CARBON GLASSY FOR ELECTRODES FROM OIL PALM EMPTY FRUIT BUNCHES

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Hard carbons or carbon glassy, are obtained from carbonization of pre-cursors such as thermosetting polymers (for example, phenol formaldehyde resins, furfuryl alcohol and divinylbenzene styrene copolymer), cellulose, charcoal and coconut shell. Hard carbon is used in the production of carbon electrodes. Commercially, carbon electrodes are made from petroleum coke and graphite and pitch that serves as a binder by heating them to high temperature (Heintz, 1985). Carbon electrodes are widely used in the electronic, chemical and metallurgical.

Carbonization of lignocellulosic materials results in hard carbons with low electrical resistivity and good electrochemical properties, hence, forming useful pre-cursor for the preparation of carbon electrical components such as batteries, carbon brushes, electrodes, fuel cells and capacitors (Marsh *et al.*, 1997). Research in producing carbon glassy from oil palm empty fruit bunches (EFB) was started in 2000 with Universiti Kebangsaan Malaysia (UKM). Various attempts in activation were carried out to enhance the physical and mechanical properties of the carbon glassy (Mohamad *et al.*, 2000). The final achievement was to use acid which increased the density, hardness, Young's modulus, as well as the electrical conductivity of the carbon glassy (Astimar *et al.*, 2004; 2005). Blending with metal powder, depending on their specification requested, can enhance their electrical conductivity.

PREPARATION OF CARBON GLASSY

The carbon pre-cursors are prepared by pre-carbonizing EFB chips, followed by grinding and hammer milling. The chemical activation is by using H_2SO_4 at a concentration sufficient to liquefy, the carbon pre-cursors, before drying. This is followed by ball milling and sieving to get the fine and highly self-adhesive activated carbon pre-cursors with an average particle size of < 53 μm. The green body is prepared by forming the carbon pre-cursor powder at 20 kg cm^{-2} compression, before carbonization at 1000°C under nitrogen. A comparison of some properties of the EFB and commercial carbon electrodes is shown in *Table 1*.

TABLE 1. COMPARISON OF SPECIFICATIONS OF COMMERCIAL AND EFB CARBON ELECTRODES

Specification	Commercial electrode	EFB electrode
Bulk density (g cm^{-3})	1.50 – 1.60	1.05 – 1.20
Electrical resistivity (x10^{-5} Ωm)	2.2 – 3.5	1.5 – 2.0
Young's modulus (GPa)	9.35 - 11.7	10.5 – 14.0
% Ash	3.8 - 6.2	4.5 – 6.0

Carbon Electrode Rod

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ECONOMIC VIABILITY STUDY

The petroleum-based carbon powder or graphite for production of carbon electrodes is getting more costly, hence, replacing it with green resources is the current global trend. The costing of process is based on the preparation of carbon powder from EFB and an additional plant for forming the electrodes. For processing 60 t EFB (wet), cost were developed assuming a 10% yield, or 6000 kg per day of carbon electrodes, and 320 days per year of production (*Table 2*). The annual production cost was estimated at RM 11 million for an output of 1 920 000 kg. Therefore, the cost of the carbon electrode made from EFB is RM 6.25 per kg. The market price for carbon is from RM 16 up to RM 17 per kg, and, therefore, there is a good margin for profit.

TABLE 2. ESTIMATED COSTS FOR PRODUCING EFB CARBON ELECTRODES

Item	Value
EFB (wet)	60 t
Equipment	RM 7 000 000
Capital cost	RM 25 000 000
Total fixed capital investment	RM 32 000 000
Total annual operating cost	RM 12 000 000
Estimated annual production of carbon	1 920 000 kg
Estimated cost of carbon	RM 6.25 per kg

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