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# Hybrid Composite of Polyaniline Containing Carbon Nanotube

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**Abstract:** Carbon nanotube-polyaniline hybrid material was synthesized by emulsion polymerization *in-situ*. The morphology of hybrid material was studied by TEM and X-ray diffraction. The conductivity of nanocomposite increases with the increasing of carbon nanotube content because of the new conductivity passageways formed by carbon nanotubes.

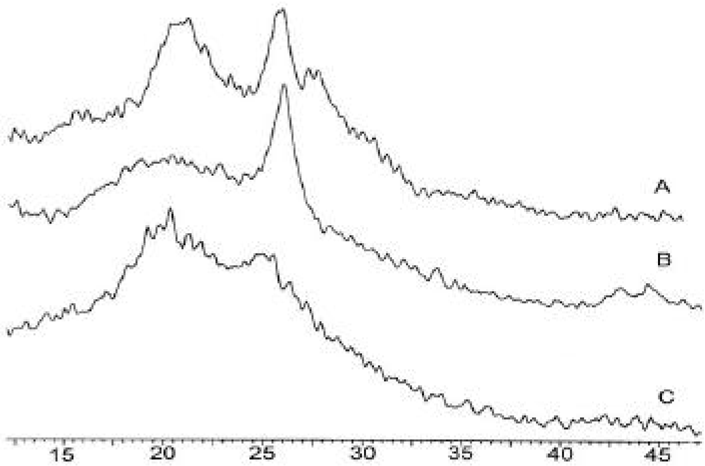
**Keywords:** Carbon nanotube, polyaniline, hybrid material.

Among various conducting polymers, polyaniline (PANI) is a unique and promising candidate for practical applications because it is not only highly stable in air and in some solvents, but also exhibits dramatic changes in its electronic structure and physical properties in protoactivate state[1,2,3]. The carbon nanotubes (CNTs) have been proven to possess exotic properties, such as high mechanical strength, flexibility and electric conductivity. The study of carbon-based nanostructures and materials has become an alluring theme since their discovery. Recently, molecular design and synthesis of organic/inorganic hybrid composite is one of the most challenging themes in synthetic materials field. In addition, recently new developments have appeared in design and synthesis of nanocluster-based material. Several hybrid materials so far have been reported to exhibit new properties. M. Higuchi *et al*.[5] reported that redox behavior of polyaniline-transition metal complexes in solution providing a novel reversible redox system. B.Z.Tang[6] prepared $\gamma$-$Fe_2O_3$/PANI nanocomposite films, which exhibit macroscopic processibility, high electrical conductivity and magnetic susceptibility. C.G.Wu *et al*.[7] reported that redox intercalative polymerization of aniline in $V_2O_5$ xerogel. M.X. Wan[8] prepared $Fe_3O_4$/PANI nanocomposite with super-paramagnetic and semiconducting behavior. CNT/polyvinyl alcohol nanocomposite was reported by S. P Shaffer and A. H. Windle[9].

Packing the nanotubes with polyaniline may synthesize novel nanomaterials with dramatic electronic, optical and magnetic properties[4]. In this work, we synthesized the CNTs/polyaniline hybrid materials by emulsion polymerization *in-situ*, and doped them with 1.5 mol/L $H_2SO_4$ for 2 hours. The XRD results indicated that the carbon nanotubes existed in hybrid materials, shown as **Figure 1**. The parent PANI powders exhibit two broad peaks at $2\theta$ angles around 21° and 26°, which are similar to those of the PANI reported by other groups[6,7,8]. When 1% CNT powders were incorporated into PANI, the peak become broader and weaker at the 2θ=21° (**Figure 1 B**), and the peak at 26° become much shaper, possibly because of the superimposition of peaks of PANI and CNT whose X-ray diffraction peak appeared at 26.1°. When the CNT content further increases to 10% (**Figure 1 C**), the peaks of complex become much broader and weaker than that of 1% or PANI, possibly because the CNT have acted as “impurities” to hamper the growth of the PANI crystallites. High-resolution transmission electron microscopy (TEM) has been used to study the structure of hybrid materials. The **Figure 2** shows the TEM micrograph of CNTs/PANI hybrid material, which displays the composite has a new network structure. The carbon nanotube was warped by PANI and the nanotubes attached each other to form networks.

The FTIR spectrum of CNT/PANI nanocomposites shows the characteristic IR pattern of emeraldine salt in the region 1000~1600 $cm^{-1}$ (**Figure 3**). The peaks of 1557 $cm^{-1}$ and 1473 $cm^{-1}$ are attributed to quinone and benzene ring deformation, which are present in the samples of PANI synthesized by other ways[9,10]. Their positions are independent of content of CNT. The peak at 1105 $cm^{-1}$ in **Figure 3** is attributed to $SO_4^{2-}$, this indicates that the samples of PANI synthesized were doped by $H_2SO_4$. In **Figure 2**, all the curves are the same, this indicated that the CNT does not affect the PANI backbone structure.

**Figure 1** XRD patterns of PANI and CNT hybrid material, recorded on a power diffractometer Philips PW1830) with CuKα radiation
A —PANI, B —1% CNT hybrid material and C —10% CNT hybrid material



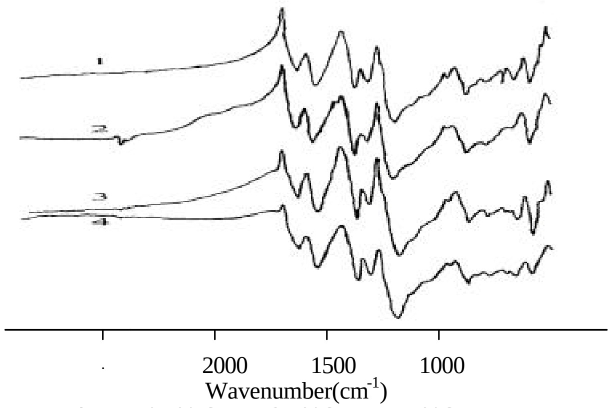

The conductivity measurements of PANI and hybrid materials were performed using HDV-7C constant voltages device. The results were shown in **Table 1**. The conductivity of the hybrid materials increases with the increasing of CNT content. The conductivity of the nanocomposite with 10% CNT is 0.66 s/cm, which is 25 times more than that of the parent PANI ($2.6\times10^{-3}$ s/cm). The TEM photographs indicate that some CNTs are linked up by the PANI chains, which looks like a network including PANI fiber and nanotubes. This can form some passageways of conductivity.

**Figure 2** The TEM photograph of CNTs and CNTs/PANI hybrid material

A B

A-CNTs(×20K), B-CNTs/PANI(×100 K).

**Figure 3** IR spectra of hybrid material with different CNTs content




1-PANI, 2-0.2% CNTs, 3-2%CNTs, 4-5%CNTs.

**Table 1** The conductivity 0f CNT/PANI hybrid materials

| CNT content(%) | 0 | 0.2 | 1 | 2 | 3 | 4 | 5 | 10 | 100 |
|---|---|---|---|---|---|---|---|---|---|
| Conductivity($\times 10^{-2}$) | 0.26 | 0.8 | 1.09 | 1.2 | 2.0 | 2.9 | 3.3 | 6.6 | 23 |

Scan rate: 5 mv/s, record time: 1/10s, pressed pellet at 20Mpa (S=0.785cm$^2$)

In conclusion, the hybrid composite of polyaniline with CNTs provides some novel properties. Further investigation is now in progress.

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