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Enhanced dispersibility of carbon black particles by PVA encapsulation using combined heating method

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Abstract: Carbon black (CB) nanoparticles were prepared by incomplete combustion of petroleum in the presence of air. CB, both hydrous and non-hydrous were encapsulated by poly vinyl alcohol (PVA) using a simple method of combined heating. The resultant powder was characterized by XRD, SEM and FTIR. The particle-size distribution measurements of the obtained PVA-encapsulated CB (CB@PVA) nanoparticles show that the diameters of were distributed within the nanoscale dimension. Simple water dispersibility test was done to check for the changes. Using this strategy, complicated polymerization process involved in the counterpart of polymer coating applications can be avoided and it is much cheaper compared to any other techniques.

Keywords: Carbon black, PVA, encapsulation, XRD, SEM, and FTIR

1 Introduction: Carbon black is a particulate form of pure elemental carbon that is produced by partial combustion or pyrolysis of gaseous or liquid hydrocarbon under controlled conditions **[1]**. The carbon black emitted from vehicles is due to the incomplete combustion and inadequate maintenance of vehicles and it contributes to a major extent in urban atmosphere pollution. Therefore, it is important to study the chemical composition of the soot particles emitted from vehicles to understand their carcinogenetic health and environment impacts. Being a solid particle, carbon black is expected to eventually end up in sediment and soil **[2 - 4]**. Easy mode of collection of particles is from vehicles. The particles collected from the vehicles were considered to have similar characteristics as those emitted into atmosphere. It has been observed that many of the immature mechanic workers clean the vehicle emission pipes, collect the carbon black, heat them in air and dispose in the nearby drains or garbage without any proper precautions and also without the knowledge of its toxic properties.

Carbon black has been frequently used to investigate the biological effect of carbon cone of particles. The toxicity of particles largely depends on the particle size **[5 - 7]**. Carbon Black is completely insoluble and leads to form clumps in aqueous solution due to structural development by aggregation and agglomeration. Many of the researchers have proposed a model for agglomerate dispersion and some research into the effects of matrix viscosity and interstitial properties on dispersion of carbon black agglomerate has also been studied **[8]**. Preparing stable dispersion of carbon black in water is of greater significance either for pigment purpose or as reinforcing filler in rubber and plastic industry due to its excellent darkness, chemical stability and heating resistance **[9]**. Therefore, for the preparation of stable dispersion of carbon black in aqueous medium by low cost, technically straight forward and environment-friendly method is of great importance and in urgent needs.

So far several methods have been developed such as, facial treatment by traditional or novel dispersion. Surface coating can avoid the complicated polymerization process when a commodity water-soluble polymer is selected as the wall material to encapsulated carbon black particle. Lie et.al., selected polyvinyl alcohol (PVA) with high hydrolysis degree to encapsulate carbon via a simple method of coacervation and the coated carbon black could keep a stable dispersion in water based medium and encapsulating carbon black by hetero phase polymerization and by phase separation method **[10]**.

2. Materials and methods:

The sample was prepared by the combustion of petroleum in engine. Internal burning of petroleum takes place to produce power. After this process, the resultant as synthesized carbon is obtained. The sample appears to be wet when collected. Wetness is due to the hygroscopic nature of the material. Then the sample is burnt in air for 30 minutes; the resultant sample appears in dry form (burnt sample). Both the samples were finely powered. The samples were analysed under Scanning Electron Microscope (SEM) coupled with energy dispersive X-ray spectroscopy (EDS) for the estimation of morphology and elemental analyses. The Fourier transform infrared (FTIR) spectroscope was used for the analysis of functional group present in the samples. The structural studies were also done using XRD.

2.1 **For PVA encapsulation:** Small amount of solid Poly vinyl alcohol (PVA) was added to the as synthesized and also sintered samples and later pressed into pellets. Then these pellets were heated in the furnace up to 500 ^{o}C for 1h. The change in the samples after heating has been studied.

3. Results and discussion:

Microscopic images of the particles are shown in Figure (1) with different magnification. The sample shows hygroscopic nature and hence agglomeration. This is due to unburnt oil in the engine and after burning it appears to be porous as can be seen from burnt sample as shown in figure. The size of the individual particle was found to be less than 200 nm making them dangerous when inhaled. Local cleaning of vehicle silencers and improper disposal of carbon waste from them is one such environmental hazard.

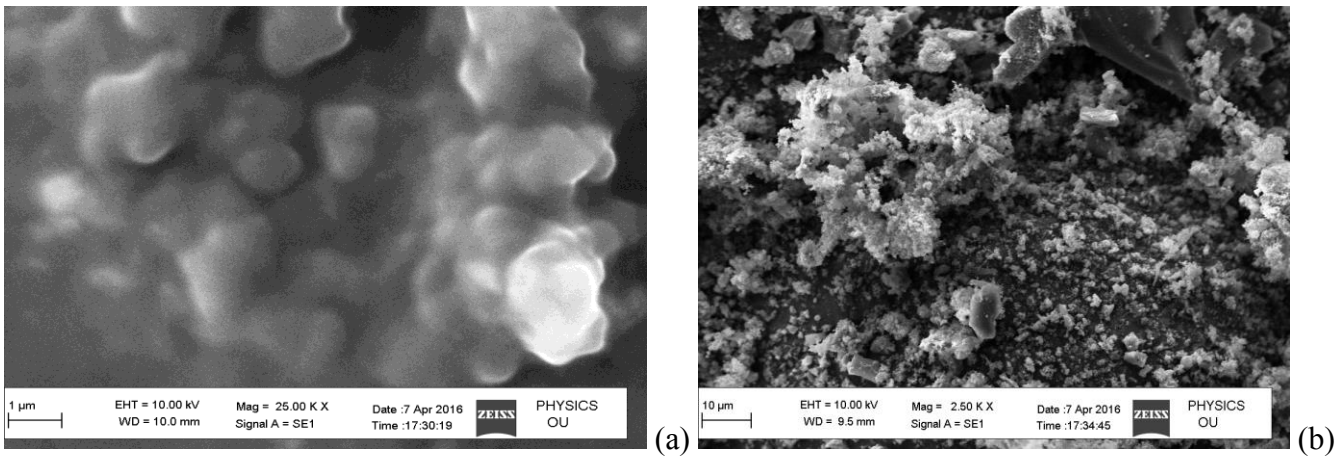
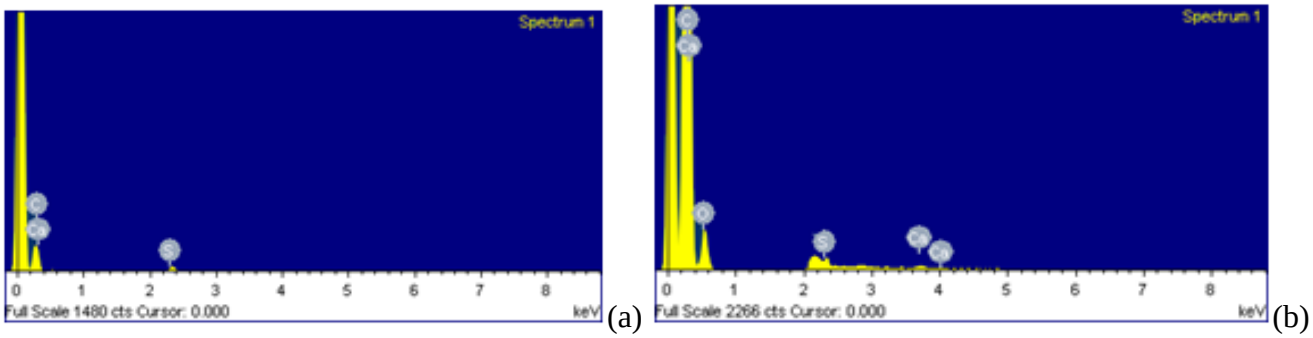


Figure (1): SEM images a) as-synthesized sample and b) burnt sample.

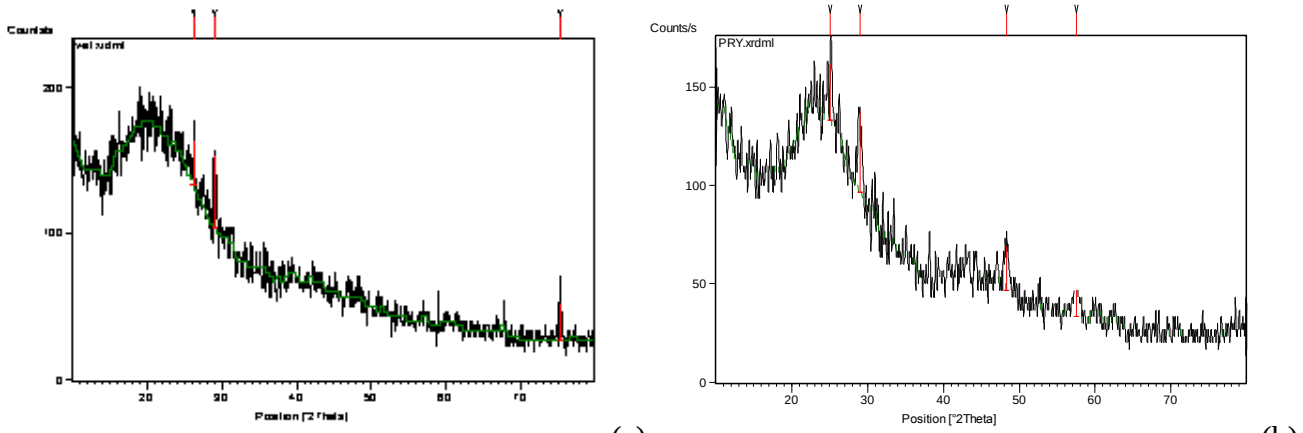
The elementary compositions of the samples are shown in Figure (2).



(a) (b)

Figure (2): EDXA of a) as-synthesized sample and b) burnt sample.

For carbon and non carbonic elements; the percentage of carbon is decreased in burnt sample as it escapes in the form of CO_2 and CO, S and Ca are present in very less percentage. Presence of O in burnt sample is due to heating in presence of air.



(a) (b)

Figure (3): XRD of a) as-synthesized sample b) burnt sample.

The XRD analysis of the samples shows amorphous nature of both as synthesized and also burnt sample. This amorphous nature can be clearly seen in Figure (3). Analysis of FTIR spectra is shown in the Figure (4). Both the samples have different spectra. The wet sample peaks observed between the band position range 3000 – 2800 cm^{-1} corresponds to H-C-H group asymmetric and symmetric stretch. The presence of C-H stretching in aliphatic groups suggests methylene and methane groups bonded to aromatic rings. Peak at 1400 – 1300 cm^{-1} corresponds to N = O bond. Peak at 1550 – 1450 cm^{-1} attributes to N – H bond. Peak at 1755 – 1650 cm^{-1} attributes to C = O stretch.

For burnt sample, peak is observed between the band position range 1600 - 1675 cm^{-1} corresponds to C-C=C symmetric stretch. Peak at 1500 – 1440 cm^{-1} attributes to H-C-H bend. Broadening in the region 1300 – 1000 cm^{-1} is observed in the spectrum where aromatic C-C and C-H plain deformation structure appears. Peaks were observed at 3400 – 2400 cm^{-1} which attributes to O-H stretch.

Figure (5) shows dispersibility of the sample in normal water. As synthesized and burnt samples show lesser lesser dispersibility when compared to their respective encapsulated samples. This is clearly visible in Figure (4) with a pattern structure of distribution.

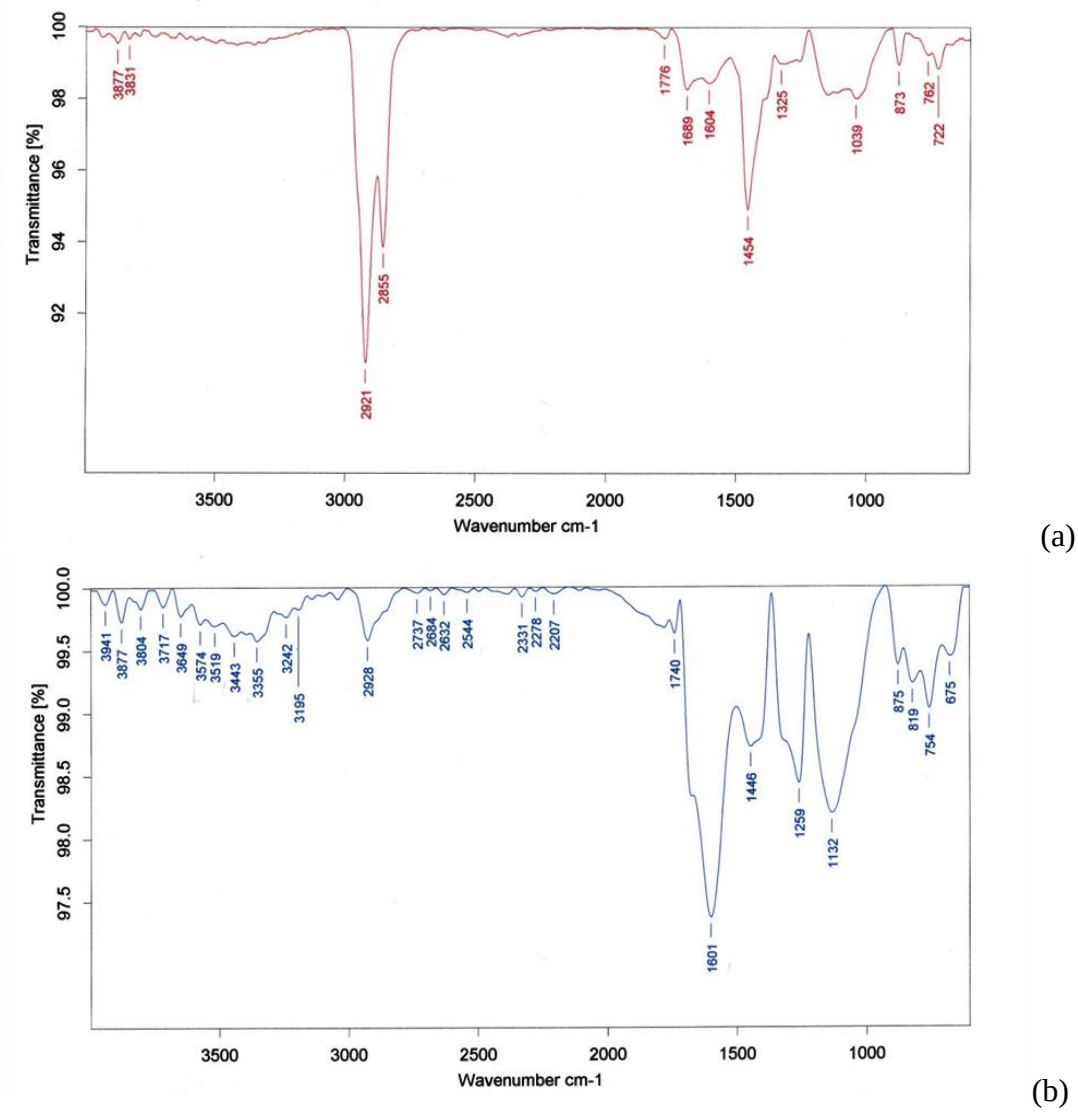


Figure (4): FTIR spectra a) as-synthesized sample b) burnt sample.

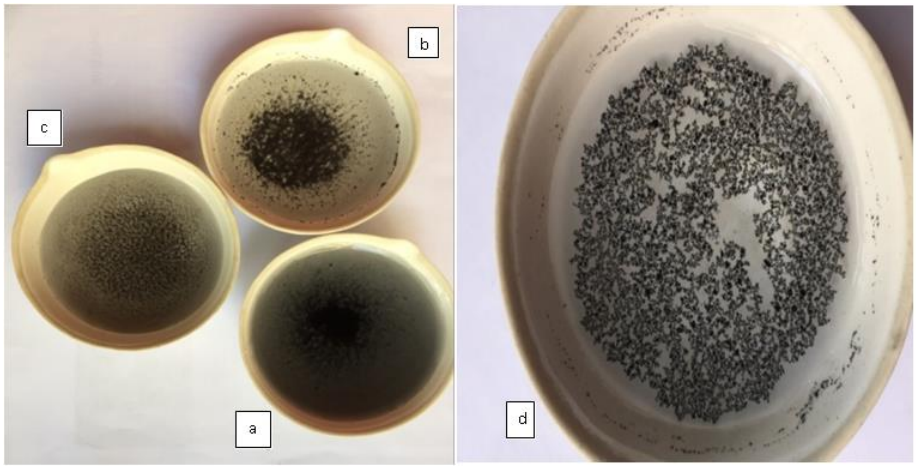


Figure (5): Simple water dispersibility test of a) burnt sample; b) PVA encapsulated as-synthesized sample; c) PVA encapsulated burnt sample; d) Dispersibility of as-synthesized sample in water.

4. References:

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