

SYNTHESIS OF SUSTAINABLE BIOPLASTIC FROM AGRICULTURAL WASTE

Submitted in partial fulfilment of the requirements for the award of

Master of Science

By:

A.SHIVA (41910019)



**DEPARTMENT OF CHEMISTRY
SCHOOL OF SCIENCE AND HUMANITIES**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

May-2023

SYNTHESIS OF SUSTAINABLE BIOPLASTIC FROM AGRICULTURAL WASTE

Submitted in partial fulfilment of the requirements for the award of

Master of Science

By:

A.SHIVA (41910019)



DEPARTMENT OF CHEMISTRY

SCHOOL OF SCIENCE AND HUMANITIES

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

May-2023



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF CHEMISTRY

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **A.SHIVA** (41910019) who carried out the project entitled "**SYNTHESIS OF SUSTAINABLE BIOPLASTIC FROM AGRICULTURAL WASTE.**" under my supervision from January 2023 to May 2023.

V. Kavitha
8/5/23

Dr.V.KAVITHA M.Sc.,M.Phil., Ph.D.

Internal Guide

HEAD OF THE DEPARTMENT
DEPARTMENT OF CHEMISTRY
SATHYABAMA
Head of the Department

Dr. J. Karthikeyan, M.Sc., Ph.D.

Jebbaar Nagar, Rajiv Gandhi Salai
Chennai - 600 119

08/05/2023

Submitted for Viva voce Examination held on 08. 05. 2023

[Signature]

Internal Examiner

[Signature]
External Examiner

DECLARATION

I A.Shiva, hereby declare that the Project Report entitled **SYNTHESIS OF SUSTAINABLE BIOPLASTIC FROM AGRICULTURAL WASTE** done by me under the guidance of **Dr.V.KAVITHA M.Sc.,M.Phil.,Ph.D.**, Professor, Department of Chemistry, Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of **Master of Science degree in Chemistry**.

DATE: 08.05.2023

PLACE: Chennai



A.SHIVA

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to Dr. Rekha Chakravarthi, Dean, School of Science and Humanities and Dr.J.Karthikeyan, Head, Department of Chemistry for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide Dr.V.Kavitha, Professor, Department of Chemistry for her valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all the teaching and Non-teaching staff members of Department of Chemistry who were helpful in many ways for the completion of the project.

ABSTRACT

India is the second-largest producer of rice, which plays an important role in the GDP of the nation, but the burning of rice straw is one of the most severe issues, which the country is facing. The government has tightly regulated this practice, and the farmers are usually advised to incorporate the residue in the soil, but this management option is minimal because of its slow degradation properties in the soil and may also foster rice diseases. A lot of lab-scale and commercial research studies have been conducted on rice straw-based nanocomposites, but rice straw-based bioplastic is a much superior latest technology that is not much explored. Only a few researchers have worked on making biodegradable bioplastic packaging materials from rice straw. The developed technology not only eradicates the pollution problems caused because of stubble burning but also resolves the problem of synthetic plastic packs, which is another major issue worldwide as 40% of the total plastic is used in food packaging. The current study is aimed to explore the feasibility of this agricultural residue to get converted into useful biodegradable packaging materials that can work for agroecological and sustainable development. The bioplastic which is obtained is also characterized by FTIR, UV-DRS and XRD and also tested for UV shielding.

TABLE OF CONTENTS

INTRODUCTION

1.1 BIOPLASTICS:	10
1.2 WHAT IS BIOPLASTIC?	11
1.3 SELECTION OF MATERIALS:	12
1.4 PRODUCTION OF BIODEGRADABLE POLYMERS	12

CHAPTER 02

LITERATURE SURVEY

2.1 THE PRODUCTION OF NANOCELLULOSE-REINFORCED BIOPLASTIC BAGS:	14
2.2 SEEDLING MIXTURE	14
2.3 BIO-PLASTIC PREPARATION AND CHARACTERIZATION	14

CHAPTER 3

AIM AND SCOPE

3.1 AIM:	15
3.2 SCOPE:	15

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS USED:	16
4.2 PREPARATION OF RICE STRAW POWDER AND LIGNIN:	16
4.3 POLYVINYL ALCOHOL SOLUTION :	16
4.4 PREPARATION OF COMPOSITE FILM:	16
4.5 CHARACTERIZATION TECHNIQUES:	
4.5.1 X-RAY DIFFRACTION (XRD):	18
4.5.2 BRAGG'S LAW	18
4.5.3 FOURIER TRANSFORM INFRARED SPECTROSCOPY	19
4.5.4 UV-VISIBLE SPECTROSCOPY	21

CHAPTER – 5

RESULTS AND DISCUSSION

5.1 SYNTHESIS OF LIGNIN

22

5.2 X-RAY DIFFRACTION (XRD)

22

5.3 FTIR SPECTRA

CHAPTER 6

SUMMARY AND CONCLUSION

LIST OF TABLE

TABLE.NO	TITLE	PAGE.NO
1	5.1 SYNTHESIS OF LIGNIN	22
2	Table 5.2 UV Shielding by lignin and composite film	23

LIST OF FIGURES

FIGURE.NO	TITLE	PAGE.NO
1.3	Classification of production processes for biodegradable polymers	13
4.4.3	Bragg's law	19
4.4.4	Working of uv-visible spectroscopy [drs]	20
5.2	XRD spectra	23
5.3	FTIR spectra	24
5.4.1	Transmittance plot for lignin and composite film	25

LIST OF ABBREVIATION

S.NO	ABBREVIATION	EXPANSION
1	XRD	X-ray Diffraction
2	FTIR	Fourier Transform Infra-red spectroscopy
3	UV	Ultra violet-visible spectroscopy [drs]

CHAPTER 1

INTRODUCTION

1.1 BIOPLASTICS:

Still the first choice in the industrial sector, despite growing concerns over their environmental impact. The production of large volumes of packaging material, the high energy consumption in production processes, the disposal of packaging waste in landfills and the persistence of these materials in the environment call for urgent and ecological solutions. Bioplastics represent approximately one percent of about 360 million tons of plastic produced annually. This amount accounts for a third of all plastics produced world-wide. It has been estimated that in western industrialized countries, half of the goods sold on the market come with a plastic packaging. In Europe (EU) alone, 70 million tons of packaging waste were produced in 2016, of which approximately 16.7 million tons were plastic waste. As to the recovered materials, the largest portion was cellulose packaging, followed by wood, glass and plastic. The development resources, such as organic waste, has received attention from governments and has become an urgent need in many industrial sectors. Unlike synthetic polymers, biodegradable polymers such as cellulose, polysaccharides, proteins, from crops or biomass, can undergo physical, chemical, or biological decomposition. This feature makes them suitable for composting processes in households and industrial plants. This will open up new opportunities for using waste, which are more advantageous than in landfills, both in environmental and in economic terms. This approach will promote the implementation of a circular economy strong innovation at the service of the packaging sector. To that end, the cereal industry and the straw deriving from it can offer opportunities that have attracted particular attention. The current production of cereals totals up to about 2640 million tons harvested from over 700 million hectares, which generate a high amount of waste material from the entire cereal supply chain. The amount of straw produced annually in the cereal industry is about 2.1 billion tons. This creates a large quantity of residues that are sometimes burnt directly on the field, not to become an additional cost for cereal companies. This waste has little potential for reuse for agronomic needs (e.g. mulch and soil improvers) or zoo technical application (litter

for livestock). This has led to a contraction of the market, with fluctuating prices and modest prospects in the collection and post-harvest phases. As an alternative to its use in the agricultural and zoo technical sectors, straw can be used in building materials and for heat production. However, in all the above mentioned sectors, there is no effective or consolidated production chain. Therefore, a complementary cereal production by transforming it from a waste product into a renewable resource. By definition bioplastics are made of natural polymers (polysaccharides such as starch and cellulose), extracted from renewable agricultural resources (corn, potato, tapioca, rice, sugarcane, etc.) as well as lignocellulosic fibres. It has been estimated that 2.05 million tons of bioplastics were produced in 2017. The aim of this study is the design of a new packaging material with a dual purpose: i) to obtain a new material from organic wastes with a view to decrease the environmental impact of plastics. ii) to develop a material, which is biodegradable and does not contribute to the plastic pollution. This material will be obtained from the combination of biodegradable compounds (straw and bio-plastics), which are capable of providing ecological alternatives to the traditional tertiary packaging, adequate technical characteristics, an efficient use of resources and the treatment of packaging waste with a low environmental impact at the time of disposal.

1.2 WHAT IS BIOPLASTIC?

Bioplastics or biodegradable plastic are plastics or substance derived from organic or renewable biomass sources from agriculture products or microbial such as vegetable fats and oils, corn starch while conventional plastics are made from petroleum. One of bioplastic is Poly Lactic Acid or polylactide (PLA) plastic. PLA is a biodegradable thermoplastic aliphatic polyester derived from renewable resources, such as corn starch (in the United States and Canada), tapioca roots, chips or starch (mostly in Asia), or sugarcane (in the rest of the world). In 2010, PLA had the second highest consumption volume of any bioplastic of the world. Bioplastics are made through a number of different processes. Some use a microorganism to process base materials, such as vegetable oils, cellulose, starches, acids and alcohols. While almost all bioplastics produce less carbon dioxide in production than conventional plastics, they are not necessarily completely green. The methods by which their base

materials are grown and the processing involved both impact their product footprint. Many bioplastics also release carbon dioxide or monoxide when biodegrading. Nevertheless, their overall environmental impact is typically lower than that of conventional plastics, and as oil costs rise, their cost becomes more and more competitive. Some biodegradable bioplastics can break down in 180 days, given the right conditions. This capacity is desirable, for example, for outdoors applications where longevity and a reduced carbon footprint in production may be the goals. In term of global production capacities of bioplastics in 2013 and 2018, the result of Asia will increase from 51.4% to 75.8% (by region) . It can be seen that Asia need to support and demand on bioplastics, Thailand one of the famous country in Asia that can produce a lot of agriculture products that can produce bioplastics

(Korawit Chaisu, Journal of Advanced Agricultural Technologies Vol. 3, No. 4, December 2016)

1.3 SELECTION OF MATERIALS:

Straw can be used either as in the form of stems or to be cut to obtain 50 mm fragments with a water content that must not exceed 14%. Chemical additives are not to be used to either treat the fibrous materials or the bioplastics during the production phase. The procedure will be carried without the use of water.

(Anetenah getachew et.,al, Production of biodegradable plastic,2016)

1.4 PRODUCTION OF BIODEGRADABLE POLYMERS

Biodegradable polymers are a unique class of polymers that are ecologically benign (biocompatible and biodegradable) shown in figure 1.3. The production process for these biopolymers is grouped into four different classifications depending on the desired products and the available materials/precursors. The classifications are chemical synthesis methods, bacterial synthesis methods, biopolymer blends, and renewable sources. The present discussion primarily focuses on the first type of production, which focuses on the production of bio-based polymers from agricultural waste. Other synthetic routes (biopolymer blends, chemical, and bacterial synthesis) are discussed briefly in the subsequent sections.

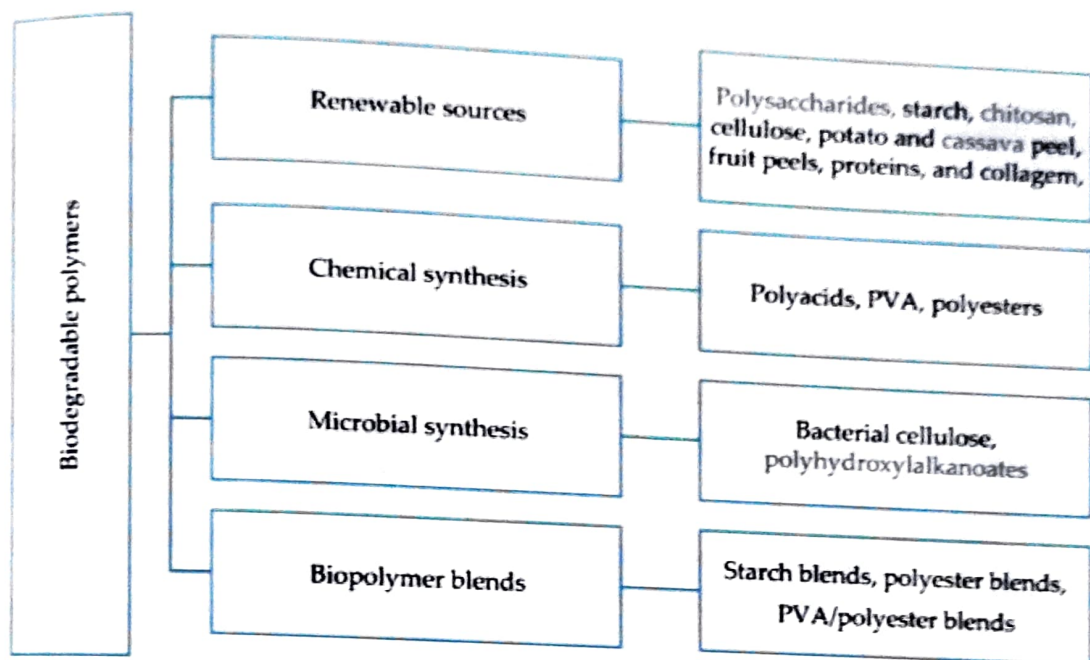


Fig.1.3 Classification of production processes for biodegradable polymers

CHAPTER 02

LITERATURE SURVEY

2.1 THE PRODUCTION OF NANOCELLULOSE-REINFORCED BIOPLASTIC BAGS:

E S Iriani et al., (2020) has explained the production of nanocellulose-reinforced bioplastic bags. The starch was mixed with nanocellulose and was destructed by using high temperature and pressure to transform its once semi-crystalline properties into amorphous. In this condition, the rigidity would be mostly reduced, making it plastic and could be shaped like the conventional plastic material and found that the potential formula for development was thermoplastic starch nanocellulose formula with glycerol plasticizer and added with citric acid before mixing with LDPE polymer, maleic anhydride and dicumyl peroxide. It was also found that sometimes the nanocellulose was not mixed with the polymer matrix homogeneously.

2.2 SEEDLING MIXTURE

Tyagi et al., (2019), studied that 90-98% silica as a raw material is found in husk of rice. Because of its large specific surface area, silica gel is an excellent drying agent. Silica has antifungal properties, making it a possible antifungal agent. In 2018, Ratnayake et al, discovered that adding rice husk to the soil boosts some chemical defense responses against fungal infections while simultaneously promoting Bitter Melon development. Ahaiwe et al, in 2016 used rice husk, straw, corn cobs and wood chips as mulching material for Ginger production. After six weeks of planting 50.0% more sprouting was observed in ginger where rice husk was used as mulching material.

2.3 BIO-PLASTIC PREPARATION AND CHARACTERIZATION

J.Kwong (2022) Cellulose regeneration from its derivatives usually requires extra time and costly chemical purification steps. In the present study, we used TFA as a unique solvent to dissolve rice straw powder; it co-solubilizes cellulose with other organic matter. Solvent cast films and sheet were obtained after TFA evaporation. Solvent-casting is a century-old film-making process that has taken many years to develop into a high precision technique.

CHAPTER 3

AIM AND SCOPE

3.1 AIM:

The aim of synthesizing bio-plastics is to contribute to a more sustainable commercial plastic life cycle as part of a circular economy.

3.2 SCOPE:

- Bio-plastics are typically plastics manufactured from bio-based polymers, which can be made from renewable resources such as biomass compounds.
- The main objective of synthesizing bio-plastics is to develop new biopolymer synthesis and modification routes in a single stage by means of reactive extrusion processes, enabling such products to be sold on the market.
- The scope of bio-plastics is extensive, and they have the potential to be used in various industries, including transportation, food, and healthcare. The use of bio-plastics can help reduce the dependence on fossil resources and contribute to a more sustainable future.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS USED:

Powdered rice straw, NaOH, Lignin, PVA, Choline Chloride, Oxalic acid.

4.2 PREPARATION OF RICE STRAW POWDER AND LIGNIN:

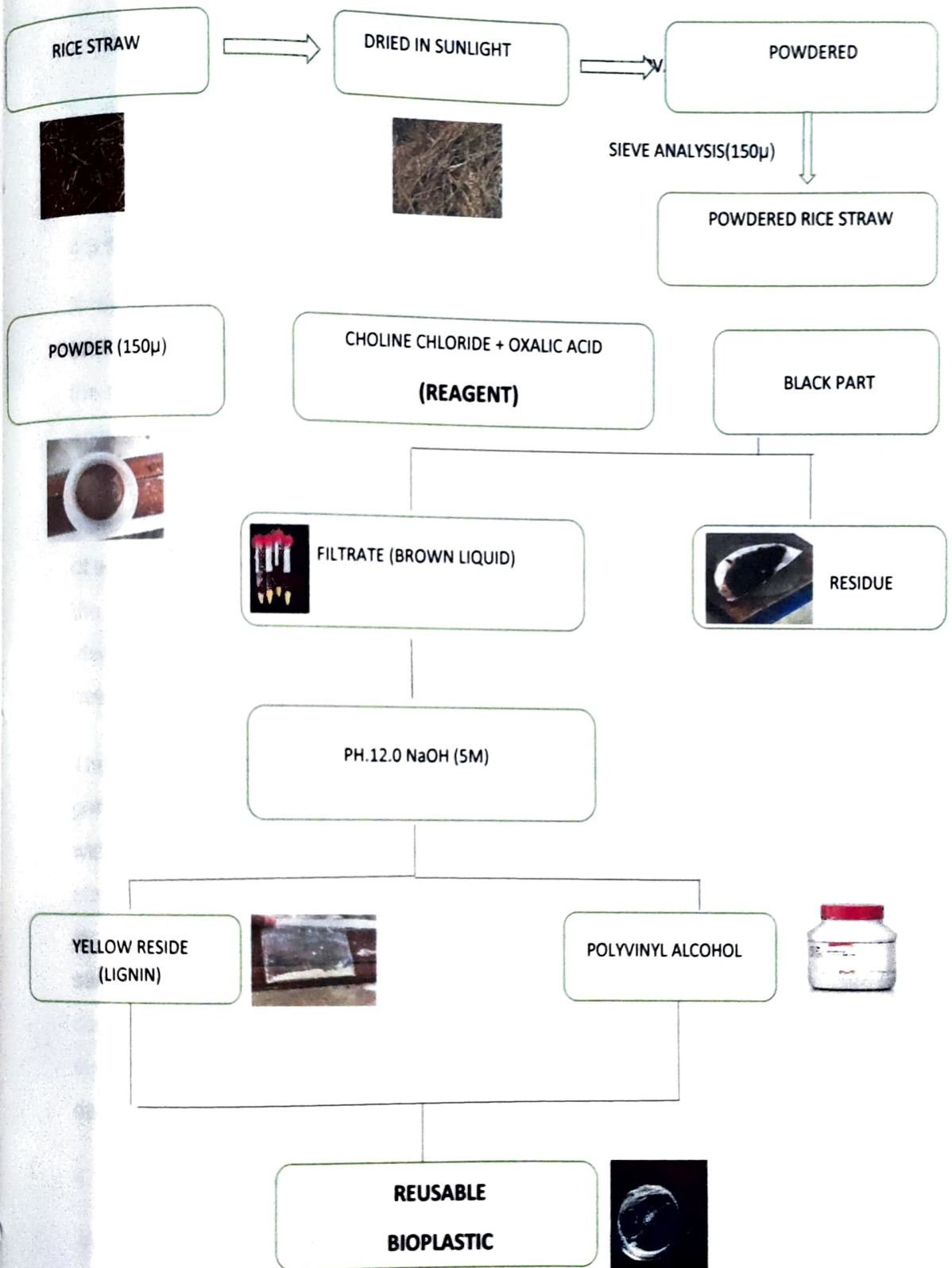
Rice straw is collected from the nearby agricultural field and kept for drying in sunlight for 2-3 days. The moisture content is reduced drastically and the rice straw is brittle in nature. The straw is grinded using a domestic mixer to a powder. It is then sieved using a sieve analyzer using 150 μ sieve, used for the synthesis of lignin. The dried rice straw powder is treated with choline chloride and oxalic acid which act as Deep- eutectic solvent and heated at 80-90°C for 2h, where the solution turns to liquid and the pH is adjusted to pH 4-5 to form a black liquor which is filtered. The pH of the filtrate is adjusted to 12 using 0.1N NaOH which is then filtered to get yellow residue of lignin.

4.3 POLYVINYL ALCOHOL SOLUTION :

1g of PVA is weighed accurately and dissolved in 100ml of distilled water. It is heated at 60°C for 30 minutes to form a viscous solution.

4.4 PREPARATION OF COMPOSITE FILM:

The composite film of PVA and lignin is prepared in different ratios. 1 ml of lignin solution and add 9 ml of PVA is mixed and poured into the petridish and the solution is left for overnight to get the PVA-lignin film. Similarly 2ml of lignin and 8ml of PVA; 3ml of lignin and 7 ml of PVA ; 5 ml of lignin and 5ml of PVA is prepared as described above.



4.5 CHARACTERIZATION TECHNIQUES

These include X-ray Diffraction (XRD), Fourier Transform Infra-red spectroscopy (FTIR), UV-Vis spectroscopy.

4.5.1 X-RAY DIFFRACTION (XRD):

X-ray diffraction (XRD) is a technique used in materials science for determining the atomic and molecular structure of a material. This is done by irradiating a sample of the material with incident X-rays and then measuring the intensities and scattering angles of the X-rays that are scattered by the material. The intensity of the scattered X-rays are plotted as a function of the scattering angle, and the structure of the material is determined from the analysis of the location, in angle, and the intensities of scattered intensity peaks. Beyond being able to measure the average positions of the atoms in the crystal, information on how the actual structure deviates from the ideal one, resulting for example from internal stress or from defects, can be determined.

The diffraction of the X-rays, that is central to the XRD method, is a subset of the general X-ray scattering phenomena. XRD, which is generally used to mean can wide-angle X-ray diffraction (WAXD), falls under several methods that use the elastically scattered X-ray waves. Other elastic scattering based X-ray techniques include small angle X-ray scattering (SAXS), where the X-rays are incident on the sample over the small angular range of $0.1-10^0$ typically). SAXS measures structural correlations of the scale of several nanometers or larger (such as crystal superstructures), and X-ray reflectivity that measures the thickness, roughness, and density of thin films. WAXD covers an angular range beyond 10^0 .

4.5.2 BRAGG'S LAW

When a material is irradiated with a monochromatic light of wavelength around the inter atomic distance of the material, light gets dispersed by the atoms and interfere to give rise to diffracted light with a higher intensity. The arrangement of atoms in the material is related to the intensity of the scattered light. If wavelength of light is λ and

the incident angle is θ and the constructive interference is obtained at an angle 2θ from the incident beam of light if Bragg's equation is satisfied. Bragg's equation is given by,

$$n\lambda = 2d \sin \theta$$

Where,

n is the diffraction order, d is the distance between the diffracting phase and θ is the Bragg's angle.

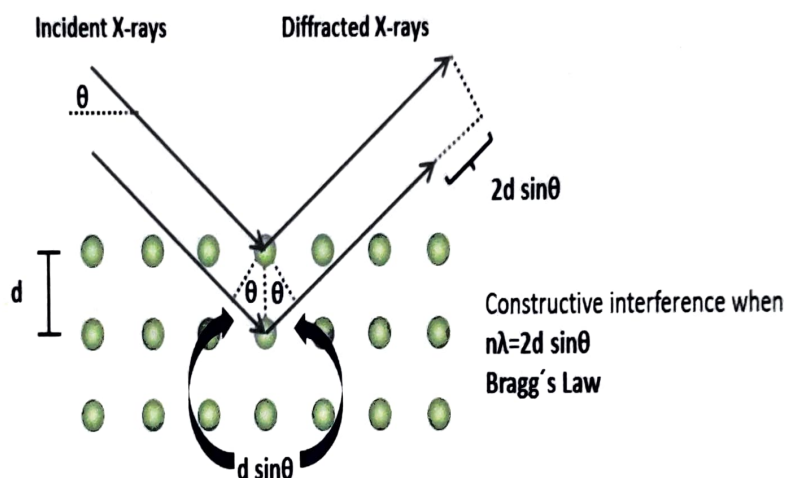


Fig. 4.5.3 BRAGG'S LAW

4.5.3 FOURIER TRANSFORM INFRARED SPECTROSCOPY

The range of Infrared region is $12800 \sim 10 \text{ cm}^{-1}$ and can be divided into near-infrared region ($12800 \sim 4000 \text{ cm}^{-1}$), mid-infrared region ($4000 \sim 200 \text{ cm}^{-1}$) and far-infrared region ($50 \sim 1000 \text{ cm}^{-1}$). The discovery of infrared light can be dated back to the 19th century. Since then, scientists have established various ways to utilize infrared light. Infrared absorption spectroscopy is the method which scientists use to determine the structures of molecules with the molecules' characteristic absorption of infrared radiation. Infrared spectrum is molecular vibrational spectrum. When exposed to

infrared radiation, sample molecules selectively absorb radiation of specific wavelengths which causes the change of dipole moment of sample molecules. Consequently, the vibrational energy levels of sample molecules transfer from ground state to excited state. The frequency of the absorption peak is determined by the vibrational energy gap. The number of absorption peaks is related to the number of vibrational freedom of the molecule. The intensity of absorption peaks is related to the change of dipole moment and the possibility of the transition of energy levels. Therefore, by analyzing the infrared spectrum, one can readily obtain abundant structure information of a molecule. Most molecules are infrared active except for several homonuclear diatomic molecules such as O_2 , N_2 and Cl_2 due to the zero dipole change in the vibration and rotation of these molecules. What makes infrared absorption spectroscopy even more useful is the fact that it is capable to analyze all gas, liquid and solid samples. The common used region for infrared absorption spectroscopy is $4000 \sim 400 \text{ cm}^{-1}$ because the absorption radiation of most organic compounds and inorganic ions is within this region.

FTIR spectrometers are the third generation infrared spectrometer. FTIR spectrometers have several prominent advantages: (1) The signal-to-noise ratio of spectrum is significantly higher than the previous generation infrared spectrometers. (2) The accuracy of wavenumber is high. The error is within the range of $\pm 0.01 \text{ cm}^{-1}$. (3) The scan time of all frequencies is short (approximately 1 s). (4) The resolution is extremely high ($0.1 \sim 0.005 \text{ cm}^{-1}$). (5) The scan range is wide ($1000 \sim 10 \text{ cm}^{-1}$). (6) The interference from stray light is reduced. Due to these advantages, FTIR Spectrometers have replaced dispersive IR spectrometers.

4.5.4 UV-VISIBLE SPECTROSCOPY

UV-Vis spectroscopy is an analytical technique that measures the amount of discrete wavelengths of UV or visible light that are absorbed by or transmitted through a sample in comparison to a reference or blank sample. This property is influenced by the sample composition, potentially providing information on what is in the sample and at what concentration. Since this spectroscopy technique relies on the use of light, let's first consider the properties of light.

Light has a certain amount of energy which is inversely proportional to its wavelength. Thus, shorter wavelengths of light carry more energy and longer wavelengths carry less energy. A specific amount of energy is needed to promote electrons in a substance to a higher energy state which we can detect as absorption. Electrons in different bonding environments in a substance require a different specific amount of energy to promote the electrons to a higher energy state. This is why the absorption of light occurs for different wavelengths in different substances. Humans are able to see a spectrum of visible light, from approximately 380 nm, which we see as violet, to 780 nm, which we see as red.¹ UV light has wavelengths shorter than that of visible light to approximately 100 nm. Therefore, light can be described by its wavelength, which can be useful in UV-Vis spectroscopy to analyze or identify different substances by locating the specific wavelengths corresponding to maximum absorbance.

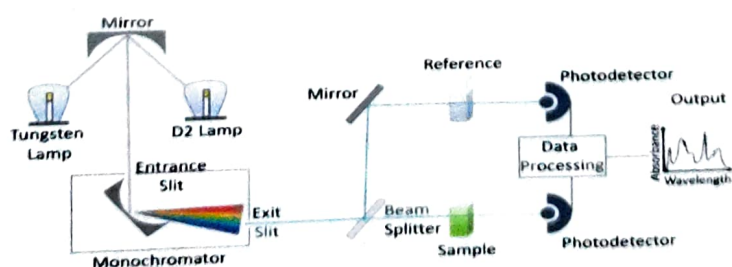


Fig.4.4.4 working of uv-visible spectroscopy [drs]

CHAPTER – 5

RESULTS AND DISCUSSION

5.1 SYNTHESIS OF LIGNIN

Table- 5.1

1	0.5 g of Rice Straw + 6 g of Choline chloride + 6 g of oxalic acid	Weight of Lignin – 3.70g
2	0.5 g of Rice Straw + 3 g of Choline chloride + 3 g of oxalic acid	Weight of Lignin - 1.51g
3	0.5 g of Rice Straw + 3 g of Choline chloride	No Reaction
4	0.5 g of Rice Straw + 3 g of Oxalic acid	No Reaction

5.2 X-RAY DIFFRACTION (XRD)

XRD is one of the characterization methodology which results from the diffraction pattern of the samples and is associated with the crystallinity of the sample. The XRD diffraction pattern of lignin, PVA and lignin-PVA composite film is shown in the Fig. The XRD pattern is obtained by scanning from 10 to 60° with a scan rate of 0.001°/sec. A sharp peak at 2θ values of 32.07°; 34.80°; 38.75°; are typical peaks of lignin particles. A peak at 29.21° and 34.36° shows an increase in intensity as the lignin content increases from 1:9 to 5:5 ratio of lignin-PVA composite mixture which indicates the interaction of lignin with PVA matrix. The crystallite size for lignin particles as calculated by Scherrer equation is found to be 144-184 nm.

CHAPTER – 5

RESULTS AND DISCUSSION

5.1 SYNTHESIS OF LIGNIN

Table- 5.1

1	0.5 g of Rice Straw + 6 g of Choline chloride + 6 g of oxalic acid	Weight of Lignin – 3.70g
2	0.5 g of Rice Straw + 3 g of Choline chloride + 3 g of oxalic acid	Weight of Lignin - 1.51g
3	0.5 g of Rice Straw + 3 g of Choline chloride	No Reaction
4	0.5 g of Rice Straw + 3 g of Oxalic acid	No Reaction

5.2 X-RAY DIFFRACTION (XRD)

XRD is one of the characterization methodology which results from the diffraction pattern of the samples and is associated with the crystallinity of the sample. The XRD diffraction pattern of lignin, PVA and lignin-PVA composite film is shown in the Fig. The XRD pattern is obtained by scanning from 10 to 60° with a scan rate of 0.001°/sec. A sharp peak at 2θ values of 32.07°; 34.80°; 38.75°; are typical peaks of lignin particles. A peak at 29.21° and 34.36° shows an increase in intensity as the lignin content increases from 1:9 to 5:5 ratio of lignin-PVA composite mixture which indicates the interaction of lignin with PVA matrix. The crystallite size for lignin particles as calculated by Scherrer equation is found to be 144-184 nm.

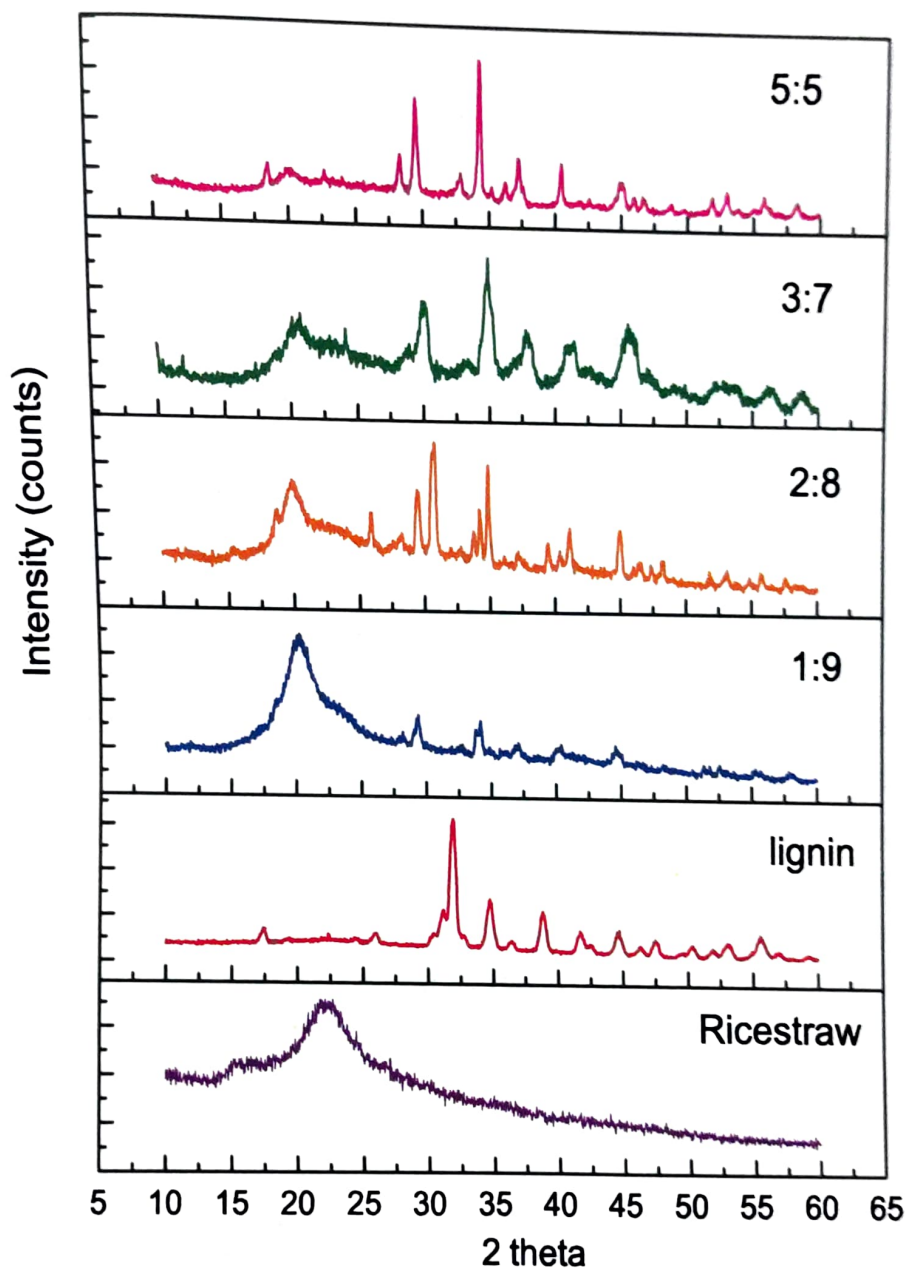


FIG.5.2 XRD SPECTRA

5.3 FTIR SPECTRA

The Lignin, PVA, lignin-PVA composite film samples were scanned in the range of 4000cm^{-1} to 400cm^{-1} to explore the nature of functional groups present in the molecule and the results are presented in Fig. The lignin particles show a characteristic peak at 3289cm^{-1} , 2984 cm^{-1} and 1056 cm^{-1} due to the presence of hydroxyl groups (-OH) stretching vibrations. A characteristic peak at 1458cm^{-1} is due to the C-H vibrations. The surface of the lignin particles is composed of hydrophilic hydroxyl groups which have a strong ability to interact with hydroxyl groups of PVA. The absorption band for PVA at 3370cm^{-1} represents the hydroxyl (-OH) stretching vibrations. This band shift to lower frequency in the composite film and exhibits a peak at 3355 and 3329 cm^{-1} for 2:8 and 5:5 ratio of lignin-PVA composite. The shift to lower frequency (red shift) in the composite film is due to the presence of lignin to PVA matrix. The shift in band indicates the presence of intermolecular hydrogen bonding between the hydroxyl groups of lignin and PVA matrix. The band at 2924cm^{-1} , 2909 cm^{-1} and 2893cm^{-1} in PVA, 1:9 and 2:8 lignin- PVA composite film which represents a characteristic peak for C-H stretching vibration. The band at 1087cm^{-1} for PVA shows a red shift to 1076cm^{-1} and 1061 cm^{-1} for 1:9 and 2:8 composite film representing C-O stretching vibration.

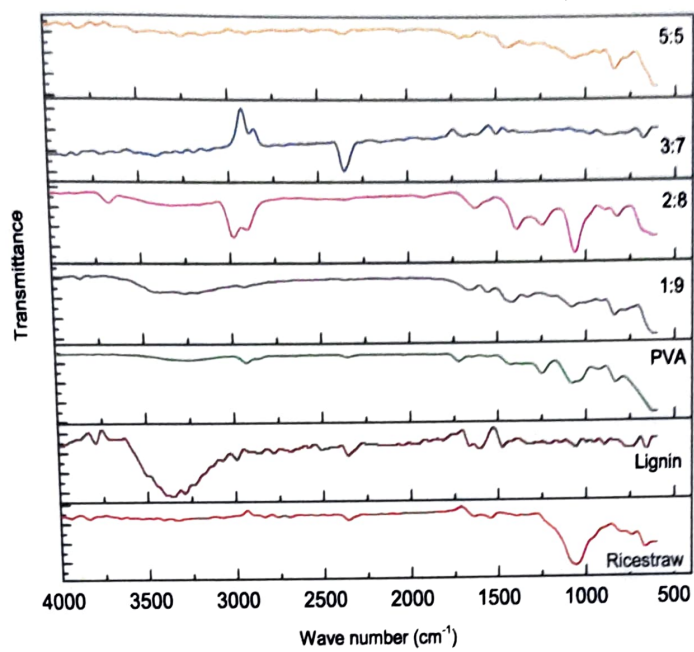


FIG.5.3 FTIR SPECTRA

5.4 UV TEST:

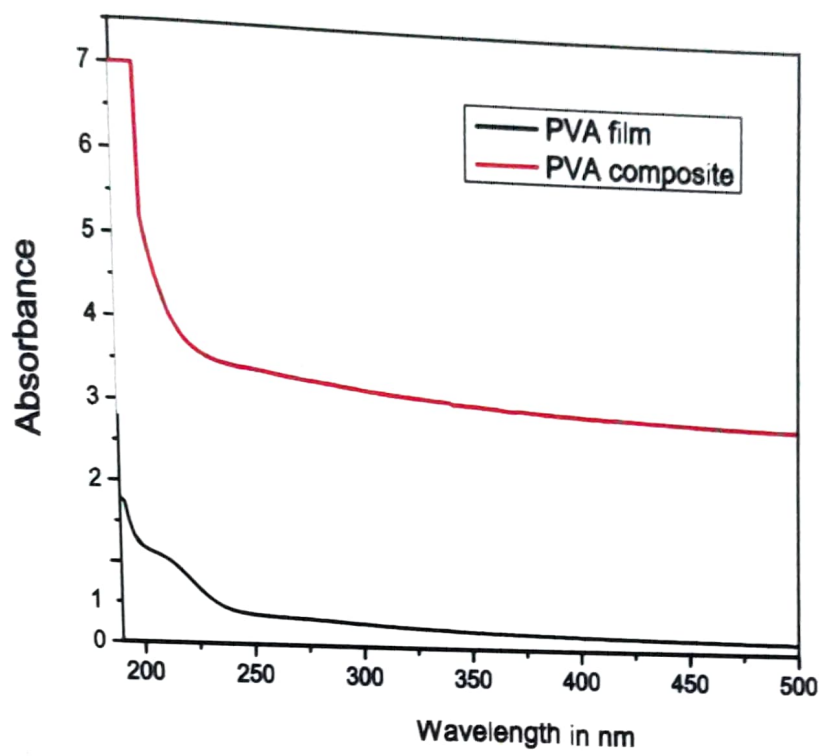


Fig 5.4 Absorbance plot for lignin and composite film

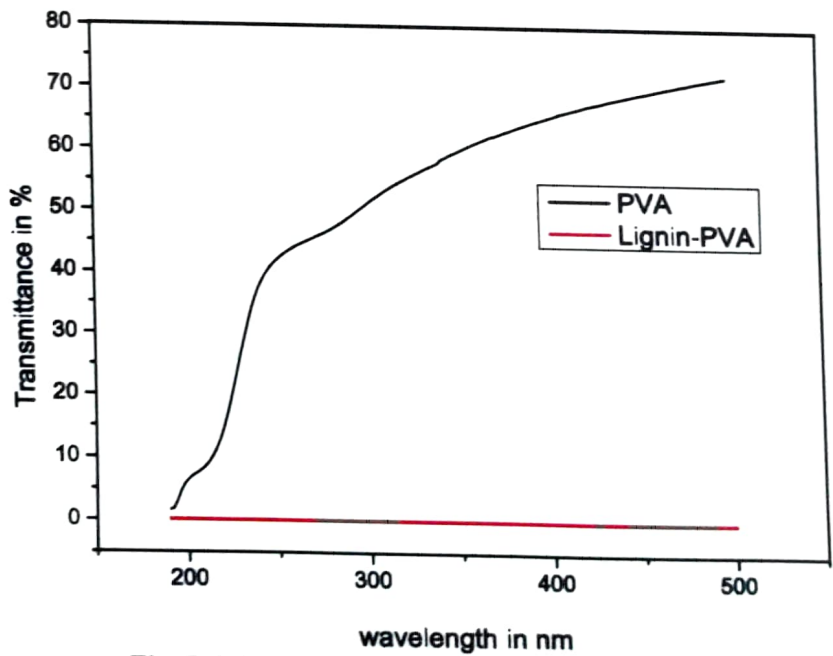


Fig.5.4.1 Transmittance plot for lignin and composite film

Table 5.2 UV Shielding by lignin and composite film

S.no	Wavelength (nm)	PVA – Transmittance (%)	Lignin-PVA Transmittance (%)
1	250 (UV-C)	41.86	0.038
2	300 (UV-B)	50.94	0.0618
3	30 (UV-C)	59.57	0.088
4	500 (Visible)	72.338	0.148

The UV shielding effect for PVA and lignin-PVA composite film is represented in the fig and in table As seen from the fig, the composite film completely shields the UV light and visible region of the electromagnetic spectrum. The composite film shows a negligible transmittance and meagre transmittance in the visible region.

CHAPTER 6

SUMMARY AND CONCLUSION

Sustainable of bio-plastic industry can be developed by combination of management such as organization management, human management, raw material quality management. Moreover, the input supply and advanced manufacturing resources puts a competitive and strategic position as a nation readying itself to become one of the global hubs for the emerging bio-plastics industry.

From the above discussion it can be concluded that

The bioplastics obtained from agricultural waste can be used as bagasse, corn cob, cellulose, sago pith waste and chitin. The trend of agro-waste as the source for bioplastics production is rising due to the relatively lower cost and easily available.