

Preliminary study on the physical properties of palm ash and PCB waste mixed with phenolic resin.

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Abstract- Brake pad is widely used in automotive industry and consists of various materials including asbestos which is harmful to the human and its production exceeds 10 or more ingredients. In this work, preliminary investigation on possibility to use combination palm ash and PCB waste was carried out in order to reduce harmful materials in brake pad and pollutions. Characterization of palm ash and PCB was done by using XRF, Malvern Particle size and Scanning Electron Microscopy (SEM). The composition palm ash and PCB waste was prepared by pre-mix the palm ash, PCB waste and aluminum powder with phenolic resins in ball mill and then compressed at 122 MPa. Samples were cured at temperature 150°C for 5 minutes. Microstructure, density and porosity, water absorption and compressive test were carried out on the specimens.

Keywords: palm ash, PCB waste, phenolic resins, aluminium,

I. I. INTRODUCTION

Brake pad is one of the important engineering parts in all types of vehicle and it used to slow down and stop moving any vehicle. Brake pad materials are generally considered as composites. Numbers of different materials

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are used and almost 20 types of raw materials are involved in producing the brake pad [1].

The brake pad materials composition can generally be classified into five materials, depending on the specific functional requirement. These include fibers, fillers, binders, friction modifier and lubricants [1-4]. This research was aimed to recycle palm ash and PCBs waste to be used in brake pad.

Palm Ash

Being the largest producer of palm oil in the world, Malaysia has to face with the consequences of the huge accumulation (30 million tons per year) of undesired solid biomass such as empty fruit bunch, fibers and shell [5]. Solid waste from the palm-oil industry is highly abundant in this country. This waste is usually used as fuel in palm-oil mill factories. Then, after the combustion of oil-palm fibers and shell (used as boiler fuel for the steam generation in palm-oil mills) ash is produced. Malaysia thus generates huge loads of palm ash each year. Hence, the utilization of such agriculture solid waste residues for wastewater treatment is most desirable, first, as wastes are available abundantly at no or very low cost; second, as the disposal of these wastes normally poses a serious environmental problem in Malaysia, which has extensive agricultural activities [6].

PCBs waste

In 2000, the numbers of personal computers consumables in Malaysia is 2.2 million and the number increase to 5.7 million in 2005 and the predict amount, it will be increase for the next year [7]. Many counties and organizations have drafted national legislation to improve the reuse, recycling and other forms of recovery of such wastes so as to reduce disposal. Recycling of PCBs is an important subject not only from the point of waste treatment but also from the recovery of valuable materials [8]. This was has been recognized as a big challenge due to contained plenty of toxic substances, such as PVC plastics, ceramics and heavy metal. In develop of cost effective and environmental friendly recovery process; physical separation process through combination dry and wet method of has been carried necessary to recover metallic concentrates from comminution fines PCBs waste [9].

II. II. EXPERIMENTAL

Materials.

Four types of raw material were used; palm ash, PCB waste, phenolic resin and aluminum. Palm ash was supplied by a local oil palm manufacturer (Seberang Perai) and used as filler. PCB waste was supplied by local recycle company (Kulim) and also as filler in the brake pad mixtures combination with palm ash. PCB waste was classified into two types indicated as PCBcy and PCBvf according to the composition supplied by the company. Term for cy and vf are only for codes for differential separation material were used by supplier of Recycle Company (KULIM). The content of PCB added to the composite brake pad mixture was based on the 50% PCBcy and 50% PCBvf. Phenolic was selected as a binder and finally, aluminum was used as an abrasive element. Palm ash was dried in oven at 80 °C for 24 hours to make moisture free.

Raw Material Characterization.

An Endecotts sieve was used to obtain an average size of palm ash. The average size is in the range of 300-600 μm . The particles size of PCB waste, phenolic resins and aluminum was determined by the Malvern Particle Analyzer Machine. The microstructures of all materials were characterized by SEM-EDX JEOL JSM-6460LA - EDX.

Sample Preparation

All the raw materials were mixed together for 15 minutes to obtain the homogeneous mixed ingredients. The weight percentage used in the brake pad mixtures are presented in Table 1.

Table 1: Ingredients used in composites.

Sample	A	B	C	D	E	F	G
Palm Ash (%)	5	15	25	35	45	55	65
PCB waste (%)	65	55	45	35	25	15	5
Phenolic (%)	20	20	20	20	20	20	20
Aluminum (%)	10	10	10	10	10	10	10

The mixtures then compacted with the pressure of 122 MPa using uniaxial hydraulic hand press machine. The compacted samples were cured at 150°C for 5 minutes.

Physical Test

Density and Porosity Testing.

Bulk density and porosity value for each sample were obtained by Archimedes method according to ASTM D792-08 standard. Distilled water was used as the liquid for the measurements. In this technique, density was determined by measuring the difference between a sample's weight in air and when it was suspended in distilled water at room temperature.

Water absorption testing:

The water absorption value for each sample was measured according ASTM D 570-98. Distilled water was used as the liquid for the measurement at room temperature until 1 hour.

Surface Morphology.

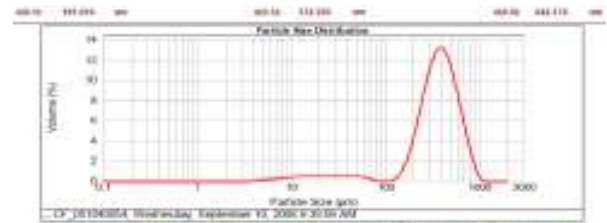
The surface of the brake pad samples were examined using SEM to observe the surface microstructure.

III. III. RESULTS AND DISCUSSION.

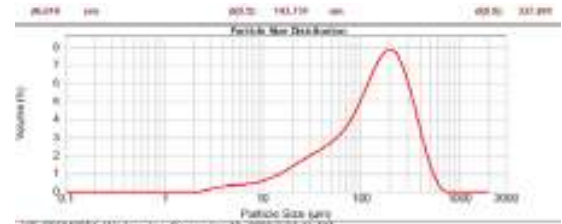
Raw Material Characterization.

Figure 1 shows the range and average particle size of PCB waste, phenolic resins and aluminum respectively. (a) The particle range of PCBcy waste is 120.226 μm to 1096.478 μm . The average size is 363.08 μm . (b) The range size for PCBvf waste is 26.610 μm to 337.281 μm . The average size is 143.73. (c) The range size for phenolic resins is 4.456 μm to 62.472 μm . The average size is 15.136 μm . (d) Aluminum range is 14.083 μm to 94.229 μm . The average size is 36.674 μm . This result indicates that the particle size of aluminum is smaller than the PCBcy and PCBvf, and phenolic resins.

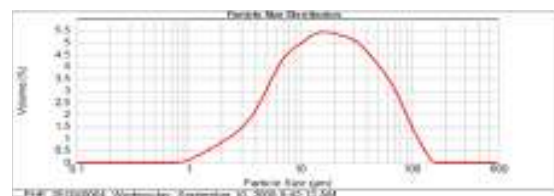
From the Malvern Particle Analysis result, PCBcy waste and aluminum are more uniform in particle distribution compare to PCBvf and phenolic resins. Particle size of the aluminum, phenolic powder and both of PCB waste is slightly in the same range. The particle range of palm ash is 300-600 μm and sieved by using Endecotts sieve.

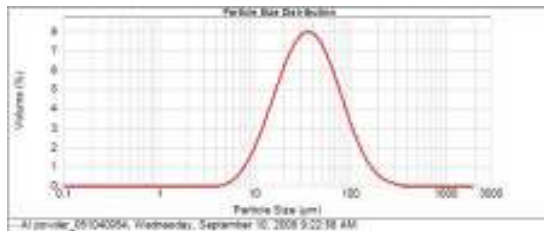


(a) PCB waste (cy)



(b) PCB waste (vf)

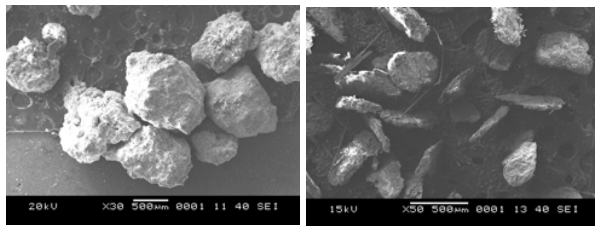




(d) Aluminum Powder

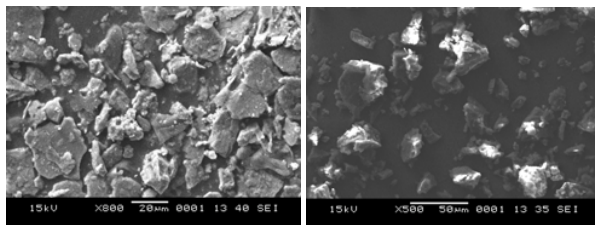
Figure 1: Particles size of raw materials

Figure 2 shows the particle shape of the raw materials including palm ash, PCB waste, phenolic resin and aluminum under SEM. Figure 2(a) shows spherical irregular shape of palm ash, which had been sieved in range 300-600 µm. Figures 2(b) shows PCBcy waste having agglomerated fibrous plate-like shape. Figure 2(c) shows particle PCBvf waste is in a form of irregular plate-like shape. Figure 2(d) indicates agglomerated irregular shape of particle phenolic resin. Finally figure 2(e) shows particle aluminum is in a form of ligamental shape.



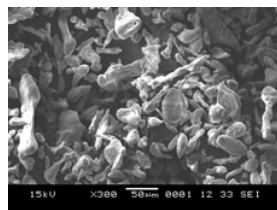
a) Palm Ash

b) PCB waste (cy)



c) PCB waste (vf)

d) Phenolic Resin



e) Aluminum

Figure 2: Scanning electron micrograph of raw materials of a) Palm Ash, b) PCB waste (cy), c) PCB waste (vf), d) Phenolic Resin, e) Aluminum

X-ray fluorescence

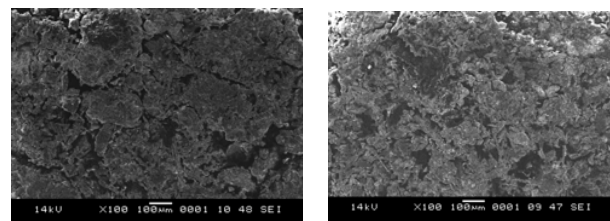
Chemical elements of raw materials were analyzed based on the point analysis by using XRF observation. This analysis was carried out to determine chemical elements of the palm ash and both of type PCB wastes. Chemical constituents of the palm ash and PCB wastes are presented in Table 2.

Chemical composition	Weight %		
	P. Ash	PCB (cy)	PCB (vf)
K ₂ O	52.7	-	-
SiO ₂	22.1	12.3	9.04
CaO	13.2	8.56	4.16
P ₂ O ₅	4.9	13.4	12.3
SO ₃	4.0	-	-
Fe ₂ O ₃	1.65	0.24	0.2
TiO ₂	0.33	0.5	0.6
Rb ₂ O	0.25	-	-
MnO	0.23	-	-
CuO	0.22	1.02	4.68
ZnO	0.15	-	-
NiO	0.072	-	0.027
SrO	0.088	0.16	-
Y ₂ O ₃	0.02	-	-
Yb ₂ O ₃	0.02	-	-
Re ₂ O ₇	0.05	-	-
Al ₂ O ₃	-	9.9	8.7
V ₂ O ₅	-	0.005	0.005
Br	-	53.66	56.36
BaO	-	0.18	0.32
OsO ₄	-	0.04	-
RuO ₂	-	-	3.6

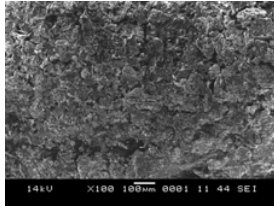
Table 2: Chemical composition in raw material using XRF analysis.

Microstructure

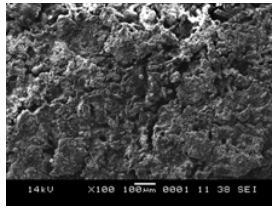
Microstructure analysis of brake pad sample after curing process was done by SEM at 100X magnification. Figures 2 (a)-(g) show the SEM micrograph of brake pad sample with different percentage of palm ash and PCB waste. Beside that, we observed pores on the surface of the samples. Figures 2 (a)-(d) show more pores are found in a-d mixture, compared to the e-g mixture. It is indicated that the presence of pores is controlled by the content of palm ash. The pores decreased with increasing content of palm ash. It is expected that the spherical shape of palm ash and the range size of particles palm ash between 300-600 µm have reduced the content of pores. This supported by average porosity and absorption water result.



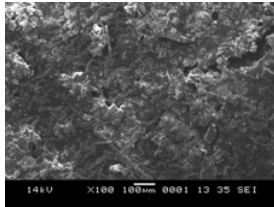
(a) PA-5%/PCBw-65%



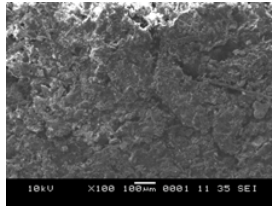
(b) PA-15%/PCBwt55%



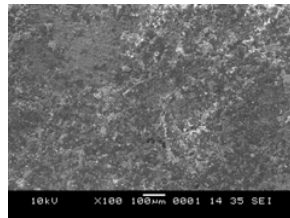
(c) PA-25%/PCBw-45%
35%



(d) PA-35%/PCBw-



(e) PA-45%/PCBw-25%
15%



(g) PA-65%/PCBw-5%

Figure 2: SEM micrograph of brake pad samples with different percentage of palm ash and PCB waste.

Density and Porosity Testing



Figure 3: Density of sample with differential percentage palm ash and PCB Waste.

Figure 3 shows the graph trend indicating the bulk density increases with increasing the palm ash in composition. PA-65wt%/PCBw-5wt% has the highest value of bulk density and PA-5wt%/PCBw-65wt% has the lowest value of bulk density. This result was influenced by porosity and water absorption testing.

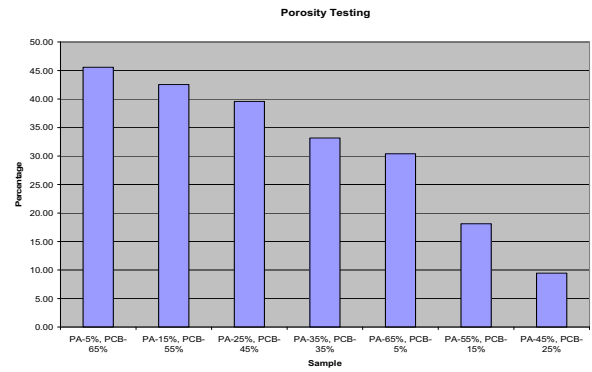


Figure 4: Porosity testing of sample with differential percentage palm ash and PCB Waste.

Figure 4 shows the graph trend indicating the porosity decreases with increasing the palm ash content. PA-5wt%/PCBw-65wt% has the highest value of porosity and PA-65wt%/PCBw-5wt% has the lowest value of porosity.

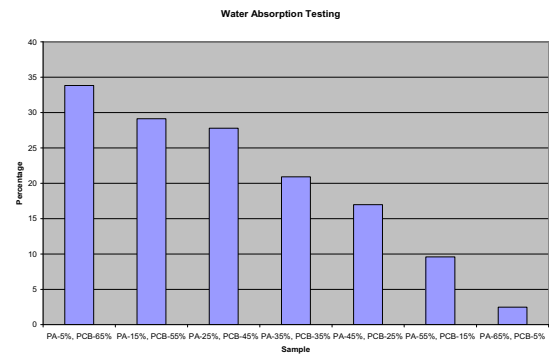


Figure 5: Water absorption of samples with different percentage of palm ash and PCB Waste.

Figure 5 shows the water absorption results for different composition of raw materials. PA-5wt%/PCBw-65wt% shows the highest value whereas PA-65wt%/PCBw-5wt% shows the lowest value of water absorption. This result was influenced by porosity and void formed in the brake pad samples.

Compressive Test.

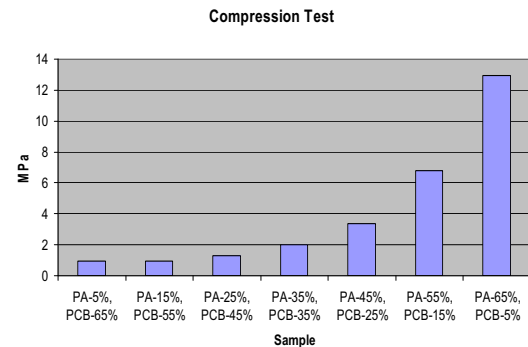


Figure 6: Compression testing of sample with differential percentage palm ash and PCB waste

Figure 6 shows the compressive strength increases with increasing the palm ash in composition. The result shows PA-65wt%/PCBw-5wt% has the highest value and PA-5wt%/PCBw-65wt% has the lowest value of strength. It was also observed by increasing the composition of PCB waste in the samples, the compressive strength decreased.

IV. CONCLUSIONS

In conclusions, increasing content of palm ash will increase the density and compressive strength of brake pad samples. Spherical shape and 300- 600 μm size of palm ash are expected to reduce the content of pores. This is proven when the percentage of palm ash content increased, the results of porosity and absorption water decreased.

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