PREPARATION OF ALUMINIUM FOOD FOILS WITH THE ADDTION OF BIO DEGRADABLE PLA

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Abstract: *In today's life, polymers form an integral part of day-to-day life due to their extensive desirable properties and ease in production. The worldwide production of plastics For many years, conventional plastics are manufactured and used for packaging applications in different sectors. As the food industries are increasing, the demand for packaging material is also increasing. Plastics have transformed the food industry to higher levels; however, conventional petroleum-based plastics are non-degradable which has created severe ecological problems to the environment like a threat to aquatic life and degrading air quality. Biodegradable polymers or bio-polymers emerged as an alternative approach for many industrial applications to control the risk caused by non-biodegradable plastic. According to the type of starting material, they have been categorized as polymers extracted from biomass, synthesized from monomers, and produced from microorganisms. The quality of bio-polymers depends on the physical, mechanical, thermal, and barrier properties.*

Keywords: non-biodegradable and bio-polymers, food packaging applications

1.0 INTRODUCTION

Biobased and biodegradable materials typically have poor water-vapor barrier properties, mechanical properties, heat stability, and processing properties compared to fossil-based counterparts Thus, the challenges of achieving suitable barrier and mechanical properties without compromising biodegradability limit their widespread acceptance, and the use of commercially available biopolymer films is limited to products with relatively short shelf lives or perishable products. for example, fruit and vegetables requiring respiration and humidity in addition to long shelf-life products such as dry pasta stated conventional plastics are not likely to be replaced by biopolymers due to their less suitable properties in meat packaging. However, conclude that techniques such as polymer modification, coating, blending, and use of Edible packaging is mainly made from proteins, polysaccharides, and lipids. Chitosan and gelatine/collagen are the two widely used components. The gelatine coatings reduce O2, moisture, and does not allow migration of oil. Sausage casing made of collagen is the most successful edible protein film commercially available. Films wrapped over thawed and refrigerated beef steak reduces exudation without affecting colour or lipid oxidation. Collagen-based films are used for processed meats to increase juiciness, to reduce shrink loss, and to absorb fluid exudates for a variety of cooked meat products. The polysaccharide-based film found an application for extending the storage life of fruits and vegetables due to their good gas barrier properties and excellent adherence to the surfaces of cut fruits and vegetables. However, they are not good moisture resistant due to their hydrophilic nature For many years the Japanese meat industry is using polysaccharide-based films and coatings commercially. During processing, the coatings get dissolved and integrate into the meat which improves texture, decreases moisture loss, and produces higher yields

Limitations:

The property ensuring their "bio degradability," and thus limiting the shelf life of these packaging films as compared to petroleum-based plastics Their inherent hygroscopicity makes these films instable in humid environments and in contact with foods with a high-water content, posing a challenge in optimizing their properties and identifying suitable applications. Further, their mechanical properties put limitations to their applications and process ability at an industrial scale; in most cases, natural biopolymer films cannot be processed by industrial methods such as extrusion or film blowing.

2.0 LITERATURE REVIEW

The packaging is an integral part of the production, storage, distribution, preservation, and other unit operations (Ivankovic et al., 2017). In recent years, bioplastics are used as an alternative approach instead of conventional plastics for many applications. Bioplastic is a plastic of bio-based origin or biodegradable characteristic of a plastic. According to European standard EN 1675 bio-based is defined as "derived from biomass" (Van den Oever et al., 2017). Production of bioplastics requires 65% less energy than conventional plastics and also contributes to less production of greenhouse gases (Ahvenainen, 2003; Halley, 2002). This paper aims to provide critical information on biopolymers as their role in packaging material which is a key innovation that can help in reducing the environmental impact of plastic pollution. Synthetic plastic products have widely used in fields of medical appliances, packaging, building materials, and packaging, etc. 43% of the synthetic polymers produced annually in India is utilized by the packaging sector (FICCI, 2014). Fig. 1 represents different sectors of plastic utilization in India (Banerjee et al., 2014). However synthetic plastic cannot undergo physical, chemical, and biological degradation and finally leads to an increase in waste (Vert et al., 2002). Waste creates numerous severe environmental and health-related problems. They accumulate on the streets and roads, choking drain that results in overflowing (Fool maun and Ramjeeawon, 2012). A large amount of plastic waste is dumped into the ocean and rivers which harms aquatic life. Incineration leads to the release of harmful gases (carbon dioxide, carbon monoxide, chlorine, 1,3-butadiene, furans, amines, dioxin, etc.) that degrades the air quality and increases the threat of global warming and possess several health concerns (Smith, 2005). The increase in the difficulties for disposing of waste and the harmful effects on the environment and public health caused by the non-degradability of many synthetic polymers have increased concerns all over the world to find an alternative material that is environment friendly. (Luckachan and Pillai, 2011). Biodegradable polymers emerged as an alternative approach for many industrial applications to control the risk caused by non-biodegradable plastic.

3.0 RESEARCH METHODOLOGY

Food processing technologies are an indispensable aid in preserving food products by prolonging shelf life and ensuring food safety, besides contributing to better resource utilization and a more stable food supply, which are important factors in reducing food loss and food waste. On thermal processing and advanced volumetric heating(e.g., high-pressure processing [HPP], microwave [MW],ultrasound [US], pulsed electric field, UV light [UV], cold plasma [CP], etc.) have received significant attention in the last decade in response to the increasing consumer demand for safe, minimally processed, and value-added products (e.g., fresh-like, healthy, long shelf life) because traditional thermal processing, extensively used in the food industry, accounts for a relatively high environmental footprint (high energy usage) and undesirable effects on food nutritional and sensory (e.g., texture, color, and taste)attributes Besides nonthermal pasteurization, a palette of commercially sound applications can benefit from such cutting-edge technologies, for example, disinfection of food-contact surfaces; process optimization (e.g., drying and freezing); extraction of intra cellular compounds; mitigation of food allergenicity; food waste valorization; food/package functionalization, and soon. The European Commission business innovation observatory has acknowledged their timely and substantial contribution to manufacturing efficiency food safety and Security (improved public health, reduced prevalence of diet-related diseases, food recalls, and associated costs), and green-shift (reduced food losses/waste and carbon footprint; energy and water savings), while creating market value through new cost-effective niche opportunities.

3.1 Synthetic biobased, bio degradable polymers for food packaging:

Polylactic acid Polylactic acid (PLA) or poly (lactide) is one of the most promising biobased polymers due to its availability, compost ability, biocompatibility, and properties close to conventional fossil-based polymers. PLA is degradable(biodegradable), but due to high melting point and glass transition temperature it requires industrial composting at55 to 60◦C Structure and properties of PLAPLA is a partially crystalline thermoplastic polyester (Table1). It can be obtained by fermentation (from wheat corn, rice, and sugar beets) or by chemical synthesis. The chemical reaction of lactide (cyclic lactic acid diester) formation is an intermediate step in the synthesis of PLA, which in its chain can have two different optically stereoisomeric forms: L (–) - lactide (S, S); D (+)-lac-tide (R, R) and optically inactive meso-lactide. By chemical synthesis, PLA is obtained by polycondensation or ring opening polymerization reactions to produce high-molecular-weight polymers The racemic mixture of L- and D-lactide is called D–L lactide, and L- and D–L lactide are used to produce

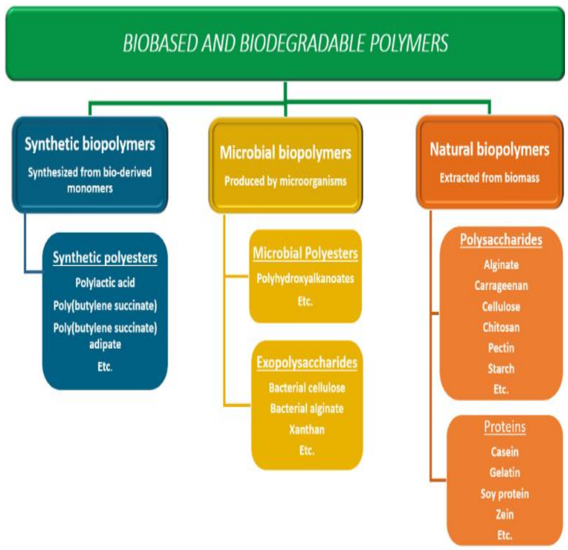


Figure 1: Schematic diagram of bio degradable polymers

PLA properties vary depending on the relationship and distribution of the two stereoisomers or co-monomers The optical purity of PLA influences the ultimate properties of polymers, such as structure, thermal, barrier, and mechanical properties. Poly-L-lactic acid with over 93% of L-lactide is a partially crystalline polymer, whereas a smaller proportion of L-lactide gives amorphous polymers, so by changing this ratio, materials with different properties can be obtained Further, crystallinity of PLA can be improved by chemical and physical modifications. Usually, chemical modifications include incorporation of small molecules in PLA polymer structure (manipulation on molecular level), whereas physical modification can include addition of, for example, nanoparticles that are going to act as nucleating agents and expand crystalline regions in the polymer matrix.

3.2 Biodegradable materials for food applications: effect on food quality and shelf-life

In this section, an overview of recent studies on the use of bio degradable materials for real food applications are pro-vided with emphasis on the effect on food quality and shelf life. food packaging" and "shelf life", combined with the different polymers. In Table3, selected studies from this search are presented, describing applications of biodegradable packaging materials for packing of specific food substrates, where the biomaterial is used as main packaging material (i.e., not as coating on or in combination with conventional packaging materials), as well as the specific effect of these systems on food shelf life and/or quality Studies related to the application and effect of biodegradable films on real food products are rather scarce. Most of the studies on biomaterials resulting from the literature search stated potential applications in the food packaging field. In addition, among the studies addressing the impact on food products, almost none use pristine materials. Most of the scientific articles describe modified biodegradable films incorporated with, for example, nanoparticles, extracts, antimicrobials and/or microencapsulation. Change in the organoleptic properties of food products packaged in active films can be a challenge due to the strong odor of, for example, EOs. This aspect is often not discussed in scientific studies.

4.0 Forms of biodegradable packaging

Biodegradable refers to the ability of materials to break down and return to nature. In order for packaging products or materials to qualify as biodegradable, they must completely break down and decompose into natural elements within a short time after disposal – typically a year or less.

Biodegradable packaging is produced using biopolymers, which are molecules often found in living organisms, like cellulose and proteins. This means they can be safely consumed, degrade quickly, and often be created from waste plant products.

Films:

Films are the widely used form of bio-packaging in every sector. Biodegradable films were originally designed for the replacement of PE film. They have better properties than non-degradable plastic has cs. Important characteristics of a good packaging film include:

- Allowing controlled respiration.
- Good barrier properties.
- To maintain structural integrity

- To prevent or reduce microbial spoilage.

A study of oxygen permeability and carbon dioxide of the biodegradable film as a form of packaging for tomatoes was carried out, results showed that films with the optimum permeability allowed proper respiration of the fruit, due to which the microbial contamination was prevented, and the quality of the fruit was maintained. Blown films have been used as bags and other packaging applications. PLA was used as a base for blown film grading with excellent transparency and mechanical properties. As the degree of crystallinity changes the sealability property changes. Due to slow crystallization, low melting strength a single biodegradable polymer cannot be used for blown film formation. The co-extrusion process is used for the lamination of polyesters. For example, thermoplastic starch (TPS) is film blown in the coextrusion process while coating with polymers like PHA and PHB.

Containers:

Thermoformed containers or trays can be used for the packaging of vegetables, salads, and fruits because a controlled atmosphere is required to maintain the quality of such food products. First, the polymer undergoes melt extrusion to form sheets and from sheets to a temp above Tg and Tm to form into a specific shape of the trays made from biodegradable polymers are brittle and resistant to moisture. There is no change in the structural properties of the tray during freezing. Trays made from oriented PLA were used for the storage of mangoes, melons, and other tropical fruits. The shelf-life of the fruits packed was the same as that of fruits packed in PET trays.

Foamed product: For loose fill-application, starch-based foams are used. Different techniques used for the formation of foamed products include loose-fill molding, foam extrusion, expandable bead molding, and extrusion transfer molding Numerous foamed products like trays, clamshell, etc, based on starch can be used for food packaging but direct food contact coatings are required.

Bags: The largest application of biodegradable bags is in the food industry because their raw material composition makes them flexible, strong, resistant to breakage, moisture, and temperature change. The biodegradable bags can be used for the storage and packaging of food products. The use of these bags in different industries requires the addition of additives The bags are completely environment friendly. Once their function of packaging is completed, they are decomposed to carbon dioxide, water, and other products within several weeks. The biodegradable bags are a great alternative to polyethylene bags.

Gels:

Biodegradable gels include hydrogels, and it is most used to prevent microbial contamination. The development of complex hydrogels is an alternative for bio-based polymer production Lettuce, when impregnating with hydrogel no positive effects were observed on maintaining the content of pectic substances and quality but when impregnated in the fruits of Solanum muricatum, the gel showed a positive effect on maintaining the beta-carotene.

4.1 Biodegradation:

Biodegradation can be defined as the conversion of polymer into carbon dioxide, water, or methane and biomass due to the action of microorganisms. During the biodegradation of polymeric materials.

- Biodeterioration- The biodegradable material is converted into tiny fractions by the combined action of microbial organisms present in the soil and other abiotic factors.
- Depolymerization- Microorganisms release different catalytic agents mainly enzymes that cleave the molecule and form oligomers, dimers, and monomers.
- Recognition- Some fragmented oligomers, dimers, and monomers are recognized by receptors of microbes, they pass the plasma membrane of the microbial cell. The unrecognized fragment is left in the extracellular surrounding.
- Assimilation- Molecules enter the cytoplasm, integrate with the metabolism to produce numerous primary and secondary metabolites with biomass and energy.
- Mineralization- Some metabolites like organic acids and aldehydes are secreted by microbial cells and they reach the extracellular surrounding. CO2, CH4, H2O, and other salts are also released in the environment.

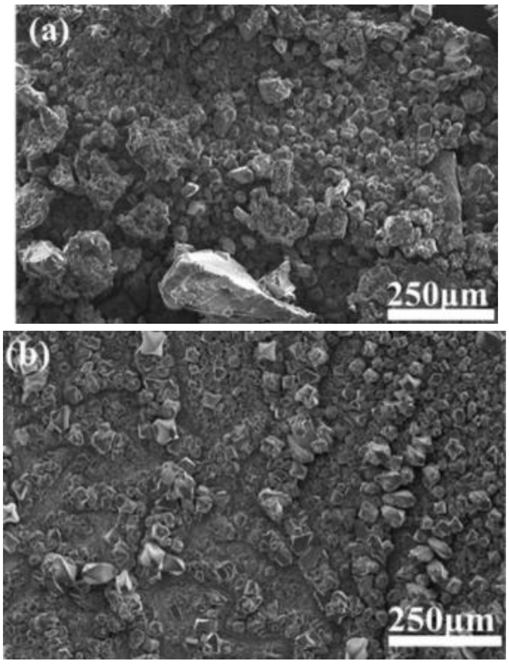
The reaction occurring during the biodegradable polymer degradation is shown below.

Biodegradable polymers → CO_2 + H_2O + Humus

Biodiversity and the presence of microorganisms responsible for polymer-degradation vary depending on the environment, soil, sea, and compost, etc. The colonization of the exposed surface after the microorganism adherence on the polymer surface is the major mechanism involved in degradation Various factors that control the rate of biodegradation include the nature of enzymes, type of enzyme, location of the enzyme (extra, intracellular), type of substrate, and environmental conditions like soil, pH, light, temperature, oxygen, moisture, etc.

5.0 Electron-deposition of aluminium foils

The experiments were carried out with a three-electrode system (Fig. S1a†). The working electrodes were glassy carbon (GC, Aida, 3 mm diameter) or graphite (Aida, 10 mm diameter), the counter electrode was glassy carbon (20 mm × 20 mm × 1 mm), pure aluminium wire (1 mm diameter, 99.9% pure, Alfa Aesar) coated by a heat shrink tube was used as reference electrode. The electrodes were first polished to a nearly mirror finish with an aqueous slurry of 0.05 µm alumina. Thereafter, they were rinsed with ultrapure water and ultrasonically cleaned in ethanol for 5 min and finally dried with cold N_2 flow.



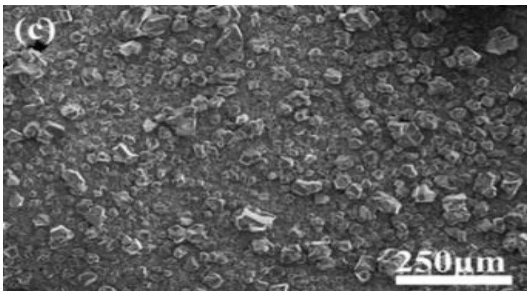


Figure 2: SEM images of aluminium foil under different current density and same applied electric charge deposition (a) 16 mA cm^{-2}, 2 h (b) 32 mA cm^{-2}, 1 h (c) 57 mA cm^{-2}, 0.55 h (temperature = 50 °C).

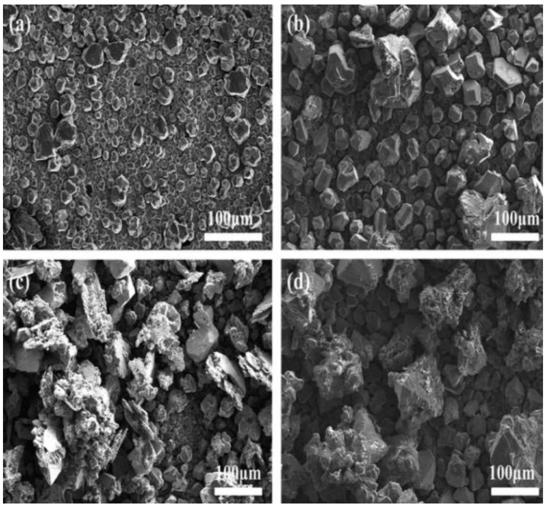


Figure:3 SEM images of the aluminium foils at different time intervals (a) 0.5 h (b) 1 h (c) 2 h (d) 4 h (current density = 57 mA cm^{-2}, temperature = 50 °C).

The possibilities for imaging and chemical analysis of thin foil specimens in the SEM. Bright field and dark field imaging provide high resolution imaging with crystallographic information within the grains Another way to increase the spatial resolution in the SEM is to make use of thin foil specimens instead of bulk specimens. This will limit the interaction volume in the same way as in the Transmission Electron Microscope (TEM), without reducing the acceleration voltage.

6.0 Conclusion:

Biodegradable polymers help in reducing the environmental impact of plastic production and processing. As biodegradable polymers are made from renewable feedstocks, agricultural waste, there is a great opportunity for research work in harnessing this economic opportunity. Biodegradable polymers at present only replace about 1% of the plastics. Several factors like policy and legislative changes, as well as world demand for food and energy resources, influences the development of biodegradable packaging. The use of bio-based polymers is increasing for the packaging of food and other applications at a great speed. In food packaging, the biodegradable packaging can be used for modified atmosphere packaging, active packaging system, and edible packaging for different high-quality food products to enhance their shelf-life. However, before adopting any packaging for food proper studies on the interaction between food components and biopolymers during processing and storage need to be carried out. Future studies need to be focused on the use of nanotechnology and sensors which can help in communicating the information to the consumers. Biodegradable polymers can help in overall environmental sustainability.

7.0 References:

1. *Abdullah, Z.W., Dong, Y., Davies, I.J., Barbhuiya, S., 2017. PVA, PVA blends, and their nanocomposites for biodegradable packaging application. Polym. Plast. Technol. Eng. 56 (12), 1307–1344.*

2. *Ahmad, M., Benjakul, S., Sumpavapol, P., Nirmal, N.P., 2012. Quality changes of sea bass slices wrapped with gelatin film incorporated with lemongrass essential oil. Int. J. Food Microbiol. 155 (3), 171–178.*

3. *Banerjee, T., Srivastava, R.K., Hung, Y.T., 2014. Chapter 17: plastics waste management in India: an integrated solid waste management approach. In: Handbook of Environment and Waste Management: Land and Groundwater Pollution Control, pp. 1029–1060.*

4. Debiagi, F., Kobayashi, R.K., Nakazato, G., Panagio, L.A., Mali, S., 2014. Biodegradable active packaging based on cassava bagasse, polyvinyl alcohol and essential oils. Ind. Crop. Prod. 52, 664–670.
5. Dias, A.B., Müller, C.M., Larotonda, F.D., Laurindo, J.B., 2010. Biodegradable films based on rice starch and rice flour. J. Cereal. Sci. 51 (2), 213–219.
6. Diawara, B., Fatyeyeva, K., Chappey, C., Colasse, L., Ortiz, J., Marais, S., 2020. Evolution of mechanical and barrier properties of thermally aged polycarbonate films. J. Membr. Sci. 607, 117630.
7. Fabra, M.J., Lopez-Rubio, A., Lagaron, J.M., 2014. Nanostructured interlayers of zein to improve the barrier properties of high barrier polyhydroxy alkanoates and other polyesters. J. Food Eng. 127, 1–9.
8. Falguera, V., Quintero, J.P., Jim´enez, A., Munoz, ˜ J.A., Ibarz, A., 2011. Edible films and coatings: structures, active functions and trends in their use. Trends Food Sci. Technol. 22 (6), 292–303. Farah, S., Anderson, D.G., Langer, R., 2016.
9. Physical and mechanical properties of PLA, and their functions in widespread applications—a comprehensive review. Adv. Drug Deliv. Rev. 107, 367–392.
10. Jang, W.Y., Shin, B.Y., Lee, T.J., Narayan, R., 2007. Thermal properties and morphology of biodegradable PLA/starch compatibilized blends. J. Ind. Eng. Chem. 13 (3), 457–464.