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CHAPTER NO-1

INTRODUCTION

1. INTRODUCTION

As we see in today's world there is lot of plastic pollution which is harmful to our environment and death of many animals. India is slowly becoming a country where people are turning health conscious. We are trying our level best to take care of ourselves. Usage of plastic cutlery and tableware has reached epic proportions, seriously harming the environment. Plastic usage in India had been growing at a massive rate of 10.5% over the last decade. Plastic items is more dangerous than any other pollution because the pollutant which is plastic roughly takes 500 years to decompose and till then, they languish in landfills, choke our drainage systems and finally seep in the oceans and seas killing millions of marine life forms.

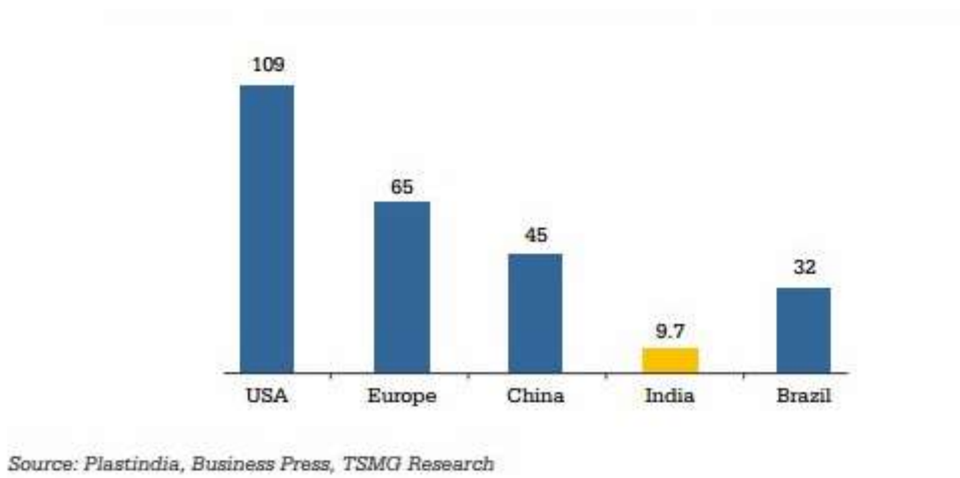

Fig: 1 per Capita plastic products consumption (kg/person)

India is a developing country and other well developed countries are also facing this problem. So our attempt is to reduce the plastic by an ecofriendly way by using plant biomass material such as husk, rice bran, bagasse, coconut coir, etc that could see a surge in usage in the coming decade. Today consumption of disposable is breaking records. Disposable products are easy to handle, economical and can be disposed easily. With the changing lifestyle of mankind, the use of disposable products is rising like anything. Plastic disposable products are very popular because it can be carried easily and very low in prices too. But on the other hand these products also harm the environment very badly.

Current Scenario

Plastic pollution has become one of the most pressing environmental issues, as rapidly increasing production of disposable plastic products overwhelms the world’s ability to deal with them. Plastic pollution is most visible in developing Asian and African nations, where garbage collection systems are often inefficient or nonexistent. But the developed world, especially in countries with low recycling rates, also has trouble properly collecting discarded plastics. Plastic trash has become so ubiquitous it has prompted efforts to write a global treaty negotiated by the United Nations.

Plastics made from fossil fuels are just over a century old. Production and development of thousands of new plastic products accelerated after World War II, so transforming the modern age that life without plastics would be unrecognizable today. Plastics revolutionized medicine with life-saving devices, made space travel possible, lightened cars and jets—saving fuel and pollution—and saved lives with helmets, incubators, and equipment for clean drinking water.

The conveniences plastics offer, however, led to a throw-away culture that reveals the material’s dark side: today, single-use plastics account for 40 percent of the plastic produced every year. Many of these products, such as plastic bags and food wrappers, have a lifespan of mere minutes to hours, yet they may persist in the environment for hundreds of years.

Biodegradable disposable flatware and utensils manufactured from wood-based or plant-based raw materials, including materials that may be traditionally discarded such as sawdust, plant stalks, seed or grain hulls or the like. The process includes the use of a resin made from the discarded materials to form disposable utensils and flatware.

Poly Lactic Acid

Polylactic acid, or **polylactide** (**PLA**) is a thermoplastic polyester with backbone formula $(C_3H_4O_2)_n$ or $[–C(CH_3)HC(=O)O–]_n$, formally obtained by condensation of lactic acid $C(CH_3)(OH)HCOOH$ with loss of water (hence its name). It can also be prepared by ring-opening polymerization of lactide $[–C(CH_3)HC(=O)O–]_2$, the cyclic dimer of the basic repeating unit.

PLA has become a popular material due to it being economically produced from renewable resources. In 2010, PLA had the second highest consumption volume of any bioplastic of the world, although it is still not a commodity polymer. Its widespread application has been hindered by numerous physical and processing shortcomings. PLA is the most widely used plastic filament material in 3D printing.

Polylactic acid (PLA) is the most common bioplastic in use today. First, corn or other raw materials are fermented to produce lactic acid, which is then polymerized to make polylactic acid (PLA). Bioplastics are expected to make major contributions to environmental protection, because they reduce CO2 and because they are biodegradable. The range of applications for bioplastics is growing, from materials used in automobile interiors to packaging for foods and cosmetics, to agricultural sheeting, to household appliances.

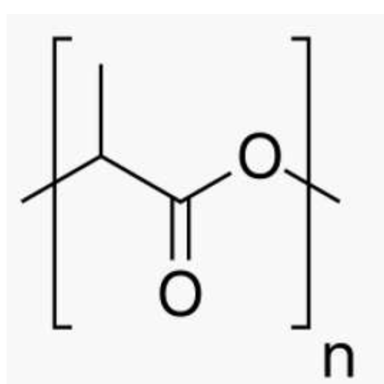

Fig 2 Polymer of Lactic Acid

CHAPTER NO 2

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Natural fibers used as biocomposite fillers have received much interest in offering notable advantages over synthetic fibers. In addition to being of low cost, they are environmentally friendly, renewable and biodegradable, as well as having a low density. Examples include althaea, artichoke, arundo, bamboo, borassus fruit, coir, curaua, ferula, jute, kenaf, oil palm and sansevieria.

In Malaysia, noted as one of the world's major oil palm producers, there is a considerable amount of oil palm biomass resulting from the milling process. The palm mesocarp fiber which is a lignocellulose fiber is a renewable material and is obtained at a very low cost directly from the oil palm mill process. It is usually burnt as a boiler fuel to generate steam and electricity for the palm oil mill. Yoon Yee Then et al. [1] have considered this as the feed material for other uses, and have successfully compounded it with thermoplastics of poly(lactic acid) (PLA), poly(butylene succinate) (PBS) or PLA/poly(caprolactone) blend to produce biodegradable biocomposites.

This type of biocomposite offers the advantages of being light weight, low cost, biodegradable, and exhibits reasonable strength and stiffness. The technique reported is based on using superheated steam as a cost effective and green processing technique designed to modify the oil palm mesocarp fiber (OPMF) and to promote the adhesion between the fiber and thermoplastic. Under controlled operating conditions, biocomposites from superheated steam treated OPMFs and poly(butylene succinate) and PBS at various weight ratios were prepared using a melt blending technique. The mechanical properties and dimensional stability of the biocomposites were evaluated. The study revealed that the superheated steam increased the roughness of the fiber surface by the removal of surface impurities and hemicellulose.

The tensile, flexural and impact properties, as well as dimensional stability of the biocomposites were markedly enhanced by the presence of treated OPMF. Scanning electron microscopy was used to show the improvement of interfacial adhesion between PBS and superheated steam (SHS)-treated OPMF for which the work concluded that superheated steam could potentially be used as an eco-friendly and sustainable processing method for modification of OPMF in biocomposite fabrication.

The majority of the world's plastics are derived from non-biodegradable petroleum-based polymers. The persistence of these materials in the environment has had a profound impact far beyond their functional life in the form of pollution, litter and waste disposal problems. There is also concern about environmental issues and preservation of natural resources. This has led to stimulation of interest in biodegradable polymers based on renewable resources. Bio-based polymers offer environmentally friendly benefits in that they have the capability to degrade naturally into organic substances without releasing any toxic components. Of these, the thermoplastic polyester poly(lactic acid) (PLA) has attracted considerable attention as a result of its versatility, biocompatibility and biodegradable characteristics. PLA is derived from renewable agricultural sources. In spite of its excellent properties, the relatively high production costs restrict the widespread use of PLA.

One way around this is through the incorporation of low cost, renewable and fully degradable natural filler, such as oil palm empty fruit bunch (OPEFB) fiber, which is a waste product generated from the oil palm industry and widely abundant in Malaysia and other South East Asia countries. Marwah Rayung et al. [2] report the preparation of biodegradable composites from PLA and OPEFB fiber by a melt blending method which involves modifying the fiber through a bleaching treatment using hydrogen peroxide. The SEM micrographs, the bleached fiber composite was then found to show improved mechanical properties compared to untreated fiber composites due to an enhanced form of fiber/matrix interfacial adhesion. Interestingly, the fiber bleaching treatment also improved the physical appearance of the composite. The study was further extended by blending the composites with a commercially available colorant.

The incorporation of peptide blocks into a synthetic polymer has opened up new challenges in areas as diverse as nanotechnology such as biosensors, and biotechnology such as drug delivery systems, tissue engineering and implants. Poly(l-lactide) (PLLA) is a well-known polymer used in a number of commodity products, such as packaging materials and films, as well as specialized applications such as biomedical devices, including implants and drug delivery systems, as a result of its degradability properties within living environments. The monomer can be obtained from renewable resources such as starch from either corn or sugar beets. The combination of PLLA with peptide blocks should modify its stability because enzymatic degradation is required to hydrolyze the peptide bonds. Furthermore, the semi crystalline character of PLLA enables the formation of crystallites and amorphous phases depending on the processing conditions, allowing modulation of the PLLA influence on the self-assembly properties of the derived block copolymer. Marc Planellas and Jordi Puiggalí [3] report their work on hybrid materials which constitute peptides and synthetic polymers. This involved the synthesis of poly(l-lactide-b-l-phenylalanine) copolymers with various block lengths by sequential ring-opening polymerization of l-lactide and the N-carboxyanhydride of l-phenylalanine. The resulting block copolymers were characterized by NMR spectrometry, IR spectroscopy, gel permeation chromatography, MALDI-TOF and UV-Vis, revealing the successful incorporation of the polyphenylalanine (PPhe) peptide into the previously formed PLLA polymer chain. X-ray diffraction and differential scanning calorimetry (DSC) data were used to suggest that the copolymers were phase-separated in domains containing either crystalline PLLA or PPhe phases. They also noted a peculiar thermal behaviour using thermogravimetric analyses when polyphenylalanine blocks were incorporated into polylactide.

CHAPTER NO-3
OBJECTIVES

3. OBJECTIVES

- To develop Biodegradable Plates and Cutlery
- To Check its Quality and Durability.
- To study its degradation in Environment.
- To provide alternative of Plastic ware.

CHAPTER NO-4

MATERIALS AND METHODS

4. MATERIALS AND METHODS

4.1 Material:

3.1.2 Chemicals: Starch, Lactic Acid, Stannus Chloride, water, gelatin, Agar and NRCL broth

3.1.3 Glass Ware: Distillation unit, Beaker, Glass Rod, Conical Flask, Measuring Cylinder, Burette, Petri Plates, Slide, Test Tubes, Saline tubes

3.2.4 Equipments: Hot Air Oven, Mixer Grinder, Microscope, Mortar Pestle, Magnetic Stirrer, Anaerobic Incubator, Shaker Incubator

4.2 Methods:

Lactic acid (LA) is a building block for the synthesis of PLA, a biodegradable polymer, which is commonly used in many different sectors due to its transparency, process ability and characteristics. LA was mainly produced by chemical synthesis starting from fossil resources. Chemical synthesis of LA always leads to racemic mixture, which is a major disadvantage. The optical purity of LA is an essential factor in determining the physical properties of PLA.

PLA is aliphatic polyester, primarily produced by chemical such as Tin octate and polycondensation of lactic acid and/or ring-opening polymerization of lactide.

LA is the project is produced by microbial fermentation routes using Lactobacillus species. Fermentative production of Lactate offers great advantage in producing optically pure L- or D-LA.

4.2.1The Production of Poly Lactic Acid Polymer consists of 4 steps:

1. **Isolation of Lactic Acid Bacteria from Curd Sample:**
   The Curd Sample was diluted using 0.85% Saline and then streaked on NRCL (Neutral Red Chalk Lactose Agar) plates and grown for 48 hours at 37◦C in anaerobic incubator. The Colonies showing zone around it were

isolated and maintained on NRCL Agar Slants. The characterization here is not required as the aim is to get the lactic acid only.

2. **Production of Lactic Acid:**
   The isolated bacteria were inoculated in NRCL broth and production of Lactic Acid was done at 37◦C for 48 to 60 hours in Anaerobic incubator.
3. **Dehydration or Oligomerization:**
   In this Process lactic acid is dehydrated by distillation Process due to which it gets reconstructed to form short chains and the final product formed after this process is very thick and viscous. To boost the speed of this process the distillation is carried out under air deficient condition.
4. **Ring opening polymerization:**
   In this process the viscous polymer is treated with Stannous Chloride which act as a catalyst due to which the polymer undergoes ring opening forming the lactic acid polymers of short length. The product is further purified by the treatment of Methanol and its exposure to air. The polymer formed is sticky in nature which is then used in the plate mixture to give binding properties to raw material.

4.2.2 The Production of Biodegradable plates and cutlery:

1. The Wheat husk and rice bran are mixed in equal proportion and grinded into fine powder.
2. This mixture is then added with starch 1% gelatin 1% and 10% polylactic produced from lactic acid monomer obtained fermented broth. Along with this the pure lactic acid solution of 88% is also taken as control.
3. This whole mixture is boiled in water for 10 minutes.
4. The mixture is allowed to concentrate and thick mass is formed.
5. This mixture is transferred to moulding apparatus for plates and bowls.
6. The mould is allowed to set in desired shapes
7. The plates are coated with film of PLA and Butter paper.

4.2.3 Degradation of PLA

PLA is degraded abiotically by three mechanisms:

1. Hydrolysis: The ester groups of the main chain are cleaved, thus reducing molecular weight.
2. Thermal degradation: A complex phenomenon leading to the appearance of different compounds such as lighter molecules and linear and cyclic oligomers with different *Mw*, and lactide.
3. Photodegradation: UV radiation induces degradation. This is a factor mainly where PLA is exposed to sunlight in its applications in plasticulture, packaging containers and films.

The hydrolytic reaction is:

$$-\mathrm{COO} + \mathrm{H_2O} \longrightarrow -\mathrm{COOH} + -\mathrm{OH}^-$$

CHAPTER NO-5

RESULTS AND DISCUSSIONS

5. RESULTS AND DISCUSSIONS

5.1 Isolation of Lactic Acid producing bacteria from curd

The saline of 1 % is percent with one day old curd sample and this is streaked on NRCL Agar Plates and colonies having zone around it are selected and purified and inoculated into NRCL agar broth

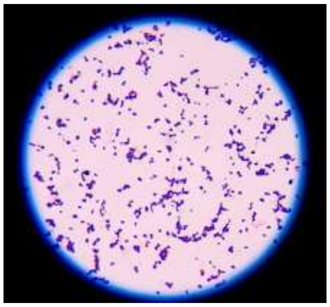

Fig 3 Microscopic filed of gram staining to confirm LAB's

5.2 Production of Lactic Acid by fermentation in flask

The colonies are inoculated in NRCL medium and fermentation is done.

Fig 4 fermented flask of NRCL broth

5.3 Production of Poly Lactic Acid

Fig 5 Oligomerization by distillation

Fig 6 Formation of Poly Lactic Acid

5.4 The Production of Biodegradable plates and cutlery:

Fig 7 Equal proportions of wheat husk and rice bran

5.5 Biodegradable Plates and Bowls prepared

Fig 8 Biodegradable Plates and Bowls

CHAPTER NO- 6

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CHAPTER NO- 7
APPENDIX

7. APPENDIX

7.1 Composition of NRCL Agar medium

Ingredients	gms / liter
Peptic digest of animal tissue	3.000
Beef extract	3.000
Yeast extract	3.000
Lactose	10.000
Calcium carbonate	15.000
Neutral red	0.050
Agar	15.000

Final pH (at 25°C) 6.8±0.2

- $CaCO_3$ to be separately sterilized

7.2 Formula of Poly Lactic Acid

$$(C_3H_4O_2)_n \text{ or } [–C(CH_3)HC(=O)O–]_n,$$