UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FABRICATION OF GREEN POLYMERIC TILES FROM POLYPROPYLENE AND TAPIOCA STARCH COMPOUND

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Manufacturing Engineering Technology (Process and Technology) (Hons.)

by

SITI AZIAN BINTI SHAFEI

B071310706

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) (Hons.). The member of the supervisory is as follow:

……..

Hairul Effendy Bin Ab Maulod

ABSTRACT

Nowadays, tiles have been invented with various type of material such as ceramics tiles which known of their durability, anti-fungal, but most of all its aesthetic quality. Polymeric tiles were found to be a good alternative to ceramic due to its low cost of raw material, ease of production, differing design and also customizable. Furthermore, most of the polymer can be reproduce and recycle to be the best tile. This research was carried out to determine the best formulation of polypropylene with tapioca starch compound used to produce polymeric tile with aesthetic value. Besides, to study their mechanical properties such as Tensile strength, hardness of material and sudden impact through the tiles. Other than research of the material compound, it also to fabricate polymeric tile based on interlocking tile design. In order to produce the product, the sample of the material compound have been made before undergo with various testing. To produce the material compound the difference composition have been study and the mixing process was done using internal mixer. After that, the material was press using hot press machine with specific dimension. Then, material sample was cut according to ASTM of each testing. This research focused on mechanical testing such as tensile test, hardness test and impact test. Physical testing on the sample also undergo swelling test and density test. The morphological analysis of the sample have been made using optical microscope. The increasing of tapioca starch content had significantly increase swelling thickness and effect to the mechanical testing behaviour. The optimum formulation of fabricated compound was observe at combination of 90 wt. % of PP, 10 wt.% of TS and 3 wt.% glycerol for applied to fabricate polymeric tile. In overall, one of the objective was not successfully achieved which is to fabricate tile product due to several factor.

ABSTRAK

Pada masa kini, jubin telah dicipta dengan pelbagai jenis bahan seperti seramik jubin yang diketahui ketahanan, anti-kulat, tetapi yang paling penting kualiti estetiknya. Jubin polimer didapati alternatif yang baik untuk seramik kerana kos bahan mentah yang rendah, kemudahan pengeluaran, reka bentuk yang berbeza dan juga bersesuaian. Tambahan pula, kebanyakan polimer boleh dihasilkan semula dan dikitar semula sebagai jubin terbaik. Kajian ini dijalankan untuk menentukan rumusan terbaik polypropylene dengan sebatian kanji ubi kayu digunakan untuk menghasilkan jubin polimer dengan nilai estetik. Selain itu, untuk mengkaji sifat-sifat mekanikal seperti kekuatan tegangan, kekerasan dan kesan secara tiba-tiba. Selain daripada penyelidikan kompaun material, ia juga untuk menghasilkan jubin polimer berdasarkan reka bentuk jubin sedia ada. Dalam usaha untuk menghasilkan produk, sampel sebatian telah dibuat sebelum menjalani pelbagai ujian. Untuk menghasilkan sebatian, komposisi campuran yang berbeza telah dilakukan dengan menggunakan pengadun dalaman. Selepas itu, sampel telah ditekan menggunakan mesin penekan panas dengan dimensi tertentu. Kemudian, sampel bahan dipotong mengikut ASTM setiap ujian. Kajian ini memberi tumpuan kepada ujian mekanikal seperti ujian tegangan, ujian kekerasan dan ujian kesan. Ujian fizikal pada sampel mengalami ujian bengkak dan ujian ketumpatan. Analisis morfologi sampel telah dibuat dengan menggunakan mikroskop optik. Peningkatan kandungan kanji ubi kayu telah banyak meningkatkan ketebalan dan kesan kepada ujian mekanikal. Perubahan optimum kompaun adalah untuk melihat kombinasi 90 wt. % daripada PP, 10 wt.% daripada TS dan 3 wt.% Glycerol boleh untuk digunakan untuk mereka-reka jubin polimer. Secara keseluruhannya, salah satu objektif tidak berjaya dicapai iaitu untuk menghasilkan produk jubin disebabkan oleh beberapa faktor.

DEDICATIONS

Thanks to my family, and to all lecturers which have been my source for me to finish this project. Thanks for all your support and give me strength until I finish this project.

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LIST OF ABBREVIATIONS

ASTM	American Standard Testing of Materials
et al.	and others
etc.	Et cetera
Eg.	Example
Wt%	Percent of weight fraction
PE	Polyethylene
LDPE	Low Density Polyethylene
LLDPE	Linear Low Density Polyethylene
PCL	Polycaprolactrone
SCFC	Sugar Cane Fiber Cellulose
PP	Polypropylene
TS	Tapioca Starch
PP/TS	Polypropylene with Tapioca Starch
SPS	Sugar Palm Starch
WVP	Water Vapor Permeability
Tg	Concentration
UTS	Universal Testing Machine
EB	elongation at break
YM	Young's modulus

CHAPTER 1

INTRODUCTION

1.0 Background of study

Aesthetic tiles are often associated with ceramic tiles. It is can be proven the structure made up from ceramic still exist now day such as Great Pyramid in Egypt and ancient Babylon. However, ceramic tile is giving bad influence to the environment due to consumption of energy source, raw material, emission and waste that emerged throughout the production. So, the other method to solve the issue of the ceramic tile, uses of polymeric tiles offer the same features as ceramic but with more economic scale. Furthermore, the uses of polypropylene as the material used in this project can improve the mechanical properties behaviour while produce green polymeric tile with aesthetics value. Polymeric tile is also have mechanical properties such as low melting point that easy to manufacture compared to ceramic tile that used high melting point. So, this project is to make a research about the material compound properties and able to fabricate green polymeric tile with more aesthetic value used in daily life.

1.1 Problem Statement

Ceramic tile is easy to obtain since different type of clays can be found everywhere on earth. However, to make the ceramic tile, it used massive amount of energy and must be fired with high firing temperature at 1204 °c. So, polymeric tile is used in other way to use as a tile that could provide other alternative from ceramic and also quit effective to use. (El-Abden et al., 2014).

Furthermore, most of the polymer can be reproduce and recycle to be the best tile. Besides, polymer can be blends with other material which can improve its mechanical properties which may result to wear resistance and improve friction properties.

1.2 Objectives

The general objective of this project is fabricated of green polymeric tiles from polypropylene (PP) and Tapioca Starch (TS) compound. The aims of this project are followed the specific study such as below:

i. To determine the best formulation of polypropylene with tapioca starch compound used to produce polymeric tile with aesthetic value.
ii. To study mechanical properties of green polymeric tile.
iii. To fabricate polymeric tile based on interlocking tile design.

1.3 Scope

The scopes for this project are focused on;

i. Produce tile based on interlock pattern.
ii. Select suitable material used for produce polymeric tile.
iii. Fabricate green polymeric tile.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The ceramic tile always often associated with ceramic tiles. Ceramic tile is giving bad influence to the environment due to consumption of energy sources, raw material, emission and waste that emerged throughout the production (Hocenski et al., 2006). So, as the other method to solve the issue of this ceramic tile, uses of polymeric tile as the other material for this product. Polymeric tile has many advantages and offers the same features on the more economic scale.

2.1 History of Tile

The historical backdrop of tile is gotten the word from the French word which is tuile, word is turn from the Latin word tegula, the significance of let go dirt created from the rooftop tile. The main decade of the twentieth century has been utilized as the primary reference to its utilization shows up.

Meantime, in the Middle East, Islamic tile workmanship has been more culminated, the Chinese kept on promoting particular styles and coatings which were broadly received by the Dutch, the English, Portuguese, Spanish, Italians and in other European nations. Tile creation immediately developed in South and North America from the endeavors of European settlers. Until now, Mexico is still perceived for the painted and hand-made tiles of its contemporary artisans. Tiles and their technologies were distributed in various ways to other cities (Baranova, 2014).

2.2 History ceramic

In the middle ages, Italy as the forefront of the tile industry has been adjust and borrowed methods and design from other cultures. Progressive factories and engineers came up with many design and innovation that modernized the industry. Last few years, many creative and innovation have revolutionized tile industry. White body ceramic wall tiles and porcelain body floor tiles use digital ink-jet technology to achieve very refined designs or authentic stone appearances .Today, interior design encourage new change and trends more rapidly than before. Italy is an important producer of ceramic tiles, with a high production share in Europe (50%) and worldwide (16%) (Breedveld, L. et al., 2007).

In Guangdong, China they have been faced a contradictory problem ceramic tile industry has their own large effect of economic benefits and adverse environment impact. After the analysis of energy efficiency and material balance it has been detect 31 different measure including technology improvement, process control, facility replacement, raw material and waste plant management, re utilization and worker training. It has been implemented and proposed in feasible way (Huang, Y., Luo, J. & Xia, B., 2013).

Recently, in the industry have various solid waste such as fly ash, glass waste, slag and sewage sludge. The materials have been recycled into various value-added products such as ceramic tile. The conventional solutions of dumping the wastes in incineration or landfills, including in Malaysia are getting obsolete as the annual huge amount of the solid wastes would boost-up disposal cost and may cause permanent damage to the flora and fauna. This recent waste recycling approach is much better and greener as it can resolve problems associated with over-limit storage of industrial wastes and reduce exploration of natural resources for ceramic tile to continuously sustain the nature. (Teo, P.T. et al., 2014.)

2.3 Green Polymer

The ecological benefits of the synthetic polymers, particularly the polyolefin, are compared with hydro-biodegradable polymers made from renewable resources with emphasis on energy utilization, environmental pollution and land utilization. It is concluded that polymers that degrade by peroxidation followed by bio assimilation of the oxidation products (Oxo-biodegradable polymers) are in general more environmentally acceptable (‘green’) than the biologically produced hydro-biodegradable polymers.

Green plastics are now a reality with bio-based sourcing already a viable option for polyolefins, polyamides and some polyesters and elastomers. This gives end-users the opportunity to use an instant, renewable, drop-in substitute. The life cycle of these materials is being carefully measured and tested to ensure that these new options fit the criteria for sustainability. The packaging industry has its own tests and leading brand owners have developed standards too.

The utilization of plant oil renewable resources as raw materials for monomers and polymers is discussed and reviewed. In an age of increasing oil prices, global warming and other environmental problems (e.g. waste) the change from fossil feedstock to renewable resources can considerably contribute to a sustainable development in the future. The synthesis of monomers as well as polymers from plant fats and oils has already found some industrial application and recent developments in this field offer promising new opportunities, as is shown in Figure 2.1 within this contribution. (Meier MA, 2016)

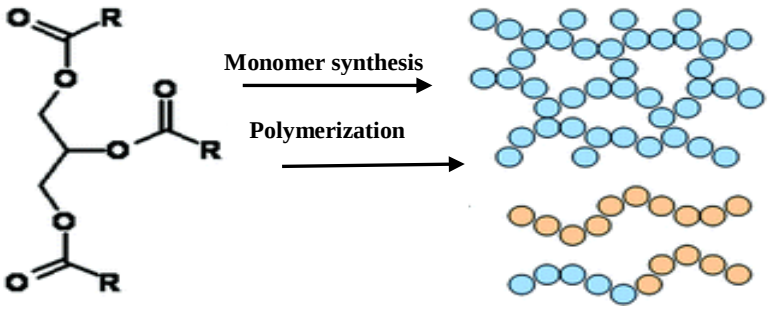

Figure 2.1: The synthesis of monomers as well as polymers from plant fats and oils

2.4 Polymer tiles

Premium Resin Interlocking Deck Tiles can include a one of a kind, textured look to open air living space. It is ecologically mindful product, the reprocessed material utilized as a part of the item guarantees that the material is occupied from landfills, and dissimilar to numerous composite materials. Also, it is Innovative and safe In addition, some formulation made up from polymers and nano mineral particle can transform its original properties with increase thermo-acoustic isolation capacity and their lifespan. Besides, the tiles also are unbreakable and impermeable. The installation will be easier due to its properties such as light allowing saving of up to 70% of the installation time. Moreover, its mechanical properties adapts perfectly to the temperature changes in which from extreme hot to cold.

Existing tile in the building mostly used layer of green waterproof polymer cement and then paste porcelain as another waterproof. Due to this problem, the general solution have be made to improve the construction method to reduce waste of resource (Patents CN203684598U, 2016).

2.5 Type of polymer

Polymer can be group with various kind of polymeric material. There are likewise diverse polymeric materials which are natural to us and wide assortment of use. There are incorporate elastomer (or elastic), plastic, coating, fibers, adhesives, film and froths. With specific polymer it might be utilized as a part of two or more application classes relying upon its properties. For instance, a plastic, if used and cross-linked over its glass move temperature, may make an agreeable elastomer.

The diverse level lists for various polymer-substrate mixes are for the most part identified with two parameters, the glass move temperature of the copolymer and the adjustment framework (steric versus cationic). Moreover tapping stage imaging uncovered huge heterogeneities in the inward structure of the polymer particles and inhomogeneous circulation at their surface most likely identified with neighborhood varieties of the defensive colloid, particularly polyvinyl liquor (Kaufmann, J., Winnefeld, F. & Zurbriggen, R., 2012).

The Biodegradability of oil-based, bio-based, and partially bio-based polymers has been shown and classified in three type of bio-based which is oil-based, partially bio-based and 100% bio-based. The Figure 2.2 shown the limited number of polymers are listed for exemplification purposes.

PE	polyethylene
PU	polyurethane
ABS	Acrylonitrile Butadiene Styrene
PP	polypropylene
PBS	Polybutylene succinate
PTT	Polytrimethylene terephthalate
PLA	polylactic acid
PHA	Polyhydroxyalkanoates
TPS	Thermoplastic starch
1,3-PDO	1,3- propanediol

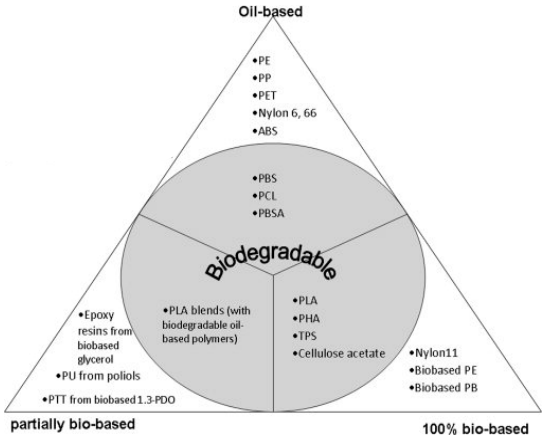

Figure 2.2: Limited number of polymers are listed for exemplification purposes.

2.6 Plastics

Many desirable properties for plastics possess including long life and water resistance for both consumer and industrial products. However, the attributes for various applications that make these products suitable are also the major cause of the waste disposal in the environment. So , the polymeric material are desire for eco-friendly due to problem associated in given rise to increasing attention with the disposal of large amount of plastic waste. Most of the contemporary researchers are focused on substitution of biodegradable materials from synthetic plastics with similar properties and lower cost (Henry & Isaac, 2014).

Synthetic plastic such as polypropylene and polyethylene have very low of water vapor transmission rate, which are biodegradable plastic. Synthetic polymer with incorporation of starch will increase the biodegradability when starch is consumed by microorganisms. Besides, it is believed that starch will be degraded under a rapid enzymatic hydrolysis to void containing matrix and reduce the mechanical properties of plastics. The biodegradation might be promote of synthetic polymer due to interaction with microorganisms when increased surface area are available (Ali et al. 2012).

Previous attempts to infuse polypropylene plastic with starch were face fracture and debonding problems (Dubnikova et al., 1997), the reason was mainly attribute to the starch and plastic surfaces at the high interfacial tension. However, the application of filler agent added of starch may be one of the solution to make the plastic material more biodegradable (Harcourt et al. 2012).

From the previous 50 years new plastic materials, in different applications, have step by step supplanted the customary metal, wood, cowhide materials. Incidentally, the most favored property of plastics sturdiness. It is applies likewise the major natural risk. Late information demonstrated that biodegradation of plastic waste with chose microbial strains turned into a feasible arrangement (Sivan, A., 2011.

2.6.1 Thermoplastic

The biggest number of various polymeric materials goes under the plastic characterization. There are two fundamental sorts of plastics which is thermoset and thermoplastic. Thermoplastics which are mollified by the warmth and can be shaped. (Infusion shaped, blow formed or vacuum framed). Great illustrations are acrylic, polypropylene, polystyrene, polythene and PVC.

Thermosets which are framed by heat handle however are then set (like cement) and cannot change shape by warming. Great illustrations are melamine (kitchen worktops), Bakelite (dark pot handles), polyester and epoxy pitches. The thermoplastic and thermoset elastomer can been seen on Figure 2.3 about on how its stress and cross link difference between the material.

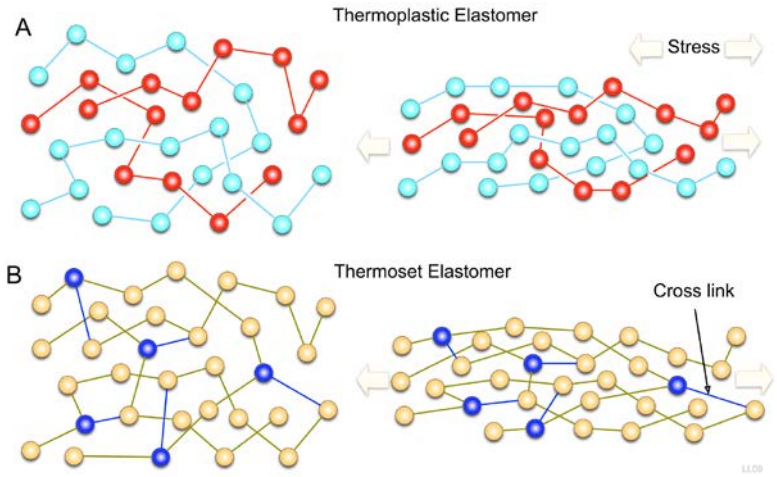

Figure 2.3: The differences between thermoplastic elastomer and thermoset elastomer.

Thermoplastic resins, which are any synthetic material that can be molded when hot but becomes hard on cooling. The copolymer blocks present a good balance between rigidity and impact strength that depends on the importance of the blocks and their distribution (Biron, M., 2007).

Thermoplastics and their composites can be machined by almost all the metal or wood machining methods, after some degree of adaptation of the tools and processes. Parts can be painted, metallized, printed, coated for decoration and other surface modifications (Biron, M., 2013).