideration of the IR spectrum of PVA films shows that intensity of the absorption band at 3360 cm^{-1} is maximum with CBS reinforcement (Figure 2,3 & 4) showing the presence of -H bonding compared to neat PVA and SCG, due to the reaction of -OH group of PVA with SCG reinforcement (Figure2). The absorption band at 1500 cm^{-1} arises due to the -CH2 group deformation from cellulose or) C-H deformation in lignin, which is present in both the composites.

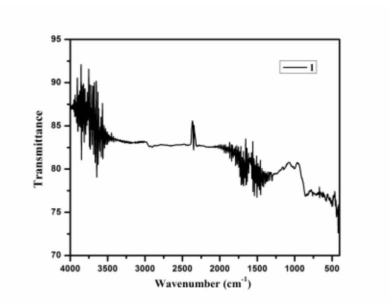

Figure 2: Neat PVA

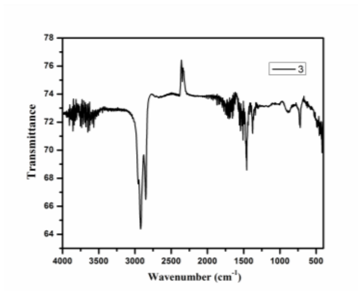

Figure3: PVA /1gm CBS

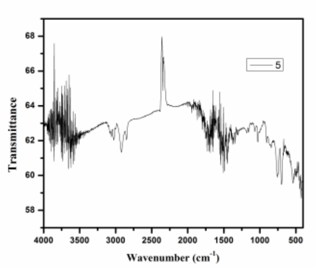

Figure 4: PVA /1gm SCG

Tensile Strength

Variation of tensile strength with respect to CBS and SCG filler reinforcement is given in Table 2. Tensile strength was found to be increase with increase in filler content. The increase in tensile strength of composites with 5wt% CBS filler is more significant when compared to that of neat PVA. This is due to the high stiffness of a CBS material leading to increment of tensile modulus [16]. Whereas in case of SCG reinforced PVA composites decrease in tensile strength was found as shown in Figure 5, which is a common observation of any natural filler composite due to the ineffective H-bonding as depicted in the IR spectroscopy.

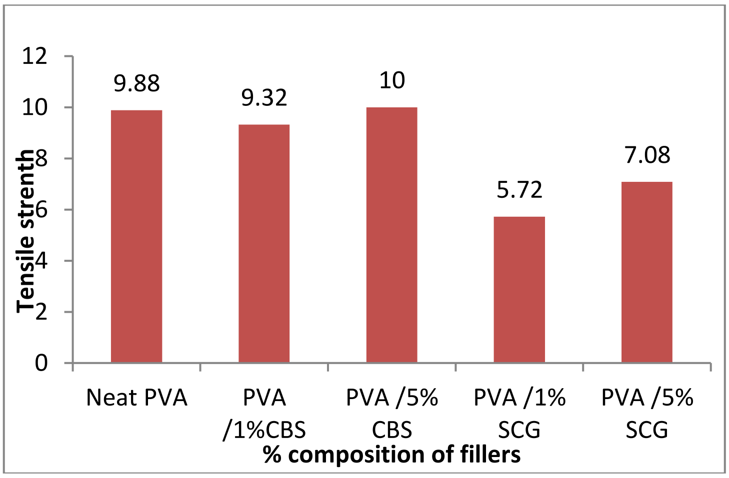

Figure 5: Graphical representation of variation of tensile strength with filler content

Table 2: Tensile Strength comparison of PVA with CBS and SCG filler

S.No	Sample	MPa
1.	Neat PVA	9.88
2.	PVA /1%CBS	9.32
3.	PVA /5% CBS	10
4.	PVA /1% SCG	5.72
5.	PVA /5% SCG	7.08

Chemical Testing

Testing with chemicals like hydrochloric acid, sodium hydroxide and acetic acids shows that the prepared composites were resistant to chemicals, little surface leaching were found after the immersion test. Testing with chemicals like hydrochloric acid, sodium hydroxide and acetic acids shows that the prepared composites were resistant to chemicals.

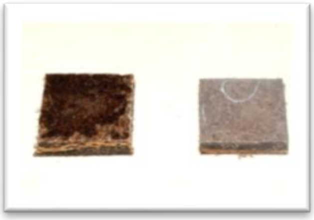

Figure 6: Samples after Chemical Testing

Soil Testing

Figure 7 and 8 shows the SEM micrographs of caesalpinia bonducella and spent coffee grounds in PVA matrix which has porous structure that can absorb the matrix material in the viscous state, although there exist some small air vents in the mixture. Subjecting the sample for soil testing shows that there is microbial formation on the surface leading to degradation.

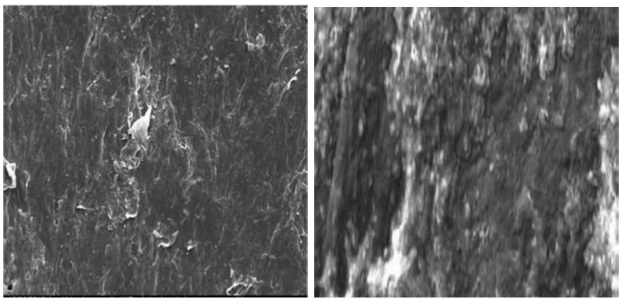

Figure 7: SEM image of 5%PVA/CBS composite before and after soil testing

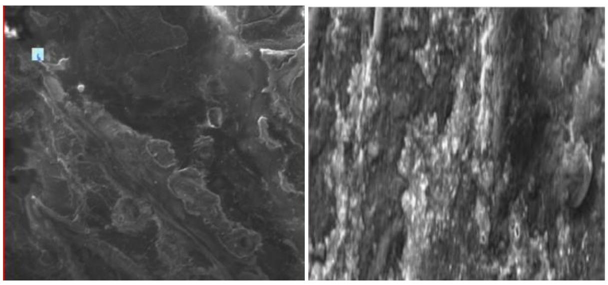

Figure 8: SEM image of 5%PVA/SCG composite before and after soil testing

CONCLUSION

The primary achievement of this work is that we had successfully synthesized a new class of composite materials with Poly Vinyl Alcohol. Limited attempts have been made so far for the processing, characterization of these composites and demonstration had been made to understand that PVA/CBS and PVA/SCG composites are suitable for many applications. In addition to reducing the waste, we utilize the thrown out biowaste to make valuable products thereby contributing to the health environment. The present work demonstrated that caesalpinia bonducella shell (CBS) and spent coffee ground (SCG) can be used as excellent reinforcing material for low cost composites and are able to satisfy economical as well as ecological interest. Further we can explore their application for low cost material to satisfy the economical and ecological interest by studying the impact, thermal and morphological properties.

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