Carbon Materials from Natural Sources

Many hidden treasures of nature have not yet been exploited fully by mankind. Materials have been catering to the needs and serving the mankind from times immemorial. Carbon materials are one such age old materials employed for the benefit of mankind in diverse ways though not to its full potential. In the form of diamond it enhances the aesthetic beauty; as graphite it is used for lubrication and intercalation purposes; as charcoal it is used for the reduction of ores, for medicinal purposes, decolourization of sugar syrups; as sensors (methane sensing) and biosensors (glucose sensing) in the form of nano tubes (CNTs). Activated carbon materials are being used for electrode (super capacitor and fuel cell) fabrication, water purification, hydrogen storage and for the removal of toxic chemicals from water and air. The applications of carbon materials to mankind are diverse.

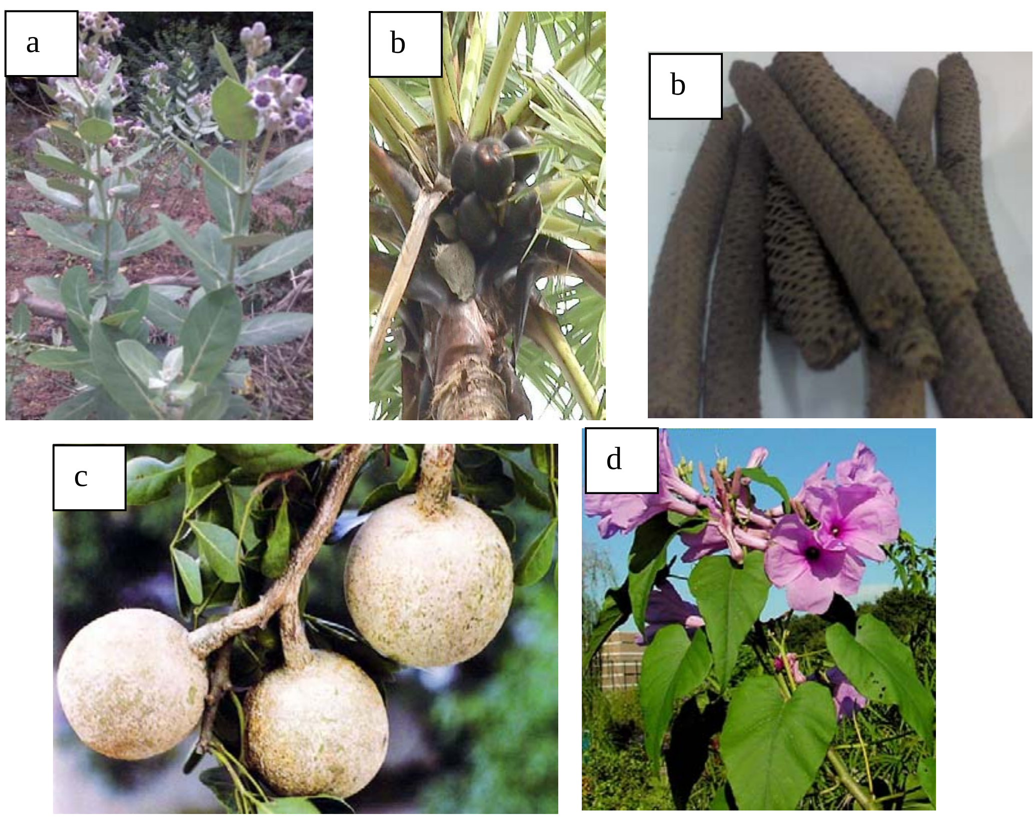

Fig. 1. Images of (a) Calotropis gigantean, (b) Borassus flabellifera, (c) Limonea acidissima and (d) Ipomoea carnea

Owing to the great utility and urgent demand for such carbon materials, we have made significant progress in evolving methods for producing micro porous high specific surface area carbon materials with several interesting properties and applications from unconventional carbon precursors like Calotropis gigantea, Borassus flabellifera, Limonia acidissima and Ipomoea carnea **(Fig. 1).** Such an attempt is necessary from economical as well as environment view points.

The high surface area carbon materials have been exploited for solving some of the major problems that are being encountered by mankind in the spheres of energy and environment. The carbon materials, have been successfully used for the fabrication of fuel cell electrode materials, designing adsorbents for the sorption of mercury and some typical dye compounds like methylene blue. Commercially available activated carbon materials like Calgon carbon, adsorbent carbon and several others have also been tailored for the removal of organo sulphur compounds for diesel (adsorptive desulphurization).

The carbon material from Calotropis gigantean offered a fine example for the tenability of the structure of the carbon material at the molecular level. Platelet like morphology with uniform distribution of spherical pores is generated when the carbon precursor is activated with K_2CO_3 (potassium carbonate). On the contrary, activation with $Na_2C_2O_4$ (sodium oxalate) resulted in the carbon material with tubular morphology (**Fig. 2**).

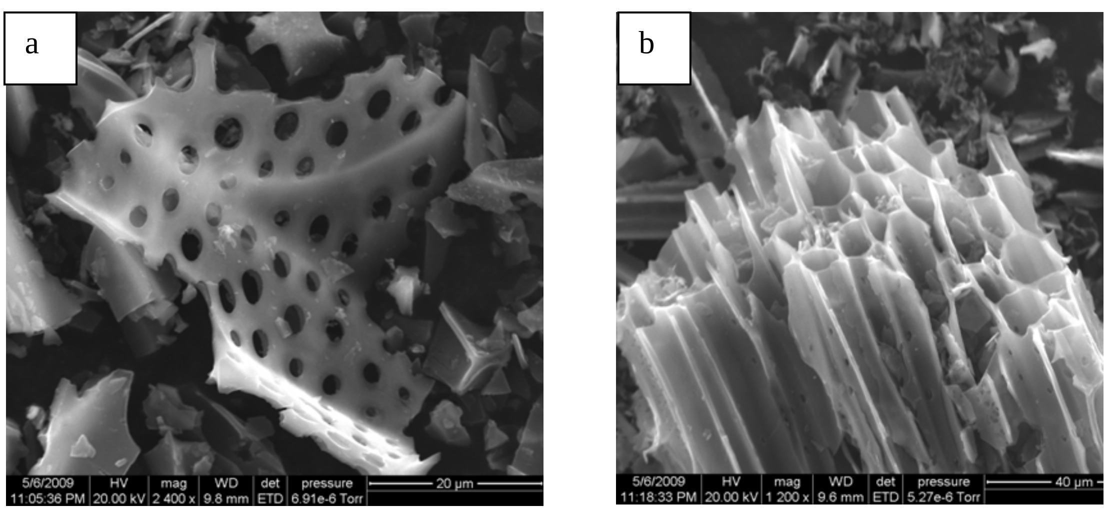

Fig. 2. Morphology of carbon material from Calotropis gigantea as a function of activating agent (a) K_2CO_3 activation and (b) $Na_2C_2O_4$ activation

The fuel cell (DMFC) electrode (GC/C_{WA}-20 wt.%-Pt-Nafion) fabricated using the carbon material from Limonea acidissima shell (C_{WA}) performed on a par with the electrocatalyst fabricated using commercial Vulcan XC 72 R carbon black. The wood apple shell based electro catalyst with 5 wt.% Pt loading (GC/C_{WA}-20 wt.%-Pt-Nafion) surpassed the activity of the vulcan carbon based electro catalyst (GC/Vulcan XC 72 R-20 % Pt-Nafion). The comparison of the activity of various electro catalysts is shown in **Table 1**. The excellent activity of the electro catalyst (5 wt.% Pt/C_{WA}) attributed to the increase in the extent of utilization of Pt metal. The TEM image of 5 wt.% Pt on the carbon material from wood apple shell is shown in **Fig. 3.**

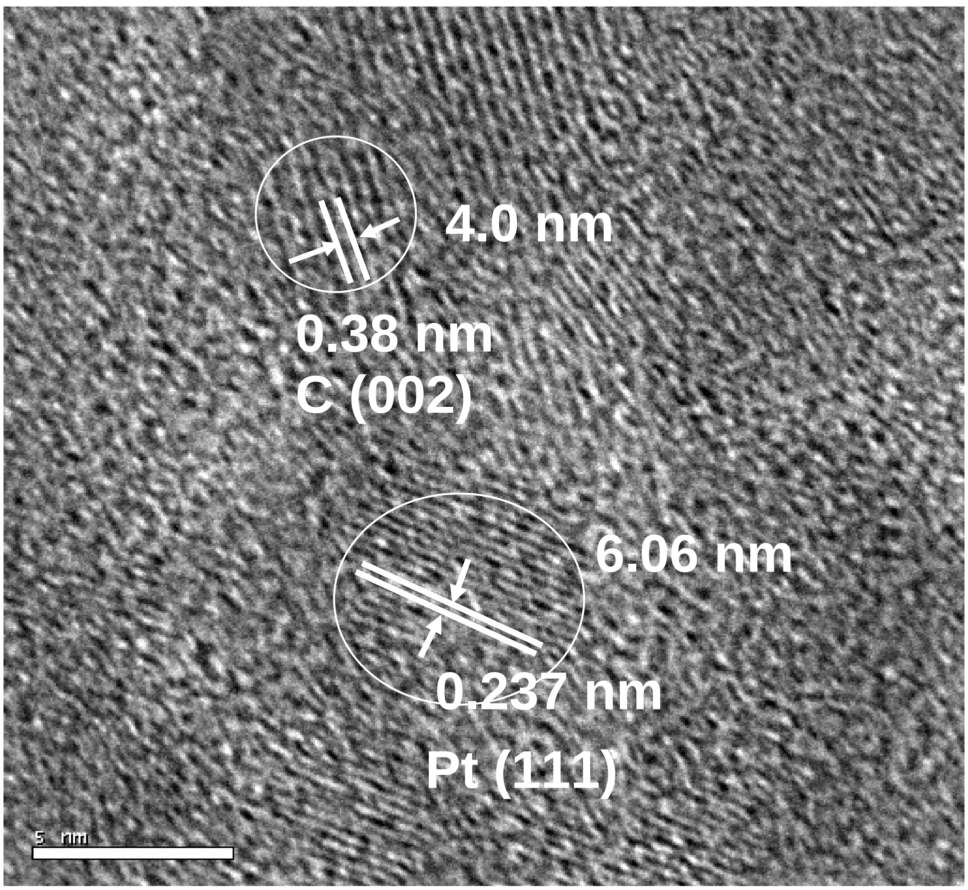

Fig. 3. TEM image of electro catalyst based on the activated carbon from Limonea acidissima, 5 wt.% Pt/C_{WA}

The Pt particle size of ~ 6 nm with a d spacing value of 0.237 nm corresponding to the Pt (111) are indicated in the TEM image. The carbon particles of 4.0 nm size with a d spacing value of 0.38 nm corresponding to the (002) place of carbon are also marked in the TEM image.

Table 1. Effect of Pt loading and the nature of the carbon support on the electro catalytic activity of methanol electro oxidation of Pt/C_{WA} and Pt/Vulcan XC 72 R

S. No.	Electrode	Onset Potential, V	i_f/i_b	Activity*			
				Forward sweep		Reverse sweep	
				I (mA/cm^2)	E (V)	I (mA/cm^2)	E (V)
1	GC/C_{WA}-5 % Pt-Nafion	0.21	14.4	69.0	0.92	4.97	0.37
2	GC/C_{WA}-20 % Pt-Nafion	0.18	1.60	58.9	0.82	37.28	0.51
3	GC/Vulcan XC 72 R-20 % Pt-Nafion	0.25	0.96	40.9	0.75	42.6	0.56

*Activity evaluated in 0.5 M H_2SO_4 and 1 M CH_3OH, at a scan rate of 25 mV/sec between -0.2 to 1.2 V Vs Ag/AgCl

S functionalized activated carbon material from Ipomoea carnea has been effectively employed as a sorbent for the removal of Hg from aqueous solution with the sorption capacity being 55.6 mg/g. S functionalized carbon material produced from Ipomoea carnea outperformed various sorbents like activated carbon materials produced from Cieba pentandra hulls, Phaseolus aureus hulls, Cicer arietinum, sago waste, Bolluca coal and also adsorbents other than activated carbon like the fuller's Herat (clay), char coal produced from camel bone, vulcanized rubber, guava bark, used tyre waste and vulcanized rubber.

Several commercially available activated carbon materials have been tested for the removal of S in SR diesel (CBR). The target was to redcued the S content from about 737 ppm to less than 200 ppm. Among different sorbents, tailored calgon carbon not only reduced the S content to desired levels but also adsorbed the most highly refractive compounds (C_2BT and C_2DBT) successfully which are in general difficult to be removed from the diesel.

Thus the unconventional natural resources have been productively and effectively utilized as precursors for activated carbon materials and the same have been successfully exploited for energy and environmental applications.