Reprint

โครงการ

การผลิตวัสดุดูดซับเสียงจากวัสดุผสมพอลิเมอร์และเถ้าแกลบขาว

(White rice husk ash composite materials for acoustic absorption board)

โดย

นางสาวดวงแข บุตรกูล

มหาวิทยาลัยศรีนครินทรวิโรฒ

พฤษภาคม 2555

โครงการสัญญาเลขที่ 095/2554

เงินรายได้ คณะวิทยาศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ

ประจำปีงบประมาณ 2554

SWU6-1084: การศึกษาความเป็นไปได้ของวัสดุคอมโพสิตจากเถ้าแกลบขาวและพีวีซีเพื่อผลิตฝ้าเพดาน

A STUDY OF WHITE RICE HUSK ASH AS POTENTIAL FILLER IN PVC FOR CEILING BOARD COMPOSITE

ดวงแข บุตรกูล
Duangkhae Bootkul

ภาควิชาวิทยาศาสตร์ทั่วไป คณะวิทยาศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ
Department of Generals Science, Faculty of Science, Srinakharinwirot University, Thailand.
Corresponding author, E-mail: mo_duangkhae@hotmail.com

บทคัดย่อ

แกลบเป็นส่วนเปลือกนอกทำหน้าที่ห่อหุ้มเมล็ดข้าว ซึ่งเป็นผลพลอยได้จากการสีข้าวคิดเป็นน้ำหนักถึง 20-25% ของข้าวเปลือก โดยทั่วไปแกลบส่วนหนึ่งถูกนำมาใช้เผาเป็นเชื้อเพลิงโดยตรงหรือแปรรูปเป็นพลังงาน ได้เศษเหลือทิ้งเป็นเถ้าแกลบ ที่มีโครงสร้างเป็นรูพรุนเปิดค่อนข้างมาก มีองค์ประกอบเป็นซิลิกามากถึง 85% คาร์บอน 1-12% สารซิลิกาถูกนำมาใช้เป็นวัตถุดิบในการสังเคราะห์วัสดุต่างๆ ที่ต้องการความแข็งแรงสูงน้ำหนักเบา ทนต่อการกัดกร่อนและใช้เป็นสารเติม (filler) ในผลิตภัณฑ์ที่ใช้งานอุณหภูมิสูงๆ ได้ แกลบที่ผ่านกระบวนการเผาไหม้อย่างสมบูรณ์ จะได้เถ้าแกลบสีขาว ที่มีปริมาณซิลิกามากกว่า 90% และมีปริมาณคาร์บอนน้อยมาก และเป็นฉนวนทางความร้อนที่มีประสิทธิภาพมาก การศึกษานี้เพื่อสังเคราะห์วัสดุคอมโพสิตจากเถ้าแกลบขาวในรูปของวัสดุเสริมแข็งแรง น้ำหนักเบา ทนการขูดขีด และเพิ่มความทนทานต่ออุณหภูมิสูง ศึกษาความเป็นไปได้ในการผลิตเป็นวัสดุโครงสร้าง เช่น ฝ้าเพดาน เนื่องจากพีวีซีพอลิเมอร์มีราคาถูก ขึ้นรูปง่าย แต่ไม่ทนทานต่ออุณหภูมิสูง โดยการอัดขึ้นรูปที่มีพอลิไวนิลคลอไรด์ผสมพลาสติกไซเซอร์ทำหน้าที่ยึดประสาน จากการศึกษาพบว่า สภาวะการขึ้นรูปที่เหมาะสมคือ คิดเป็นน้ำหนักของเถ้าแกลบขาวต่อพีวีซีและพลาสติกไซเซอร์ เป็นร้อยละ 30/65/5 ได้วัสดุคอมโพสิตที่มีสมบัติทางกายภาพที่ดี เช่น มีน้ำหนักเบาคิดจากผลของความหนาแน่นต่ำ การดูดซึมน้ำต่ำ สมบัติเชิงกลที่ดี เช่น สมบัติการทนต่ออุณหภูมิสูง การไม่ติดไฟ และไม่ลามไฟ

คำสำคัญ: เถ้าแกลบขาว วัสดุคอมโพสิต วัสดุน้ำหนักเบา วัสดุทนอุณหภูมิสูง พอลิไวนิลคลอไรด์

Abstract

Rice husk (RH) is the outer covering which surrounds the paddy grain. Consequently, RH is produced as agricultural waste in huge quantity as a part of rice milling and accounts for 20–25% of its weight. It is generally used as a fuel for heating which results in the production of rice husk ash, the high ash content due to combustion of rice husk leads to poor efficiency of carbon conversion. The present investigation has been focused on the utilization of abundantly available agricultural waste rice husk-ash in useful manner by dispersing it into polymer to produce composites by compression molding method. As the results show a good interfacial interaction between rice husk and polyvinylchloride has been achieved by modifying the surface using diisononyl phthalate (DINP) as a compatibilizing agent. The positive effect of rice husk reinforcement improved mechanical properties of the resulting PVC-based composite. High filler concentration of rice husk, i.e. 40 wt% is proved to be the optimum concentration to achieve maximum strength as well as thermal properties. Particularly, the possibility of producing ceiling board from rice husks has been pursued. The mechanical properties of the 30/65/5 of WRHA/PVC/DINP blend were investigated over a range of WRHA loadings (0 to 45%). The WRHA filled PVC/DINP blend was prepared by using a twin roll at 150°C mixing temperature 50 rpm rotor speed for 30 minutes. Changes in WRHA loadings were investigated with tensile strength (Ts), flexural modulus and hardness. The results revealed that the tensile strength (Ts) and hardness increased with the WRHA loading while the flexural modulus decreased. Additional, the water absorption and fire resistance provides evidence for the good adhesion between the WRHA and the blend matrix.

Keywords: White rice husk ash (WRHA), Composite materials, Elevate resistance temperature, Polyvinyl chloride (PVC)

Introduction

Rice is one of the most popular and largest grown agriculture crops in Thailand. Rice husks are an agricultural residues material abundantly available in rice production. As per the annual generation of rice husk in Thailand is nearly 5 million tons and hence its efficient utilization is urgently needed to avoid environmental pollution. This husk contains about 75% organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process which is known as rice husk ash (RHA). Formation of the application of rice husk as (RHA) fuel in power plant is increasing due to its high calorific power. In some areas, a large amount of RHA is treated as waste and disposed at landfill site, RHA usually has a light weight; thus produced also contributes to air pollution and water pollution. The disposal of bulky RHA could be a problem therefore; the airborne particles have been linked to respiratory disease in humans [1]. Recently, efforts are being made not only to overcome the pollution but also to find value addition to these wastes by using them as secondary resource materials. RHA usually contains over 60% silica, 10-40% carbon and minor other mineral composition. Due to RHA can be an economically viable raw material for the production of silicates and silica in recent years [2]. The white rice husk ash (WRHA) obtained from the combustion of RHA at moderate temperature contains 87±97% high silica in an amorphous form and some amount of metallic impurities [3]. Polymer matrix composites (PMCs) possess significantly improved properties including high specific strength; specific modulus and good wear resistance compared to unreinforced polymers. In recent years, Natural reinforced fillers have been widely used as reinforcing in thermoplastic polymer composites. Using cellulose and lignocellulose materials as fillers have several advantages, such as their low cost, low density, renewability, biodegradability and absence of associated health hazards [4]. Flammability is an important criterion in material selection for building and consumer product applications. In general, synthetic polymers are highly flammable due to their petroleum origin. Particularly important natural resource are lighter, cheaper and provide much higher strength per unit mass than most inorganic fillers such as carbon black, calcium carbonate, talc and zinc oxide [5-6]. Especially silica has been shown to be a good material for the synthesis of very pure silicon, silicon nitride, silicon carbide and magnesium silicate [1, 7]. In this study, Polyvinyl chloride (PVC) is a versatile thermoplastic which has a range of applications in domestic as well as industrial uses by virtue of its high abrasion and solvent resistance. However, the cost of the products based on PVC can be significantly reduced if weight reducing filler (or plasticized PVC) can be used which will make the composite lighter and will not be detrimental to the mechanical or physical properties of polyvinylchloride as polymer matrix. Rich silica of White rice husk ash (WRHA) has been investigated the fire resistance with different compositions.

Objectives

The thermoplastic polymer PVC with constant plasticizer and WRHA filler composites has been evaluate the physical properties, the thermal stability, mechanical properties. Also to examine the effect of WRHA content on degradation temperature for the potential to ceiling board pursue.

Methods

Materials preparations

Rice husk was procured from local sources in Khonkhean province (Thailand) and was thoroughly washed with water to remove the dust and dried at room temperature for 1 day. Washed rice husk was then heated to 200°C for 1 h in order to remove the moisture and organic matter as shown in figure 1 (a). During this operation, figure 1 (b) the color of the husk changed from yellowish to black because of charring of organic matter. It was then heated to 600°C for 12 hrs to remove the carbonaceous material. After this operation, the color changed from black to grayish white. Thus, the silica-rich ash gave the amount of Si-OH left and Si-O groups undestroyed firing. WRHA was generally 1-5 mm long was grinding closed system to fine powder. Ground WRHA powder was sieved through screen sizes to get 300-400 um uniform particle size as shown in figure 1 (c).

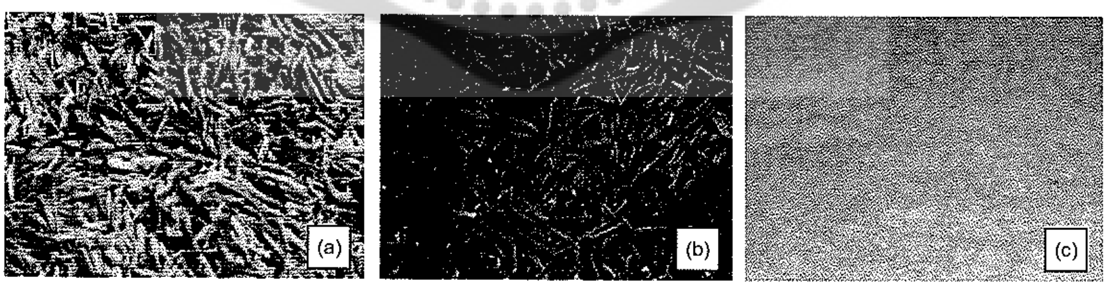


Figure 1 (a) Rice Husk (RA) (b) Rice Husk Ash (RHA) (c) White Rice Husk Ash (WRHA)

Formulations

The recipes used to prepare the composites are given in Table 1. The WRHA filled PVC/DINP blends were prepared by mixing 5% constant of DINP with PVC polymer.

Table 1 Recipes used to prepare WRHA filled PVC/DINP blends.

Materials	Weight percentages									
DINP	5	5	5	5	5	5	5	5	5	5
PVC	95	90	85	80	75	70	65	60	55	50
WRHA	0	5	10	15	20	25	30	35	40	45

Compounding process

PVC suspension powder for general rigid applications purpose and the 5% weight constant DINP stabilizer were premixed at room temperature. WRHA was carried out added into PVC/DINP at 150°C and 50 rpm rotor speed in a two roll mill mixer for 30 minutes.

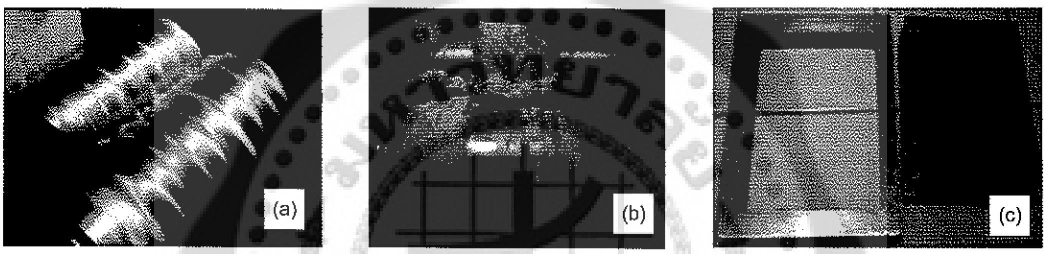


Figure 2 (a) Two roll mill (b) Two roll mill operation of PVC/DINP/WRHA (c) Stainless steel mold

Molding process

PVC/DINP/WRHA blends were molded and subsequently compressed at about 150°C in an electrically heated hydraulic into sheets of 5 mm thickness under a pressure of 14.7 MPa at 180°C continuously pressed for 30 minutes. The sheets were immediately cooled between two plates of a cold press at 25°C.

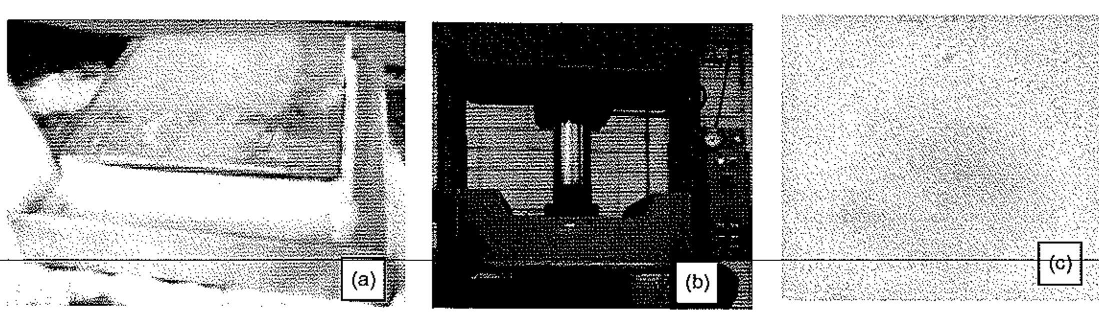


Figure 3 (a) Molding of PVC/DINP/WRHA (b) An electrically heated hydraulic (c) PVC/DINP/WRHA composite

Results

Bulk density

Density measurements were carried out on the samples using Archimedes's principle. The buoyant force on a submerged object is equal to the weight of the fluid displaced. This principle is useful for determining the volume and therefore the density of an irregularly shaped object by measuring its mass in air and its effective mass when submerged in water (density = 1 gram/cm^3). This effective mass under water will be its actual mass minus the mass of the fluid displaced. The difference between the real and effective mass therefore gives the mass of water displaced and allows the calculation of the volume of the irregularly shaped object. The mass divided by the volume thus determined gives a measure of the average density of the object. The results reveal in Fig.4 that an increase in the percentage of WRHA particulates in PVC decreases the composite material density, this is due to fact WRHA particles density (0.80-1.10 g/cm^3) are lesser denser than PVC (1.35-1.55 g/cm^3).

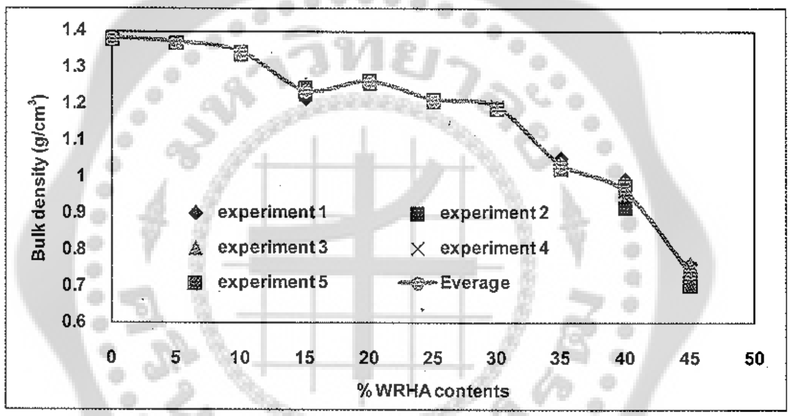


Figure 4 The results of density measurement on the base PVC/DINP and % WRHA contents reinforced.

Water Adsorption

The water adsorption measurements were performed according to ASTM standard method D 570-99 (ASTM 1999). From each sample, five 3 x 12 x 50 mm^3 samples were cut. The samples were subjected to heat treatment in an oven at 50°C for about 24 hrs, then immediately weighed (Wo). To measure water absorption of composite materials, all of the samples were then immersed in distilled water at ambient temperature for 240 hrs, and then taken out weighted every 48 hrs (Wf). The percent weight gain (PWG) was calculated as:

$$PWG = [(Wf-Wo)/Wo] \times 100$$

The water adsorption of composite materials from Figure 5 shown water absorption increased with increases of WRHA powder loading into PVC matrix. This is because RHA powder is a natural materials and its surface area of hydroxyl groups.

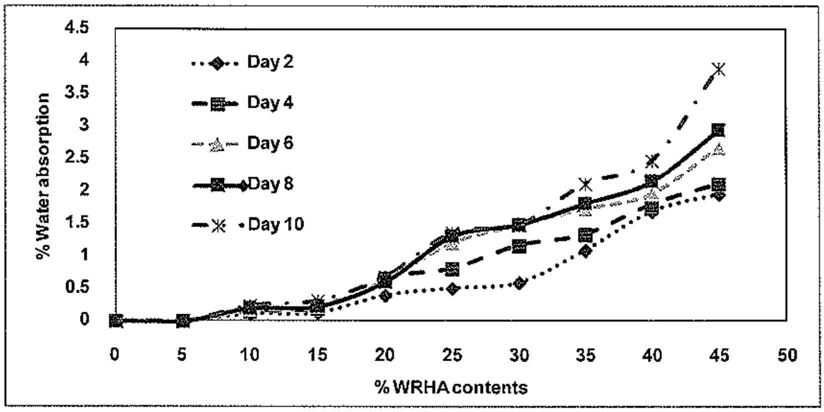


Figure 5 shows the water adsorption of WRHA/PVC/NIDP.

Tensile strength (Ts)

The incorporation of WRHA to a PVC matrix may increase the Ts of the resulting composites. Fiber type fillers normally result in improved Ts, as the fibers are able to support the stresses transferred from the PVC polymer. Figure 6 shows the effect of WRHA loading on the Ts of WRHA/PVC/DINP blend. Ts found show dramatic increase with the addition of 5-30% WRHA. However a further increase in WRHA loading reduces the Ts of the blend. As the filler loading is increased, eventually a level is reached whereby the filler particles or aggregates are no longer as equally separated or wetted by the polymer matrix. The possibility caused from the poor interfacial bonding between white rice husk ash powder and PVC matrix.

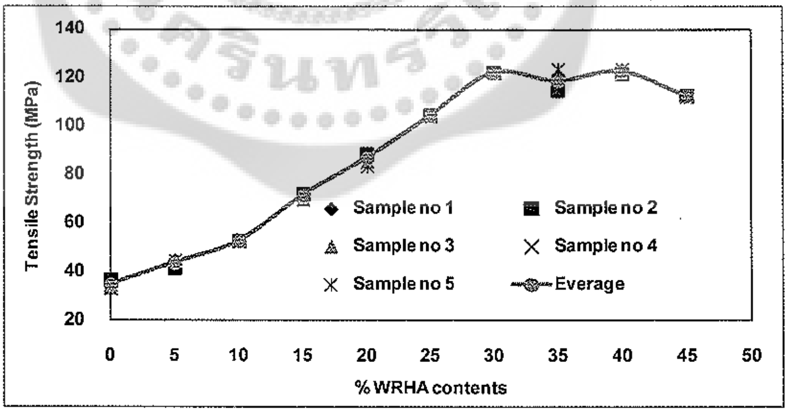
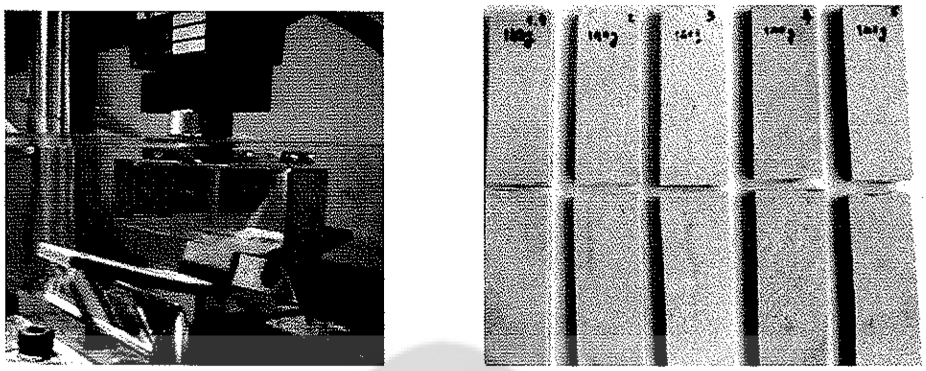


Figure 6 shows the Tensile strength of WRHA/PVC/NIDP.

Flexural strength

One of the primary intentions of filler incorporation into polymers is to increase the stiffness of the resultant material. The flexural modulus was determined with ASTM D 790 standard. Five rectangular bar shaped specimens are tested for each composition with a thickness of 5 mm and their average values were calculated. Figure 7 depicts the flexural modulus of the WRHA filled PVC/DINP blends.



(a) (b)

Figure 7 (a) The flexural modulus test and (b) the WRHA filled PVC/DINP blends.

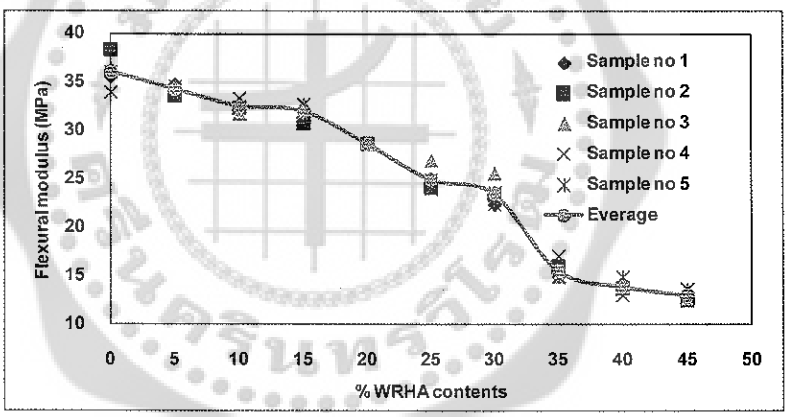


Figure 8 The flexural modulus of the WRHA filled PVC/DINP blends.

An increase in WRHA loading decreased flexural modulus, indicating higher stiffness in the WRHA-filled composites, whereas the tensile strength and flexural strength increased. The addition of WRHA in the PVC/DINP composite improved the flexural strength to a higher level than PVC/DINP, therefore giving rise to a stronger but less flexible composite material.

Hardness

The hardness test was carried out according to Durometer (Shore-D) as ASTM D2240. The measured value of hardness was taken after 15 seconds of contact in obtained at three different points distributed over the test piece. Three test pieces were used and their average value was determined.

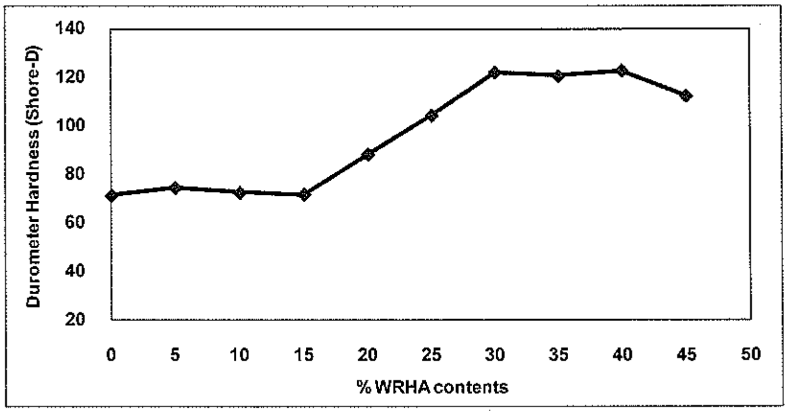
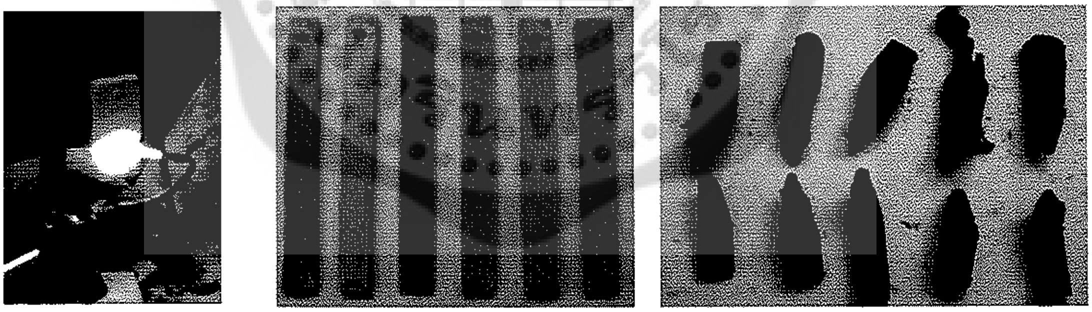


Figure 9 The Durometer Hardness (Shore-D) of the WRHA filled PVC/DINP blends.

It is apparent from Figure 9 that the WRHA filled PVC/DINP blends results in enhancement in hardness of composite materials. This trend of results is expected because as more filler particles incorporated into the polymer matrix, the elasticity or flexibility of the polymer chain is reduced, resulting in more rigid blends. This observation is in perfect agreement with the results on flexural modulus

Fire resistant

Sample PVC/DINP will also hold the potential to suppress the flammability of synthetic polymers due to the high content of silica present in its composition. Result of fire resistant of WRHA with different compositions.



(a) (b) (c)

Figure 10 (a) Fire resistance test (b) WRHA/PVC/DINP composite materials before testing and (c) WRHA/PVC/DINP composite materials after testing

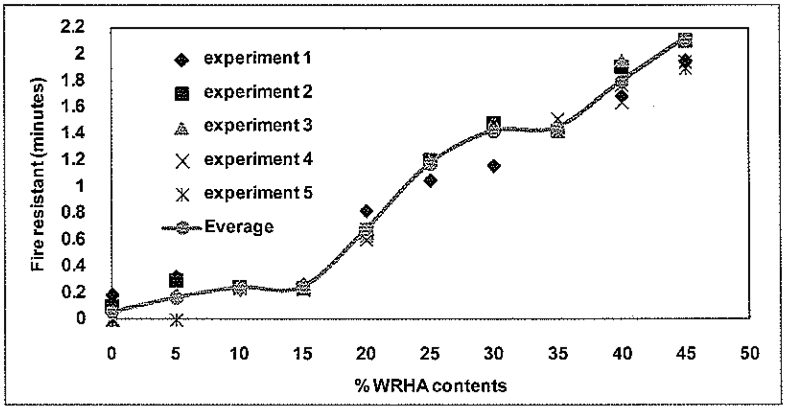


Figure 11 The fire resistant of the WRHA filled PVC/DINP blends.

Conclusions and Discussion

1. The utilization of White Rice Husk Ash (WRHA) solves the problem of its disposal thus keeping the environment free from pollution. The maximum yield of WRHA was 45%, which could be achieved under the mild reaction conditions.

2. WRHA powder filled in PVC polymer and DINP plasticizer composite could be successfully developed having different WRHA weight percentage.

3. Density of WRHA/PVC/DINP composite decreased with increasing WRHA loading in the PVC matrix.

4. Tensile strength, hardness of WRHA/PVC/DINP composite increased on WRHA.

5. Fire resistant of WRHA/PVC/DINP increased on WRHA.

Acknowledgements

This research was supported by a grant from the Faculty of Science, Srinakharinwirot University. The authors wish to thank all of students under project of "The rice husk ask reinforced thermoplastic polymer for ceiling board" as Miss Doungkamol Remwanich, Miss Manutchanok Kruasri Miss Sunisa Thongpunya, Miss Chutima Thongtem, Mr. Pakorn Thongmul and Miss Pornpimol Lertnanawong.

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