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Sustainable Crockery Materials- A Review Of Pretreatment Methods And Proposed Mechanisms

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Abstract: Owing to the United Nations' Sustainable Development Goals, it has been essential that we find alternative means for all those processes that contribute to pollution. Plastic was invented in the wake of long-lasting materials, and it completely revolutionized the packaging industry. However, the plastic used hitherto calls for the usage of petrochemical reserves around the globe. The manufacturing of bioplastics has been boosted by the expanding effects of using fossil fuels and petrochemicals, rising consumer awareness of these issues, and an improving economy. Biobased, biodegradable, or both types of plastics are referred to as "bioplastics.". An excellent substitute for plastics made from petrochemicals is bioplastics. They have all the properties of conventional plastic in addition to being sustainable. At most, 1% of the 360 million tons of plastic generated annually are bioplastics annually, but the demand and preference for bioplastics continue to rise, with Europe being the largest producer of bioplastics. This paper gives an insight into various protocols that can be followed to manufacture bioplastics.

***Index Terms* - bioplastics, sustainable, pre-treatment, bamboo, sugarcane**

Introduction

While bioplastics are manufactured, considerations regarding the source of the raw materials have to be made. Sources of raw material that can be used as a direct source of food by humans or any other species should not be used as this would stress the food availability in the world. There are currently three defined generations of bioplastics. The first-generation bioplastics are those that have been manufactured using starch and sugar-rich materials like corn, potatoes, wheat grains, etc. The second-generation bioplastics are manufactured from food and agricultural waste products. The third generation of bioplastics is prepared directly from the microorganisms by culturing them. Resource [28] emphasizes the manufacturing of second-generation bioplastics due to the growing concerns about the pressure upon the food sources that occurs due to the manufacture using direct food supplies. These types of bioplastics are still in the research phase [21]. The pretreatment methods have to be such that they can be applied to the various types of organic waste products that come from industries. Organic waste generally contains lignocellulosic biomass, which is a combination of lignin, cellulose, and hemicellulose. The success of a pretreatment method lies in its ability to remove the lignin content with minimal loss of cellulose and hemicellulose that can be further treated for the production of saccharides. Apart from these considerations, economic feasibility, affordability of these items, production scale, safety, and quality assurance are other factors that also need equal attention [25]. Bioplastics have been in the limelight because even conventional plastic recycling has become an environmental threat. It is good that bioplastics will always be biodegradable. They can be biobased, biodegradable, or both.

1. Sources of the Raw Material

    a. Wood and Furniture Industries generate a lot of wood waste. Hence wood, both hard and soft, can be a potential source of raw material [1].

    b. Among the most prevalent types of organic agricultural waste are corn straw, wheat straw, and rice straw [2].

    c. Kitchen Waste and Municipal Sewage waste can also be effectively pre-treated to make the cellulose content available for enzymatic action that converts it to sugars which can be further fermented. [2]

    d. Cafeteria waste can also be used to produce bioplastic Polyhydroxyalkanoate (PHA) [6].

    e. Cocoa pod husk can also be a potential raw material for bioplastic production [11].

    f. Potato and banana peels are excellent raw materials for bioplastic production [11].

    g. Sago starch and jackfruit waste also form a good source of raw material [35].

I. PRETREATMENT METHODS

2.1 CHEMICAL PRETREATMENT METHOD

1. **Using Peracetic Acid for Pretreatment** [1]: In order for the manufacture of platform chemicals to be economical and sustainable, pre-treatment techniques are crucial. High temperatures may be necessary to separate the Hemi cellulosic sugar xylan during alkaline or acidic hydrolysis. Using diluted acid at high temperatures is one of the most economical pretreatment techniques. It is possible to effectively isolate lignin without losing many carbs by diluting peracetic acid at temperatures up to 90 degrees Celsius for five hours. When hydrogen peroxide and acetic acid react with sulphuric acid acting as a catalyst, peracetic acid is created. Pretreated organic waste shows improved carbohydrate recovery. Increasing the pretreatment time from 1 hour to 5 hours results in an increase in carbohydrate recovery except for that of glucan. Glucan is an important saccharide component of cellulose, and increasing the amount of pre-treatment time has a negligible impact on its recovery percentage. This method can be used for woody waste materials (Hardwood or Softwood). The Procedure has been summarised in Fig. 1.

2. **Alkali Pretreatment** [2]: The addition of alkalis has been shown to destroy the bonds between the polymers and reduce their crystallinity. The success of this particular treatment is attributed to the lignin content in the biomass. It is found that it works best for biomass with low lignin content. Sodium, potassium, and calcium hydroxides are the most widely utilized alkalis. Although NaOH and KOH are efficient, salt discharge can be challenging to recycle and has been linked to pollution. Calcium hydroxide can be used to tackle these pitfalls, but since it is a weaker alkali, the effectivity of the pretreatment will get reduced. This type of pretreatment, when combined with mechanical pretreatment, yields very good results. This can be followed by the fermentation processes, which convert C5 and C6 sugars to final products [4]. Different acetyl and uronic acid replacements in hemicellulose are eliminated by alkali pretreatments. Such substances reduce hemicellulose's susceptibility to enzymatic pretreatment [4]. Alkali treatment degrades biomass less quickly than acid treatment, but it is still possible and simple to remove and recover caustic salt [3].

3. **Acidic Pretreatment** [2]: Acidic pretreatment uses acetic acid, sulfuric acid, and hydrochloric acid. This method relies on the hydrolysis of cellulose and hemicellulose to disrupt van der Waals forces, covalent bonds and hydrogen. Dehydration of produced simple sugars can lead to the formation of furfural and hydroxy methyl furfural, which may prevent further hydrolysis of the biopolymer. Dilute acid hydrolysis has proven to be an effective pretreatment. Reaction kinetics for each pair of acids and biomass needs to be known properly for acidic pretreatment. Organic acids such as fumaric and maleic acid can also be employed in place of inorganic acids. This method can use a variety of reactor designs, including percolation, counter-current reactor, shrinking-bed, batch, and plug flow [3]. Two categories of weak acid hydrolysis exist 1. A continuous flow, a high-temperature method for low solids loading that operates at a temperature of at least 160 °C and a substrate concentration of between 5 and 10 wt.% 2. Batch high-solids loading at low temperature, where the temperature must be less than or equal to 160 °C and the substrate concentration must range between 10 and 40 % by weight [4].This procedure can also be carried out using powerful acids. The adaptability of raw materials is a significant benefit. This procedure does not require extremely high temperatures or pressures. However, concentrated acids are more expensive, and recycling the acid is necessary to make the process more profitable. Additionally, the monomeric compounds may be harmed by the acids' corrosiveness [4].

4. **Ammonia Fiber Explosion**: Ammonia liquid swells under high temperatures and pressures, then contract at a lower pressure, causing the polymer bonds to break. The procedure employs 1000-2000g of ammonia per kilogram of dry biomass for 30 minutes at a temperature of 90 degrees Celsius [4]. For low-lignin biomass, this technique works better [7].

5. **Ozonolysis**: This mainly involves using ozone as an oxidising agent to treat the breakdown of lignin. For the disruption of cellulose and hemicellulose bonds, the technique is ineffective [3]. It has been noted that cellulose has essentially no modifications, whereas hemicellulose experiences relatively minor changes [3]. The equipment for the ozone treatment includes an iodine trap for testing the effectiveness of the catalyst, an ozone catalytic destroyer, an oxygen cylinder, an ozone UV spectrophotometer, an ozone generator, a three-way valve, a pressure regulation valve, a process gas humidifier, a vent, and an automatic gas flow control valve. It has been discovered that lignin oxidation declines as biomass moisture content rises. Dry biomass can also interfere with the mass transfer of ozone. Therefore, this approach is not recommended for pre-treatment.

6. **Oxidative Delignification** [4]: This pretreatment method focuses on the breakdown of lignin. The principle is based on the oxidation caused by various oxidising agents like Ozone, oxygen, or hydrogen peroxides. These agents react with the aromatic monomer of the polymers to form carboxylic acids. These acids may hamper the further fermentation process, so they must be removed.

7. **Organosolv process** [4]: This process uses various organic solvents or their mixtures and water to remove lignin from the biomass. Along with the degradation of lignin, the hemicellulose is also hydrolyzed in this process. This makes the end product more susceptible to enzymatic treatments on the cellulose. The lignin produced in this process can also be used to manufacture different platform chemicals. The organic solvents most often are

methanol, ethanol, acetone, and ethylene glycol. Alcohol-based organosolv pre-treatment combined with ball milling to pre-treat Japanese cypress has shown a synergistic effect on the digestibility of the biomass [3].

8. **Liquid Hot Water**: In this procedure, water is utilized to process the biomass under higher pressure and temperature conditions. At 200–230 °C, water and biomass react for about 15 minutes. Between 40% and 60% of the entire biomass, of which 4–22% is cellulose and 35%–60% is lignin, are dissolved by this process. This method dissolves the full hemicellulose. Additionally, the process produces acetic acid, which facilitates the hydrolysis of the polysaccharides [4]. This technique can be used to treat corncobs, sugarcane bagasse, wheat rye straw, and corn stover. This process is not particularly sustainable because to the high energy requirements caused by using a lot of water. However, this technique does not include any pricey chemicals, and it does not result in any side effects or the production of inhibitors.

9. **Ionic Liquid Pre-treatment** [4]: Ionic liquids with organic cations or anions are polar solvents with low melting and boiling points and great thermal stability. Anions are small, whereas cations are massive. The characteristics of the cations and anions that make up the ionic liquid determine its properties. Ionic liquids have been found to interact with biopolymers and cause their depolymerization. Time of exposure, temperature, and nature of Ionic liquid and biomass are the determining factors of the success of this process. This method can be used to treat materials including rice husk, water hyacinth, rice straw, kenaf powder, poplar wood, wheat straw, and pine. Ionic liquids include substances like 1-ethyl-3-methylimidazolium diethyl phosphate-acetate, 1-butyl-3-methylimidazolium acetate, choline amino acids, choline acetate, and 1-allyl-3-methylimidazolium chloride. The drawback of this approach is the incompatibility between cellulase and ionic liquids, which causes cellulase to unfold and become inactive. High temperatures may result in unfavourable side effects and reduce the stability of ionic liquids.

10. **SPORL Pre-treatment method** [3]: This is a Sulphite Pre-treatment to Overcome Lignocellulose Resistance. It has been summarized in Fig 3.

11. **Deep Eutectic Solvent Pre-treatment**: Using hydrogen bonding, two or more organic solvents are combined to form deep eutectic solvents. These solvents have lower melting points than the solvents that make up their composition [7]. They are a superior option to ionic liquids in terms of their economic viability and biodegradability. Quaternary ammonium salts combined with a metal salt or a hydrogen donor yield deep eutectic solvents.

2.2 PHYSICAL PRETREATMENT METHODS

1. **Mechanical Pretreatment of organic mass** [2]: The major method of mechanical preparation is milling. Attrition milling, ball milling, centrifugal milling, colloid milling, hammer milling, extruders, knife milling, pin milling, ball milling, planetary milling, and vibratory milling are a few examples of the various types of milling operations. Planetary milling has produced glucose and galactose with excellent results [7]. By doing this, the polymers' crystallinity is decreased, and their surface area is increased, improving the effectiveness of chemical or enzymatic treatment. This indicates that the surface-to-volume ratio is increased by the process [4]. The milling process is influenced by the feed rate, beginning particle size, moisture content of the biomass, and machine parameters. An advantage of this process is that there is no formation of any inhibitors like hydroxymethyl furfural. However, the biggest disadvantage of this process is its energy requirement. Milling may also be incapable of removing lignin which might also be a disadvantage [3].

2. **Steam Explosion** [2]: The lignocellulosic biomass is exposed to saturated steam during this process. For some time, this steam is kept at high pressure (5-50 atm) and high temperature (160-260 degrees Celsius). The standard unit of time is the minute. As the pressure progressively drops, the steam expands as a result. The biomass's polymeric structure is subsequently disturbed. For even greater yields, this can also be combined with a 1% acid treatment, while it is not required.

3. **Microwave Radiation Pre-treatment** [2]: The biomass's capacity to store electromagnetic energy is indicated by its dielectric constant, and its capacity to transform that energy into heat, which will aid in the polymer's bond-breaking, is shown by its dielectric loss factor. The polar molecule vibration and ionic movement caused by the heat generated cause collisions in the mass. This is brought about by the rapidly changing electric and magnetic fields with respect to their orientation. The rate of change of orientation can be as high as 2.4 X 10^9 per second. The microwave makes for a good process as there is a uniform distribution of heat in the biomass, and this reduces any temperature gradient [3]. Additionally, this approach prevents lignocellulosic material from degrading into humic acid and furfural [3]. This technique is currently used in laboratories, and research to expand its use is still popular. It can, however, be employed as a support technique for pre-treatments using alkali, acids, water, salt, or ionic liquid. It has been demonstrated that pre-treatments with microwave radiation improve the yields of carbohydrates and remove more lignin from the biomass.

4. **Mechanical Extrusion**: The biomass is placed into an extruder using this technique. A revolving barrel and blades make up the extruder. High temperatures are also applied to the biomass. Due to the high temperatures and shear stresses produced by the moving blades of the barrel, the extruder disrupts the internal structure of the polymer

and breaks it down. The breakdown products are fermentable sugars. This sugar recovery can be improved by adding acid/alkali. Alkali is preferred considering the corrosion that acid may cause in the extruder machine [3].

5. **Pretreatment with a Pulse Electric Field** [3]: This process involves brief, high-voltage electric pulses that are applied to the biomass for a few nanoseconds or milliseconds. Typically, electric pulses are applied as square waves or exponential decay. Due to this voltage, there are pores are created in the biomass cellulose and lignin content. This process, when followed by enzymatic hydrolysis, allows the enzymes or chemicals to enter the interior of the molecules through this pore and bring about hydrolysis. A simple schematic that shows the process of PEF is shown in Fig 4.

6. **Ultrasonication and PEF** are processes that function similarly. It causes cavitation in the polymeric structure of the biomass components using ultrasonic radiations [7]. This is an effective method influenced by the ultrasonic frequency, exposure duration, power applied, and temperature conditions. Overexposure can lead to negative effects like collision and aggregation of biomass particles into lumps.

2.3 BIOLOGICAL PRETREATMENT METHODS:

Microbiological Pretreatment [2]: The principle of this treatment is based on the function of certain species of bacteria and fungi to produce cellulose, hemicellulose, and lignin-degrading enzymes that convert these polymers into their compositional monomers. These enzymes include lignin peroxidase, laccases, versatile peroxidases, and manganese peroxidases [7]. Phanerochaete chrysosporium is a species of fungus that is most researched and gives good results. The advantage of biological treatment is that it does not cause pollution and is very cost-effective. However, this treatment requires huge space and takes a lot of time to complete since it relies on the metabolic activities of the microorganisms. These microorganisms can also use the produced sugar as a source of their own food rendering this a disadvantageous method. The most widely utilised types of white rot fungi are Pleurotus ostreatus, Ceriporiopsis subvermispora, Ceriporia lacerata, Pycnoporus cinnabarinus, Cyathus cinnabarinus, and Phanerochaete chrysosporium.

II. BIOP

3.1 CONVERSION TO BIOPLASTICS

Polyhydroxyalkanoate (PHA) has become a great alternative to conventional plastic. Its greatest advantage is that it is produced from organic, renewable biomass, is biodegradable and has the same properties as conventional plastic.Combined UASB-SBR system [6]: For the manufacture of PHA from cafeteria trash, this technique combines an Up-flow Anaerobic Slug Bed and a Sequencing Batch Reactor. The wastewater from sinks and kitchens makes up this trash. In this procedure, no toilet wastewater is used. UASB pre-treats the wastewater slurry, which is maintained for about 25 days, and the supernatant is passed to the SBR, which has the necessary mechanism to culture the necessary bacteria for converting it into PHA. This process takes about a month.Bioplastics can be given plasticizers [32]. They are utilised to make the bioplastic more resilient and less brittle and crystalline. The most often used plasticizer is glycerol [26].Reference [28] mentions the various techniques that can be used to convert source materials into bioplastics. Fermentation, casting, and evaporation can be used to produce PHA from the bacterial source material. Polymerization, blow moulding, and thermoforming [29] can be used to convert lactic acid or paper into PLA. Casting can be used to manufacture PVA (Polyvinyl Alcohol).The combination of sugar production with the production of bioplastics and bioethanol is mentioned in the resource [33]. As a result, the sugars and starches found in sugarcane have a longer life cycle. These techniques are widely used in the sugarcane fields of Brazil. In this process, PHB is created. The fermentation procedure, in which Ralstonia eutropha and Bhurkolderia SP are cultured, is the initial stage. They initially grew aerobically, but as time went on, there were fewer nutrition sources available. The carbon source is increased by feeding highly concentrated sugar syrups. The process is stopped after 45-50 hours, and almost 60-70% PHB is obtained. It is thermally inactivated, diluted with water, and flocculated. Separation techniques are then applied, and PHB is extracted as pellets [33].Bioplastic PHA can be produced very effectively by culturing a bacterium called Bacillus megaterium. This bacteria naturally produces the biopolymer. The bioplastic obtained is heat tolerant and clear and can be used in food packaging. PHA is a better plastic than PLA [31].The conversion of agricultural waste (cotton and flax waste) into cellulose acetate (CA) based bioplastics is mentioned in the resource [34]. Thusly manufactured plastic eventually breaks down in water and soil. Without leaving any leftovers, they can also be recycled, composted, or burned. This process relied on the acetylation of plant cellulose, and the process is as follows:Bioplastics can be made from banana peels using HCl acid hydrolysis and glycerol as plasticizer and NaOH for pH balancing and then separating and drying it at 1200 degrees Celsius. [36].

3.2 APPLICATIONS OF BIOPLASTICS

1. Packaging: Bioplastics possess the property of impermeability to water and moisture, just like conventional plastics. Hence, they make up a huge chunk of the packaging industry. Almost 50% of Western goods are packed using bioplastics [25].In food and beverage packaging, the prime requirement is to prevent contact with water and air. Using PHA or microcrystalline cellulose or casein in Polycaprolactone (PCL) in the packaging materials improves the hydrophobic nature and oxygen impermeability of packages [19]. Due to good biocompatibility, bioplastics like PHA and PLA have also proven to be useful in the manufacturing of surgical films in the medical sciences. A capsule made from starch can replace the conventionally made gelatin capsule. Bioplastics are used in the manufacturing of tonic bottles or even surgical instruments. They also find a place in the body part transplant sciences, especially in bone transplants, blood vessels and epithelial tissue engineering. [20]. However, their usage safety is still not completely verified [19]. Polylactic acid (PLA) and Poly lactic co glycolic acid (PLGA), a copolymer, have also been used in

Nanomedicines for effective Drug Delivery Systems. Bioplastics like PHA and its composites have been put to use in the manufacturing of a wide range of products, from surgical meshes to meniscus repair devices, rivets, bone plates, surgical meshes, cardiovascular patches etc. [32].The addition of PHA and starch in cosmetic products and cosmetic packaging also improves their cytocompatibility [19].

2. Mulching films: Biobased polyethene is a very good material for mulching films on farms. These films are used to cover the seeded areas of the field to protect them from pests and weeds. They act as mini-greenhouses [25]. The advantage of using bioplastic in these films is that it can degrade or fragment into the soil without causing any environmental harm or without hampering the microbial life in the soil.

3. Microplastic: Conventional plastic though not 'biodegradable', is definitely degradable. However, it takes a very long time for it to degrade hence not considered degradable. The fragmented plastic called microplastic enters the food chains through water and accumulates in the bodies of the living entities in the food chain, ultimately causing ecological harm. Bioplastics, if used, would not cause as much harm if at they entered the food chain. Hence such bioplastics can also be used in cosmetics and similar products. Contact lenses also contain bioplastics as a more sustainable alternative.

4. Automobiles: Bioplastics are gaining popularity as alternative materials for making automobile parts by many manufacturers. Bioplastics have been used for the manufacturing of a variety of automobile parts that, include chassis, fuel tanks, bumpers, doors and even upholstery. Companies like Ford, Toyota, and Fiat claim to use sugarcane-based polyethene terephthalate (PET) and soybean-based foam in their vehicle parts [25].

5. Hydrophobicity, bio-compatibility, and non-toxicity are the properties that have rendered Bioplastics useful in tissue engineering and bio-scaffold synthesis for cell culturing [20].

6. Bioplastics like PLA are also used greatly in 3D Printing technologies [20].

III. CONCLUSION

1. Recent trends in the research on bioplastics show that certain methods can be applied to certain raw materials to manufacture bioplastics. Organic waste from sources like small-scale industries or restaurants, or even kitchen waste consists of a mixture of waste materials like potato peels, rice husk, leaves, etc. We propose a method for converting the bioplastics from such assorted and miscellaneous waste altogether. This method is still testing and would be restricted to laboratory-level manufacturing. The first step would consist of mechanical grinding of the raw waste material. This would be done in a simple grinder/mixer. The raw material can be heated to about 45 degrees Celsius to increase the effectiveness of the grinding process. The mechanical grinding process has been hitherto defined under physical pretreatment. Some researchers also mention it is an essential step before performing any additional pretreatment steps. Before grinding the waste, we propose that the waste material be washed with water and sundried for at least 5 days. They should be sun-dried for about a week if there is more water content. The fermentation process with the usage of microorganisms is a time-consuming process. So, we propose the usage of chemical and physical or physicochemical methods solely for the manufacture of bioplastics. Acidic hydrolysis yields certain products which inhibit the further process. However, they are effective where lignin content is higher. Alkaline hydrolysis methods using NaOH and high temperatures work best for lignin-containing raw materials. Acetylation works well with cellulosic content. Hence, we propose a combination of acidic, alkaline hydrolysis, and acetylation of the cellulosic material to form bioplastics.We also want to mention the use of antioxidants and preservatives to increase the biodegradation time of bioplastics.

2. Bamboo of lengths varying from 250-500cm can be used. The bamboo is passed through a metal slitter and then planned to the desired size eliminating the irregularities such as the green outer layer and the internal nodes. It is now heated at 150 Celsius for 48+ hours. Optionally, bamboo slats are treated in a high-pressure environment. The combination of heat and pressure releases natural starch from the bamboo slats. The slats are plain and side-pressed to obtain 1-2mm sheets of bamboo. The shreds obtained from this process will be used to make cutlery with the addition of lignin adhesive. The fibre is to be treated at 180 Celsius and 5MPa pressure to increase the internal bonding strength of the material. Lignin is abundantly obtained from rice straw. It is biodegradable. It also acts as a waterproof cement wall. Its purpose in the cell walls is to store water; likewise, it can be used to eat food with high water content.

3. In This method, we do not need segregation of the waste material; this method combines acid hydrolysis along with distillation and sedimentation to form the bio-plastic. The entire waste would be divided into batches of a specific amount, and then each batch would be dipped in a solution of Sodium Bisulfite($Na2S2O5$) or sodium benzoate($C7H5NaO2$), both of which act as oxidants and preservatives, they increase the biodegradation period of the plastic. Now the material will be boiled with distilled water, and then it will be allowed to dry. The product will now be crushed in a hand grinder to form a paste-like, slushy paste which now is the raw material for the process of manufacturing bioplastic.

The steps to make the bio-plastic from the above raw material are as follows

Step 1: 50gm of raw material is placed in a beaker

Step 2: 4.5ml of (0.5 N) HCl is added to this mixture and stirred using a glass rod.

Step 3: 2ml Plasticizer (Glycerol/Glycerine) is added and stirred.

Step 4: 0.5 N NaOH is added according to the pH desired.

Step 5: The mixture is then put in the oven at a suitable temperature and is baked.

Step 6: The tile is allowed to cool, and the film is scraped off the surface.

A completely alternative way to the above can even be done in a household kitchen.

Step 1: 25 g of the raw material to be taken in a saucepan

Step 2: To the above paste, 10ml of distilled water, 1ml of vinegar, 1.5gm of glycerol, and 1.5 gm of corn starch should be added

Step 3: The above mixture should be heated on a medium flame stove for about 30 mins

Step 4: Cornstarch can be substituted with the use of gelatin or agar-agar powder/solution.

Step 5: The mixture, when it becomes translucent or starts hardening, can be removed and placed on parchment. If desired, suitably shaped moulds can be used to shape the plastic when it’s hot.

4. Sugarcane top/leaf (5-10 parts by weight) and bagasse (33-55 parts by weight) are added into clear water. This mixture goes through thermophilic digestion. The digestion time here is 1-3 hours. In order to not influence the crushing effect, it is necessary to remove sugar and moisture as far as possible. Therefore, the mixture then goes through extrusion cooking. The cooking pressure is 0.15-0.3MPa, and the boiling temperature is 100-150 °C. Once the sugar content from the sugarcane top and the water content from the bagasse is less than 15%, they are then placed in a pulverizer to get smashed, are placed into a refiner and are ground, and the long fibre of the sugarcane top and bagasse are broken. Finally, the fibre is made of Powder. The fibre dust granularity is 50-80 mesh. The clear water of 3-4 times its weight is added in fibre dust, and then we add starch (10-15 parts by weight), polyacrylate dispersion (5-10 parts by weight), oil-proofing agent (5-8 parts by weight), and stirring is done with high speed. The starch is either the potato starch or the starch of cereals (sometimes both mixed). The oil-proofing agent can be cationic sheet paper fluorocarbon. Polyacrylate dispersion is used as a stabilizer. Further, the waterproofing agent(3-6 parts by weight) and Nano Silver(0.1-0.2 parts by weight) are added, and the mixed slurry is made. Nano Silver is added in composition and can play antibacterial action. Therefore, the food holding time can be effectively increased. The mixed method can use the ultrasonic wave to mix. The mixing time is around 20-30 minutes. Once blended, the mixture is piped into a Preparation Tank, where water absorption takes place. After water suction is done, the mixture is placed on the net mould and taken to forming machine. On the net mould of the paper pulp moulding device, pressing sizing drying is carried out to obtain the head product. The forming machine press temperature is 120-150 °C, and the forming machine press time is 1.5-4 seconds. The head product is then placed in a shaving die where the unnecessary corner is cut off by a trimming device, and we get the finished tableware product.The present method is primary raw material using byproduct-bagasse after sugar cane crushing sugaring and sugarcane leaf, and the cost is cheap, and the raw material is wide It is general, can be environmentally friendly with complete biodegradable, the product such as disposable tableware.

References

[1] Kundu, Chandan, et al. "One-step peracetic acid pretreatment of hardwood and softwood biomass for platform chemicals production." Scientific reports 11.1 (2021): 1-11.
[2] Amin, Farrukh Raza, et al. "Pretreatment methods of lignocellulosic biomass for anaerobic digestion." Amb Express 7.1 (2017): 1-12.
[3] Aftab, Muhammad Nauman, et al. "Different pretreatment methods of lignocellulosic biomass for use in biofuel production." Biomass for bioenergy-recent trends and future challenges (2019): 1-24.
[4] Harmsen, Paulien FH, et al. Literature review of physical and chemical pretreatment processes for lignocellulosic biomass. No. 1184. Wageningen UR-Food & Biobased Research, 2010.
[5] Tsang, Yiu Fai, et al. "Production of bioplastic through food waste valorization." Environment international 127 (2019): 625-644.
[6] Din, M. F., et al. "Raw material resource for biodegradable plastic production from cafeteria wastes." (2012)..
[7] Baruah, Julie, et al. "Recent trends in the pretreatment of lignocellulosic biomass for value-added products." Frontiers in Energy Research 6 (2018): 141.
[8] Jõgi, Katrin, and Rajeev Bhat. "Valorization of food processing wastes and by-products for bioplastic production." Sustainable Chemistry and Pharmacy 18 (2020): 100326.
[9] Onen Cinar, Senem, et al. "Bioplastic production from microalgae: A review." International journal of environmental research and public health 17.11 (2020): 3842.
[10] Coppola, Gerardo, et al. "Bioplastic from renewable biomass: a facile solution for a greener environment." Earth Systems and Environment (2021): 1-21.
[11] chemmatters-april2010-bioplastics

[12] Azmin, Siti Nuurul Huda Mohammad, and Mohd Shukri Mat Nor. "Development and characterization of food packaging bioplastic film from cocoa pod husk cellulose incorporated with sugarcane bagasse fibre." Journal of Bioresources and Bioproducts 5.4 (2020): 248-255.
[13] Yaradoddi, Jayachandra, et al. "Biodegradable plastic production from fruit waste material and its sustainable use for green applications." Int. J. Pharm. Res. Allied Sci 5.4 (2016): 72-81.
[14] Chen, Ying Jian. "Bioplastics and their role in achieving global sustainability." Journal of Chemical and Pharmaceutical Research 6.1 (2014): 226-231.
[15] Shamsuddin, Ibrahim Muhammad, et al. "Bioplastics as better alternative to petroplastics and their role in national sustainability: a review." Advances in Bioscience and Bioengineering 5.4 (2017): 63.
[16] Benn, Nicholas, and Daniel Zitomer. "Pretreatment and anaerobic co-digestion of selected PHB and PLA bioplastics." Frontiers in Environmental Science 5 (2018): 93.
[17] Chen, Zheng, Teddy Ko, and Wei Wei. "An Investigation into Sustainable Materials for Reusable Cutlery A Triple Bottom Line Assessment." (2011).
[18] Marichelvam, M. K., Mohammad Jawaid, and Mohammad Asim. "Corn and rice starch-based bio-plastics as alternative packaging materials." Fibers 7.4 (2019): 32.
[19] Nasir, Nur Nadia, and Siti Amira Othman. "Application of Bioplastic Packaging in Industry." Journal of Advanced Research in Materials Science 74.1 (2020): 19-28.
[20] Narancic, Tanja, et al. "Recent advances in bioplastics: application and biodegradation." Polymers 12.4 (2020): 920.
[21] Brizga, Janis, Klaus Hubacek, and Kuishuang Feng. "The unintended side effects of bioplastics: carbon, land, and water footprints." One Earth 3.1 (2020): 45-53.
[22] Abe, Mateus Manabu, et al. "Advantages and disadvantages of bioplastics production from starch and lignocellulosic components." Polymers 13.15 (2021): 2484.
[23]Joshi, Sudhanshu, Ujjawal Sharma, and Garima Goswami. "Bio-Plastic from Waste Newspaper." International Conference on Emerging Trends of Research in Applied Sciences and Computational Techniques. 2014.
[24] ##Brosch_Bioplastics (not found)
[25] Lackner, Maximilian. "Bioplastics." Kirk-Othmer Encyclopedia of Chemical Technology (2000): 1-41.
[26] Shah, Manali, et al. "Bioplastic for future: A review then and now." World Journal of Advanced Research and Reviews 9.2 (2021): 056-067.
[27] Review on Recent Developments and Future Scope in using Biodegradable Materials for Food Packaging
[28] Sidek, Izathul Shafina, et al. "Current development on bioplastics and its future prospects: an introductory review." INWASCON Technology Magazine 1 (2019): 03-08.
[29] Kumar, Yogesh, et al. "Bio-plastics. A perfect tool for eco-friendly food packaging: A Review." Journal of Food Product Development and Packaging 1.1 (2014): 01-06.
[30] Van den Oever, Martien, et al. Bio-based and biodegradable plastics: facts and figures: focus on food packaging in the Netherlands. No. 1722. Wageningen Food & Biobased Research, 2017.
[31] Pei, Lei, Markus Schmidt, and Wei Wei. "Conversion of biomass into bioplastics and their potential environmental impacts." Biotechnology of biopolymers (2011): 57-74.
[32] El-Kadi, S. "Bioplastic production from inexpensive sources." Bacterial Biosynthesis, Cultivation System, Production and Biodegradability (2010): 145.
[33] Nonato, R., P. Mantelatto, and C. Rossell. "Integrated production of biodegradable plastic, sugar and ethanol." Applied microbiology and biotechnology 57.1 (2001): 1-5.
[34] Mostafa, N. A., et al. "Production of biodegradable plastic from agricultural wastes." Arabian journal of chemistry 11.4 (2018): 546-553.
[35] Krishnamurthy, Akshaya, and Pavithra Amritkumar. "Synthesis and characterization of eco-friendly bioplastic from low-cost plant resources." SN Applied Sciences 1.11 (2019): 1-13.
[36] Gaonkar, M. R., Prashant Palaskar, and Rishikesh Navandar. "Production of bioplastic from banana peels." Proceedings of 146th The IIER International Conference, Hong Kong. 2017.
[37] Ghosh, Koushik, and Brad H. Jones. "Roadmap to Biodegradable Plastics—Current State and Research Needs." ACS Sustainable Chemistry & Engineering 9.18 (2021): 6170-6187.
[38] Latos-Brozio, Malgorzata, and Anna Masek. "THE PROSPECT FOR THE USE OF BIODEGRADABLE POLYMERS AS A MODERN AND PROECOLOGICAL PACKAGING MATERIALS." WYDAWNICTWO POLITECHNIKI ŁÓDZKIEJ 105 (2019).
[39] Filiciotto, Layla, and Gadi Rothenberg. "Biodegradable plastics: standards, policies, and impacts." ChemSusChem 14.1 (2021): 56.
[40] Giosafatto, C. Valeria L., et al. "Preparation and characterization of bioplastics from grass pea flour cast in the presence of microbial transglutaminase." Coatings 8.12 (2018): 435.
[41] Ibrahim, Nor Izaida, et al. "Overview of Bioplastic Introduction and Its Applications in Product Packaging." Coatings 11.11 (2021): 1423.
[41]### Current Research in Biodegradable Plastics
[42] ##Production of bioplastic products, entrepreneurindia
[43] Yaradoddi, Jayachandra S., et al. "Biodegradable carboxymethyl cellulose based material for sustainable packaging application." Scientific reports 10.1 (2020): 1-13.
[44] Rohmawati, Baiti, et al. "Synthesis of bioplastic-based renewable cellulose acetate from teak wood (tectona grandis) biowaste using glycerol-chitosan plasticizer." Oriental Journal of Chemistry 34.4 (2018): 1810.
[45] Vieira, Melissa Gurgel Adeodato, et al. "Natural-based plasticizers and biopolymer films: A review." European polymer journal 47.3 (2011): 254-263.
[46] Phinichka, Natthapong, and Sirinun Kaenthong. "Regenerated cellulose from high alpha cellulose pulp of steam-exploded sugarcane bagasse." Journal of materials research and technology 7.1 (2018): 55-65.

[47] Azmin, Siti Nuurul Huda Mohammad, and Mohd Shukri Mat Nor. "Development and characterization of food packaging bioplastic film from cocoa pod husk cellulose incorporated with sugarcane bagasse fibre." Journal of Bioresources and Bioproducts 5.4 (2020): 248-255.
[48] Kim, Misook, and Donal F. Day. "Composition of sugar cane, energy cane, and sweet sorghum suitable for ethanol production at Louisiana sugar mills." Journal of industrial microbiology and biotechnology 38.7 (2011): 803-807.
[49] Sarkar, Supta, and K. Aparna. "Food packaging and storage." Research Trends in Home Science and Extension AkiNik Pub 3 (2020): 27-51.
[50] Petersen, Karina, et al. "Potential of biobased materials for food packaging." Trends in food science & technology 10.2 (1999): 52-68.
[51] Pizzi, A. "Types, processing and properties of bioadhesives for wood and fibers." Advances in Biorefineries. Woodhead Publishing, 2014. 736-770.
[52] Marichelvam, M. K., Mohammad Jawaid, and Mohammad Asim. "Corn and rice starch-based bio-plastics as alternative packaging materials." Fibers 7.4 (2019): 32.
[53] Coppola, Gerardo, et al. "Bioplastic from renewable biomass: a facile solution for a greener environment." Earth Systems and Environment (2021): 1-21.
[54] Bamboo plate manufacturing method, bamboo plate continuous cutting device, and bamboo plate obtained from these method and device
[55] Li, Dong-Li, et al. "Effect of lignin on bamboo biomass self-bonding during hot-pressing: lignin structure and characterization." BioResources 10.4 (2015): 6769-6782.
[56] Chen, Chen, et al. "Properties and Applications of Bamboo Fiber–A Current-State-of-the Art." Journal of Renewable Materials 10.3 (2022): 605.
[57] Benn, Nicholas, and Daniel Zitomer. "Pretreatment and anaerobic co-digestion of selected PHB and PLA bioplastics." Frontiers in Environmental Science 5 (2018): 93.
[58] Azieyanti, N. A., et al. "Mechanical and morphology studies of bioplastic-based banana peels." Journal of Physics: Conference Series. Vol. 1529. No. 3. IOP Publishing, 2020.
[59] Chodijah, S., A. Husaini, and M. Zaman. "Extraction of pectin from banana peels (musa paradiasica fomatypica) for biodegradable plastic films." Journal of Physics: Conference Series. Vol. 1167. No. 1. IOP Publishing, 2019.
[60] Ramadhan, M. O., and M. N. Handayani. "The potential of food waste as bioplastic material to promote environmental sustainability: A review." IOP Conference Series: Materials Science and Engineering. Vol. 980. No. 1. IOP Publishing, 2020.
[61] Fernandez, Javier G., and Donald E. Ingber. "Manufacturing of large-scale functional objects using biodegradable chitosan bioplastic." Macromolecular Materials and Engineering 299.8 (2014): 932-938.
[62] Ivanov, V., et al. "Production and applications of crude polyhydroxyalkanoate-containing bioplastic from the organic fraction of municipal solid waste." International Journal of Environmental Science and Technology 12.2 (2015): 725-738.
[63] Lubis, M., et al. "Production of bioplastic from jackfruit seed starch (Artocarpus heterophyllus) reinforced with microcrystalline cellulose from cocoa pod husk (Theobroma cacao L.) using glycerol as plasticizer." IOP Conference Series: Materials Science and Engineering. Vol. 309. No. 1. IOP Publishing, 2018.
[64] Samer, Mohamed. "Bioplastics production from agricultural crop residues." Agricultural Engineering International: CIGR Journal 21.3 (2019): 190-194.
[65] Liu, Lillian. "Bioplastics in food packaging: Innovative technologies for biodegradable packaging." San Jose State University Packaging Engineering 13 (2006): 1348-1368.