ELECTRICAL CONDUCTIVITY CONTROL IN SPNT PROCESS

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ABSTRACT

Electrical conductivity in SPNT (Solid Phase Nano Tube) had been found strongly depends on baking process and baking temperature, chemistry of solid carbon source. First, in the SPNT process, the material and process control must provide tube shape product from the key baking step in inert gas environment. Certain range of the metallic catalyst amount and only few of carbon sources having specific cellulose chemical functionality does show tube shape. Secondly, for the electrical conductivity control, baking process including baking mode, baking temperature, baking time seems to play the key role. These two baking modes give a big deal on the hollowness of the tube and electrical conductivity

Keywords: SPNT, electrical conductivity, slow baking mode, fast baking mode, solid rod

1 INTRODUCTION

SPNT (Solid Phase Nano Tube) had been known as carbon nano tube produced by solid carbon sources[1] in comparison with Gas Phase Nano Tube (GPNT) conventionally prepared from gas phase carbon sources. The SPNT products had been successfully manufactured from many different sources of wood, paddy husk, coffee bean, cedar wood, showing geological effect including various shapes (diameter, length, and howllowness). The most substantial feature of SPNT over GPNT may be the superior compatibility with various media due to short length in the range of several ten nm to several thousand nm when formulating a nanocomposite for different applications. The second advantage of SPNT may be the superior high heat resistance over SWNT or MWNT products of GPNT. Actually, SWNT and MWNT from GPNT process only survive at burning temperature less than 500C in atmosphere while SPNT can survive up to 1400C.

2 EXPERIMENT RESULTS

In the present report, we are studying the fabrication process related factors which show significant effect on electrical conductivity of SPNT. Several solid carbon sources had been tested including paddy husk, cotton, and pine wood. .These solid carbon sources are somehow ground into very fine dust using wood grinder. The fine powders are then soaked into the catalyst solution and dried to get catalyst molecules evenly absorbed onto it. The final precursor for SPNT is powder of solid carbon dust carrying catalyst on the surface. The SPNT precursor was fed into a quartz tube where N2 gas can flow through during the reaction. The air inside the quarzt tube containing precursor was removed by a vacuum pump then kept filled up with N2 during burning period. In the Fast Bake NF process (N= N2, F= Fast), the oven was heated up to targeted temperature first then the quartz tube containing precursor was inserted and kept there for 60minutes .
In the Slow Bake NS process (N=N2, S=Slow) , the temperature of the reaction chamber was slowly raised from room temperature up to targeted temperature and the reactor was kept at this temperature until the end of the process. In either case of baking process; the N2 gas is always flowing through the reaction chamber (quartz tube) even after the baking temperature is turned off until it reaches room temperature. Fig.1 exhibits the SEM image of

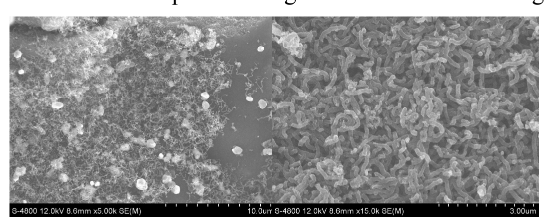

Fig.1 SEM image of SPNT product in -situ

the product in-situ baked at NF1200 condition, 1200 means 1200C.
First, the metallic catalyst in the in-situ product was removed by stirring it in 6M HCl at 70C for 1 hr followed with water wash until no acid detected. Next, the removal of amorphous component was carried out by a proprietary process to convert all of amorphous carbon into soluble species which can be filtered out with DI water.

It should be noted that the amorphous can be a non tubular component or it can fill up the howllow tube into a ***solid rod*** . It should be also noted that the amorphous removal in the present study didn't leave any metallic or electrical conductive element in the purified product.

In order to measure resistivity, CNT powder was pored into a syringe and pressed strongly with the piston until it cannot move any further more. When piston was pressed, a vacuum source from a vacuum pump was applied to suck the air inside the syringe out to produce a firm packing of CNT. Then a bias was applied between two ends of the CNT pack to measure resistor R. The resistivity of the CNT was calculated from the length, R and area of well pressed CNT compact based on the formula (1)

Fig.2 set up to measure resistivity

$$\rho = R \times L/S \qquad (1)$$

In which ρ= resistivity, R= resistor, L= length, S= area

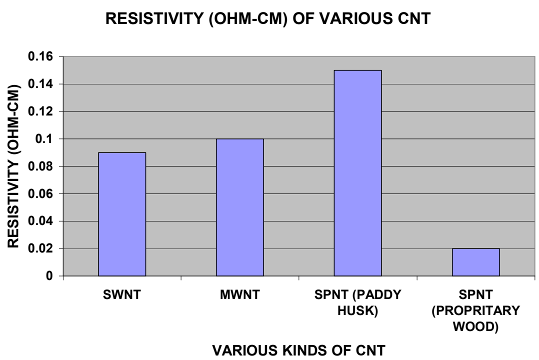

Fig.3 Resistivity of several CNT products

Fig.3 exhibits the resistivity (ohm-cm) of various kinds of CNT. Some specific SPNT shows higher electrical conductivity than that of SWNT, MWNT prepared from gas phase carbon sources. The electrical conductivity of some SPNT can go beyond that of GPNT in the order of 10X. Next, we will discuss the effect of baking mode on the hollowness of the tube product. Fig.4 shows TEM images of SPNT prepared from the same precursor (paddy husk) but at different baking modes (a) for FB process and (b) for SB process. In many cases, it is observed that FB the higher baking temperature gives more amorphous in either cases but less in the FB process. The solid rod product may be comprised of amorphous component filled up the tube.

Next, Fig.6 exhibits electrical resistivity of SPNT products made at different baking mode. It is observed that FB product exhibits higher conductivity than that of SB

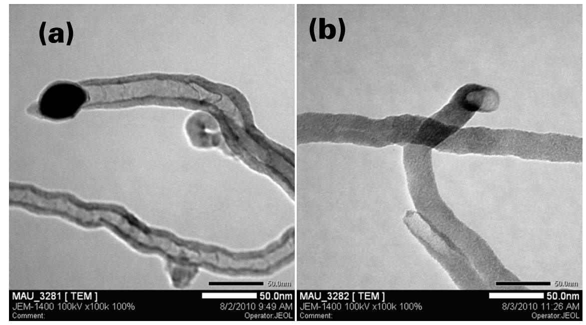

Fig.4 TEM image of SPNT produced from paddy husk (a) NF750C (b) NS750C

product. Also, longer baking time gives higher conductivity process easily gives rise to light, hollow tube while SB

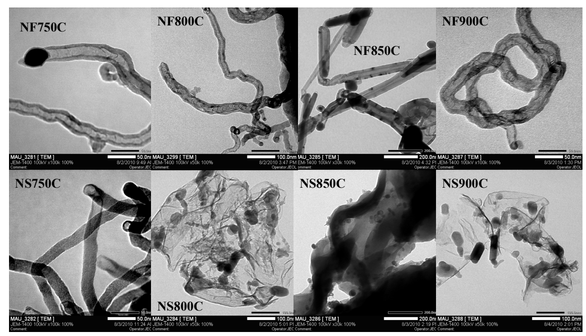

Fig5. TEM images of SPNT made out of paddy husk at different temperatures

process gives more ***solid rod*** than tube.

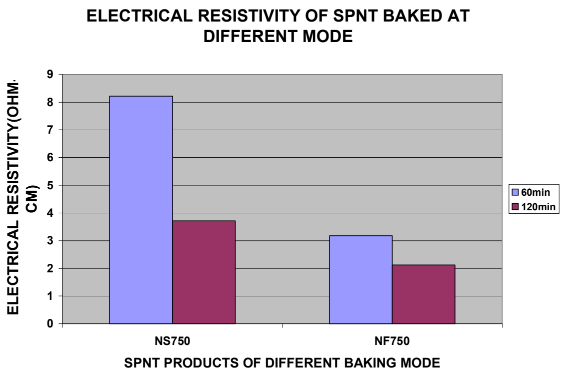

Fig. 6 Electrical resistivity due to different baking mode

Fig.7 exhibit electrical resistivity as function of baking temperature at two different baking modes. It is observed that these two baking modes give a big deal on the electrical conductivity: higher conductivity comes out from the fast baking mode with electrical conductivity varies in an order of 10^3 when baking temperature changes between 700C and 1000C.

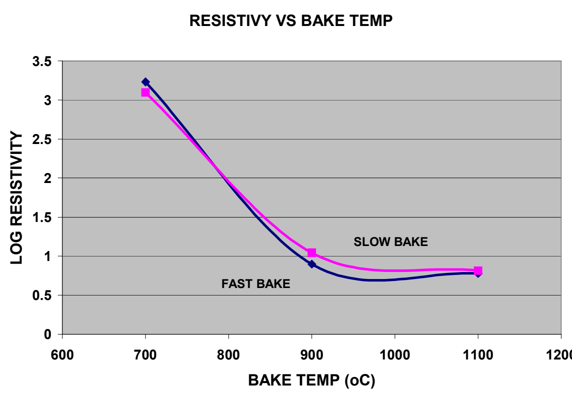

Fig.7 Electrical resistivity as functions of baking temperature for two different baking modes: Fast and Slow

One can see that at baking temperature less than 800C, Slow Bake gives slightly higher conductivity but after that Fast Bake gives better conductivity

3 CONCLUSIONS

It is concluded that

a) Fast Bake process gives more hollow tube and better electrical conductivity
b) Slow Bake process gives more amorphous and /or solid rod filled of amorphous and less electrical conductivity

However, it is also dependent on the chemistry of solid carbon source and it should be clarified in another work.

REFERENCES

[1] Khe et all, Nanotech 2007. 2008, 2009, 2010 proceedings