11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Synthesis of carbon nanospheres from petroleum residues

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Abstract – Carbon nanospheres were produced from the light residue obtained as a by-product of the production of carbon materials from a decant oil, in a continuous process and with good yield. The precursor has a complex composition and the process depends strongly on the reaction temperature, with organic by-products observed at lower temperatures. Good mass yields were obtained, up to 50%, depending mainly on temperature and flow rate of the precursor.

A number of potential applications for carbon nanospheres have been identified, including catalyst support, lithium-ion battery electrodes, lubricants, field emission devices and biosensors. Carbon nanospheres have been produced successfully by chemical vapor deposition (CVD) from a variety of pure hydrocarbons, light hydrocarbon mixtures, and solid by-products of petroleum refining. Liquid residues from petroleum refining are a traditional raw material for the production of carbon materials but have not been previously used in CVD production of nanomaterials.

Heat treatment of a decant oil sample for the production of carbon materials yielded, as a by-product, a lighter residue suitable for vaporization [1]. This residue was fed into a vertical tube furnace at temperatures between 800 and 1200º C, using argon as carrier gas. No catalyst was used.

Carbon nanospheres were obtained at temperatures of 1000°C and higher. Nanosphere purity depended on process temperature, with samples produced at 1000°C containing ~3-5% of organic byproducts, not observed in samples produced at 1200°C. Spheres produced at 1200°C showed a higher oxidation resistance, with oxidation peak at 620-640°C, compared to 580-590°C for spheres produced at 1000°C but XRD analysis did not reveal significant differences in structure between the samples. Diameters varied from 100nm to 600nm, depending on process conditions.

Mass yields depended strongly on reaction conditions, specially temperature and flow rate of precursor, varying between 20 and 50%.

Different residues of similar composition were also used as precursor, with similar results, showing that the process is fairly robust and adequate for large scale production, where variations in feed composition are to be expected.

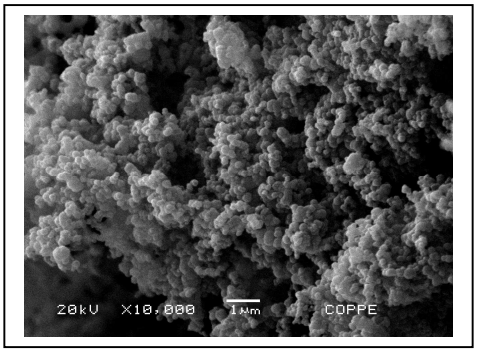

Figure 1: SEM image of nanospheres obtained at 1000°C.

References

[1] Dutra, C.H.M.C. Heavy petroleum residues behavior under pyrolysis of FCC residues and the production of precursors for new materials. Doctorate Thesis. Universidade Federal do Rio de Janeiro, 2009.