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NANO-RANGE OCTOPUS TYPE VAPOR GROWN CARBON FIBERS FROM CAMPHOR

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Carbon nanofibers are synthesised by pyrolysis of camphor vapor in nitrogen atmosphere in the temperature range of 650°C to 750°C. Thickness of carbon fibers increases from 30 nm to 250 nm with an increase of pyrolysis temperature. Characterizations of these fibers were done by SEM and TEM. A novel growth of carbon nanofibers of octopus type has been seen on the electrochemically nickel-plated copper sheet. At higher magnification of TEM studies, carbon nanofibers are found to made up of many thin cotton threads like structures.

Keywords: carbon nanofibers; camphor; pyrolysis

INTRODUCTION

Since last one and half decade, many carbon nano structure materials came to existence in laboratory and became industrially established due to extensive successful research in this particular area. Although most of the research in this new area has been centered on the controlled synthesis, growth mechanism and the application of carbon nanotubes due to its extraordinary electronic, mechanical and other physical properties, very few studies have high lighted in the synthesis, growth process and application of carbon nano-fibers. Carbon nanofibers have been found suitable in field emission [1,2], hydrogen storage [3,4], anode in lithium battery [5] etc. It is also worth noting that, most of the research for the synthesis of carbon

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nanomaterials have been carried out with precursor like graphite, acetylene, benzene etc. [6–9], which are limited and some of them are poisonous and hazardous as well. In this study, authors have made an attempt to prepare carbon nanomaterials from Camphor, which is a natural source, as it is extracted from the bark of PINE trees, mostly seen in The Himalayan region (China, Japan and India). Due to low boiling temperature of 180°C, camphor needs low temperature to vaporize.

Sharon *et al.* has reported fullerene [10] and other form of carbon materials [11–13] taking camphor as a precursor. This report deals with synthesis of carbon nanofibers from same natural precursor, camphor and its novel growth process.

EXPERIMENTAL

Pyrolysis of camphor was carried out inside a long cylindrical quartz tube that kept inside two furnaces. Detailed of experimental set-up has been given elsewhere [14]. Briefly, furnace 1 was used to vaporize camphor at temperature of 180–200°C and furnace 2 for pyrolysis of camphor vapor over the substrate at different temperatures (650–750°C). The vaporized camphoric gas from furnace 1 was carried by incoming flow of nitrogen gas in to the second furnace for pyrolysis. In addition to creation of inert medium inside the silica quartz tube, nitrogen also acts as a carrier gas in this case. Instead of taking a nano size catalyst particles (as generally taken for production of nanotubes/nanofibers or catalytically patterned substrate) we plated nickel on 0.15 mm thick copper sheet electrochemically, taking nickel sulfate as an electrolyte. Depositions were carried out at different pyrolysis temperature keeping vaporization temperature and substrate constant for all the experiments. The surface morphologies and microstructures were characterized by scanning electron microscope and transmission electron microscope, respectively.

RESULTS AND DISCUSSION

Figures 1(a), 1(b) and 1(c) shows the scanning electron photographs of samples deposited at 650°C, 700°C and 750°C respectively. All these figures reveal dense growth of carbon fibers and well uniformly distributed all over the substrates. Carbon fibers thickness was 30–50 nm, 150–200 nm and 200–300 nm at pyrolysis temperature of 650°C, 700°C and 750°C respectively. A novel shape has been seen in all these cases. Though in Figure 1(a), this type of growth is not very well defined but at a closer look, we have seen same growth. The bright dots of these photographs are nickel particles, lifted to top of the substrates. This new type of growth of carbon

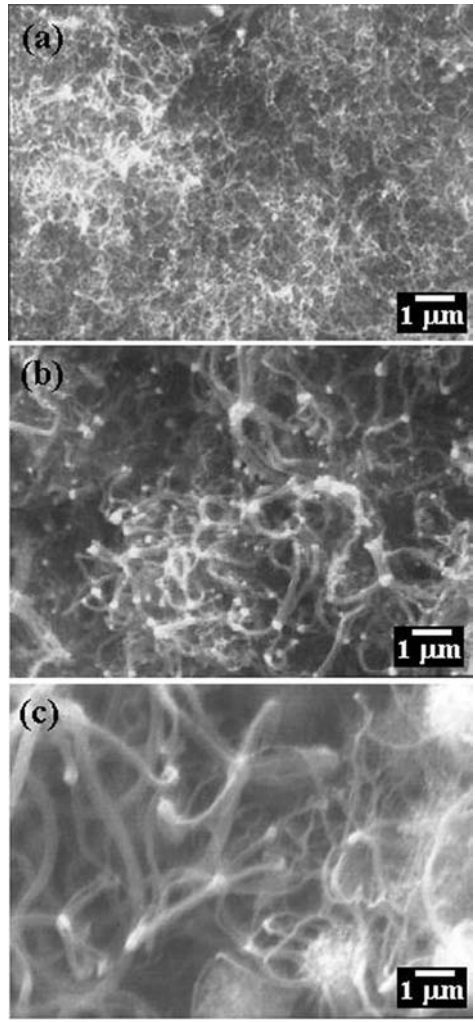

FIGURE 1 Scanning Electron photograph of samples deposited at pyrolysis temperature of (a) 650°C, (b) 700°C and (c) 750°C.

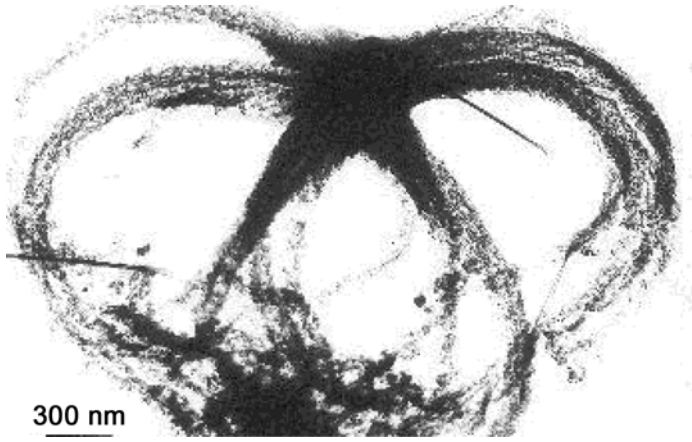

FIGURE 2 TEM image of one octopus carbon fiber growth.

fibers looks like an "octopus" and hence we call it as "octopus carbon fiber". There are two established mechanisms: one formulated by Baker and Harris [7] (many others supported this for the growth of carbon fiber), known as "floating catalyst" and other is "base mode growth" mechanism. As we have taken nickel-plated copper sheet as a substrate, it can come under "base mode growth" mechanism. But contrary to base growth mechanism, we find that nano particles (i.e., catalysts) are lifting up to a certain height and acting as a multi-nucleation center. We believe that different faces/edges of lifted nickel catalyst act as a nucleation site for the growth of one fiber and making the total as branched structure. Here, question arises why nickel is lifting to a certain height. It may be due to weak interaction between substrate and plated nickel, as deposition forms many islands on the rough copper substrates. Actually, TEM images (Fig. 2) confirm the existence of these thread like nanostructure morphologies of SEM as carbon fibers. From the Figure 2 it is also observed that these fibers are made up of cotton thread like structures and may act as good candidate for hydrogen absorption study. Diffraction study suggests these fibers to possess partly crystallized containing (002), (101), (004) and (112) planes.

CONCLUSION

Taking a natural source, camphor, carbon nanofibers are successfully produced. Though conventionally hydrogen atmosphere is used for the growth of carbon nanofibers, here we report the growth in presence of nitrogen atmosphere. A new type of growth has been seen and fiber thickness was found to increase with pyrolysis temperature.

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