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Characterization of Bio-Polymer Composite Thin Film Based on Banana Peel and Egg Shell

Nik Alnur Auli NIK YUSUF[1,a*], Mohammad Khairul Azhar ABDUL RAZAB[1,b], Nor Hakimin ABDULLAH[1,b], An'Amt MOHAMED NOOR[1,c], Mahani YUSOFF[1,d], Arlina ALI[1,e], Nurul'Ain MOHD KAMAL[1,f], Nadiah AMERAM[1,g], Mohd Nasha'aain NORDIN[2,h]

[1]Faculty of Bioengineering and Technology, Universiti Malaysia Kelantan Jeli Campus, Locked Bag No. 100, 17600 Jeli, Kelantan, Malaysia.

[2]Advanced Materials Research Centre (AMREC), Lot 34, Jalan Hi-Tech 2/3, Kulim Hi-Tech Park, 09000 Kulim, Kedah.

[a]alnurauli@umk.edu.my, [b]azhar@umk.edu.my, [c]norhakimin@umk.edu.my, [d]mahani@umk.edu.my, [e]arlina@umk.edu.my , [f]nurul'ain@umk.edu.my , [g]nadiah@umk.edu.my, [h]nashaain@.sirim.my

ABSTRACT. This research study of xrd characterization analysis of organic filler comprise waste banana peel and waste egg shell as matrix and reinforcement in bio-composite thin film. Banana peel fibers exhibit good renewable material for the substitution of bio based composite. The banana peel and egg shell were separately cut into smaller pieces and boiled for 20 min before drying in oven at temperature 80 ˚C for 30 min. These pieces were then ground using mechanical blender into fine powder sizes ranging from 80 -100 µm,. This bio-composite thin film will investigate by using X-ray diffraction (XRD) analysis to determine of crystallinity of a compound, distinguishing between amorphous and crystalline material and to quantification of the percent crystalline of a bio-composite thin film. shows that the sharp peaks on egg shell graph at 2θ = 28˚ and 42˚which represent the $CaCO_3$ and it has high crystallinity degree which is 82.9% compared to banana peel.

Keywords: *Bio-polymer, Composite, Egg shell, Banana peel;*

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1. INTRODUCTION

Vast amounts of food waste around the world can cause significant health and environmental problems that ultimately lead to economic world. However, most food wastes contain valuable minerals that could serve as raw materials for the production of glass, ceramics, and glass-ceramics. Organic waste typically has value in terms of energy, water content, and mineral content, but current methods of waste disposal do not utilize these resources. Instead, communities incur costs to store synthetic plastic thin film in landfills, where it emits uncontrolled greenhouse gasses and poses risks to pollution. Recent government regulations regarding landfills, for example, those in Europe,lead to a direct economic stimulus to create value out of waste. Solutions to reduce the mass of landfills could be coupled with extraction of the resources they contain. Banana peel is a waste material with rich of starch. This characteristic makes them potential to produce bio-polymer thin film which is more environmentally friendly due to its biodegradable abilities compared to the conventional synthetic petroleum-polymer. In addition, banana peels are agricultural waste that discarded as useless material. This waste contributed to waste management problems although they have some compost and cosmetics potentiality [1]. Banana peels are readily available, low cost and environmental friendly bio-material. This agriculture waste is also inexhaustible, cheap, non-hazardous and specifically selective for heavy metals and able to dispose easily by incineration [2]. For this reason, application of waste natural fiber of bio-polymer are being investigate as good alternative resources. Natural fibers as reinforcement for polymeric matrices have been studied due to it numerous of the advantages and their ideal environmental performance when compared to inorganic fibers such as glass or carbon fibers [3]. The main advantages were presented by these fibers are abundance and therefore low cost, biodegradability, flammability, flexibility during processing, relatively high tensile and non-toxicity [4].

Banana (*Musa sapientum*) is the herbaceous plant that belongs to the family Musaceae. Bananas are the most important tropical fruits in the world market and it is most eaten fruits in this world. Banana also named as the World Healthiest Fruit. Banana peel (also known as banana skin) is the outer covering of banana fruit. At present, the banana peels are not being used for any other purposes and generally removed and dumped as solid waste at large expense. Therefore, a significant amount of organic waste is generated. There are several utilizes of wasted banana peels such as it is used for water purification, as fertilizer and used in the production of ethanol, cellulose and laccase. However, sometimes wasted banana peel is used as feedstock typically in small farms for pigs, goats, rabbits, cattle and other several species [5].

Eggshells are litter and kitchen waste that can be collected in a large amount from many places such housing areas, restaurants, hotels, food industries and even from the hatcheries and farm [6]. Eggshell consists of 95% calcium carbonate ($CaCO_3$) as its main component and it is in the form of calcite. In the form of calcium carbonate, calcite is the most stable which forms elongated structures called columns, crystallite or palisade [7]. Besides that, there are remaining 5% of others inorganic material in the eggshell which are calcium phosphate, magnesium carbonate, soluble proteins and insoluble proteins. Calcium carbonate is a compound that brittle white stuff that limestone, chalk, sea shells, coral and pearls are made of [8].

Eggshell containing calcium carbonate (94%), calcium phosphate (1%), organic compounds (4%), and magnesium carbonate (1%). The high contains of calcium in eggshells can be converted as a CaO catalyst by calcinations process at temperature around 800 ºC for 2 hours where the reaction takes place as exothermic reaction.

Nowadays, natural fibers have become attractive to those researchers, scientists and engineers as an alternative reinforcement for fiber reinforced polymer composites. Natural fiber reinforced polymer matrix got considerable attention in numerous applications due to its good properties and superior benefits of natural fiber over synthetic fibers. Besides the advantages of eco-friendly and biodegradability, fiber reinforced polymer are low weight, low cost, high specific strength, non- abrasive, fairly good mechanical properties such as tensile modulus and flexural modulus, improved surface finish of molded parts composite, renewable resources, flexibility during processing, being abundant, and also minimal health hazards [9].

2. MATERIALS AND METHODS

Banana peel was obtained from an available cafeteria at University Malaysia Kelantan (UMK) Jeli as solid waste. Then, banana peel was cleaned with water to remove undesired materials. Banana peel was next left to dry under sun light for 7 days, then it was dried in a drying oven at 70°C for 4 hours to remove water contentThen, egg shells also were collected from the nearest UMK Jeli cafeteria. This eggshells were washed with water to remove the dirt and membranes. Later, the cleaned eggshells were dried in the oven for an hour. Then, dried eggshells were blended by using blender. The dried banana peels and egg shell were were trimmed and crushed in simple crusher and sieved into particles with an average size of 0.725 mm.

Banana peels was boiled in water for 20 min to make it soft. The volume of water (ml) and weight of banana peels (g) were in the ratio of 4:1. After 20 min, banana peels were blended with glycerol for 10 min. The amount of glycerol were used is 15% w/w of the dried banana peels. Then, the blended mixture was boiled for 15 min at 70 ^{o}C.

Meanwhile, the mesh surface of the silkscreen was moistened with water. The boiled blended mixture was spread over the mesh using spatula. A roller was used to ensure the film surface to be more flat. Then, the mixture on silkscreen was placed in the oven at 80 °C for 3 hours for drying. Lastly, the dried bio-composite thin film was taken from the silkscreen. The thickness of the thin film was in the range of 0.10 mm to 0.15 mm.

The bio-composite films were ready to analyze the chemical elements presents in the bio-composites by using XRD anlaysis. The film samples were cut into small pieces (20 mm × 20 mm) and dehydrated in a desiccator with silica gel (~0% RH) for 3 weeks before being characterized. The crystalline structures of the samples were determined using X-Ray Diffraction (XRD) technique. XRD analysis was carried out by using Bruker D8 Advance Powder XRD with CuK-α radiation (λ=1.5404 nm) and operated at a voltage of 40 kV with a current density of 30 mA. XRD data were collected within 2θ range of 10° to 40° at room temperature.

3. RESULTS AND DISCUSSION

The bio-composite thin film isolated from the banana peel and egg shell fillers presented homogeneous surface with no bubbles or cracks, as well as good handling characteristics. This means that the films could be easily detached from the plates without tearing, and that they were not sticky or too brittle. X-ray diffraction (XRD) of bio-composite thin film was analyzed the crystalline phases of the thin films. Banana peels are mainly composed of pectin, cellulose and hemicelluloses and the functional groups associated with these polymers as well as the proteinaceous matter may be involved. The patterns exhibited an intense peak at around 2θ = 30 ° (I_{200}) for banana peel and egg shell fillers. XRD plots as shown in Fig.1 and 2.These types of peak represents the crystallinity region in samples. The XRD results analyzed using X'PertHighScore software shows in Fig. 1.The average crystallite size is determined from the full width at half maximum (FWHM) of the X-ray diffraction peak using Scherrer's eq. 1:

$$D = K\lambda / (B \cos\theta) \quad (1)$$

Where D is the particle diameter, λ is the X-Ray wave length, B is the FWHM of the diffraction peak, θ is the diffraction angel and K is the Scherrer's constant of the order of unity for usual crystals.

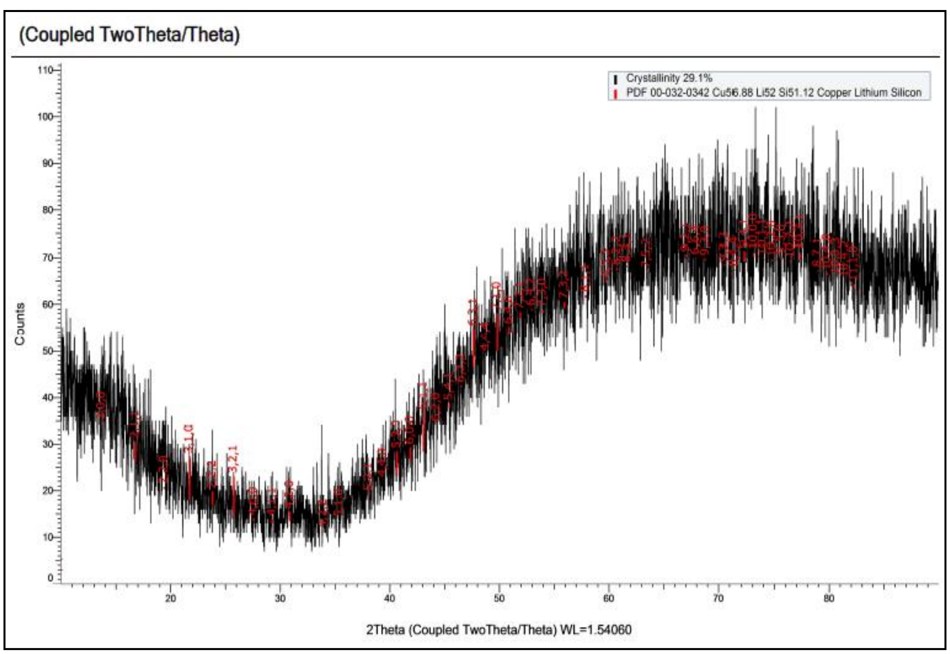

Fig.1. X-ray diffraction pattern for the banana peel waste sample

Fig. 1 shows that XRD pattern of amorphous of banana peel and it presence of containing copper, lithium and silicon has small number of crystallinity which is 29.1%. Amorphous or non-crystalline solid is a solid that lacks the long-range order characteristic of a crystal. The X-ray diffraction data indicate of broad peaks at an angle 2 theta of 24 and 44 degrees. Fig. 1 shows the X-ray diffraction pattern of amorphous materials of banana peel in bio-polymer thin films. Some sharp peak also exist in the thin film that indicated the existence of other elements that are crystalline characteristic [10].

Lignocellulocis fibers of waste banana fibers studied by Pereira et al. [11] shows the X-ray diffractograms pattern amorphous of the banana fibers. This peaks was observed for thin film samples at 2θ= 16° and 2θ = 22°, representing the cellulose crystallographic planes I_{101} and I_{002}, respectively.

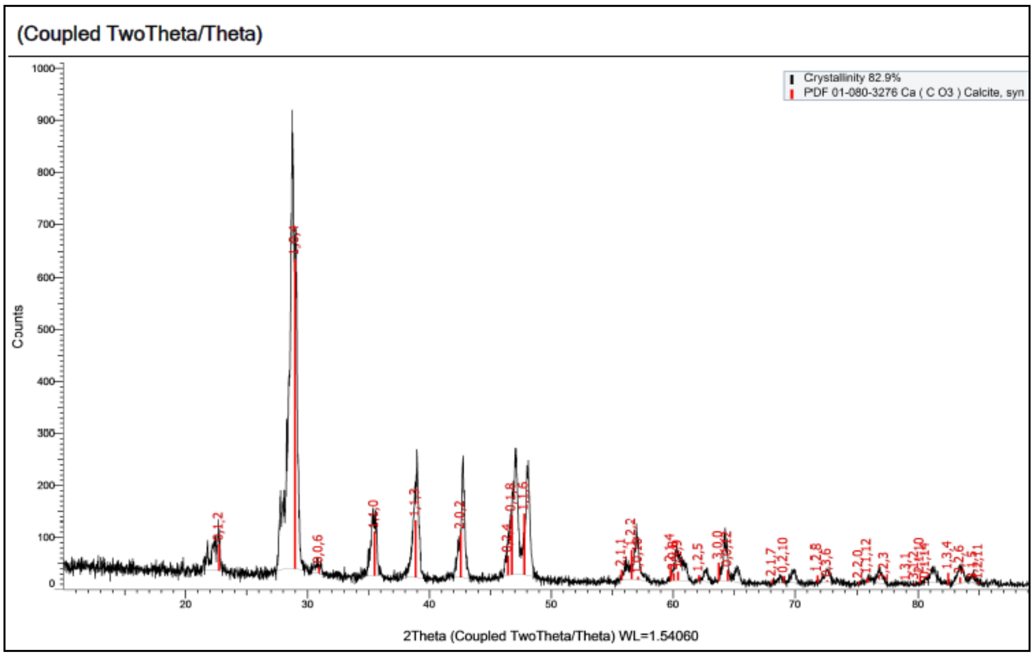

Fig. 2 X-ray diffraction pattern for the eggshell waste sample

Fig. 2 shows the result of XRD spectrum for egg shell waste sample. The peaks on the spectrum can be informative to estimate the crystallization. The mineral phase present in the as-collected eggshells was identified as calcite; no other crys- talline species was detected. As shown in Fig. 1, the X-ray reflections correspond to the PDF files for calcite. The material obtained after drying process and thin film fabrication at 80 °C has a porous appearance, white color and fragile consistence. The corresponding X-ray diffraction pattern Fig. 2 shows reflections corresponding to PDF 010803276 files for ($CaCO_3$); again no other species was found. It is confirms the presence of calcite ($CaCO_3$) indicating $CaCO_3$ is the main constituent in the egg shell. Calcite is the thermodynamically most stable form of $CaCO_3$ at room temperature. X-ray diffraction (XRD) analysis was conducted with the aim of comparing XRD patterns of bio-composite thin film. than egg shell containing calcite with crystallinity of 82.9% as shown in Fig. 2.

It also clearly shows that the sharp peaks on egg shell graph at 2Ɵ = 28˚ and 42˚ which represent the $CaCO_3$ and it has high crystallinity degree which is 82.9%. The degree of crystallinity has a significant on hardness, density, transparency and diffusion.

4. SUMMARY

This paper discusses a technique for processing of bio-polymer thin film using waste banana peel and egg shell contains $CaCO_3$ which extracted from eggshell waste. XRD analysis confirmed that this thin film of bio-composite shows amorphous pattern of banana peel and it presence of

containing copper, lithium and silicon has small number of crystallinity which is 29.1%. Other than that, it also reveal that eggshell particles were primarily composed of calcite ($CaCO_3$) with high percentage of crystallinity which is 82.9%. Calcite is the thermodynamically most stable form of $CaCO_3$ at room temperature. From Fig. 3, it is indicating that egg shell fillers have high crystalline which is 82.9% and confirms of presence calcite ($CaCO_3$). It can be indicated that egg shell characteristics (like commercial calcite and availability makes egg shell a potential source of filler for bulk quantity, inexpensive, lightweight and low load-bearing composite application.

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