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Morphology and Biodegradable Properties of PVA - Biofilms Minored With Coconut Shell Powder (CSP)

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ABSTRACT

Ecofriendly and biodegradable plastic materials have greatly increased the interest among research and industries owing to the ecological problem including the accumulation of plastic waste. Ecocomposites are made of natural filler and bioplastic that are ecofriendly and biodegradable. Further natural fibres tend to be applied for engineered PVA materials and can provide desired mechanical properties and used in short life cycle application like trays, food containers and cutlery. With recycling of natural filler PVA ecoocomposites causes no harm to environment and with effective biodegradability. The morphology and structural properties of PVA biofilms minored with Coconut shell powder are found using techniques XRD, FESEM and EDX.

Keywords: *PVA; Coconut shell powder (CSP); Ecocomposite; biodegradability*

INTRODUCTION

The usage of synthetic food packaging is common in the society, but it makes an adverse impact on the environment. The usage of nonbiodegradable synthetic polymers will account for air, water, and soil pollution[1,2]. These environmental issues can be overcome by using biodegradable polymer-based packaging since microbes can degrade them [1,3]. Biodegradable packaging materials have widespread acceptance since they can replace the nonbiodegradable, petrochemical-based synthetic plastic material[1,4,5]. In general, the mechanical properties of biodegradable polymer-based packaging film are not good compared to synthetic, nonbiodegradable polymers. Organic nanofillers derived from natural sources are most advisable to enhance their properties because of their renewability, non toxicity, biodegradability, low density and mechanical strength[5].

The rate of plastic waste generation was growing annually. Although, plastic material can be recycling, but just a small number of plastic can actually be recyclable. Therefore, biodegradable bioplastic becomes important and replaces some of the conventional plastic in short life cycle product[. Polyvinyl Alcohol (PVA) reinforced with biowaste like coconut shell powder, beetel shell powder, groundnut shell powder, corn husk forming an ecocomposite and it is a biodegradable plastic, which is highly suitable for short life cycle application such as packaging tray, food container, and cutlery[1,3]. Ecocomposites are made of natural filler and bioplastic that are ecofriendly and biodegradable[3]. Nowadays, various combinations of lingo cellulosic filler and bioplastic have been successfully made into ecocomposites with enhanced mechanical properties as well as to achieve products with low cost [7].PVA has Non –toxic nature, biodegradability a bit long, low cost, and efficient film-forming ability are the main advantage of PVA-based food packaging [4]. A study reported that PVA-based polymer has gas barrier properties; hence, it is a better choice for food packaging film development with natural fillers. Major drawback of PVA is the biodegradability. In the present study Coconut shell powder is added to enhance the biodegradability by maintaining the same physico-mechanical properties.

The top five coconut producing countries in the world are Indonesia, Philippines, India, Brazil and Sri Lanka[11]. The places in India include Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Bihar, Andhra Pradesh, West Bengal, Orissa, and Assam. A coconut usually contains coconut water and core which is consumed and the remaining is left a shell as waste. These shells contain Natural fibers which are eco-friendly, biodegradables that are eco-friendly, cheap and renewable to the environment.

Chemical composition of coconut shell powder consists of Lignin (29.4%), Pentosans (27.7%), Cellulose (26.6%), Moisture (8%), Solvent Extracts (4.2%), Uronic Anhydrides (3.5%) and Ash (0.6%) [8].Furthermore these reinforcements can easily be prepared from waste products and have a minimal effect on environment, due to their biodegradable properties. Thus in recent years the emphasis on research has increasingly been placed on these composites, which may play a phenomenon role in reducing the alarming environment pollution issues. One of the greatest advantage of using renewable products is they do not emit any harmful byproducts to the nature in the process [2].

The eco-friendliness and the availability, the reinforced composites have gained considerable attraction towards them as potential substitute for non-biodegradable synthetic fiber[6]. Further natural fibers tend to be applied for lightweight engineered materials and can provide desired mechanical properties. In some research works modified natural fibers with various organic and inorganic materials as fillers to develop the mechanical properties of polymer composites [7].

The present study includes the synthesis of coconut shell powder dissolved in deionised water mixed with PVA solution in different concentrations. The mixture is poured on glass plates allowed them to dry at room temperature. The obtained films are characterised for morphology, biodegradability and structural properties with control PVA film for packaging applications. The film is also exhibited excellent biodegradability. The dimensions are measured before keeping in soil and after 25 days again the dimensions are measured which shows the degradability physically.

MATERIALS AND METHODS

Polyvinyl Alcohol (PVA) is purchased from SIGMA Premier Chemicals and the raw material, coconut was gathered from local markets of Hyderabad. The ripen coconut is taken and by removed its coir, water & kernel (flesh) in order to collect its shell.

Coconut Shell Powder(CSP) solution :

The coconut shell taken and scrubbed the shell with a cleaned with knife and sandpaper inside& outside of the shell, to remove the residues of the kernel & coir layers completely, natural dried for two days. Then, make the shell into small pieces and make it into a very fine powder using a mortar (china dish). The powder was sieved in accordance with BS 1377:1990 standard. To make coconut shell powder solution, take 60ml of distilled water in a beaker and heat it on a hotplate at 80°C and stirring rate of 500rpm. Monitoring the temperature of water,1gm of as prepared coconut shell powder using a digital balance is added to the water at 80^{o} C.By maintaining the same parameters (i.e.,80°C, 500rpm) heated the solution for 20 minutes and allowed it to cool to room temperature. Now using a filter paper, filtered the coconut shell powder solution and collected the filtered solution. The same procedure is repeated for 2gm coconut shell powders concentration.

Preparing PVA Solution

70ml of distilled water is taken and heated it on a hotplate at 100°C and fixing the stirrer rate at 500rpm. When the water reached to 95°C & water level dropped to 50ml, add 1gm of PVA powder to it. And continue heating for 20 minutes at the same parameters (100°C, 500 rpm). After 20 minutes, the solution has become thick (i.e., gluey) then the hotplate is turned off and place the solution aside for further usage.

Fabrication of Biofilms of different concentrations of CSP

2ml of freshly prepared PVA solution (i.e., above solution) is taken and mixed with 2ml of 1gm C.S.P solution in a crucible and mixed it thoroughly for uniform mixing. Then, spread the mix on a clean glass slab without spilling it out from the corners.

Precautions have been taken that no air bubbles are formed during the spreading of the mixture, since it degrades the quality of the films.For every 15 minutes add another coating of the same mix, to prepare the film at required thickness. And allow it to dry so that the total 4ml mix (2ml +2ml) is completely spread on the glass slab. Similarly, using the same procedure as mentioned above, the films are prepared of different concentrations (i.e.,1gm, 2gm C.S.P solutions with 2 ml of PVA solution respectively).

one pure PVA film is also prepared for comparative studies. After allowing the films to dry for a day (24 hours), the films were collected. Carefully removed the films from the edge using a new blade without touching (to avoid contamination).

Fig 1. Preparation CSP solution in different Concentrations, films and buried in soil for biodegradation.

Characterisation of PVA + CSP Biofilms

The films are removed carefully without touching from glass plates with new blade to avoid contamination. The removed films are kept for characterisation and other set is dipped in soil to check the biodegradability of CSP + PVA films. One set of films are sent for XRD, FESEM .

X- ray Diffraction (XRD)

The interaction of the incident rays with the sample produces constructive interference (and a diffracted ray) when conditions satisfy

Bragg's Law ($n\lambda=2d \sin \theta$). The crystalline structure of the biofilms was determined by X – ray diffraction (XRD) with a Bruker D8 Advance instrument.

FESEM

The surface morphology and size of the synthesized biofilms were investigated using scanning electron microscope (SEM). Thin films of the nanoparticles were prepared on carbon –coated copper grids and examined using a ZEISS Merlin Compact instrument operating at an accelerated voltage of 20kV. The SEM analysis allowed for the visualization of the nanoparticles and the determination of their size distribution and morphology.

In addition to FE-SEM, energy-dispersive X-ray (EDX) was conducted on the same specimens for further analysis. EDX is an X-ray technique used to identify the elements existing in biofilms.

A typical FESEM morphology for PVA + CSP powder reported in results and discussed. The basic FESEM micrographs of PVA film alone, and PVA with with 1gm, 2gm, 3gm CSP concentration films are presented in the results.

Biodegradation of Biofilms

So far biodegradability of a polymer film is not very eco-friendly but after addition of the bio-waste materials such as coconut shell powder, rice husk and others have been improved the biodegradation rate. They have been utilised as packaging material for its out-standing film-forming ability, superior mechanical properties, non-carcinogenic and good bio-adhesive characteristics. The blending of PVA films with bio-waste materials could be a genuine choice because of easy availability and lower the overall cost.

In the present study the PVA + CSP films of different concentrations (1gm,2gm) along with PVA are kept in soil for about 25 days. The measurements are taken before and after keeping the films in soil. The results are presented in the Results section. PVA and PVA with CSP films are cut from above pieces, measured the dimensions and buried in the soil. After 25 days the PVA and PVA with CSP films are collected from the soil and measured the dimensions with travelling microscope. The dimensions are presented in the results.

RESULTS AND DISCUSSION

XRD : 2θ values XRD were found to be same in PVA and PVA with CSP films. Indicating the basic properties of PVA was not changed by adding the CSP in different concentrations. They are in agreement with the recorded values.

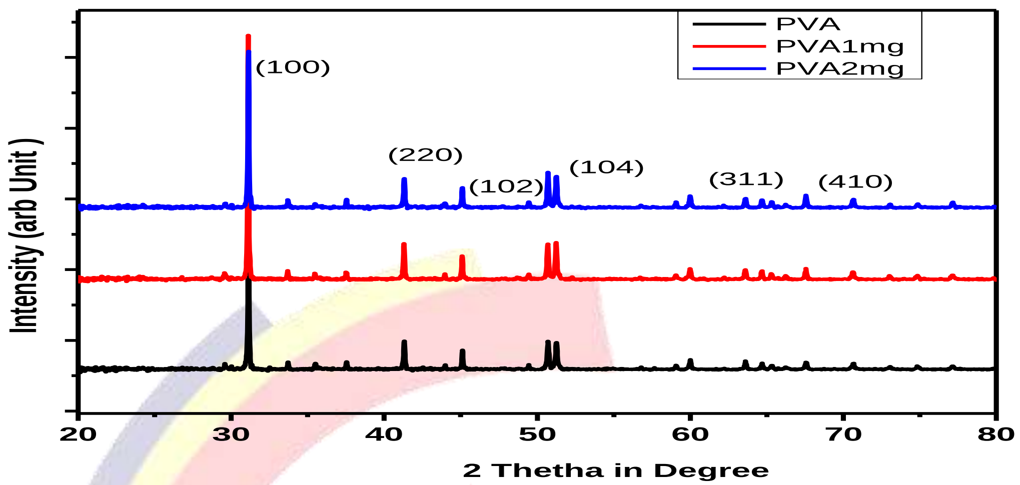

Fig.2 The XRD pattern of PVA,PVA + 1 gm CSP and PVA+ 2 gm CSP

The degree of crystallanity of developed films can be evaluated with the help of XRD pattern. With XRD patterns the crystallanity and amorphous domains were confirmed. X-ray diffraction patterns of different concentrations of 1gm and 2 gm are shown in the figure. The results suggested that the strong peak at 2θ values are at 31, 41 and 51 in all the films. The particular peaks corresponds to [100], [220],[102],[104],[311] and [410] planes depicting semi crystalline structure due to physical interaction or hydrogen bonding between –OH groups. The results are in agreement with [4,6, 8, 9,10]

FESEM

The relationship between the structure and the property of the developed films can be evaluated by analysing morphological features using SEM micrographs. Qualitative analysis of the SEM was used to describe the homogeneous distribution of constituents of the developed film. The figures represent the SEM micrographs of the surfaces of PVA film, and PVA with 1gm, 2gm CSP concentrations. The smooth and homogeneous surface was noticed for Pure PVA film which shows the film is without any other constituents. The clear surface of pure PVA film was proved good integrity cohesive and continuous with no separation between the polymer phases [6].

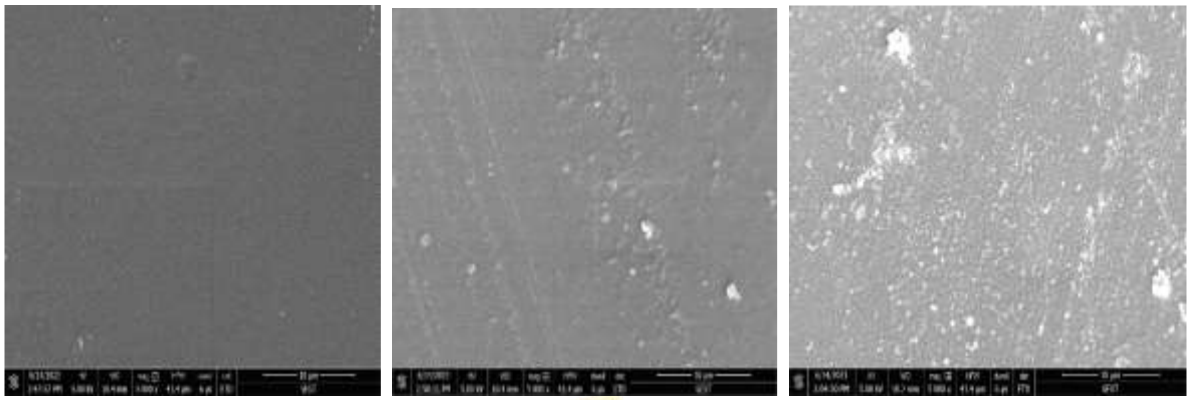

Fig 3. PVA film PVA+ 1 gm CSP sol PVA + 2 gm CSP sol

The heterogeneous surface was reported in PVA with 1 gm and 2gm CSP concentrations, apparently due to an increase in the roughness of films as the amount of CSP incorporated is increased. This was possibly due to the outcome of the aggregation of CSP molecules on the surface of PVA films. The white dots were observed on the surface on PVA film may be due to dispersion of the CSP on PVA film.

EDAX data:

The control sample represents PVA sample without CSP concentrations and with concentrations of 1gm, 2gm, CSP. The appearance of Gold (AU) as seen in the EDS results was due to coating of Gold to prevent the charge on PVA + CSP films.

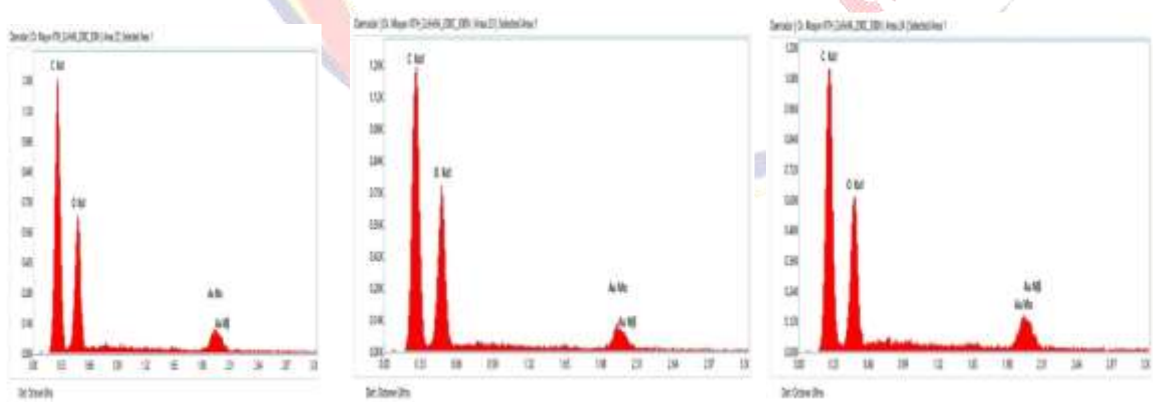

Fig. 4 PVA , PVA + 1 gm , PVA + 2 gm CSP

Biodegradability of PVA + CSP Biofilms

The soil burial provides qualitative and quantitative implications of biodegradability. The soil burial method will be more effective compared with enzymatic test, if the samples are buried in suitable climatic conditions and the various populations of microorganisms that are involved. In this project the degradation of PVA and PVA with CSP of different concentrations are buried in soil collected locally for about 23 days in normal conditions. The physical measurements are taken before buried into soil and collected the films after 23 days. Again the measurements are taken using travelling microscope. The results are presented in the table. 1

Table containing the readings of Films

Object	Readings on 1st day	Reading on 25th day	Difference Observed Cm
PVA film	3.355	3.13	**0.225**
PVA + 1 gm CSP	3.275	2.256	**1.019**
PVA + 2 gm CSP	3.654	2.652	**1.002**

The differences in the films before and after buried in the soil for PVA and PVA with CSP of 1gm, 2gm concentrations are 0.225 cm, 1.019 cm and 1.002 cm respectively. The difference in the measurements were clearly indicating that the PVA with CSP films are biodegradable.

CONCLUSION:

PVA with Coconut shell powder (CSP) green biofilms are fabricated at different concentrations by solution casting method. The composite films are showing the same elasticity, crystallanity and morphological nature. However the films are showing enhanced biodegradable nature by adding CSP at different concentrations. To reduce the pollution of environment, the films have got potential for packaging industry as the films are used for one time use.

FUTURE SCOPE OF THE PROJECT:

The PVA films for packaging industry may be blended with bio- waste material like coconut shell powder, ground nut shell powder and other materials would help the environment from pollution by increasing the biodegradability. The fabricated composite films may be incorporated with antioxidant and antimicrobial nanoparticles to maintain the freshness of vegetables and food items for long time.

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