



## Properties & Use of Carbon Based Nanomaterial in Energy Harvesting: A Electrochemical Studies

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### Abstract:

Nanotechnology has been attracted imaginable attention for many scientists worldwide. Nanomaterial's can simply be defined as the technology at the scale of one-billionth of a meter. It is the design, characterization, synthesis and application of materials, structures, devices and systems by controlling shape and size at nanometer scale. The small dimensions, strength & the remarkable physical properties of these structures make them a very unique material with whole range of promising application. In this paper the studies of electrochemical properties, source & application of various nanomaterials is present.

*Keywords:- Electrochemical Properties, Carbon nanotube, Energy Source, Electro deposition, Graphene, properties of Nanomaterial's, Fuel Cell, Solar Cell.*

### Introduction:

The Nanotechnology is employed to describe materials, devices and systems with structures and components exhibiting new and significantly improved physical, chemical and biological properties as well as the phenomena and processes enabled by the ability to control properties at Nano scale. These materials are characterized by at least one dimension is in the nanometer rang. The nanostructure constitutes bridge between molecule and infinite bulk system. The physical and chemical properties of nanomaterial's are differ significantly from those of the atomic, molecular or the bulk materials of the same composition, because when the size of the structure is decreased, then surface/volume ratio increases considerably & the surface phenomena predominate over the chemistry & physics in the bulk [1,2]. Therefore the nanomaterial's have attracted particular interest due to their unique morphology, Nano sized scale, novel physic-chemical properties and for their versatile application in all area worldwide [3,4] Carbon -based material such as diamond , Carbon nanotube, carbon Nano fibers, carbon Nano spheres and graphenes are more favorable in terms of their better stability and mechanical strength. Among these carbon nanotube and graphene do possess unique structural, electronic, mechanical and optical properties, hence they are actively sought as an effective component of verity of devices including field effect transistor's (FET) , Li-ion batteries, light emitting diode(LED) and also as a catalyst supporting fuel cell [5,6] . The carbon nanotube could be visualized as rolled sheet of graphene that is  $sp^2$  carbon arranged in homocomb lattice .There are two groups of carbon nanotube, multiwall carbon nanotube, and single wall carbon nanotube can be visualized as concentric and closed graphite tube with multiple layers of graphite sheet defining a hole typically from 2 to 25 nm separated by distance of approximately 0.34 nm [7-9]. The basis for this development is the nanomaterial has superior properties than ones.

### Electrical studies of carbon nanotubes:

Multi walled carbon nanotubes show superconductivity with a relatively high transition temperature. Nano particles are a connection between isolated atoms and condensed matter. Electron transport in nanotubes is described as ballistic, i.e. the resistance of the nanotube does not depend on its length as the mean free path  $\lambda_m$  is longer than the



nanotube itself.  $\lambda_m = 30 \mu m$ , which was much longer than the nanotube used [10]. Recent measurements of the magnetic properties of nanotubes indicate that SWNT might be the long sought material for room-temperature superconductors [11, 12]. Carbon Nanotubes are particularly attractive due to their tubular shape, low density, tunable electrical properties, ballistic electrical transport, lack of skin effect, current carrying capacity exceeding superconductors and greater mechanical strength than any other materials.

#### **Optical and Electrochemical studies of CNT:**

Carbon Nanotubes are unique one-dimensional material, whose tube have unique and highly ordered atomic and electronic structure and can be made in wide range of application. One of the more recently researched properties of multi-walled carbon nanotubes (MWNTs) is their wave absorption characteristics, specifically microwave absorption. Numerous studies have been performed in the field of nanotube light absorption, Raman scattering, fluorescence photo induced molecular desorption [13] and nonlinear optical properties [14, 15]. The photoconductivity of films of single-wall carbon nanotubes has been studied under continuous-wave near-infrared illumination. The photocurrent exhibits a linear response with the light intensity and with bias voltage up to 5 V. The temporal photo response of on/off step illumination shows a relatively slow relaxation time  $\sim 4.3$  s for films with a thickness of; 500 nm, which can be interpreted in terms of a kinetic model that takes into account the binding of photoelectrons with adsorbed oxygen. It was demonstrated that single-wall carbon nanotubes are capable of absorbing NIR light and generating a photocurrent under low applied bias. Common types of carbon nanotube pastes are soft and non-compact, and have to be kept in special bodies. A holder for carbon pastes can be realized as a well drilled into a short Teflon rod, a glass tube, or a polyethylene syringe filled with a paste, which is electrically contacted via a conducting wire. Such constructions are very simple; however, there is one aspect which makes them not very convenient for practical use and this is the necessity of refilling the carbon paste in experiments requiring a regular removal of the electrode surface layer [16].

The electrode can be constructed by mixing graphite powder and multiwall carbon nanotubes in a mortar and pestle. Using a syringe, paraffin was added to the mixture and mixed well for 40 min until a uniformly-wetted paste was obtained. The paste was then packed into a glass tube. Electrical contact was made by pushing a copper wire down the glass tube into the back of the mixture. When necessary, a new surface was obtained by pushing an excess of the paste out of the tube and polishing it on a weighing paper. The percent of graphite, carbon nanotube and the mineral oil can be adjusted. A lot of searches used a ratio of 60:7:33 respectively and gave good results [17-19]. All the electronic, Optical, electrochemical and mechanical properties of carbon nanotube are tunable.

#### **Li-ion battery:**

The Carbon Nanotube shows great potential as anode material for li-ion batteries due to their unique structural mechanical and electrical properties. The outstanding mechanical properties and the high surface-to-volume ratio (due to their small diameter) make carbon nanotubes potentially useful as anode materials or as additives in lithium-ion battery systems. The electrode containing 10 wt % of carbon nanotubes as the additive displays a homogeneous distribution of nanotubes in synthetic graphite. With increasing weight percent of carbon nanotubes, the cyclic efficiency of the synthetic graphite battery anode increases continuously, and, in particular, when 10 wt. % of the nanotubes was added, the cyclic efficiency was maintained at almost 100% up to 50 cycles [20-22]. At higher concentrations, the nanotubes interconnect graphite powder particles together to form a continuous conductive network [23]. So with progress in the research on CNTs and nanomaterial's the application of CNTs is emerging because of its excellent electrochemical properties the CNTs



are widely used in Li-ion batteries both as anode materials and conductive additive in the composite electrodes

#### **CNTs in Pb-Acid batteries:**

The CNTs in Lead-Acid batteries enhances its lifecycle by reducing the sulfation phenomenon through the formation of conductive matrixes in active masses. In order to increase the conductivity of electrodes in lead-acid batteries, different weight percent of carbon nanotubes are added to the active anode material (with average diameters 2–5 nm) of the positive electrode. The resistivity of the electrode is lowered for the case of 1.5% nanotube addition. When this sample (0.5–1 wt %) is incorporated in the negative electrode, the cycle characteristics are greatly improved compared with those of an electrode without additive [24]. This is probably due to the ability of carbon nanotubes to act as a physical binder, resulting in electrodes that undergo less mechanical disintegration and shedding of their active material. Therefore, it is expected that the use of carbon nanotubes as an electrode's filler should produce an enhanced cyclic behavior for electrodes in lead-acid batteries compared with electrodes using conventional graphite powder, because the unusual morphology of the carbon nanotube, such as the concentric orientation of their graphite crystallites along the fiber cross-section, induces a high resistance towards oxidation, and furthermore the nanotube network embedded in the polymer would enhance the reactivity of the electrode. The improvement in this it can open several new fronts of technological advancement in different sectors like automobile, telecommunications and renewable energy.

#### **Use of CNTs in Fuel cell:**

The Carbon Nanotube can store hydrogen which enable electron to flow or to increase catalytic activity. The CNTs is being added to Platinum-Carbon catalyst mixture at anode to improve the efficiency of the catalyst. The Fuel cells have been considered as next-generation energy devices because these types of systems transform the chemical reaction energy from hydrogen and oxygen into electric energy. Carbon nanotubes decorated with metal nanoparticles as electrodes have doubled the fuel performance due to increased catalytic activity of nanotube-based electrodes [25]. It has been reported the efficient impregnation of Pt nanoparticles on the carbon nanotubes. The use of multiwall carbon nanotubes as a platinum support for proton exchange membrane fuel cells has been investigated as a way to reduce the cost of fuel cells through an increased utilization of platinum. Carbon nanotubes were employed as the support for the subsequent platinum catalyst, which is electrodeposited on the carbon nanotubes. The feasibility of a fuel cell using the carbon nanotube-based electrodes was improved.

#### **The Role of CNTs in Solar cells:**

The extensive progress has been realized that the use of CNTs in Optoelectronic and energy harvesting devices including Solar cell. Carbon nanotubes (CNTs) have attracted great attention in improving photovoltaic performance of dye-sensitized solar cells because of their high electrical conductivity, chemical stability, high surface area, and tubular structure [26]. High electron affinity at CNTs can be used to act as electron collector and to enhance carrier mobility in dye-sensitized solar cells. The performance of dye-sensitized solar cells by applying carbon nanotubes (CNTs) to the counter electrode using two different methods: screen printing and chemical vapor deposition was investigated. When the highly purified and aligned CNTs were used as the counter electrode, a conversion efficiency of dye-sensitized solar cells of over 10% was recorded. This CNT-deposited counter electrode shows higher photo conversion efficiency than CNT-printed and Pt-coated electrodes under the same conditions. The large surface area and high electron conductivity of CNTs contributed to the high dye-sensitized solar cells efficiency. The CNT-based counter electrodes could herald a new route to producing non-platinum-based counter electrodes in dye-sensitized



solar cells devices [27, 28]. Studies were performed on Dye-sensitized solar cells dye-sensitized solar cells using multi-walled carbon nanotube (MWCNT)–TiO<sub>2</sub> Nano composite as a light scattering layer.

#### **Electro-deposition on carbon nanotubes:**

The metal Nanoparticles can be electrodeposited on Carbon Nanotube under potential control. The nanotube sidewalls serve both as electro deposition template and as the wire electrically connecting the deposited nanoparticles. Electro-deposition offers many advantages over high temperature metal deposition for metal nanoparticle formation on SWNTs. One of the most significant advantages of electrochemical deposition is the ability to control size and distribution of nanoparticles by varying potential, time or solution concentration. Most studies involving metal nanoparticle electro-deposition focus on noble metals such as Ag, Au, Pt, and Pd with a few exceptions Ni, Cu primarily due to the need for components of alternate energy sources. Electro-deposition of metal nanoparticles on carbon nanotubes depends on various parameters, such as pretreatments, method of manufacturing for SWNTs, type of SWNTs, distance of the nanotubes from contact electrode, density of SWNTs in network, etc. oxygen functionalities serve as axial ligands for metal nanoparticle precursors to bind to the SWNTs. Therefore, the most common pretreatment methods involve treating them with strong acids or oxidizing agents such as H<sub>2</sub>SO<sub>4</sub>/HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O<sub>2</sub>, HNO<sub>3</sub>, O<sub>3</sub>, and KMnO<sub>4</sub>. This is essentially a controlled method of damaging the tubes [29]. An alternative pretreatment method, involving electrochemical oxidation, was studied. Oxide functional groups at defect sites on the ends and sidewalls of SWNTs were produced by cycling electrochemical potential in 0.5M sodium sulfate, following a similar procedure used for activating glassy carbon electrodes. They employed a three-step process to deposit Pd and Pt nanoparticles on the SWNTs. The Carbon Nanotube is a promising candidate for lightweight material, the introduction of metal particles on CNTs can effectively improve its electrical conductivity.

#### **Conclusions:**

The energy and environment are major global issue. The energy generation from conventional Fuel has limitation so Nanotechnology plays an essential role in revolutionizing the application for energy conversation and storage. The numbers of publications that directly or indirectly show the relation of CNTs with electrochemistry. The unique electrical, mechanical, and chemical properties of CNTs have made them intensively studied materials in the field of electrochemistry fields.

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