Enhanced Knowledge in Sciences and Technology Vol. 3 No. 1 (2023) 294-297

EKST

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ekst
e-ISSN : 2773-6385

Starch Bio-Plastics for Packaging Application

Nur Nadia Nasir[1], Siti Amira Othman[2*]

[1, 2] Department of Physics and Chemistry,
Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia (Pagoh Campus),
84600 Pagoh, Muar, Johor, MALAYSIA.

*Corresponding Author Designation

DOI: https://doi.org/10.30880/ekst.2023.03.01.033
Received 15 August 2023; Accepted 13 February 2023; Available online 3 August 2023

Abstract: Bioplastics are made from either biodegradable and/or biobased material. The use of starch-based bioplastics in packaging has been limited due to a lack of water barrier qualities and poor mechanical capabilities. In recent year, there has been a lot of research done to improve the properties of starch-based bioplastics and one of the new technologies that have been introduced were gamma irradiation. Gamma irradiation is well-established process for modifying polymeric materials. As a result, this research was carried out to produce a com-based bioplastic with the optimum glycerol-to-starch ratio, assess the effect of gamma radiation on com-based bioplastic properties, and determine the feasibility of using irradiated com-based bioplastic as a packaging material.

Keywords: Starch, Bioplastic, Packaging, Irradiation.

1. Introduction

Approximately 1 billion tans of plastic have been dumped since the 1950s and some of the plastic might exist for centuries or even longer [1]. Advantage and also their disadvantage of plastic is their durability. Increasing utilization of plastic has turned into an issue in numerous perspectives. Bioplastic or biodegradable plastic production is expected to grow by 2020 [2]. Therefore, there is a growing interest in bioplastics. Bioplastic means plastic that is biodegradable and/or biomass- based [3]. Commercial biodegradable plastic can be divided into; a) starch- based plastic, b) Polylactide-based plastic (PLA), c) Polyhydroxyaltanoate-based plastic, d) Aliphatic aromatic polyester-based plastic, e) Cellulose-based plastic and f) Lignin-based plastic. PLA is already being used in the packaging industry.

Changing from PLA to starch based that is because of starch- based containing polyesters that will improve the handleability, water-repellent and tensile strength [4]. Also, most of the starch is polysaccharides. Polysaccharides make up around 75% of all organic material on the earth. Rice, wheat, corn, and potatoes are commonly used to produce starch-based plastic. Corn starch is the most affordable and widely used starch-based plastic. Unfortunately, starch-based bioplastics have a number

Corresponding author: sitiamira@uthm.edu.my

of drawbacks, including a lack of water resistance and poor mechanical characteristics [5]. Various research has been conducted to improve starch- based bioplastic properties. Growing interest in research, the impact of ionizing radiation on polymer because of changes in physicochemical properties were influence by crosslinking or degradation process induction, change in crystallinity degree, isomerization and more [6].

Ionizing radiation include the x-ray, gamma ray, electromagnetic waves, beta ray, electron beam, heavy particle and neutron beams. Commonly used radiation in industrial was electron beam and gamma radiation. The advantage of gamma radiation then other radiation is it's very penetrating. Cobalt-60 is commonly used radioisotope for gamma ray. Due to the clean process, product quality can be control and many more, radiation is preferred then conventional method [7]. The main reason to applied gamma radiation on corn- based bioplastic is to improve their properties.

2. Problems in Current Plastics

Plastic waste (24 percent) is the second major contributor to the average composition of solid waste in Malaysia [8]. There is a growing debate about environmental concern with plastic are becoming a more serious topic. Technically all conventional plastics are degradable but because of slow breakdown it's considered as non-degradable. The major contributor to plastic waste is polyethylene. One of extensive practice to reduce plastic waste in the environment is recycling plastic. However, a lot of problems occur using this process and sometimes this process more expensive then to produce new plastic. Therefore, the rise favour in bioplastic is observed.

There are several types of bioplastic such as PLA, starch- based plastic and more. In recent year, starch- based plastic have drawn interest of the researcher. Some of the factor influence the development of starch- based plastic is a higher-quality product, plentiful, inexpensive and continual resource [9]. Corn starch is the most prevalent starch for the production of starch-based bioplastics. However, starch-based plastic is fragile and naturally fond with water. As a result, their production and implementation were limited, resulting in issues such as an inadequate water barrier, poor mechanical qualities, and more.

When a polymer is exposed to ionising radiation, it can produce free radicals, ions, excited states, and a variety of other highly reactive intermediates [6]. After the irradiation process, ionising radiation also will be involved in a variety of chemical reactions. The impact of high-energy gamma radiation on polymers has been documented, with the polymer being modified through cross-linking [9]. To summarize, this project is using gamma irradiation on corn- based bioplastic to improve its properties.

3. Effect of Radiation

Exposure polymer to ionising radiation can result in the formation of free radicals, ions, excited states, and plenty of other highly reactive intermediates, alongside a lot of chemical reactions even after the irradiation process, which is lead to intensive research on the impact of radiation on starch-based bioplastic properties [10].

According to Salwa to modify the polymeric materials, the ionizing radiation is established well for material processing [7]. The types of ionizing radiation including the x-ray, gamma ray, electromagnetic waves, beta ray, electron beam, heavy particle and neutron beams. Commonly used radiation in industrial were electron beam and gamma radiation [7]. Ionizing radiation can lead to modification of polymer properties through cross- linking and it also led to the formation of free radical ions, excited state and many very reactive intermediates [6], [9].

Krystyna et.al state that irradiation using gamma source led to the enhancement of water-insoluble abilities of the potato-based and wheat-based films. Also, there is an improvement in the strength and flexibility of the potato starch-based film [11]. By using scanning electron microscopy (SEM), it has

been discovered the irradiation improves the structural properties of the potato starch- based film. Krystyna et al. concluded that radiation treatment appears a proper method to improve the starch- based film properties and it also possible for edible packaging [11].

Based on Ali and Ghaffar **(2016),** radiation processing has proven to be a viable substitute for chemical alteration. Starch- based bioplastic is appropriate for packaging material when it was irradiated by 5kGy dosage which cause the enhancement on the mechanical and thermal properties. However, when the irradiation dose was higher than 20kGy there is decreasing in tensile strength [9].

Another study has been done by Antonio et al. on the influence of ionizing radiation on starch-based plastic for food packaging application, is shown that by using irradiation dose below 25kGy will not damage the polymer's structure [6].

Shafik et al. conducted research about the impact of gamma radiation on starch- based film with addition of PVA led to improvement on durability and flexibility because of cross- linking process caused by a chemical reaction under influence of ionizing radiation [5]. The sample was irradiated up to 95kGy, as the dosage increases, the tensile strength increases however if the dose continues to increase (≥60kGy), the tensile strength will decreasing due to degradation at higher dosage [5].

According to Natalia et.al, irradiation of cassava starch based using gamma radiation produce a stable formulation and as a result, the mechanical and water barrier properties have improved [12]. As the dosage increase, the water absorption will increase however it still acceptable compare to non-irradiated cassava starch based [12].

4. Conclusion

Bio-plastics have proven to be quite useful in the irradiation of medical devices and food. Many difficulties might be resolved and a green environment could be maintained for a long time with the use of bio-based plastics.

Acknowledgement

The authors would like to thank the Applied Physics Programme, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia for the facilities provided and gratefully acknowledged the financial support a research grant (H074) that make the research possible.

References

[1] Maximilian Lackner. 2015. Bioplastics- Bio-based Plastics as renewable and/or biodegradable alternative or petroplastic. International Journal of Biobased Plastics.

[2] Martien van den Oever, Karin Molenveld, Maarten van der Zee, Harriëtte Bos. 2017. Bio-based and biodegradable plastics - Facts and Figures. Wageningen Food & Biobased Research

[3] Andrej Krzan. 2012. Biodegradable Polymers and Plastic. Innovative value Chain Development for Sustainable Plastics in Central Europe (PLASTiCE).

[4] Gadhave, R.V., Das, A., Mahanwar, P.A. and Gadekar, P.T. 2018. Starch Based Bio-Plastics: The Future of Sustainable Packaging. Open Journal of Polymer Chemistry, 8, 21-33.

[5] Shafik S. Shafik, Kawakib J. Majeed, Mohanad I. Kamil. 2014. Preparation of PVA/Corn Starch Blend Films and Studying the Influence of Gamma Irradiation on Mechanical Properties. International Journal of Materials Science and Applications. Vol. 3, No. 2, 2014, pp. 25-28. doi: 10.11648/j.ijmsa.20140302.13

[6] Antonio Jedson Caldeira Brant, Natalia Naime, Ademar Benevolo Lugao, Patricia Ponce. 2018. Influence of Ionizing Radiation on Biodegradable Foam Trays for Food Packaging Obtained from Irradiated Cassava Starch. Brazilian Archives of Biology And Technology An International Journal. Vol.61: e18160520, 2018 http://dx.doi.org/10.1590/1678-4324-2018160520

[7] Salwa Abdel Sadic Khalil. 2010. Effect of ionizing radiation on the properties of prepared plastic/starch blends and their applications as biodegradable materials. National Center For Radiation Research And Technology Atomic Energy Authority.

[8] N.A Faris, N.Z. Noriman and Sam.S.T. 2014. Current Research in Biodegradable Plastics. Applied Mechanics and Materials, 2014 doi: 10.4028/www.scientific.net/AMM.679.273

[9] Ali, H.E. and Ghaffar, A.M. 2016. Preparation and Effect of Gamma Radiation on The Properties and Biodegradability of Poly(Styrene/Starch) Blends. Radiation Physics and Chemistry Journal 130 (2017) 411– 420 http://dx.doi.org/10.1016/j.radphyschem.2016.09.006.

[10] Shristi Basnet. 2016. Production of Polylactic Acid in Laboratory Scale, and Characterizing The Thermal Properties. Material Processing Technology : Arcada

[11] Krystyna A. Ciesla, Andrzej Nowicki and Marek J. Buczkowski. 2010. Preliminary studies of the influence of starch irradiation on physicochemical properties of films prepared using starch and starchsurfactant systems. International Conference on Recent Developments and Applications of Nuclear Technologies Nukleonika 2010;55(2):233−242

[12] Natalia Naime, Patricia Ponce and Ademar B. Lugao. 2009. Gamma Irradiation Effect on Mechanical and Barrier Properties of Foamed Articles Based on Cassava Starch. International Nuclear Atlantic Conference INAC 978-85-99141-03-8