International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

Investigation on Corn Starch based Bio plastics for Packing Application with Various Additives

M. K. Marichelvam[1*], K. Manivannan[2] and M.Geetha[3]
[1] Department of Mechanical Engineering,
Mepco Schlenk Engineering College,Sivakasi, Tamilnadu, India
[2] PG Scholar, Department of Mechanical Engineering,
Mepco Schlenk Engineering College,Sivakasi, Tamilnadu, India
[3] Department of Mathematics,
Kamaraj College of Engineering & Technology,Virudhunagar, Tamilnadu, India

Abstract: *Bioplastics are the plastics derived from renewable biomass sources, such us vegetable fats and oils, starch etc. The extensive production of conventional plastics and their use in different commercial applications poses a significant threat to both the fossil fuels sources and the environment. This result in increasingly spotlighted on bioplastics as a means to saving fossil fuels, reducing carbon-dioxide emission and plastic wastes. Biodegradability of bioplastics has been widely publicized in society and the demand for packaging is rapidly increasing among the producers and retailers. Therefore, it is the demand of the day that biodegradable plastics should be produced and used. The number of plastic bags used and discarded worldwide has been estimated to be on the order of 1 trillion annually. Plastic bags can be made with a variety of polyethylene plastics films include the low density polyethylene (LDPE), high density poly ethylene (HDPE). One of the main problems of polyethylene is that without special treatment it's not readily biodegradable. Starch is one of the most common and easily obtained natural polymers, making it attractive as a potential bio-based alternative to synthetic polymers. This project involves making bioplastic from starch extracted from corn starch. The bioplastics so prepared from starch is found to exhibit properties that are comparable to the already available commercial packaging material. The bioplastic was also found to be soluble in water and degradable in soil by conducting respective tests, thereby making it environment-friendly. Such bioplastic formulations can be effectively used in packaging applications due to their advantageous characteristics.*

Keywords: Bioplastics; Packaging; Biodegradable; Starch; Natural polymer

1. Introduction

Plastics play a vital role in almost every aspect of our lives. They are used to manufacture everyday products such as food-packaging films, beverage containers, toys, and furniture etc. The widespread use of plastics demands suitable end of product-life management. The extensive global use of plastics has contributed immensely to environmental pollution; as plastics are not always properly discarded, reused or recycled and consequently persist within the environment for longer durations. The manufacturing processes of plastic articles also create large quantities of chemical pollutants [2]. The prominence of plastic pollution is correlated with plastics being cheap and durable, which leads to high levels of plastics used by humans. The production of biodegradable alternatives with greater compatibility in the environment is necessary if the applications continue to grow.

Biodegradable plastics are best used in the making of products where biodegradability is of intrinsic value. Bioplastics are derived from renewable biomass sources such as vegetable fats and oils, starch or microbiota etc. [3-4]. These can be made from agricultural byproducts and also from used plastic bottles and other containers using microorganisms. Commonly used plastics, such as fossil fuel plastics (also called petro-based polymers), are derived from petroleum products. Production of these plastics tends to require more fossil fuels and produces more greenhouse gases than the production of bioplastics. Biodegradable bioplastics can break down in either anaerobic or aerobic environments compared to the petro- based polymers [5].

Bioplastics are normally composed of cellulose, starches, biopolymers, and a variety of other materials. Starch-based plastics currently represent the most widely used bioplastic, constituting about 50 percent of the total bio plastics market [9]. They can be made at home and can be extensively used for food-packaging applications. Starch is able to absorb humidity, and is thus suitable for the production of drug capsules by the pharmaceutical sector. Plasticizers such as glycerol can also be added so that the starch can be processed thermoplastically. The characteristics of the resulting bioplastic can be tailored to specific needs by adjusting the amounts of these additives. Starch-based plastics are often blended with biodegradable polyesters which are used for industrial applications. This work briefs about the fabrication of bioplastic films using corn starch with suitable additives like glycerol. The obtained bioplastic films were characterized by employing FTIR analysis, SEM analysis, water solubility test, water absorption test and biodegradability tests.

2. Materials and methods

The following section illustrates the materials and methods used in the present work.

2.1. Extraction of starch

Corn is chosen for conducting the experiment as they serve as rich source of starch and are easily available. The experimental set-up consisted of Filter, Mortar, Container, Plastic Plate, and a 250 ml Beaker. The following points mention the procedure for extracting the starch from corn by manual method 100 g corn was taken and cleaned by washing with water. Then it is boiled with water for 1 hour then corn was put into the mortar and 100 ml distilled water was added. It was then grounded carefully into a paste. The mixture was then poured onto the filter to remove the water content. The solid mass left behind was then put into the mortar and 100 ml distilled water was added again and the process of grinding and straining was repeated for 5 times for obtaining more quantity of starch. The mixture was left to settle in the beaker for 5 minutes. The supernatant liquid from the beaker was decanted, leaving behind the white starch which had settled at the bottom. 100 ml distilled water was added to the starch and was stirred gently. The process was repeated for 3-4 times, and the water was then decanted. The starch obtained was white in colour. Extracted FTIR for obtained starch was compared with the starch available in the literature. 40 g of starch was obtained from 100 g of corn. The starch obtained is shown in Figure 1.

Figure 1 Starch

2.2 Preparation of bioplastic

Bioplastic film was prepared according to the following procedure: 100 ml distilled water was taken in a beaker. To this various quantity of starch, glycerol, vinegar, coconut oil added in the calculated quantity. The mixture is stirred at 180rpm for 10minutes.Then the mixture is heated on a hot plate at 100oC with continuous manual stirring for 45 minutes [3]. It was then poured onto a Teflon coated glass plate and spread it uniformly. The mixture was left to dry out for 3 days. The cast film was later peeled off. Various samples were tried out for the preparation of bioplastic prior to obtaining the optimized concentration. The concentration of starch, glycerol, vinegar and coconut oil in the mixture were varied according to the information available in the literature and also on account of trial and error method till the optimized concentration was found out. The varying concentrations of the constituents also influenced the characteristics of the bioplastic obtained.

3. Testing and analysis

The following section illustrates the testing and analysis of the present work.

3.1 FT-IR Spectroscopy analysis

When infrared radiation passes through a material, some intensity passes through without interacting with the molecules, while the remainder interacts with molecules and is absorbed. The proportion of absorbed intensity over the total intensity that enters the material is in direct relation to the concentration of absorbing molecules. This is the principle Fourier Transform Infrared (FT-IR) Spectroscopy Analysis. The resulting spectrum represents the molecular absorption, creating a molecular fingerprint of the sample. Like a fingerprint, no two unique molecular structures produce the same infrared spectrum. This makes infrared spectroscopy useful for several types of analysis [7]. The mid-infrared spectrum (4000–400 cm^{-1}) is approximately divided into four regions. The nature of group frequency is determined by the region in which it is located. The regions are generalized as follows: The X–H stretching region (4000–2500 cm^{-1}), the triple-bond region (2500– 2000 cm^{-1}), the double-bond region (2000–1500 cm^{-1}) and the fingerprint region (1500–600 cm^{-1}). The fundamental vibrations in the 4000–2500 cm^{-1} region are generally due to O–H, C–H and N–H stretching. O–H stretching produces a broad band that occurs in the range 3700–3600 cm^{-1}.

3.2 water contact angle

Wettability and hydrophobicity play very important role in many natural products that could change the physical and chemical properties of a substance. The contact angle is a simple technique that gives a measure of the hydrophobicity of a solid surface by examining its wettability. The sample has to be flat and positioned horizontally on a holder that ensures that the only factors which affect the shape of the water drop are interfacial tension and gravity. Above the sample there is a syringe that has pure water in it. The sample should be between a light and the camera but in the same angle, allowing a flat baseline to be determined for the contact angle measurement. After dropping one water droplet and taking an image by the camera which is connected to a computer which saves the image and then calculates the contact angle. The contact angle range will vary from 0° to 180° depending on the solid material wettability, the more hygroscopic the material the smaller the contact angle. Thus, the contact angle of a very hydrophobic material will be close to 180° with an almost spherical drop on the surface, while the very hydrophilic substrate will give a contact angle of nearly 0° with the drop spreading almost flat on the surface. In general, the partial wetting of a substrate gives a contact angle between 0° to 90°, but when the contact angle is more than 90° that means the droplet does not wet the surface completely.

3.3 Water solubility test

The film samples were cut into square pieces of 4.0 cm^2 and accurately weighed to record the dried film mass. The films were placed into test beakers with 100 mL distilled water. The samples were immersed and shaken under constant agitation at 180 rpm for 6 h at 25 °C. After that period, the remaining pieces of film were then filtered and dried in a hot air oven at 110 °C until a final constant weight was obtained [1-2]. The percentage of total soluble matter (% solubility) was calculated as

$$WS\ (\%) = ((W_0 - W_f)/W_0) \times 100$$

where WS is solubility in water; and W_0 - is the initial weight of the bioplastic film expressed as dry matter and W_f - is the final.

3.4 Moisture content

The moisture content was determined by measuring the weight loss of films the bioplastic samples were cut into square pieces of 4.0 cm2 and accurately weighed to record the dried film mass upon drying in an oven at 110 ˚C until a constant dry weight was obtained [3]. Three replications of each film treatment were used to measure the moisture content.

$$\text{Moisture Content in } (\%) = ((W_i - W_f)/W_0) \times 100$$

Where W_i is the initial weight of the bioplastic and W_f is the final weight of the bioplastic. The bioplastic samples were cut into square pieces of 4.0 cm^2 for the test.

3.5 Biodegradability test

Biodegradable plastic is defined as a degradable plastic in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi, and algae [10]. Biodegradation is a natural process by which organic chemicals in the environment are converted to simpler compounds, mineralized and redistributed through elemental cycles such as the carbon, nitrogen and Sulphur cycles. Biodegradation can only occur within the biosphere as microorganisms play a central role in the biodegradation process. Under appropriate conditions of moisture, temperature and oxygen availability, biodegradation is a relatively rapid process.

The specimen of the starch bioplastic film prepared was cut into pieces of 4.0 cm^2. 500 g of slightly wet soil found near the roots of plants which are rich in nitrogenous bacteria was collected and stored in a container. One sample is placed at the top of the soil and another one is buried inside the soil at a depth of 3 centimeters for 15 days under the condition of room. The weight of the specimen before being placed in the container was noted, for any weight loss of the specimen would indicate the process of biodegradation of the specimen by the micro-organisms. Scanning Electron Microscopic (SEM) images of the specimen [8] before being subjected to the test was taken and SEM image was taken after the test and results were compared.

Biodegradability (%) $=((W_o-W)/W_o)\times100$

Where Wo is the weight of Sample before the test and W is the weight of Sample after the test.

3.6 Electrical insulation test

The Megger insulation tester is essentially a high-range resistance meter (ohmmeter) with a built-in direct-current generator. This meter is of special construction with both current and voltage coils, enabling true ohms to be read directly, independent of the actual voltage applied. This method is nondestructive that is, it does not cause deterioration of the insulation. The generator can be hand-cranked or line-operated to develop a high DC voltage which causes a small current through and over surfaces of the insulation being tested. This current (usually at an applied voltage of 500 volts or more) is measured by the ohmmeter, which has an indicating scale shows a typical scale, which reads increasing resistance values from left up to infinity or a resistance too high to be measured.

4. Conclusion and future research

Using conventional plastics comes with a multitude of drawbacks like the large amount of energy that is required to produce the plastic, the wastes formed as a result of plastic production, and the use of materials that do not biodegrade readily. In order to shift the production of plastics towards a more sustainable path, research is being conducted to determine the types of renewable bioplastic resources that could be converted into plastic form. The optimized concentration for preparation of the bioplastic using the various constituents were found and studied.

References

1. Gómez-Heincke, D., Martínez, I., Stading, M., Gallegos, C., & Partal, P. (2017). Improvement of mechanical and water absorption properties of plant protein based bioplastics. Food Hydrocolloids, 73, 21-29.
2. Ghasemlou, Mehran, et al. "Physical, mechanical and barrier properties of corn starch films incorporated with plant essential oils." Carbohydrate polymers 98.1 (2013): 1117-1126.
3. Muscat, D., B. Adhikari, R. Adhikari, and D. S. Chaudhary. "Comparative study of film forming behaviour of low and high amylose starches using glycerol and xylitol as plasticizers." Journal of Food Engineering 109, no. 2 (2012): 189-201.
4. Salarbashi, D., Tajik, S., Ghasemlou, M., Shojaee-Aliabadi, S., Noghabi, M. S., & Khaksar, R. (2013). Characterization of soluble soybean polysaccharide film incorporated essential oil intended for food packaging. Carbohydrate polymers, 98(1), 1127-1136.
5. Emadian, S. M., Onay, T. T., &Demirel, B. (2017). Biodegradation of bioplastics in natural environments. *Waste Management*, *59*, 526-536.

6. Falguera, V., Quintero, J. P., Jiménez, A., Muñoz, J. A., &Ibarz, A. (2011). Edible films and coatings: structures, active functions and trends in their use. *Trends in Food Science & Technology*, *22*(6), 292-303.
7. Wajira S.Ratnayake and David S.Jackson (2006). "Gelatinization and Solubility of Corn Starch during Heating in Excess Water: New Insights", Journal of Agricultural and Food Chemistry 54:10 (2006), Pp. 3712–3716.
8. N. A. Azahari, N. Othman and H. Ismail (2011). "Biodegradation Studies of Polyvinyl Alcohol/Corn Starch Blend Films in Solid and Solution Media", Journal of Physical Science, Vol. 22(2), 15–31.
9. Schirmer, M., Höchstötter, A., Jekle, M., Arendt, E., & Becker, T. (2013). Physicochemical and morphological characterization of different starches with variable amylose/amylopectin ratio. *Food Hydrocolloids*, *32*(1), 52-63.
10. Gonzalez-Gutierrez, J., Partal, P., Garcia-Morales, M., & Gallegos, C. (2010). Development of highly-transparent protein/starch-based bioplastics. *Bioresource technology*, *101*(6), 2007-2013.