MAKERERE  UNIVERSITY

COLLEGE OF NATURAL SCIENCES

SCHOOL OF PHYSICAL SCIENCES

DEPARTMENT OF CHEMISTRY

BACHELORS OF SCIENCE IN INDUSTRIAL CHEMISTRY

SYSTHENSIS OF BIODEGRADABLE PLASTIC FILMS FROM MODIFIED CASSAVA STARCH USING DIFFERENT GLYCEROL CONCENTRATIONS.

BY

TURYASINGURA WYCLIFF

SEPTEMBER, 2022

A RESEARCH PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CHEMISTRY IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY OF MAKERERE UNIVERSITY

DECLARATION

I **TURYASINGURA WYCLIFF** do hereby state that this report is a record of my own research and findings and has not be done by anyone and it's to the best of my work and knowledge.

NAME..TURYASINGURA WYCLIFF.....

Signature: .....

i

APPROVAL

This is to certify that this report is truly out of findings from my research under the supervision of my supervisor and is ready to be submitted to the college of natural sciences for partial fulfillment for the award of degree in Bachelor of Science in industrial chemistry.

UNIVERSITY SUPERVISOR

NAME.....

Signature: .....

Date: .....

ii

DEDICATION

With due respect, this report is dedicated to my supervisor Prof. R. Byamukama and Dr. John Wasswa that played a big role in guiding me for the best of this report.

This report is also dedicated to laboratory attendants Mr. Moses and Mr. Kavuma who provided the necessary chemicals and apparatus for conduction of the experiment.

My dear mother Mrs. Mary Jamoti who financially supported me in buying the required materials and printing of this report is greatly thanked.

I pray that may the almighty reward all of you with the gift of life.

ACKNOWLEDGEMENT

I would like to thank the department of chemistry and the lab attendants for allowing me and providing me with the necessary chemicals, materials and space to conduct my experiments.

It is my radiant sentiment to place on record my best regards, deepest sense of gratitude to my supervisor Prof. R. Byamukama for the guidance and advice towards the best of this report.

TABLE OF CONTENTS

List of figures

ABSTRACT

Environmental pollution due to plastic wastes that take too long to decompose has become a global problem. Incinerating plastic waste leads to release of hazardous gases, which are not good for humans and other living organisms in the nature. The development of bioplastics from modified cassava starch which may decompose with the assistance of microorganisms serves as the best alternative to overcome this problem. Therefore, the aim of this research study was to synthesize biodegradable plastic films from modified cassava starch using different glycerol concentrations as the plasticizer. Cassava flour was modified by heating a solution of cassava starch, PVA and citric acid at 75^{o}c in a water bath for 1 hour. Cassava flour was modified because starch based bioplastics have low mechanical strength and damage if exposed to water. Hard cream like plastic films were synthesized.

CHAPTER ONE

INTRODUCTION

1.1 background

Petroleum-based plastics do not to degrade naturally and with poor disposal methods, their presence in the environment has led to detrimental problems such as drainage of channels, found their way into water bodies making water un safe for both aquatic life and human consumption and many other effects and this was according to the study report made by Rugwiza, (2012). In addition, the International Research Journal of Multidisciplinary Technovation suggests that the burning of such plastics result into production of carbon emissions which pollute air leading to cancer related diseases and global warming. The development of bio plastics made from renewable bio-based materials such as starch, cellulose, collagen or casein from the readily available raw materials such as agricultural crops like cassava can save the environment since they can easily decompose after being used.

Biodegradable plastics are made up of bio polymers which are capable of breaking down into simpler components. The chemistry of bio polymers (starch polymers) is that they degrade into smaller molecules either chemically or by organisms producing environmental friendly products such as carbon dioxide, water and quality compost (Dami at el., 2010). This degradation process of starch products recycles the atmosphere with Carbondioxide that is trapped by starch producing plants during growth thus completing the biological carbon cycle. In addition, this process does not require energy which thus leads to conservation of energy (Souza, 2016).

This project therefore aims on production of degradable bio plastic films from modified cassava starch as the main raw material with different glycerol concentrations used as the plasticizer.

1.2 problem statement

According to the Ministry of Water and Environment, the usage of plastic packaging is growing yearly as indicated by the rise in the amount of soft drinks and mineral water that are packaged in such bottles of various sizes. Additionally, the majority of store goods are packaged in polythene bags, and due to Ugandans' poor rubbish disposal practices, these plastics have entered the environment, and given that they are made from non-biodegradable petrochemical polymers, the ecosystem has been severely affected making it difficult for people, plants, animals, and other organisms to survive. NEMA statistics reveal that over 600 tonnes of plastic trash are produced

every day throughout the year, of which 40% is collected and properly disposed of, while the remaining 60% makes its way into the environment and causes a multitude of issues (Report from The Independent Magazine 30th May, 2022). Therefore, the ideal replacement of non-biodegradable plastics with degradable bio plastics made from modified cassava starch may help to protect and preserve the environment.

1.3 Objectives of the study

a) General objective

To synthesize biodegradable plastic films from modified cassava starch using different glycerol concentrations as the plasticizer.

b) Specific objectives

i) Testing biodegradability by burying different samples and taking results at different days

ii) Testing for moisture absorption of the film basing on ASTM D570

CHAPTER TWO

2. 0 LITERATURE REVIEW

A plastic is made up of large chains of carbon molecules known as polymers. Different combinations and different polymers make different kinds of plastics (Souza, 2016). Plastics made from plants are called bio plastics and it all starts by photosynthesis. Plants form sugars from Carbondioxide and water using energy of sunlight (Yang, 2006). Bio plastics are made by converting sugars (starch) into plastic.

Starch consists of two types of polysaccharides namely amylose (20% to 25%), amylopectin (70% to 85%), and other components such as protein and fat (5% to 10%). Amylose is a linear glucose polymer that binds to α-1,4, while amylopectin is a highly branched glucose molecule consisting of short chain α-1,4 that binds to β-1,6 (Syamani, 2016). Amylose is easier to form entanglement when starch is heated, compared to amylopectin. The linear amylose molecules forms more effective entanglements than amylopectin molecules thus resulting into a better performance, such as an increase in tensile strength (Soest, 1997). Therefore, increase in amylose content rises the tensile properties of bio plastics. Starch modification which involves conversion of amylopectin to amylose ensures optimal use of starch (Ceseracclu, 2015).

Starch modification involves the use of polyvinyl alcohol (PVA) which is a biodegradable synthetic material that has hydroxyl groups in its structure which allows it to form the intermolecular and intramolecular hydrogen bonds with thermoplastic starch, thereby increasing the integrity of the mixture (Fahma, 2017). PVA has the advantage of good film forming, strong conglutination, and high thermal stability (Follain, 2005). In addition, in order to increase the water-resistant and thermal stability properties of thermoplastic starch, citric acid is added (Yu J, 2005).

The disadvantages of starch-based bio plastics are low water stability, high moisture sensitivity, and brittle behavior at room temperature. However, these properties of starch-based bio plastics can be improved by addition of additives such as fillers, glass fibers and plasticizers (Syamani et al., 2020).

Bioplastics are biodegradable plastics which can be degraded by microorganisms from plant-derived compounds, such as starch, cellulose, and lignin (Averous, 2004). Biodegradable plastics have the same functional quality like conventional plastics, but they can be decomposed by the

action of microorganisms, which produces water, carbon dioxide. In other words, they can return back to nature after its use because it can be broken down in the environment, hence eco-friendly plastics. Conventional plastics take 50 years to decompose in nature, while bioplastics can be degraded 10 to 20 times faster (Kartika, 2012). Starch is a natural polymer extracted from plants and can be used to produce biodegradable plastics due to its eco- friendliness, abundance, and low cost (Domenek, 2004). Cassava contains a large amount of starch, which can be suitably used for the production of bioplastics. This potential is a great opportunity to add value to cassava as the raw material in the manufacture of eco-friendly plastics.

CHAPTER THREE

MATERIALS AND METHODS

3.1Materials required

Materials to be used in this study are cassava starch, sodium acetate, acetic acid, distilled water, glycerol, polyvinyl alcohol and citric acid.

3.2Modification of cassava starch

Cassava starch is modified using acetate solution at a pH 7. Acetate solution is prepared by dissolving sodium acetate (44.52g) in 50ml of distilled water and then acetic acid added gradually until pH 7. Distilled water is added to make a 1L solution. Modification of cassava starch is done by dissolving 100g of cassava starch into 200ml acetate buffer solution in a glass beaker and then the mixture stirred and heated on a hot plate at a temperature of 40^0c to thicken, after which it is dried at room temperature. After drying, the modified starch is mashed and sieved at 80 mesh (Syamani et al., 2020; Utami, 2010).

3.3Production of a bio plastic

The modified cassava starch is dissolved in distilled water with a ratio of 1:20. As much as 2.5g of starch is dissolved in 50ml in a glass beaker, the solution is heated on a water bath at 75^0c for one hour. The solution is stirred at a constant speed of a mechanical stirrer 200rpm, until its shape is like a clear gel. At the same time, in a separate beaker, 0.625g of polyvinyl alcohol (25% of starch dry weight) is dissolved in 50ml distilled water using a hot-plate magnetic stirrer. After the starch solution is gelatinized, glycerol plasticizer of percentage 5%, 10% and 20% of the dry weight of starch is added, followed by addition of PVA and continued stirring for 10 minutes. Finally, citric acid (5% of the dry weight of starch) which is dissolved in 5ml distilled water is added to the solution. The mixture is stirred again until homogenous for ± 5 minutes at the same speed and temperature (Maulida et al., 2016; Bonilla et al., 2015).

The final solution is then poured into a petri dish to form a thin film and dried it in the oven at 50o C for 6 hours. The bio plastic is removed from the mold using tweezers and the film is ready to be characterized.

CHAPTER FOUR:

RESULTS AND DISCUSSION

4.1 synthetic bio plastic films

Modified cassava starch powder (figure a) was used to produce a little hard cream bio plastic films (figure b).

Figure a

Figure b

4.2Conclusion

Biodegradable plastic films of different glycerol concentrations were successfully synthesized.

4.3 Recommendation

I recommend that biodegradability and moisture absorption tests should be investigated on the synthesized bio plastic films so that a better choice of glycerol concentration may be chosen for the production of good quality packaging materials.

REFERENCES

1. Ceseracciu L, Heredia-Guerrero J A, Dante S, Athanassiou A and Bayer I S 2015 Robust and biodegradable elastomers based on corn starch and polydimethylsiloxane (PDMS) ACS Appl. Mater. Interfaces 7: 3742–53
2. Darni, Y., and Utami, H. (2010), Study preparation and characteristics of mechanical properties and hydrophobicity biodegradable plastic from sorghum. Journal of Starch Chemical and Environmental Engineering Vol. 7, No. 4, hal.88-93 2010 ISSN 1412-5064. University of Lampung.
3. Fahma F, Sugiarto, Sunarti T C, Indriyani S M and Lisdayana N 2017 Thermoplastic cassava starch-pva composite films with cellulose nanofibers from oil palm empty fruit bunches as reinforcement agent Int. J. Polym. Sci article ID 2745721 doi: 10.1155/2017/2745721
4. Follain N, Joly C, Dole P and Bliard C 2005 Properties of starch based blends part 2 influence of poly vinyl alcohol addition and photocrosslinking on starch based materials mechanical properties Carbohydr. Polym. 60:185–192
5. J. Bonilla, Vicentini M, Dos Rodolfo M C, Bittante Q B, and Sobral Paulo J A, "Mechanical properties of cassava starch films as affected by different plasticizers and different relative humidity conditions," Int. J. Food Stud., vol. 4, no. April, pp. 116–125, 2015.
6. L. Averous, "Biodegradable Multiphase Systems Based on Plasticized Starch: A Review," Macromol. Sci. Part C Polym. Rev., vol. 44, no. 3, pp. 231–274, 2004.
7. Logeshwaran.V, Sabarinath.K, Ishwarya.R, Sandhiya.S, Kousalya.N and Arun. P, "Bioplastic from Cassava Starch", International Journal for Modern Trends in Science and Technology, 6(12): 286-289, 2020.
8. M. I. Kartika, "Pati, Bahan Dasar untuk Membuat Plastik," Kompas, 2012.
9. Massardier-Nageotte V., Pestre C., T. Cruard-Pradet, and Bayard R., "Aerobic and anaerobic biodegradability of polymer films and physico-chemical characterization," Polym. Degrad. Stab., vol. 91, no. 3, pp. 620–627, 2006
10. Maulida et al 2016 J. Phys.: Conf. Ser. 710 012012, ''Production of Starch Based Bioplastic from Cassava Peel Reinforced with Microcrystalline Cellulose Avicel PH101 Using Sorbitol as Plasticizer''

11. P. Kampeerapappun, D. Aht-ong, D. Pentrakoon, and K. Srikulkit, “Preparation of cassava starch/montmorillonite composite film,” Carbohydr. Polym., vol. 67, no. 2, pp. 155–163, 2007.
1. R. Di Franco, V. P. Cyras, J. P. Busalmen, R. A. Ruseckaite, and A. Vázquez, “Degradation of polycaprolactone/starch blends and composites with sisal fibre,” Polym. Degrad. Stab., vol. 86, no. 1, pp. 95–103, 2004.
12. R. Di Franco, V. P. Cyras, J. P. Busalmen, R. A. Ruseckaite, and A. Vázquez, “Degradation of polycaprolactone/starch blends and composites with sisal fibre,” Polym. Degrad. Stab., vol. 86, no. 1, pp. 95–103, 2004.
13. Rugwiza, E. (2012),″ Plastics waste management in Kisenyi, Kampala Central Division.”
14. S. Domenek, P. Feuilloley, J. Gratraud, H. Morel Marie, and S. Guilbert, “Biodegradability of wheat gluten based bioplastics,” Chemosphere, vol. 54, no. 4, pp. 551–559, 2004.
15. S. Wafiroh, T. Ardiarto, and E. T. Agustin, “Pembuatan dan Karakterisasi Edible Film dari Komposit Kitosanpati Garut (Maranta Arundinaceae L) dengan Pemlastis Asam Laurat,” J. Math. Sci., vol. 13, no. 1, 2010. [24]G. Junjie and M. A. Hanna, “Functional properties of extruded foam composites of starch acetate and corn cob fiber,” Ind. Crops Prod., vol. 19, no. 3, pp. 255–269, 2004.
16. S.Sharmiladevi 1,*, N. Ramesh 2 , S. Ramesh 2 ,” Production of Bio Degradable Bags Using cassava Starch’’, International Research Journal of Multidisciplinary Technovation /2019, 1(6), 553-559
17. Selvamurugan M, Sivakumar P. 2019, ‘’ Bioplastics- An Eco-friendly Alternative to Petroleum Plastics.’’ Curr World Environ 2019; 14(10
18. V. G. L. Souza and F. A. Luisa, “Nanoparticles in food packaging: Biodegradability and potential migration to food-A review,” Food Package. Shelf Life, vol. 8, pp. 63–70, 2016.
19. Van Soest J J G and Essers P 1997 Influence of amylose-amylopectin ratio on properties of extruded starch plastic sheets J. Macromol. Sci. A: Pure and Applied Chemistry 34(9): 1665- 1689.
20. Yu J, Wang N and Ma X 2005 The effects of citric acid on the properties of thermoplastic starch plasticized by glycerol Starch 57(10): 494–504

APPENDIX