Summary
Composites of carbon a nanotube with polymers are a developing and interesting area of research. The dispersion of the nanotube in polymer matrices is an important factor while making its nanocomposites. Even though in-situ polymerization approach offers a better approach for synthesizing homogeneous polymer nanotube composites, the dispersion of the nanotubes in the monomer solution is a problem. In this article we report a new chemical method for dispersing nanotubes in monomer and the preparation of uniform tubular composite of polyaniline (PANI) and multiwalled carbon nanotube (MWNT). For this the oxidized multiwalled nanotube (o-MWNT) was functionalized with p-phenylenediamine, which gave phenylamine functional groups on the surface. This functionalization helped to disperse the nanotubes in acidic solution. The in-situ polymerization of aniline in the presence of these well dispersed nanotubes gave a new tubular composite of carbon nanotube having an ordered uniform encapsulation of doped polyaniline. The phenylamine functional groups on the surface were grown into polyaniline chain so that the composite contains polyaniline functionalized CNT and they were no more an “impurity” in the final nanocomposite. The microscopic and structural properties of this composite were compared with that of a composite prepared under identical condition using o-MWNT.

Introduction
Carbon nanotubes, the smart hollow tubular carbon architecture of nano range, are attractive candidates for use as nano materials and nano devices on account of their structural characteristics and promising electronic and mechanical properties. Embedding of carbon nanotubes in conducting polymeric matrices like polythiophene, polyaniline, PPV etc for various nanocomposites material is now a popular area of research especially in organic electronics [1-5]. The combination of CNT with conducting polymers offers an attractive route to reinforce polymer as well as introducing electronic properties based on morphological modification or electronic interaction between two components. The chemical tailoring of CNT surface with polymeric architectures and construction of complex nano structured composite
materials in bulk broadened the applicability of these materials. The quality of nanocomposites depends on the dispersion of carbon nanotube in the polymer matrix or homogeneity of the material. In the case of nanotube their insolvency and poor compatibility with the polymer make the uniform dispersion of carbon nanotubes in the polymer matrix very difficult, and the resulting inhomogeneous nanocomposites often have unsatisfying properties.

Currently different methods are used to incorporate nanotubes into polymer matrix. The common methods are:

i) Direct mixing: carbon nanotubes are dispersed into a low-viscosity thermosetting resin followed by curing [6] ii) Solution mixing: carbon nanotubes are dispersed in a solution of thermoplastic polymer followed by removal of the solvent or precipitation of the polymer. Some times the carbon nanotubes are chemically attached to the matrix polymer [7-9]. iii) Melt mixing: carbon nanotubes are mechanically dispersed into a polymer melt (prepared by heating) using a mixer or a compounder. The composite is processed using processing techniques such extrusion, injection molding and compression molding [10, 11]. iv) In –situ polymerization: This is a good approach for synthesizing homogeneous polymer nanotube composites where the matrix polymer is formed in the presence of nanotube [12-14]. In some in-situ polymerizations the surface of the nanotubes are grafted with polymer [15]. Generally in this method the carbon nanotubes are dispersed in a solution of monomer of the matrix polymer followed by the addition of the polymerization initiator. So the polymer is formed in the presence of the carbon nanotube and a composite is formed in a single step. This method usually leads to a firm wrapping of polymer on nanotubes. In such a method the homogeneity of the composite can again be affected by the dispersion of the nanotubes in the monomer solution. The more it is dispersed the higher will be the homogeneity of the composite.

In this work we used polyaniline, the conducting polymer which is a promising candidate for the synthesis of nanocomposites due to its ease of synthesis, electrical conductivity and environmental stability. Many groups have reported on the synthesis and properties of polyaniline/ carbon nanotube composites [16-18]. Cochet et al. reported that the in-situ chemical oxidative polymerization of PANI in the presence of CNT led to the formation of true composite material with enhanced electronic properties. In that composite effective site-selective interactions between the quinoid ring of the PANI and the MWNTs facilitated charge-transfer processes between the two components [19]. In such composites, CNT can improve the polymer properties by (i) inducing additional structural ordering of the polymer (ii) improve the compactness and conjugation or chain length (iii) higher delocalization of charges in composite (iii) thermal stability (iv) charge carrier mobility [17].

In this work we report a new approach for the preparation of homogeneous nanocomposite of polyaniline and MWNT by the in-situ polymerization. For this we covalently functionalized the multiwalled nanotubes with para-phenylene diamine expecting that,

i) the phenylamino groups on the surface helps to disperse them well in the dopant acid solution

ii) the phenylamine functional part will no longer be an ‘impurity’ in the composite since it can also be converted to polyaniline during polymerization. For comparison we also prepared a composite in the same way in which CNT is not functionalized with para-phenylene diamine.