contents

Wishing all chinese members and readers
" Gong Xi Fatt Chai"

Prof. Dr. Mohd Kamal Harun (R) receiving the medallion from Dato' Dr. Ong Eng Long

*C*hange of *G*uard

*C*ongratulations! The Institute of Materials, Malaysia (IMM) is 25 years old this year and will celebrate its Silver Anniversary in 2012 in conjunction with the 8th International Materials Technology Conference and Exhibition (IMTCE2102).

The predecessor, Malaysian Materials Science & Technology Society (MMS) was registered with the Registrar of Societies on 6th November, 1987. The main objective of MMS was to actively create and promote awareness of Materials in Malaysia, which the society did so since 1988. In 1996, the change of name to the Institute of Materials, Malaysia (IMM) was effected on 16th June 1997 with a newly-elected Council. Since then, IMM has not looked back and has continued its policy of being a non-profit society of professionals who continues to promote honourable practice and professional ethics and encourage education in materials science, engineering and technology.

Twenty five years on, IMM now have several courses that are specially created to meet industry needs, such as the Blasting and Painting Certification, Coatings Inspector, Quality Control Technician, Welding Inspector schemes amongst many other technical courses. To promote awareness of materials, relevant seminars on materials, materials technology and engineering are being held at regular intervals. Biennially, the international technology conference and exhibition are held to provide an avenue to professionals, industrialists and academicians to share their research work. There will also be opportunities to network amongst the local and international materials fraternity.

For the last four years, IMM was very fortunate and privileged to have Dato' Dr OngEng Long, a rubber researcher sit as the President. With Dato Dr Ong at the helm, several milestones were achieved. These include the first IMTCE being outside Kuala Lumpur. In 2010, Kuching hosted the 7th IMTCE with much grandeur. The Annual IMM Golf Invitational was introduced in 2010 to offer networking opportunities in a relaxed and friendly environment. Three Memorandums of Understanding were signed under his leadership – with the Institute of Materials, Minerals and Mining, SSPC: The Society for Protective Coatings and the Sabah Skills and Technology Centre in Kota Kinabalu. In an unprecedented move by any society, IMM now offers free membership to active members of other societies.

In March 2012, Prof Dr Mohd Kamal Harun was installed as the President of IMM. Prof Dr Kamal completed his PhD at the University of Manchester, Institute of Science and Technology (UMIST). He served as a professor of chemistry at the Faculty of Applied Science in UniversitiTeknologi MARA, Shah Alam, until his secondment to the Universiti Malaysia Kelantan (UMK) as the Head of Research. Prof Kamal's main interest is electrochemistry, in particular metallic corrosion.

IMM also salutes Dato Dr Ong for his vision, guidance and leadership during his tenure. TerimaKasih and Syabas!

Green...

Green...is not just that... electromagnetic radiation
The wavelength which is in the visible light spectrum
Neither is it...those novices in organisation
Nor the immaturity of any governance system

Green...can be clever ways and actions
To sustain natural resources and environment
Purification, Remediation, and Caption
Reclaim and Recycle...deserving compliments

Green Technology and Green Materials
Are emerging to reduce dependency
From wasteful practices that gave denial
The time for mother-nature from recovery

Green in Cultures connote meanings
From Love and Lust, to Evil and Death
But civilized worlds are all agreeing
That it means Hope and prospects for mother Earth

Alas... if greed is allowed to prevail
Creating disharmonies in the brew
All commendable efforts are bound to fail
This blue green planet will eventually... lost its hue

Would we then look at outer space?
Unload our mistakes as inter-galactic litterings
Or would we eventually evolved as...
The incredible...

Green beings?

Maimunah Ismail
Kuala Lumpur
10th July 2012

Effect of Temperature on the Strength Properties of Adhesively Single-Lap Bonded Joint for Composite Laminates

Siti Noorseri A. Razak[1], A. R. Othman [†1, 2], L. W. Sheng[2]

[1] Advanced Composite Processing Lab, School of Aerospace Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia
[2] School of Mechanical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia

ABSTRACT

The use of adhesive bonding is valued in structural design in which the single-lap joint has been widely used in the manufacture of aerospace and automotive structures. It has been anticipated that improper or inadequate surface treatment is the most known cause of failure in adhesive bonding. Hence, the objective of this research was to study the effect of surface preparation with different surface roughness by using different number of grit (#220, #400 and #600) of sandpapers on the joint strength of adhesive bonding for glass fiber composites. In addition, effect of various temperatures for different surface roughness on the joint strength has also been investigated through tensile tests under different temperatures. The relationship between joint strength with its surface roughness and temperatures effect was observed. It was found that as the mesh number of grit increased, surface roughness decreased, leading to the increase in joint strength due to better mechanical resistance or interlocking of joints. At temperature below T_g, the adhesive became brittle, leading to a reduction in strength. But, as the testing performed at higher temperature (70°C), the highest strength of bonding was obtained. At 130ºC, the adhesive softened and was unable to sustain the load which led to the decrease in joint strength. Finally, the failure mode on the bonded region was analyzed and categorized as adhesive failure, cohesive failure, and mixed failure.

Keywords: *Adhesive bonding, joint strength, single lap joint, failure analysis*

INTRODUCTION

The use of structural adhesives in engineering applications can offer substantial benefits in comparison to more traditional joining such as mechanical fastening and welding. Many authors have made various attempts to investigate the effects of various factors on the stresses in the adhesive layer and the joint strength [1-6]. These factors include spew fillet [7], bondline thickness [8], overlap length [9, 10], environmental conditions [11] and surface preparation [8, 9]. Single lap joint was widely known and used to characterize bond strength [9, 12], as its arrangement is very common in practice and simple design rules should be available for design purposes.

A proper surface pretreatment is essential for achieving good bond strength with any adhesives, which include physically, mechanically and chemically alteration of the surfaces. At minimum, the adherend surfaces that are prepared for bonding should be clean enough to provide a good adhesion. A variety of surface treatments have been used to increase surface tension and surface roughness and to change the surface chemistry, thereby increase bond strength and durability of adhesive joints [13-15]. Grant et al [12] has used acetone to degrease the adherend surfaces and followed by grit blasted to give a surface finish of 2.5 μm of surface roughness. Lucas et al [9] has used #800 SiC sandpaper to treat the surfaces of adherend, together with the acetone to degrease and clean the surface. Kim et al [8] and Katona et al [14] have observed that as mesh number of abrasive paper increased, surface roughness has decreased within the range from 0.5 to 2.1 μm, thus improving the joint strength [8]. Comyn [13] has indicated that surface treatment was very important in removing contamination and weak boundary layers and hence, changing the morphology and surface chemistry of the adherends. In addition, wet channel treatment was also proposed to improve the durability of bond in wet air.

Normally, the adhesives used for the adhesive bonding have its specific properties within the certain range of temperature. The adhesive and the adherend can become brittle due to low temperatures or may melt or decompose under conditions of extreme heat. Grant et al [16] has found that failure load of lap joints under tension at both 90°C and -40°C showed some decrease in strength of the joint as the bondline thickness increased in comparison to those joints tested at 20°C. Likewise, Zhang et al [17] has proposed the effect of low and high temperatures on tensile behavior of adhesively-bonded glass fiber reinforced polymer (GFRP) joints. The failure mechanism has changed with increasing temperature from fiber-tear to adhesive failure. The temperature changes in adhesively bonded joints would cause a wide variety of different stress states [18, 19]. As the adhesive was heated, its viscosity was reduced, thus enabled it to flow and wetted the surface. In contrast, the adhesive will turn brittle at lower temperature, leading to a reduction in strength and greater scatter in the results.

METHODOLOGY

The adherend used was 6-layer of Glass fiber 7544/7000 plain weave with 600g/m2 and the resin was a high temperature epoxy Epolam 2025 with glass transition temperature, Tg of 140oC. The laminate was cured in the oven at 100oC for 90 min and left it under vacuum for 1atm of pressure. The average thickness of the six layers of fiberglass after curing was about 2.7mm. Araldite 2014 was selected as the adhesive for this study where it can sustain high temperature condition with good chemical resistance.

The adherend surfaces were treated using three different mesh numbers (#220, #400 and #600) of sandpapers to analyze the effect of grit number to the value of surface roughness of the adherends. Following the treatment, the specimens were placed into the ultrasonic bath with acetone solvent at 50°C for 15 minutes to clean and degrease from any contamination. A clean surface is necessary condition for adhesion [1] and is very important for the efficient bonding. Following the ultrasonic cleaning, the specimens were dried at 80°C for 15 minutes. Prior to the bonding, the surface of the adherends was analyzed using Alicona Optical machine to determine the surface roughness.

The specimens were bonded with 0.5 mm of adhesive thickness for single-lap joint (SLJ) by using the bonding jig to ensure the bonding in the good alignment and dimensions as shown in Figure 1. The SLJ specimens were then cured using vacuum bagging and were placed in the oven at temperature of 80°C for 4 hours. The vacuum bagging process was performed in order to eliminate the void at the adhesive layer, hence enhance the bonding.
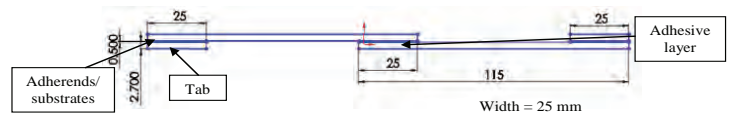

Figure 1: Single-lap joint with dimensions in mm

A total of 12 specimens have been proposed for the project with the specified conditions as shown in Table 1 below. Tensile tests were conducted using Universal Testing Machine (UTM) under three different temperatures of ambient temperature (25^{0}C), 70°C and 130°C to study the effect of temperature on the joint strength. The specimens were subjected to loading under a constant crosshead rate of 1.0mm/min until total failure.

Table 1: Testing sample with conditions

Specimen	Surface preparation	Testing temperature	Specimen	Surface preparation	Testing temperature
A	Without sanding	Ambient	G	*#400	70 °C
B	*#220	Ambient	H	*#600	70 °C
C	*#400	Ambient	I	Without sanding	130 °C
D	*#600	Ambient	J	*#220	130 °C
E	Without sanding	70 °C	K	*#400	130 °C
F	*#220	70 °C	L	*#600	130 °C

*: mesh number of sandpaper used for surface preparation

RESULTS AND DISSCUSSION

Surface Roughness Analysis

Figure 2 shows the 2D and 3D profiles of the adherends for

different mechanical treatments. It was noticed that the adherend surface

without the sanding provided the roughest surface properties. The surface roughness of the adherend surfaces changed when treated with the sandpapers. It was found that the surface of the adherends showed some noticeable scratches on the macro-scale.
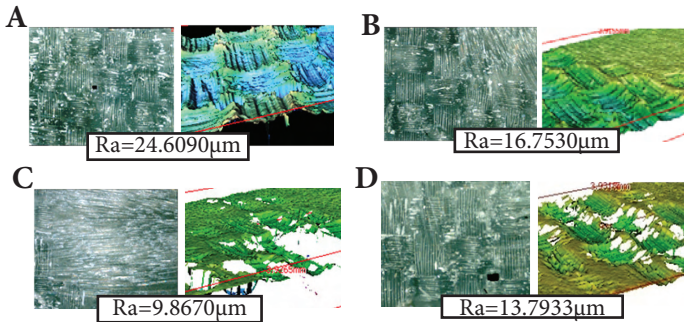

Figure 2: 2D and 3D images for glass fiber adherends: (a) without sanding, (b) sandpaper #220, (c) sandpaper #400 and (d) sandpaper #600

As the mesh number of sandpaper increased to #400, the surface roughness, Ra has found to decrease. Among the considered range of the sandpapers, the mechanical treatment using #400 sandpaper has caused the lowest surface roughness. However, the surface treated with #600 sandpaper has not changed significantly if compared to those of the #400 sandpaper. As the sandpaper with higher mesh number is extremely smooth, it is unable to create a distinct effect on the surface of the adherend. The average surface roughness, Ra for the specimens with respect to mesh number of sandpaper was given in Figure 2.

Joint strength analysis

Figure 3 indicates the joint strength of the adhesive bonding with respect to mesh number of sandpaper at three different temperatures. It was clearly shown that the SLJ strength of the adhesive bonding has increased when treated. At ambient temperature, the untreated specimen has attained the lowest SLJ strength of 26.63 MPa. The joint strength was found to increase after the treatment with #220 sandpaper. It has obtained the increase in strength of approximately 10.5% compared to the untreated counterpart. The surface sanding enables loose and unstable polymers to be removed from the surface, thus increasing the contact surface area [20]. The adhesion is resulted from the molecular contact between the adhesive and adherends, in which the surface forces are developed; as a result of spontaneous wetting.

The SLJ strength was at the highest when adherend was treated with #400 sandpaper, which was at 29.958 MPa. It was shown that the wetting ability of the specimen was better compared to those treated with #220 sandpaper. However, the SLJ strength has decreased slightly as the #600 sandpaper was used. This was attributed to the extremely smooth abrasive materials, unable it to create a distinct effect on the adherend surface as those of using #400 sandpaper. Similar results were observed for those specimens treated in different environmental conditions with temperatures of 70°C and 130°C. The untreated specimens have achieved the lowest single lap joint strength whilst the highest single lap joint strength was obtained for the specimens treated with #400 sandpaper.
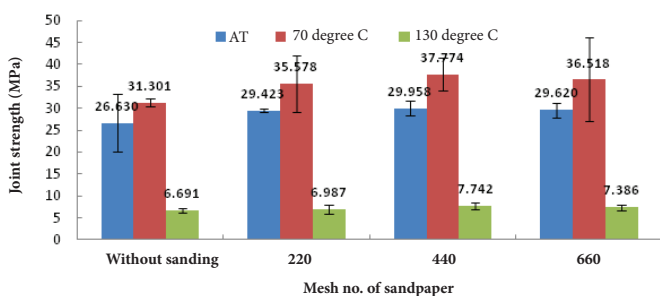

Figure 3: Joint strength of adhesive bonding with respect to mesh no. of sandpaper at AT, 70°C and 130°C

It has been noticed that the joint strengths were increased for all types of specimens when the environmental temperature changed to 70°C from the ambient temperature and were decreased when environmental temperature reached 130°C. As adhesive used is a temperature-dependent, the structural behavior of adhesively-bonded joints is expected to change significantly with temperatures. At 25°C (ambient), the adhesive behavior is relatively hard, inflexible and brittle, at very low

viscosity. When the temperature (70°C) was approaching T_g, more uniform stress distribution occurred at the joint, as adhesive behavior became more soft and flexible. The adhesive viscosity was at optimum and a complete wetting of adhesives was observed uniformly over the surface of adherends. However, at temperature above T_g (i.e. 130°C), the joint strength of adhesive bonding strength and stiffness has decreased. The ductility of the adhesive was higher than those in other temperatures as strain capability was increased but the load capability was low due to extremely high viscosity.

Failure mode

The failure mode of the specimens is summarized in Table 2. Significant differences in failure mechanisms were observed at different temperatures and different surface roughness. Although in all cases cracks nucleated and propagated at both ends of the bonded region, the failure processes could be classified into three distinct categories: cohesive failure, interfacial failure and mixed failure. At ambient temperature, an interfacial failure was observed because of the brittle property of the adhesive. At 130°C, the dominant failure mode was a cohesive failure as the adhesive became ductile with lower tensile strength. But, the failure mechanism changed at the glass transition temperature, from mixed failure to cohesive failure for specimen treated with #400 sandpaper. This was attributed to the effective and good adhesion of mechanical interlocking between interface of adhesive and adherend.

Table 2: Failure mode for specimens tested

Failure mode		
Cohesive failure	**Interfacial failure**	**Mixed failure**
Without sanding (130 °C)	Without sanding (AT)	Without sanding (70 °C)
#220* (130 °C)	#220* (AT)	#220* (70 °C)
#400* (130 °C)	#600* (AT)	#600* (70 °C)
#600* (130 °C)		#400* (AT)
#400* (70 °C)		

*: mesh number of sandpaper used for surface abrasion; Cohesive failure: separation is within the adhesive; Interfacial failure: separation appears to be at the adhesive-adherend interface; Mixed failure: a mixture of different classes

CONCLUSION

Joint strengths were found to increase for all types of specimens at 70°C; a complete wetting of adhesives was observed uniformly over the surface of adherends. At temperature above Tg, the joint strength of adhesive bonding strength and stiffness has decreased. The failure modes observed could be classified into three distinct categories: cohesive failure, interfacial failure and mixed failure

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Oil Palm Trunk Biocomposite:
Mechanical and Morphological Properties

C. K. Abdullah[1*], M. Jawaid[2], H.P.S. Abdul Khalil[1], and M.R. Nurul Fazita[1]

[1]*Division of Bioresource, Paper & Coating Technology, School of Industrial Technology, Universiti Sains Malaysia, 11800 Penang, Malaysia*
[2]*Department of Polymer Engineering, Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 Johor, Malaysia*
*ck_abdullah@yahoo.com

ABSTRACT

In this research oil palm trunk biocomposites were produced by impregnating dried oil palm trunk with phenol formaldehyde resin. Peripheral region of oil palm trunk bottom parts were kiln dried until it attain 13%–15% moisture content, after that dried oil palm trunk impregnated with phenol formaldehyde resin by using high pressure vessel. In this study impact and compression properties of oil palm trunk biocomposites were studied. It observed that impregnation of oil palm trunk with phenol formaldeyde resin improves the impact and compression properties of oil palm trunk biocomposites.The oil palm trunk biocomposite with 60% resin loading showed better mechanical performance than other oil palm trunk biocomposites but still lower than rubberwood. Scanning electron microscope was used to study the surface morphology of oil palm trunk, and location of resin in the oil palm trunk biocomposites at different resin loading. The phenol formaldehyde resin showed better interaction in oil palm trunk impregnated with 60% resin loading and resin penetration still retain the original dried oil palm trunk structure.

Keywords: *oil palm trunk biocomposite; dried oil palm trunk; rubberwood; phenol formaldehyde*

INTRODUCTION

Oil palm plantations in Malaysia is close to 4.05 million hectares and during replanting process, it generates approximately 8.2 million tons of oil palm trunk (OPT). Constraint for the use of oil palm trunk as value added product making it a serious pollution problem in the field. Te OPT are normally left to rot or burnt in the field and this method is now unacceptable because it could affects the process of planting new crops [1,2]. The high density variation within the oil palm trunk has a significant effect on its strength properties. Based on study by Lim and Gan [3], the modulus of rupture (MOR) and modulus of elasticity (MOE) are found to be linearly correlated to the OPT density. Therefore, the selection of OPT to be value-added product need to consider the variability over the trunk, both radially and vertically.

Phenol Formaldehyde (PF) resins are the most important and common class of resin adhesives. The PF resin is the most frequently used and environmentally more acceptable because of negligible formaldehyde emission. PF resins tend to be the most widely used adhesives for bonding wood products due to the excellent adhesion to lignocellulosic, durable, provide high quality wood bonding and suitable for use under all climatic conditions [4]. However, conventional PF adhesives are slow curing, require higher curing temperature, and are less tolerant to variations in anatomical features and wood substrate. The role of the PF resin in the oil palm trunk is to transfer the load to the stiff fibers through shear stress at the interface. In addition, with the help of PF resin properties, the fiber will acts as obstacles to impede the crack propagation [5].

Studies on the enhancement of OPT characteristic to become high performance product in dimensional stability, durability, and strength has been done by Edi Suhaimi [6], Erwinsyah [2] and Bakar [7]. The thermal properties of OPT modification has been studied by Bhat et al. [1] and showed a great thermal and degradation stability. In the other hand, the biodeterioriation exposure of modified OPT with termite have been done by Edi Suhaimi [6] that exhibited better resistance properties compared to unmodified OPT. Oil palm trunk is largely composed of parenchymatous tissues with numerous fibrous strands and vascular bundles. The tough vascular bundles are scattered in soft parenchyma tissue. Toughening the oil palm trunk with PF resin is novel approach to produce a new type of palm lumber and as an alternative source for wood based industries.

EXPERIMENTAL
Materials

The oil palm trunks at 25 years old were taken from KL-Kepong Berhad Plantation in Kulim, Kedah. Only bottom parts and outer region

from oil palm trunk were chosen for drying and impregnation process. The phenol formaldehyde (PF) resin was obtained from Hexion Specialty Chemicals Sdn. Bhd

Preparation of Oil Palm Trunk Biocomposite (OPTB)

The outer parts of the OPT were cut into dimensions 1000 x 70 x 70 mm and later kiln dried for 20 days using kiln dried schedule IV to obtain approximately 13–15% of moisture content. The dried OPT was impregnated with PF with different resin loading (30%, 60%, and 90%) using a high-pressure vessel. The dried OPT were put in the pressure vessel for impregnation process at 5 bar pressure. Figure 1 (a) and (b) showed the schematic of impregnation process which occurs in oil palm trunk. The time of impregnation varied from 15 to 45 min for different percentages of resin loading. The oil palm trunk biocomposite (OPTB) impregnated with PF resins were cured for 2 hours in an oven at 150ºC respectively.
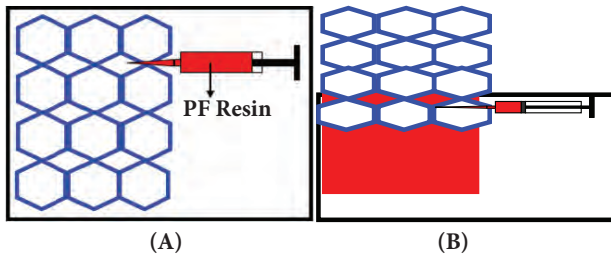

(A)   **(B)**

Figure 1: (a) The schematic drawing of dried oil palm trunk intercellular cavities structure, (b) PF resin penetrated into the oil palm trunk intercellular cavities structure.

Impact test

Impact tests were based on ASTM D256; Standard Test Method for determining the Izod Pendulum Impact Resistance of Plastics. Sample dimension for impact test is $60 \times 20 \times 12$ mm. Sample was tested using charpy test. Before test is done, V-notch must be made on the sample. V-notch can be done using Gotech V-notch machine. Depth of V-notch is 2 mm and angle of V-notch is 90°. Weight of impact pendulum is 2.72 J and speed 3.46 m/s.

Compression test

Compression test is done with sample dimension of $60 \times 20 \times 20$ mm according to BS EN 373: 1957. This test is conducted using Instron machine with speed of moveable head is 0.64 mm/min.

Scanning Electron Microscopy (SEM)

Scanning electron microscope (Leo Supra, 50 VP, Carl Ziess, SMT, Germany) from Unit of Microscope Electron, School of Biology, Universiti Sains Malaysia, Penang was used to analyze the morphological images of OPTB and dried OPT. A thin section of the sample was mounted on an aluminum stub using a conductive silver paint and was sputter-coated with gold prior to morphological examination. The SEM micrographs were obtained under conventional secondary electron imaging conditions with an acceleration voltage of 5 kV.

RESULT AND DISCUSIION

Impact Properties

Impact strength of OPTB with different resin loading, dried OPT and rubberwood were shown in Figure 2 at primary axis. The impact strength of OPTB increased with the increase in resin loading. However, after resin loading exceeds 60%, there was a considerable decrease in impact strength. Also, the impact strength of OPTB with 60% resin loading is comparable with rubberwood properties.

The enhancement of interfacial friction stress and chemical bonding between matrix and fiber may cause the strength to improve. Brown [8] obtained that extra energy was needed to be absorbed by composite in order to do the work of debonding between filler and matrix. Thus, the OPTB impact strength continued to increase at higher resin loading. Previous study by Seena et al. [9] suggested that the impact failure of the composite may be caused by matrix fracture, fiber/matrix debonding and fiber pull out. In this experiment, the extensive decrease of impact strength in case of OPTB with 90% resin loading was

more related to the matrix fracture. The matrix fracture occurred, when the fiber and the resin were not bonded during curing process. This may be due to PF resin which not has proper interfacial adhesion between the fiber and matrix.

The impact properties were directly related to the overall toughness of the materials, which were highly influenced by the interfacial bond strength, matrix and fiber properties [10]. In case of 60% resin loading impact strength is due to greater impregnation of the resin within the pits or pores of the OPTB, thereby enhancing its impact properties. Furthermore, with the help of resin properties, the fiber acts as obstacles to impede the crack propagation. In order to move past the obstacles, more energy is needed to propagate the cracks and thus increase the impact strength [5,11].

Therefore, the impulsive forces applied during the impact test were being absorbed efficiently by the fibers of the OPTB [12]. The resin loading beyond 60% impart brittleness to the composite materials and thus the material cannot efficiently resist fracture under stress applied at high speed. This phenomenon also was due to its low strength nature, irregular cross–section and the presence of fiber bundles [13]. Besides, previous study by Lai [14], the increase of impact strength is attributed to the effective stress transfer between strongly adhered filler and matrix due to the physical and chemical bonding between them. Moreover the PF resin acts better stress transferring medium in OPTB.
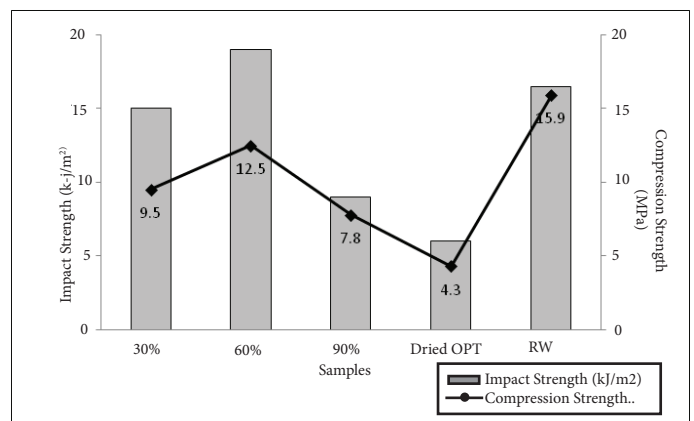

Figure 2: Impact Strength (primary axis) and compression strength (secondary axis) for OPTB with different PF resin loading compared to dried OPT and rubberwood.

Compression Properties

Compression strength of OPTB with different resin loading, dried OPT and rubberwood were displayed in Figure 2 at secondary axis. In general, OPTB with 60% of resin loading attained highest compression strength among the OPTB with 30% and 90% resin loading. However, like other mechanical properties, rubberwood again exhibited the highest compression strength as compared to OPTB. The effectiveness of PF resin in enhancing compressive properties showed a similar trend as flexural and impact properties. This result showed that, OPTB with 60% resin loading has capability to absorb more energy during stress, whereas the OPTB with 90% resin loading showed stiffer properties due to presence of excess resin.

The compressive strength of composite is strongly dependent on the effectiveness of the matrix in supporting the fibers against buckling. Also, research by John and Reid [15] reported that, epoxy matrix acted effectively as a stress transfer medium between fibers in the composite. While, low compression strength of dried OPT probably was due to high porosity. Starnes et al. [16] stated that, a gap or holes in the epoxy laminate enhanced the degradation of compression strength. This condition will be due to the inability of impregnated OPT to resist the break under compression stress Nevertheless, the presence of PF resin in OPTB structures is effective in resisting fiber buckling.

Scanning Electron Microscopy (SEM)

The morphological analysis of dried OPT and presence of PF resin in OPTB structures were carried out with the help of scanning electron microscope. The morphological detail about dried OPT structures, particularly vascular bundle was presented in Figure 3 (a).

The micrograph was obtained using SEM and from this picture, the existence of parenchymatous ground tissue, fibers, and vessels was easily recognized and identified.

Figure 3 (b) shows the damage of parenchyma tissues when 90% resin loading were force to be located in OPTB. The high pressure intakes during impregnation process, forced the resin to locate in parenchyma tissue and of vascular bundles. In resin penetration, optimum impregnation process is an important factor. In case of high force of resin penetration, the OPT structure may collapsed and hence giving poor mechanical locking. Besides that, the rupture of parenchyma tissue may occur due to reaction of moisture evaporation during the curing process. Recent study by Siimer et al. [17], reported that the resin cured on wood substrate is different as compared to the resin cured alone. When the resin overloaded in wood structure, the diffusion for moisture evaporation would not work as usual. This reason can be related with strength reduction in the mechanical properties of the IOPT with 90% rein loading.

Views of OPTB with 60% resin loading which incorporates within the parenchyma cell is shown in Figure 3 (c). The high porous morphology of dried oil palm trunk helps the resin to be located and filled within the space which will improve the characteristics of OPTB. After impregnation and curing process, PF resin were seen located in the parenchyma tissues. The parenchyma cells which are fully covered by PF resin were quite similar by attaining elongated shape. However, the PF resin only located in the parenchyma cells showed poor bonding.

The location and interaction of PF resin in OPTB with 30% resin loading as observed from the SEM is shown in Figure 3 (d). For the samples of OPTB with 30% resin loading, there are some spaces that are not filled by resin and the presence of these voids can lead to poor interaction between resin and OPT structure. Moreover, these voids may arise due to the inadequate amount of resin during impregnation process. During curing process, the evaporation of moisture creates the compound of solid content. The presence of less PF resin generate less solid content of PF resin which located in parenchyma tissues. Based on drying studies, when moisture released from OPT structures, shrinkage process will occur. This condition can be compared with OPTB 60% resin loading where the degree of parenchyma tissues shrinkage is less because of amount of PF resin located in OPTB structure. From the observation, it can be seen that, the extreme shrinkage of composite structure related to reduction of the matrix volume and generate weak interfacial bonding which will be affect the characteristic of composite [18].
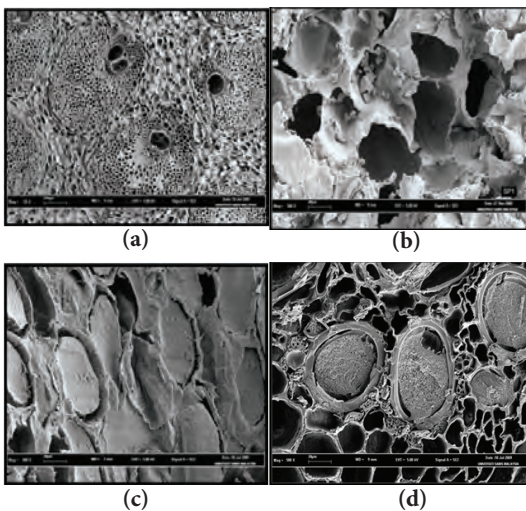

Figure 3: Scanning electron micrograph (SEM): (a) dried oil palm trunk (50x magnification), (b) OPTB with 90% PF resin loading (500x), (c) OPTB with 60% PF resin loading (500x), (d) OPTB with 30% PF resin loading (500x).

CONCLUSION

In this article, the dried OPT were impregnated using PF resin as a matrix to be a high performing products. The aim of this study was to characterize the mechanical and morphological properties of oil palm trunk biocomposite (OPTB). From our result, we conclude that usage of PF resin as matrix in the dried OPT improve properties of OPTB, such as impact and compression strength.

After the testing, the OPTB with 60% resin loading have better mechanical properties than OPTB with 30% and 90% resin loading. The mechanical properties of OPTB showed more solidity on 60% resin loading and the strength decreased when the resin loading exceed 60%. The morphological analysis of the OPTB with 60% resin loading illustrated better allocation of resin in OPTB compared to OPTB with 30% and 90% resin loading.

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Incorporation Of Rice Straw Into Clay Bricks

Y. Mubarak Sani[1], A.B. Ayu Haslija[1*], and S. Noor Rosyidah[1]

[1] *Department of Chemical Engineering, UCSI University, Kuala Lumpur, Malaysia*
[*]mubaraksarina@yahoo.com

ABSTRACT

The number of manufacturing/processing industries has currently been increasing. However, this rapid development has consequently resulted to an increase in the amount of sludge (solid residue) generation, which in most times disposed by open burning,incineration, land disposal etc. either of the disposal methods used can result to an endangering degradation of our environment and the ecosystem. This research paper report the utilization of fibre sludge (Rice Straw) generated from agricultural activities as raw material in clay brick manufacturing, In order to offer an alternative solution to the environmental effects cause by the disposal of the rice straw, at the same time making sure that the required brick properties such as compressive strength, water absorption, firing shrinkage etc were within the standard acceptable range. After the clay was obtained as the main raw material, the physical and chemical characterization of the raw material was carried out and some properties of the rice Straw as well, in order to determine the feasibility of incorporating the raw materials and to identify, if necessary, any pre-treatment requirement. Bricks were produced with the rice straw ranging from 1.5% to 10% by dry-weight. The general production sequence involves moulding, drying, firing and testing. During the testing period, experiments were done to analyze some important brick properties such as water absorption, firing shrinkage, compressive strength and weight loss. The result obtained shows that the 1.5 wt. %, 2.5 wt.% and 5 wt. % rice Straw can be utillized as brick material, because the properties analyzed were within the standard limit.

Keywords: *clay brick, brick, sludge, fiber sludge. rice straw*

INTRODUCTION

Rice straw is an agricultural sludge generated from rice production activities. It is one of the most abundant lignocellulosic waste materials in the world [1]. Its annually production is 731 million tons, in Africa 20.9 million tons, Asia 667.6 million tons and Europe 3.9 million [1]. The disposal method of rice straw is one of challenging problem faced by many countries, the most commonly used and cheap method of disposing rice straw is through open burning; however there are numerous concerns regarding the environmental effect cause by this disposal method, due to the potential CO_2 emission into the atmosphere, air pollution and formation of haze. However it has been reported that alternative methods of utilizing rice straw are making breakthrough; such as commercial scale production of bioethanol from rice straw [3], incorporating rice straw into soil, use of rice straw as one of the ingredient to synthesis marginal food for animals [11] etc .

Even though the above mention potential methods of useful utilization of rice straw are signs of progressive approach toward tackling this problem related, the environmental concern are still worrying because of the annual increase in rice production, which is geared by the increasing world population. For example in Malaysia, according to the survey from Food and Agriculture organization of United Nation, the total rice production of the country increase from 2.20 million MT in 2002 to 2.54 million MT by the year 2010 [4]. Therefore, the need for the evolution of more potentially effective and environmental friendly methods of proper utilization of rice straw is necessary to upset this increase.

It is obvious that the recovery of sludge and utilization of sludge as building and construction raw material can be considered as an alternative to the right direction [5]. This study investigated the incorporation of rice straw into clay bricks. A proper characterization of clay was made and the effect of rice straw composition on the properties of the final products was examined.

EXPERIMENTAL PROCEDURES
Raw Materials

The raw materials used in this study were clay which was obtained from local clay brick manufacturer from Kuang, Malaysia, while the rice straw was obtained from local paddy field in Sekinchan, Malaysia.

Preparation of Raw materials

Clay bricks of 1.5%, 2.5%, 5% and 10% mixture of rice straw were prepared. The formulation of raw materials involved mixing the rice straw with the clay and appropriate amount of water added for each proportional increase of rice straw as reported in Table 1. The rice straw amended clay brick were hand moulded into a custom made wooden brick mould of 212mm x 95mm x 70mm dimension. The brick mould was coated with formica layer and lubricating oil applied to the surface to avoid the mixture sticking on to the wall of the brick mould. This sticking effect prevents the brick from being gently removed from the mould after casting. During moulding, the brick was compacted using hammer to enhance the cohesiveness of the raw material, hence resulting into less pore space or holes.

The wet brick were dried in the laboratory scale drying oven at approximately 115°C for 48 hours. After drying before putting into the furnace for firing, the length and weight of each brick were measured, and then the brick was put into furnace with temperature stir step increase from 150°C to optimum of 900°C for 8 hours and then left at this constant optimum temperature for 12 hours and finally cooled down to the ambient room temperature for 7 hours.

Table 1: Amount of water and mass of raw materials required per brick

Ratio of clay: rice straw Mixture (wt %)	Clay (g)	Rice Straw (g)	Total Mass of Raw Material (g)	Water Added (mL)
100:0 (control)	2000	0	2000	550
98.5:1.5	1970	30	2000	553
97.5:2.5	1950	50	2000	600
95:5	1900	100	2000	650
90:10	1800	200	2000	800

RESULT AND DISCUSSION
Characteristics of clay

The PH value of clay was found to be 3.87 and the moisture content was found to be 0.67% which is a very low value and this was caused due to the dryness of the clay sample obtained from the local brick manufacturer from Kuang, Malaysia, while the moisture content of rice straw was 9.7% .

Plasticity is another important parameter that describes the ability of material to undergo irrevocable deformation at constant volume without crumbling or crushing [6], in this study clay sample showed a plastic limit of 32.37% and liquid limit of 36%, hence, the plasticity index is 3.63%. The occurance of plasticity in clay may be due to the presence of clay minerals that give rise to its cohesive nature, thus, causing it to act as a cement or paste [7].

Physical and mechanical properties of rice straw amended brick
Water Absorption

One important property in determining the strength of clay brick is the water absorption, the extend of cohesiveness and firmness of the brick is measured by the level of water absorption and it has been reported also depends on type of clay and method of production used [8]. From Figure 1 and Table 3, it can be analyze that water absorption of bricks increased with addition of rice straw, the observed increase in water absorption was due to poor application of compacting pressure due to the hand-moulding using manual compaction and the formation of voids due to the burning of organic matter in the rice straw.
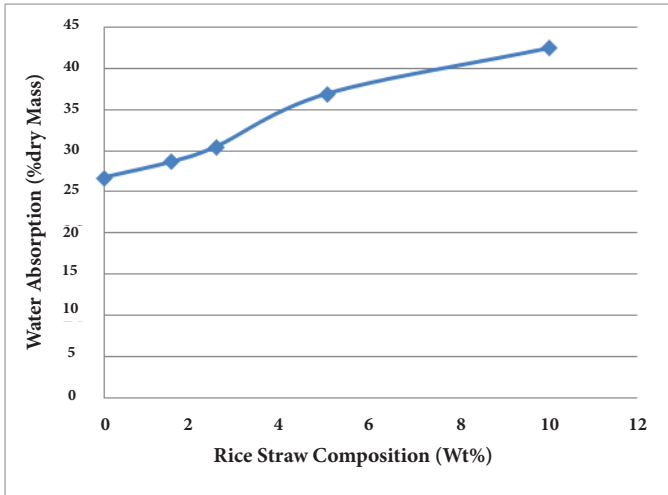
Figure 1: Effect of Rice Straw composition on Water Absorption

Compressive Strength

All construction or building materials without any exception must resist stress due to the load of building, therefore the strength of material is equivalent to the stress at which it failed or crumbled. In contract to water absorption, the compressive strength of the brick material decreased as a result of rice straw addition. From Figure 2, the resulting compressive strength ranges from 8.30 N/mm2 for 1.5 wt % rice straw amended brick to 3.95 N/mm2 for 10 wt % rice straw amended brick. In fact, 5% rice straw addition caused a 32% reduction in compressive strength compared to the reference specimen (with clay: rice straw ratio of 100:0) which is 8.68 N/mm.
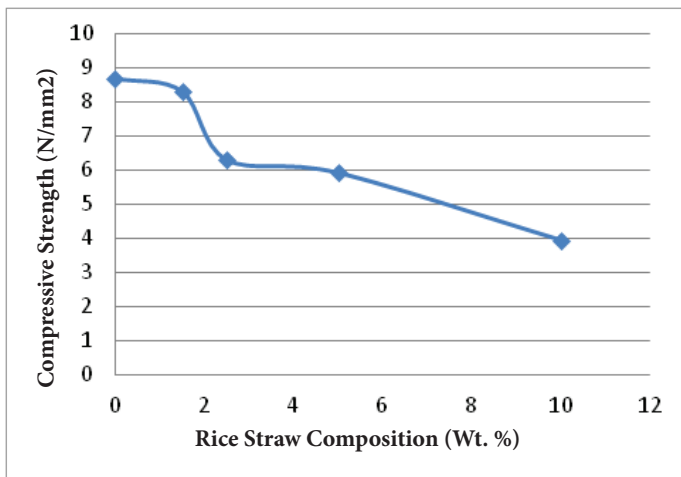

Figure 2: Effect of Rice Straw composition on Compressive Strength

Furthermore, by making comparison to the British standard BS 3921:1985 for compressive strength of brick, as shown in Table 2, the value obtained for compressive strength of 1.5, 2.5 and 5 wt. % were well above the standard compressive strength for the "Damp-proof course" and "All others" classes of brick, hence they can be utilize for normal brick application, however, the compressive strength for the 10 wt. % rice straw brick exceeded the limit

Table 2: Classification of Rice straw-Amended Clay bricks by compressive strength according to BS 3921:1985

Rice Straw Composition (Wt %)	Commpressive Strength (N/mm²)					Value obtained
	Engineering		Damp-proof course		All Others	
0						8.68
1.5	A	B	1	2		8.30
2.5						6.30
5	>70	>50	>5	>5	>5	5.92
10						3.95

Linear Shrinkage and Weight loss

Shrinkage during firing is unavoidable. In this study firing shrinkage increased with higher addition of sludge, similar finding was reported by Alleman [9]. Table 3 highlights the effect of rice straw addition on the properties of brick, the highest shrinkage occur for the 10 wt. % rice straw addition while the lowest is for the control specimen (0% rice straw composition). Fortunately, the firing shrinkage value obtained in this study for all the rice straw amended brick samples and the control specimen were quite below the acceptable shrinkage limit of between 6% and 8% [10].

The results from the analysis on weight loss highlighted that as the proportion of rice straw increase from 1.5 wt. % to 10 wt. % the percentage weight loss increased and was caused due to the burning of the organic matter present in the rice straw as a result of excessive firing at the high temperature of 900ºC. This findings was also confirmed from previous study conducted by other researcher utilizing other type of sludge that contained significant amount of organic contents [11]. Hence from an economical point of view the reduction in weight of the final brick production can resulted into a prosperous financial saving in terms of brick transportation cost.

Table 3: Effect of Sludge Addition on the properties of brick

Proportion of rice Straw added (wt. %)	Shrinkage on firing (%)	Weight loss due to firing (%)	Water absorption (wt. %)	Compressive Strength (Nmm2)
0	0.48	4.4	26.78	8.68
1.5	2.38	10.73	28.67	8.30
2.5	4.76	11.53	30.50	6.30
5	5.58	12.28	36.96	5.92
10	6.04	24.85	42.53	3.95

Appearance of the Rice Straw-Amended Clay Brick

Most of the rice straw supplemented brick simple were subjected to development of minor crack on the surface. The problem of cracking is an indication of an undesirable gas (such as steam and CO_2) evolution from the decomposition of organic matters present in the chemical constituents of the rice straw during firing.

From the esthetic point of view, the surface finishing of the brick body was quite less appealing due to the appearance of many pore spaces and effect of manual hand-moulding, thereby it can't be use as facing brick.

Conclusion

The results presented and discussed in this project showed that rice straw from agricultural activities can be used constitutively as a supplementary raw material in clay manufacturing at various proportion. This project study involved the utilization of rice straw in the proportions of 1.5 wt. %, 2.5 wt. %, 5 wt. % and 10 wt. % and then analysis of some important brick properties such as compressive strength, water absorption, linear shrinkage and weight loss. The result obtained from the analysis shows that the brick amended with 1.5 wt. %, 2.5 wt. %, and 5 wt. % of rice straw can be utilised as brick material according to British Standard (BS 3921:1985).

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Study of Cocoa Pod Husk / Polyvinyl Alcohol (PVA) as A New Biodegradable Composite Film

Fei-ling,Pua[1], Sapuan, S.M.[1], and Kumaran, A.[1]

[1] *Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, Selangor, Malaysia*
feilingpua@yahoo.com

ABSTRACT

This paper present the possibility for the use of cocoa pod husk in composite with poly(vinyl alcohol) (PVA). In this study, we preparad a new green composite film from cocoa pod husk (CPH) and poly(vinyl) alcohol (PVA) and to characterize the morphology and mechanical properties of the composite film. The effect of fiber loading, plasticizer (glycerol) and effect of alkaline treatment were investigated. Poly (vinyl acohol) (PVA) with 5, 10, 15wt% cocoa pod husk (CPH) powder were prepared by aqueous mixing. The mixture was casted as composite film prior characterizations. The effect of plasticizer (glycerol) was investigated in the study and it was found that the film showed some good mechanical properties with addition of glycerol and increasing fiber loading. The effect of alkaline treatment on fiber was investigated.

Keywords: *Cocoa pod husk; Poly (vinyl) alcohol; Biodegradable polymer; alkaline treatment; Composite*

INTRODUCTION

Nowadays, thermoplastic composites produced from synthetic polymers filled with renewable natural resources start to gain the attention from world as they are considered as one of the environmental friendly biomaterials. Most of the researches focus on the use or the potential of inexpensive polymeric raw materials such as cellulose, starch, cellulosic resources and other. It is predicted and expected the resulting products are eco friendly and cost effective. Those biodegradable materials can be completely degraded into our ecosystem [1-2]. Moreover, the application of biodegradable polymers and renewable agro wastes as packaging materials is one of the alternatives to solve the problem of solid waste from inert polymers. There are several of synthetic aliphatic polyesters and natural resources are being used as biodegradable materials [3-4]. According to [5-6], most of the organic materials have the natural tendency to decompose or degrade. In our current century, the needs of degradable disposable containers or packaging materials are high. More and more researches and investigations are now being applied to produce plastic materials high biodegradability by involves abundant agro wastes, plant carbon hydrates, vegetables oils and etc. in their countries respectively.

Polyvinyl alcohol (PVA)-starch blend plastics are one of the most popular of the biodegradable plastics, and are widely used in packaging and agricultural mulch films [7-8]. However, according to [7,9], an amylose-PVA composite (PVA-starch blend) was biodegraded slower which was ~75% weight loss required 300 days in a degradation test with activated sludge [3]. PVA is non-toxic, water soluble, highly polar and synthetic polymer which has been used vastly in biomaterial technology. It has excellent film forming, emulsifying and adhesion properties. Degree of hydrolysis can affect properties of PVA and its film quality [10].

Cocoa pod husk (CPH) is a by product of the cocoa harvesting industry whereby it forms about 80% of the cocoa fruit and it is a waste product which can be utilized fully [11]. Besides, it can be used as filler in biodegradable mulch films as the high cellulose fiber content of CPH will provide reinforcing effect in the mulch films [12]. Besides that, the use of CPH as fertilizer can increase the soil macronutrients content because of high Na, P, K, Mg and Ca concentrations of CPH when it degrade in the soil [13]. Natural fibers with good biocompatibility, which can act as green filler in composites have gained interest to replace synthetic fiber. Natural fibers in composites are low cost, good thermal and low density. Combination of natural fiber and biopolymers where both are derived from natural has the potential to provide materials with enhanced mechanical properties. At present time, many studies have investigated the biodegradable polymers filled with natural fibres [14].

In this study, we present the preparation of a new green composite film from cocoa pod husk (CPH) and poly (vinyl) alcohol (PVA) and to characterize the composite film. The effect of chemical modification, fiber loading and effect of plasticizer (glycerol) were investigated. Tensile properties and functional groups of this new composite film were studied. Biodegradability of the films was studied via soil burial test.

EXPERIMENTAL
Materials

Poly (vinyl alcohol) (PVA) and glycerol used were supplied by Innovative Pultrusion Sdn.Bhd, Negeri Sembilan. Cocoa pod husk (CPH) was collected from a rural cocoa farm located in Kluang, Johor Darul Takzim, Malaysia. The collected CPH was dried under sun for one week after collected from the farm. Sun-dried CPH is crushed into smaller pieces of cocoa pod husk for easier processing via strong plastic crusher. Then, crushed CPH was oven-dried in Memmert model oven at 80°C for 24 hours to remove all the moisture and kills living bacteria or microorganism in the cocoa pod husk. Oven-dried CPH was pulverized and sieved into 250 μm.

Alkalisation of Cocoa Pod Husk Powder

The CPH powder was treated with alkaline solution to remove the impurities , waxy substances and lignin covering the surface of the fibers. CPH powder was mixed with 5 wt% aqueous solution of sodium hydroxide (NaOH) and stirred for 24 hours, rinsed , and washed with distilled wáter until the wáter becomes neutral. After washed and filtred, chemically treated CPH powder was oven-dried at 105°C for further use.

Preparation of Composite

The calculated amounts of CPH aggregate suspension was added to 10 wt% PVA solutions and stirred at room temperature with magnetic stirrer. The mixtures were homogenized in water bath via magnetic stirrer at 70-80°C for ~45-60 minutes. Glycerol was used as plasticizer in the experiments. Glycerol was added and the mixtures were stirred at 80°C until got a homogenous mixture. Mixture was distributed into glass plate. Each solution was dried at ~45°C for 24 hours to form the desired films. According to [4], complete drying was avoided because the composite film required some moisture to remain flexible and to avoid any cracking on the film surface. The formed films were then peeled off carefully from the glass plates and placed into sealed containers to avoid any moisture exchange.

Characterizations

Moisture content of the CPH powder and composite film were determined by drying the film in an oven at 60°C for 24 hours. American Standards Testing and Machine (ASTM), D638 was used to carry out mechanical testing on each sample. ASTM D638 was used to determine the tensile properties of unreinforced and reinforced plastics in dumbbell shape of specimens. The samples were cut according to the specification size to be tested on the mechanical properties. Tensile strength (TS) and elongation at break (%E) were evaluated for each sample using the INSTRON 3365 testing machine. Fourier transform infrared studies of the samples were performed with a Perkin Elmer spectrometer. The samples were prepared in transparent film for analysis by FTIR spectroscopy. Soil burial test for the composite film deterioration in soil was conducted by referred to the similar test on composite film in previous studies [2,15,16]. The small pieces of film (2 x 2 cm) was cut and completely covered by the test soil from all sides. The soils were exposed to atmospheric conditions for 7 and 15 days. After the soil test period, the samples were removed, washed with distilled water and dried to their constant weight in oven. The weight of the samples before and after soil burial test was recorded.

RESULTS AND DISCUSSIONS
Moisture content

Table 1 shows the moisture content of the composite films after oven dry for 24 hours. It found that the moisture content of composite film increase significantly after the addition of glycerol. The composite film made from 10wt% PVA solution without any fibres achieved 6.60% moisture content, however moisture content of composite film increased after the addition of plasticizer. Glycerol has strong hydrophilic character, it is expected the film with glycerol has higher moisture content with those without addition of glycerol.

Table 1 Moisture Content of NaOH Treated CPH/PVA Composite Film

CPH Loading	Moisture	Content (%)
	Content (%)	With Glycerol
0%	6.60	26.37
5%	3.40	12.31
10%	5.94	11.86
15%	8.11	11.72

Tensile properties

Tensile properties were measured for the CPH/PVA composite film containing 5, 10, and 15 wt% of CPH powder. The results of tensile properties (elongation rate, tensile strength) are shown in Figure 1 and 2. Figure 1 shows the effect of fibre medication on the percentage of elongation on composite film. The overall composite films made from NaOH modified CPH achieved higher percentage of elongation. The composite film prepared from 5wt% NaOH-modified CPH powder plasticized with glycerol exhibited the greater percentage of ~864% , which may be due to better cross linking between modified CPH powder and glycerol. Figure 2 shows the tensile strength of alkaline treated CPH/PVA film with and without addition of plasticizer. From Figure 2, tensile strength was decreasing gradually with the increasing fibre loading. It might due to the inability of fibre and the irregularity shape of fibre to support stress which moved from the polymer to fibre. Besides, the decrease of tensile strength also might due to the bubble formation which results in weal interfacial adhesion. The existence of partially spaces between fibre and polymer will results in weak structure of the composite film [3].
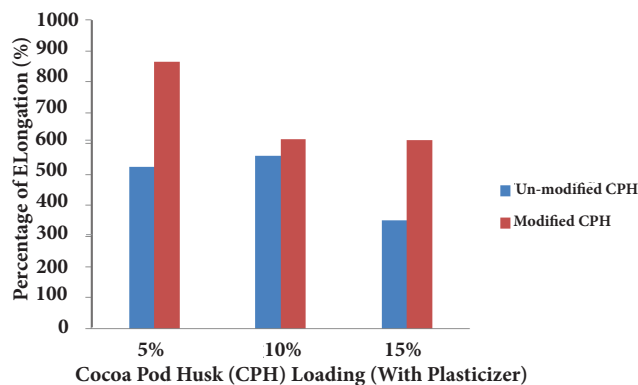

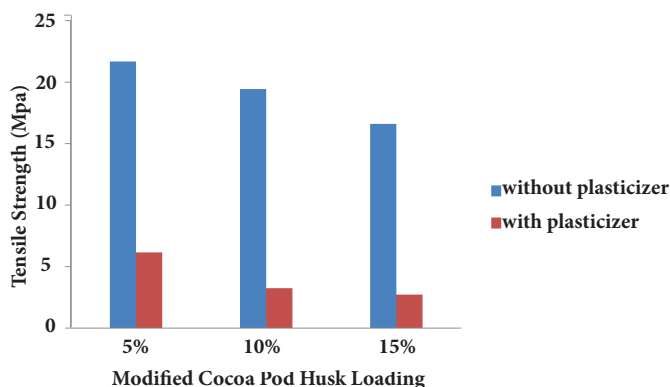**Figure 1:** Elongation Percentage of CPH/PVA film (modified & unmodified CPH)

Figure 2: Tensile Strength of Alkaline Treated CPH/PVA film (with & without plasticizer)

FTIR analysis

The FTIR spectrum for 15 wt% NaOH modified CPH/PVA composite film after plasticized with glycerol. The spectrum exhibited a broad peak at around ~3677 -3100 cm-1 which can assigned to hydrogen bonded O-H group or due to –OH stretching. The peaks between ~2700

cm^{-1} and 2900 cm^{-1} corresponded to C-H stretching. The absorptions near ~1250 to 1300 cm^{-1} maybe due to the carboxylic acids and its derivatives which may corresponded to the organic components from cocoa pod husk fibres.

Soil burial test

Biodegradability of the composite was studied by soil burial test. It revealed that the CPH/PVA composite films are biodegradable in nature environment. It achieved the highest ~53.77% reduction after 15 days exposed to environmental condition. The size of composite films had significantly diminished after 7-15 days of exposure in soil as shown in Figure 5 and 6. The films appeared in fragile and brittle after soil burial test. The degradation of composite film was examined by measuring its weight loss which can refers to the erosion of molecules from solid phase [2]. From Figue 4, it is clear that samples with higher fibre loading had the higher weight changes after both 7 and 15 days. This may due to the higher filler loading than the polymer content make it easier to degrade in soil. However, the weight changes were probably undersestimated as there was some soil debris strongly adhered to the film surface which unable to rinse off. Meanwhile, Table 2 presented the effect of fibre modification on the degradation rate of composite film. It founds that the film formed by modified CPH fibre has a better weight changes compare with the film withou any chemical modification.
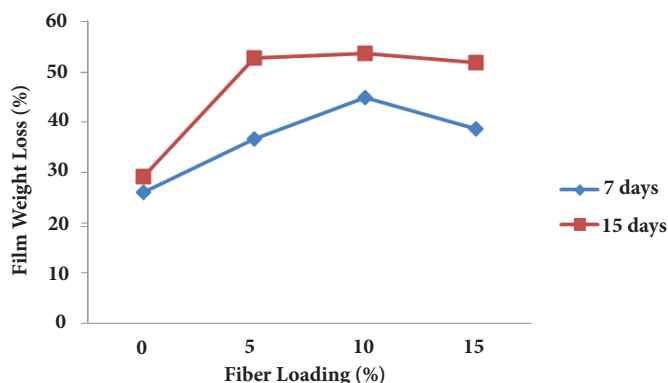

Figure 3: Film Weight Loss (%) of Modified CPH/PVA Films After 7 & 15 Days Soil Burial Test

Table 2 Effect of NaOH Fibre Modification on Biodegradability of Films

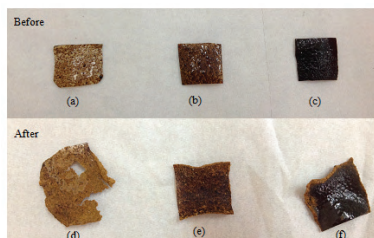| CPH Loading(%)	Weight Loss After 15 Days (%)	
	Without Modification	NaOH Modification
5	30.46	52.86
10	35.93	53.77
15	33.62	51.81

Figure 4: Modified CPH/PVA composite films after soil burial test for 7 days: Before test (a) 5% CPH, with glycerol; (b) 10% CPH, with glycerol; (c) 15% CPH, with glycerol; After test (d) 5% CPH, with glycerol; (e) 5%CPH, with glycerol; (f) 10% CPH, with glycerol
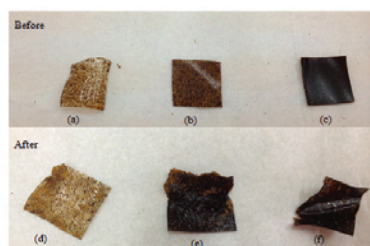

Figure 5: Modified CPH/PVA composite films after soil burial test for 15 days: Before test (a) 5% CPH, with glycerol; (b) 10% CPH, with glycerol; (c) 15% CPH, with glycerol;

After test (d) 5% CPH, with glycerol; (e) 5%CPH, with glycerol; (f) 10% CPH, with glycerol.

CONCLUSIONS

A simple route to study the potential uses of the waste cocoa pod husk from cocoa form was carried out. Composite film prepared from 5 wt% CPH powder plasticized with 10wt% glycerol achieved the excellent elongation percentage. However, the overall tensile strength of the composite films decreased after addition of glycerol. Weight loss after soil burial test revealed that the potential of CPH/PVA composite film to degrade in nature environmental condition. The basic advantage of this product is its good elongation for packaging purpose and its biodegradability which can ensures a safe disposal of waste plastic to our environment.

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Extending the Service Life of Crude Oil Export Line using PIPEASSURE™ Composite Overwrap Repair System

M.A. Nurnisham[1*]

[1] M.A Nurnisham (Field Engineer, Pipeline Division, Innovative Oilfield Services, Bangi, Malaysia)
*nurnisham@iossb.com.my

ABSTRACT

Corrosion failure of steel pipelines has become highly expensive maintenance in oil & gas industry. Many of the structures affected are those in marine environments, and some are even critical lines. Fibre reinforced composite wrapping is one of the most cost-effective solution for corrosion prevention in high humidity atmosphere. One such case is discussed here which consist of the installation of PIPEASSURE™, a novel epoxy-glass fibre composite wrapping to provide corrosion barrier and strengthening of a 30" carbon steel crude oil export line situated directly across a river. From the data collected during site assessment, the remaining strength of the pipeline was calculated to be less than 1 year using ASME B31.G manual. Subsequently, ISO TS 24817 was used as the basis for engineering design of the live repair for a design life of 5 years. After 3 days of curing, post installation inspection reveals no discontinuities on the repair when holiday test was conducted. Hardness test result was found to be satisfactory and comply with client's acceptance criteria. The successful rehabilitation of the pipeline using PIPEASSURE™ helped the client avoid costly shut down if the pipeline is to be cut and replaced.

Keywords: *PipeAssure, corrosion failure, live repair, composite wrapping, integrity*

INTRODUCTION

Pipeline is the lifeline of oil & gas industry. Any pipeline or piping failure is definitely a nightmare for oil & gas operators. Such failure might cause massive losses to operating company in terms of people, environment, asset and also reputation. Hence, operator will be on constant alert to avoid facing a loss of containment incident. Maintenance cost for pipelines can be costly however as saying goes 'prevention is better than cure', the cost of failure will definitely dwarf that of maintenance(1). As such, operators must balance between tight maintenance budget with pipeline integrity and ultimately flow assurance.

There are multiple approaches for a successful pipeline repair whether it is leak repair, strengthening or simply corrosion protection. Total replacement via cut-and-replace provides permanent solution; however it requires costly shutdown and loss of production besides having to deal with hot-work. Mechanical steel split sleeve provides best structural reinforcement however its deployment can be very slow due to long lead time for fabrication and expensive installation cost especially in offshore. Among others, composite wrapping provides the best of almost every aspect due being cost effective and fast deployment. In most cases, live repair can be done without having to shut down the line under repair.

PIPEASSURE™ COMPOSITE OVERWRAP REPAIR SYSTEM

PIPEASSURE™ is a novel pre-impregnated composite resin system for pipeline repairs, both onshore and offshore.The system was jointly developed by PETRONAS Research SdnBhd (PRSB) from Malaysia and Commonwealth Scientific and Industrial Research Organisation (CSIRO) based in Melbourne. It consists of "E-Glass fibre" pre-impregnated with a proprietary underwater epoxy resin formulation. The glass fibre content enables cheaper repairssince glass fibre is cheaper than carbon fibre, despite losing out in terms of strength and stiffness of fibre(2). The resin is designed to be hydrophobic, which keeps moisture away from bare metal thus providing effective corrosion protection and pipe reinforcement properties. Controlled manufacturing process gives the system very homogenous fibre to matrix ratio as compared to wet lay-up system. This in turn provides superior mechanical interlocking and adhesion strength, both in lap shear and transverse direction.

Unlike other competing products, PIPEASSURE™ is curable underwater and is capable of withstanding wet environments without loss of adhesion and mechanical properties. The system was designed to perform in accordance to two international standards; ISO TS 24817 and ASME PCC-2 making it suitable for almost all sorts of repair in the oil & gas industry.

Innovative Oilfield Services SdnBhd (IOSSB) signed a commercialisation agreement with PETRONAS Technology Ventures SdnBhd (PTVSB), the technology commercialisation arm of PETRONAS. IOSSB as the licensee was appointed the official applicator for PIPEASSURE™. Till date, IOSSB has successfully completed numerous pipeline and piping rehabilitation works in various oil & gas facilities, both onshore and offshore.

CASE STUDY: 30" CARBON STEEL CRUDE OIL EXPORT LINE REHABILITATION

One such case of PIPEASSURE™ application is discussed in this paper. IOSSB was invited to provide corrosion barrier and strengthening maintenance work on 30" crude oil export line in Miri, East Malaysia. This particular line is very critical to our client's operation since crude oil will be exported from the terminal via this line during single buoy mooring (SBM) loading to tanker. During peak loading, the line transports up to 130,000 barrels of oil per day, making it also critical to client's coffer.

Defect Assessment

The pipeline is located in a swampy region alongside Miri coastal land, right behind the process area of the terminal. A section of the 2 km long pipeline is located directly across the Lutong River. This section will be partially submerged during high tide and at times exposed to impact from logs. Latest inspection report reveals severe external corrosion due to high humidity with multiple pittings and gorges. Some areas of the pipe possess serious integrity issues with wall loss up to 70% from the original wall thickness. This led to the service request by the client to avoid any catastrophic failure. Summary of the defect assessment is as per Table 1 below.

Table 1: Summary of Defect Assessment

Pipe Material	Pipe size (inch)	Nominal Wall Thickness (mm)	Minimum wall thickness (mm)	Maximum defect depth [mm]	Length of repair [m]
API 5L X52	30	12.7	4.0	8.7	4.0

Design Calculation

Based on the site assessment and inspection report, IOSSB recommended PIPEASSURE™ as the solution for this repair due to its superior mechanical properties, cost effectiveness and fast deployment. The idea behind pipeline strengthening is to restore the integrity and pressure containment capacity of the pipe to that of its design.As a start, ASME B31G-2009was used to determine of remaining strength of the pipeline(3). Based on the rate of corrosion and corrosion allowance, the remaining life was found to be less than a year. The result was used as input for ISO TS 24817 to determine the minimum laminate thickness, tmin required for this particular repair as given by Eq. 1 below(4).

$$t_{min} = \frac{D}{2_s} \cdot \left(\frac{E_s}{E_C} \right) \cdot \left(P_{eq} - P_s \right) \qquad \ldots\ldots\ldots(Eq.1)$$

where

D	= external diameter [mm]
s	= remaining pressure capacity of pipe [MPa]
E_c	= circumferential modulus of PIPEASSURE™ = 15400 [MPa]
E_s	= modulus of substrate[MPa]
p_{eq}	= equivalent internal pressure [MPa]
p_s	= maximum allowable operating pressure, MAWP [MPa]

As a minimum, the repair was engineered for a design life of 5 years since the pipeline is scheduled to be decommissioned and replaced in year 2016.The required number of layers can be easily calculated by dividing t_{min} with the ply thickness of PIPEASSURE™, t which is roughly 0.8mm. Since the wrapping will be done spirally with 50% overlap,one

wrap is equivalent to two layers. The required wrap angle and length of each wrap, L_w i.e. length of PIPEASSURE™ material required for one complete wrap is calculated using Eq. 2 and Eq. 3 respectively(5).

$$\tan\theta=(2\pi)\,(D/w) \qquad\qquad ....(Eq.1)$$

$$L_w= \frac{L}{\cos\theta} +2\,\pi\,(D+4nt)\cos\theta \qquad ....(Eq.2)$$

where

θ	= wrap angle [°]
w	= width of PIPEASSURE™ tape = 300 [mm]
L	= length of repair [mm]

Summary of the design calculation is tabulated in Table 2 below.

Table 2: Summary of Design Calculation

Design pressure [bar]	Design temperature [°C]	Minimum laminate thickness [mm]	No of wraps	Length of wrap [m]	Wrap angle [°]	No of rolls
44.1	43	9.6	6	68.0	86.4	20

Installation Procedure

Since PIPEASSURE™ is a pre-pregsystem; it can be applied much faster than wet lay-up system which requires time consuming field impregnation prior to application. The frozen roll of PIPEASSURE™ is left to thaw for few hours while preparation work was done. Once soft, the PIPEASSURE™ tape must be prepared for wrapping by first cutting the tape to Lw and tapering the ends. The taper length is double the circumference of the pipe.

The system is designed best to work when applied to bare metal, thus the pipeline section to be wrapped was grit blasted up to SA 2.5. The surface was then cleaned using acetone as per SSPC-SP1 requirement to remove any impurities prior to application of metal recovery compound (MRC). The load transfer material was used to fill up any wall loss and make up the surface profileof the pipe. The fast acting MRC cured in approximately 5 minutes, after which rough surfaces weresmoothen out using sand papers. The prepared surface was then coated with base coat of primer. The PR25 primer comes in two components, epoxide base (Part A) and polyamine hardener (Part B). Both parts were mixed with ratio of 100:17 and mixed portion has a pot life of roughly 45 minutes. The primer was then applied on the bare metal surface of the pipe using roller brush.

To begin wrapping, the tapered end of the tape was aligned at the edge of repair zone perpendicular to the pipe's axial direction. A 50% overlap was maintained at all times as the material was spiralled upwards in clockwise direction. Iron roller was used to squeeze out any air bubbles in between layers. Whenever one roll of PIPEASSURE™ was exhausted during a wrap, another roll was used to continue the wrap using butt joint, by overlapping the tape by 2 inches. The first wrap terminates at the opposite edge of the repair zone. Subsequent wraps were applied by repeating the same steps with alternating wraps beginning at opposite edge of the repair zone.

Once all six wraps were completed, final coat of primer was applied thoroughly on top of the PIPEASSURE™ wrappings especially along the edges of the wrap to avoid any water ingress. Finally, cling film was wrapped along the length of repair to avoid any contamination and to ensure proper curing.

Post Installation Inspection

After 3 days of curing, the site was revisited for post installation inspection, which covers general visual inspection, Holiday test and Shore D hardness test. The wrapping was visually inspected for any delamination or disbondment of layers after removing the cling wrap. Holiday testreveal no discontinuities and result was found to be satisfactory in accordance to NACE RP0188-99 requirements i.e. no void, leak or pinhole. Shore D hardness test was conducted to measure the degree of curing. The measurement was taken at 3 locations along

the length of repairs and 4 readings at cardinal clock position at each location. The acceptance criterion for the test is 70 Shore D units. Result as per Table 3 below.

Area	Right Edge	Middle	Left Edge
12 o'clock	74	75	78
3 o'clock	78	72	77
6 o'clock	70	68	71
9 o'clock	78	78	75

CONCLUSION

Overall, the successful rehabilitation of the pipeline has further increased the client's satisfaction and trust on PIPEASSURE™ as composite wrapping of choice. The system may not be the right repair option every time but it is a viable solution for pipeline rehabilitation especially during live repairs when operators can't afford costly shutdown.PIPEASSURE™ technical capabilities such as curable in wet condition and superior adhesion strength gives the system competitive advantage over other competitors in the market. Being a cost effective solution compared to other alternative repair method, PIPEASSURE™ has great prospect to convince operators especially those with tight maintenance budget.

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Composite Polymer Electrolytes Based on MG49 and Cellulose from Kenaf as Reinforcing Filler

J. Serawati [1], A. Ishak[1*], A. Azizan[1], Z. Siti Yasmine [1] & H. Kargarzadeh[1]

[1] *School of Chemical Science and Food Technology, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor Darul Ehsan, Malaysia*
*Corresponding Author: gading@ukm.my

ABSTRACT

The aim of this project is to explore the possibility of using celluose from biomass such as kenaf in solid polymer electrolyte in order to increase the mechanical performances at the same time maintaining its ionic conductivity. Lithium-conducting composite polymer electrolytes based 49% poly (methyl methacrylate) grafted natural rubber (MG49) were prepared from cellulose which was extracted from kenaf fiber and lithium triflate salt by solution casting. Prior to that kenaf fibers undergo several treatments (alkali, bleaching) in order to yield the white cellulose. White cellulose then treat with silane to decrease hydrophilic nature of CF which was then used as reinforcing filler in the composites polymer electrolytes. High performance composite electrolytes based on cellulose were prepared with various composition of filler (0-10 wt%). Field emission scanning electron microscopy (FESEM) were used for morphology studies of kenaf fiber for each stage of treatments. The films were analyzed by electrochemical impedance spectroscopy (EIS). Ionic conductivity measurement showed that the addition of various wt% of cellulose give a weak decrease of conductivity with respect to unfilled polymer electrolytes. The effect of different cellulose content of composite polymer electrolytes on mechanical properties was evaluated through tensile modulus test. Result showed that the composite electrolytes with 4 wt% cellulose exhibited high mechanical performance.

Keywords: *Composite Polymer Electrolytes, Kenaf, Cellulose, Ionic Conductivity, Mechanical Properties*

INTRODUCTION

Natural fibers, as reinforcing elements in polymer composites, offer several advantages over conventional reinforcing materials such as glass fibers. Due to their low tool wear, low density, cheaper cost, availability, and biodegradability, cellulose serves as promising candidates for the preparation of biocomposites [1]. A potential characteristic of cellulose fiber (CF) in the composite fibers made CF has broad range applications such as filler in the preparation of polymer electrolyte composite. Solid polymer electrolyte (SPE) was used as ion-carriers in secondary batteries lithium polymer. SPE have grabbed attention many researchers because the potential of SPE as rechargeable batteries, fuel cells, light-emitting fuels, and many other applications in electrochemistry [2]. One of main advantages of SPE was free solvent which have possibility to reduce electrolytes thickness and result in decreases internal resistance of the battery at the same time maintaining conductivity [3]. The main objective in polymer research is to develop polymer systems with high ionic conductivity with the encouraging mechanical properties. The good interactions between CF/MG49 provide better final properties of composite polymer electrolyte.

Moreover, polymer electrolytes must be exhibit, in addition to high conductivity and wide electrochemical stability, high thermal and mechanical performances for safety and performances reasons. Since the original work of Weston and Steel (1982) that use α-Al_2O_2 as inorganic filler in polymer electrolytes, the understanding of impact of filler in the polymer electrolytes have been extensively studied. Recent year, research on the use of cellulosic resources as filler in the SPE has grown rapidly. In addition, these fibers showed better thermal properties that make it suitable to be used as filler in the composite polymer electrolytes [4].

Kenaf (*Hibiscus cannabinus*) is a plant that belongs to the Malvaceae family and grows commercially in many places worldwide. The fibers derived from the outer fibrous bark, which are also known as bast fibers, have cellulose contents ranging from 30% to 63%, making them a good source for cellulose extraction [5]. Furthermore, the use of kenaf or lignocelluloses fiber as organic filler is a wise step in replacing inorganic filler because it is cheap, easily available, the resources are not limited to, improving the mechanical properties of composites and is not harmful to health.

The aim of this project is to explore the possibility of using cellulose from kenaf in modified natural rubber (NR) based SPE in order to improve the mechanical performances at the same time maintaining its ionic conductivity. Extractions of cellulose from kenaf undergo several treatments which are alkali and bleaching treatment. Treatment CF with silane decrease its hydrophilic to make sure it compatible with matrix which is MG49 that more hydrophobic [1]. So it can interact well in matrix in preparation SPE. Morphology analysis was evaluated to see the effect of different stages of kenaf fiber treatment. The effects of different filler contain on mechanical performances and conductivity was investigated.

EXPERIMENTAL

Materials

Kenaf fiber was provided by Kenaf Fiber Industry Sdn. Bhd. (Malaysia). Sulphuric acid (98%), sodium hydroxide (99%), sodium chlorite (80%) and acetic acid glacial (99.5%) were purchased from SYSTERM-chemAR (Malaysia) and Sigma-Aldrich (Germany). All the chemicals were used without purification. MG49 was commercially obtained. Lithium triflate ($LiCF_3SO_3$) salt were supplied by Fluka.

Preparation of cellulose from kenaf

Preparation of white cellulose consisting two steps, the first step was alkali treatment and followed by bleaching process according to Kargarzadeh et al. [5]. Prior to that, kenaf fibers were cut into small pieces. Briefly, kenaf fiber was treated with 4%wt NaOH solution in round bottom flask under mechanical stirring at 80°C 3 h. Reflux process was conducted three times and it was then filtered several times using distilled water to remove alkali component. 5% (w/v) of fiber was undergoing bleaching treatment 4 times with 1.7% (w/v) of sodium chlorite solution and acetic buffer at 80°C under mechanical stirring for 4 hours. The extracted cellulose and was allowed to cool and then filtered using excess distilled water and air dried [5]. Finally, the cellulose was soaked in 5% concentration of silane for 1 h, filtered using distilled water and then dried at room temperature.

SPE Film processing

All polymer electrolytes samples were prepared by the solution casting method [2, 6]. MG49 rubber was sliced into grain size and then was dissolved in conical flasks containing THF. After 24 h, the solution was stirred with magnetic stirring for the next 24 h until complete dissolution of MG49 into clear viscous solution. 20 % wt $LiCF_3SO_3$ salt was stirred in THF solution for 12 h and it was added to the MG49 solutions for the next 24 h with continuous stirring. White cellulose was dissolved in THF after undergoes solvent exchange (cellulose suspension, acetone, THF). THF suspension of cellulose was added to the MG49/salt in conical flask with continuous stirring for 24 h to obtain a homogeneous solution. The electrolyte solutions were cast onto a glass petry dish and the solvent was allowed to slowly evaporate in a fume hood at room temperature. Resulting films were dried under vacuum oven for 24 h at 50°C to remove remaining solvents. The samples were then stored in desiccators for further use [6].

Characterization

The morphology of the fibers after each treatment was investigated using a Zeiss Supra 55VP field emission scanning electron microscope (FESEM) with a magnification of 400×. All samples were sputter-coated with gold before observation to prevent charging.

The ionic conductivity measurements were carried out by EIS using a high frequency resonance analyzer (HFRA) model 1255 with applied frequencies from 1MHz to 0.1 Hz at a perturbation voltage of 1000mV. All experiments were conducted at room temperature [1]. The ionic conductivity [σ] was calculated according to the equation

$$\sigma = [l/ (A.Rb)] \qquad …………. (Eq.1)[6]$$

The bulk resistance [Rb] was obtained from the intercept on the real

impedance axis (Z-axis), the film thickness [l] and the contact area of the thin film [A = πr2 = π (0.80 cm^2]^2 = 2.01 cm^2].

Mechanical performance of the films was evaluated with universal testing machine (Instron model 5566, USA) at room temperature according to ASTM D882. A crosshead speed of 50 mm/min, initial grip distance of 40 mm and load cell of 50 N were used to perform this test. The samples were cut into a dumbbell shape and average value of 7 replicates for each sample was taken.

RESULT AND DISCUSSION

Morphology Studies

Figure 1 presents field emission scanning electron microscope (FESEM) of kenaf fiber after different stages of treatment. Raw fiber (Figure 1a) had a rough surface with impurities and contains by cellulose, hemicellulose, pectin, lignin, and other chemical composition. However, after alkali treatment (Figure 1b) the surface become less rough. The important modification that was done by alkaline treatment was the disruption of hydrogen bonding in the network structure. From the observation, almost all impurities have been removed from the fiber surface which induced the separation of fiber bundles into individual fibers [5].This treatment removes certain hemicelluloses, lignin, wax and oils covering the external surface of the fiber cell wall, depolymerizes cellulose, and exposes the short length crystallites [2,8,1]. As for kenaf fibers after bleaching, more significant physical change on the fibril surface can be observed (Figure 1c). Fiber has decomposed to the individual microfibril which is caused by the removal of most of the remaining lignin fiber. In other words, this treatment reduces fiber diameter and thereby increases aspect ratio[1].
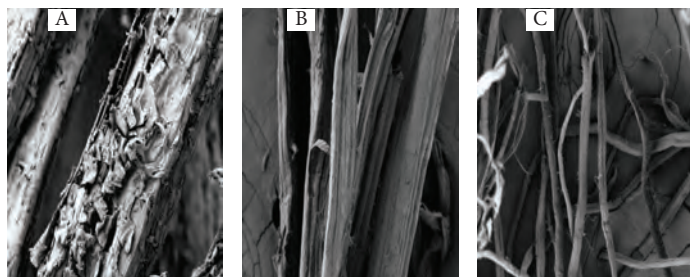
Figure 1: Micrograph FESEM for kenaf fiber a) Raw b) Alkali treatment c) Bleaching

Ionic Conductivity

As can be seen from Table 1, the introduction of cellulose only had a modest influence on the ionic conductivity of the composite. The conductivity of the composite was reduced from 1.2×10^{-7} to 5.4×10^{-8} upon introduction of 2% wt of cellulose fiber. However, the values of ionic conductivity in the composites remain higher with respect to unfilled SPE. A decrease of the ionic conductivity with the addition of tunicin whiskers in PEO based electrolytes was also observed by Azizi et al. [3]. The different in conductivity observed between filled and unfilled composite may be due to the existence of interactions between cellulose and MG49 or lithium salt [7]. Nevertheless, interactions between anions and surface hydroxyl groups of CF via hydrogen bonding lead to decrease the mobility of former [3]. The highest conductivity for filled polymer electrolytes obtained with 2 % wt of CF which is 5.4×10^{-8} Scm^{-1}compared others. This may due to the increasing of CF content result in increasing crystallization kinetic presence of CF, which undergoes crystallization process and reduce the mobility of lithium ion.

Table 1: Ionic conductivity of SPE MG49-LiCF3SO3/Cellulose

Cellulose content, wt%	Conductivity ,σ [Scm^{-1}]
0	1.2×10^{-7}
2	5.4×10^{-8}
4	4.8×10^{-8}
6	1.4×10^{-8}
8	7.5×10^{-9}
10	9.6×10^{-9}

Mechanical Properties

Tensile strength of SPE was determined and the results are plotted in Figure 2. As shown in Figure 2a, the tensile strength increased with cellulose loading with the optimum fiber loading at 4% due to effective interaction between CF/MG49/salt. This is explained by the increase of uniformity that contributes to the increase in strength, due to the removal of the impurities. The formation of a rigid percolating cellulose fiber network also assumed to be formed through strong hydrogen bonds interactions in cellulose fiber [3]. It is reported that alkaline resulting in better mechanical interlocking, and then increases the amount of cellulose exposed on the fiber surface. Thus the number of possible reaction sites was increase and has effect on the mechanical behavior of natural fibers [1]. From Figure 2b, the Young's Modulus also highest in 4 % cellulose loading and the value (995 MPa) was much higher than unfilled SPE (380 MPa). Generally, optimum tensile properties and Young's modulus are dictated by the volume of reinforcing fiber used for the composites [10]. However, when the percentage of CF further increased up to 6-10% the SPE tensile strength and Young's Modulus tends to stabilize. Rigidity of this network depends on the concentration of filler with respect to the interaction of filler/filler through the hydrogen bonding [9]. Addition of salt was induces the CF flocculation demonstrating the main role of the electrostatic interaction between cellulose and result in a loss homogeneity of the cellulose dispersion. Non uniform distribution of cellulose in the matrix, induces agglomeration hence restrict filler reinforcement within a polymeric matrix [9]. Therefore, the mechanical behavior of SPE will decrease for 6-10% wt of CF.
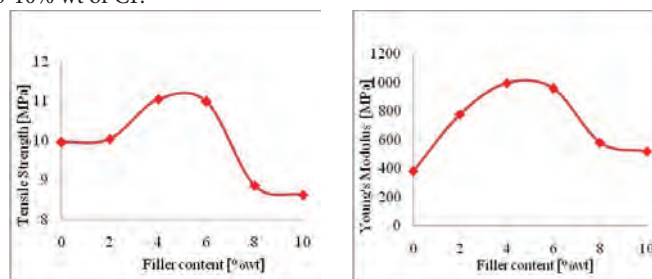

Figure 2: a) Tensile Strength b) Young's Modulus for SPE

Conclusion

Composite polymer electrolytes have been prepared using MG49, LICF3SO3 and cellulose from kenaf fiber. Alkali and bleaching treatment of kenaf fiber showed significant physical changes to the fiber. The effect of cellulose loading was investigated by EIS and mechanical test. The presence of cellulose fiber induces weak decrease of polymer electrolytes conductivity due to the interaction between cellulose and MG49 or salt. Cellulose fiber as reinforcing filler for SPE leads to improve the mechanical strength for SPE prepared even small percentage of CF was added.
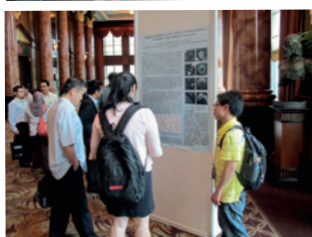
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CORROSION COURSES
- Corrosion Control By Cathodic Protection   2
- Cathodic Protection Technologist   4
- Corrosion Technician   4

VIBRATION SPECIALISTS
- Level 1 - 4

COURSES AVAILABLE UPON REQUEST
- Blasting & Painting Course   5
- Welding – SMAW, GMAW, GTAW (1G - 6G)   5
- API-570 Piping Inspector
- API-510 Pressure Vessel Inspector
- API-653 Above Storage Tank Inspector
- Microbiologically Influenced Corrosion (MIC)   2
- Management of MIC   1
- Welding and Joining Technology for Non Welding
- Personnel   1

MTE **PRIMOS**

MATERIALS TECHNOLOGY EDUCATION
No. 10-1, Jalan Bandar 3, Pusat Bandar Puchong,
47160 Puchong, Selangor
Tel : 03-5882 3574/3584 Fax : 03-5882 3524
website : www.mte.com.my
Email: info@mte.com.my

AWF COMMON WELDER CERTIFICATION SCHEME

INSTITUTE OF MATERIALS MALAYSIA

AWF

The Asian Welding Federation (AWF) Common Welder Certification Scheme (CWCS) is based on the ISO-9606-1 International Standard for qualification testing of welders.

OBJECTIVES

The AWF-CWCS was developed by the welding societies of Japan, Singapore, S. Korea, China, Indonesia, Malaysia, Thailand, Philippines, and India since 2002 with the objective to standardize and harmonize the welding practices throughout Asia

SCOPE

Most oil & gas and petrochemical construction and fabrication works in Asia have been subjected to interpretation of many different welding codes and practices. This has led to many quality issues and performance concerns by many oil & gas companies operating in Asia. ISO-9606-1 harmonizes all the existing welding codes and practices into a single standard for low carbon steels. The Asian Welding Federation identified the need to engage all parties within Asian countries to adopt a Common Welder Certification Scheme. To ensure consistency of quality welding, welders in Asia will be required to be registered and monitored under the AWF-CWCS scheme. A Registration and Monitoring Software was developed to manage the scheme with internet-based capabilities. The software is called the Manpower Optimization System (MOS).

In each Asian country, the AWF appoints an Authorized Certification Body (ACB) to oversee and manage the AWF-CWCS scheme.

AWF has appointed the Institute of Materials, Malaysia (IMM) as the ACB to manage the AWF-CWCS scheme and the Manpower Optimization System (MOS) in Malaysia.

Certification of the welders shall be valid for five (5) years during which time the welder shall not lapse more than six (6) months without work or re-certification will be required. During active work within the 5 years, welders will not be required to re-qualify or recertify when working within the oil & gas industry in Malaysia provided their records are regularly monitored by a registered Welding Inspector and updated on the MOS register. It is the intention of the AWF to eventually allow cross-border acceptance of the AWF-CWCS scheme throughout the Asian Countries.

REQUIREMENTS

All Welding Testing Centres, Welding Training Centres, Welding Inspectors, Welding Contractors and Freelance Welders shall register with the ACB in Malaysia and be given a password to enter the MOS website. Oil & Gas Operators are encouraged to subscribe to MOS to be able to view the records of the welders, welding contractors, testing centres, training centres, and welding inspectors, to monitor their work performance.

Welding Testing Centres and Welding Training Centres shall be audited by AWF officials before acceptance for registration. Once audited and approved, they shall be known as " Authorized Test Centres (ATC) " and " Authorized Training Bodies (ATB) ".

MOS registration rates:-

- Welder - RM 120 per year
- Welding Inspectors - RM 150 per year
- Welding Contractor - RM 600 per year
- Authorized Test Centers (ATC) - RM 600 per year
- Authorized Training Bodies (ATB) - RM 600 per year
- Oil & Gas Operator - RM 5000 per year

Registration can be made using the registration form to initiate the application process. The ACB Secretariat will process the applications and engage the applicants to appreciate the operations of the MOS Website.

ABOUT IMM

Institute of Materials, Malaysia (IMM) is a non-profit professional society that promotes honourable practice, professional ethics and encourages education in materials science, technology and engineering. Engineers, academicians, technicians, skilled workers and professionals are amongst its members exceeding 4000.

Registered with the Registrar of Societies on 6th November 1987, the Malaysian Materials Science & Technology Society (MMS) changed its name to the Institute of Materials, Malaysia (IMM) on 16th June 1997. The objectives of the IMM include the training and development of individuals and companies in Malaysia to attain professional recognition in various fields of materials science, technology and engineering.

IMM is administered by a council of 30 members, with volunteers leading 12 materials committee, and 7 regional chapters, and supported by a secretariat with full time staff.

Membership of IMM is categorised into 7 different grades and open to anyone above the age of 17 years - individuals and companies keen in developing and contributing towards the growth of materials science, technology and engineering in Malaysia.

Over the years, IMM have conducted courses on coatings, corrosion and welding in support of the oil and gas industry in Malaysia. Over 600 Coating Inspectors have been trained and certified as well as 2,500 Blasters & Painters, supervisors and Corrosion technicians. Its certification programmes are recognized by PETRONAS and all oil & gas operators. Since January 2011, 42 Associate Welding Engineers, 33 Welding Engineers and 8 Senior Welding Engineers were trained and certified.

IMM has also organised 8 International Materials Technology conferences (IMTCE) on a biennial basis, and numerous technical seminars, educational programmes, technical visits, and materials awareness programmes since 1988.

Public courses, such as Microbiologically Influenced Corrosion (MIC) and Welding Technology for Non-Welding Personnel, are been offered occasionally. Training on materials awareness has also been conducted in public listed companies.

The courses and programmes are being organised by Materials Technology Education Sdn Bhd (MTE), a joint-venture between IMM and InterMerger Group.

Collaborations with the Asian Welding Federation, American corrosion society SSPC, Sabah Skills Technology Centre (SSTC), and local universities continue to be part of IMM's vision and long term mission to educate, train and serve the materials fraternity

INSTITUTE OF MATERIALS MALAYSIA

CONTACT INFORMATION

Institute of Materials Malaysia
No. 10-1, Jalan Bandar 3
Pusat Bandar Puchong
47160 Puchong Selangor

Email : iomm@po.jaring.my
Website: www.iomm.org.my
Tel. 03-5882 3574
Fax. 03-5882 3524

IMM MEMBERSHIP GRADES

Honorary Fellow (Hon. FIMM) - Fellow (FIMM)
Professional Member (MIMM) - Associate Member (AMIMM)
Company Member - Ordinary Member - Student Member
        * Details and forms are available in IMM website
        * Term and condition apply for each grade of membership

CATEGORY/FEE	A	B	C	D
Fellow (F.I.M.M)	-	RM 300.00	RM 10.00	RM 150.00
Professional Member (M.I.M.M)	-	RM 150.00	RM 10.00	RM 100.00
Company Member	RM 50.00	-	-	RM 200.00
Associate Member (A.M.I.M.M)	-	RM 150.00	RM 10.00	RM 80.00
Ordinary Member	RM 20.00	-	-	RM 40.00
Student Member	RM 10.00	-	-	RM 10.00

Note: (A) Entrance (B) Processing (C) Transfer (D) Annual Subscription
For membership details, contact the Secretariat at:
Tel: (603) 5882 3574   Fax: (603) 5882 3524   Email: iomm@po.jaring.my