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ELECTROCHEMICAL STUDIES OF CARBON BASED NANOMATERIAL

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ABSTRACT: -*Nanomaterial's have been attracted imaginable attention for many scientists worldwide. 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 we discuss electrochemical properties, source & application of various nanomaterial.*

KEYWORDS: - Carbon nanotube, Energy Source, Electro deposition, Graphene, properties of Nanomaterial's.

INTRODUCTION:

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 significantlyfrom 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, multiwalled 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].

ELECTRICAL PROPERTIES OF CARBON NANOTUBES:

Nanoparticlesare a connection between isolated atoms and condensed matter. Multi walled carbon nanotubes show superconductivity with a relatively high transition temperature. 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 λm is longer than the nanotube itself. λm= 30 μm,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].

OPTICAL PROPERTIES OF CARBON NANOTUBES:

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 ~ 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.

APPLICATIONS OF CNT IN ELECTROCHEMICAL SYSTEMS:

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].

BATTERIES:

Lithium-ion battery:

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. The characteristics of a carbon nanotube when used as filler in the electrodes of lithium-ion batteries[23]

Lead-acidbatteries:

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 of ca. 2–5 mm) 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.

FUEL CELL:

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 multiwalled 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.

SOLAR CELLS:

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 photoconversion 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)–TiO2 Nanocomposite as a light scattering layer.

ELECTRO-DEPOSITION OF METAL NANOPARTICLES ON CARBON NANOTUBES:

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 H2SO4/HNO3, H2SO4/H2O2, HNO3, O3, and KMnO4. 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:

CONCLUSIONS:

A widespread number of publications that directly or indirectly show the relation of CNTs with electrochemistry or at any rate aspires of future interest in this science are revised. The unique electrical, mechanical, and chemical properties of CNTs have made them intensively studied materials in the field of electrochemistry between and other fields.

REFERENCES

- J. Riu, et al. Talanta 69 (2006) 288–301
- Dresselhaus M. S., Dresselhaus G., Eklund, P. C. Science and fullerenes and carbon nanotubes. // Academic, London. 1996. 1st edn, pp. 1–505.
- Harris P. J. Carbon nanotubes and related structures: new materials for the twenty-first century. // Cambridge University Press.1999. 1st edn, pp. 1–293.
- Ajayan P. M., Zhou O. Z. Application of CNT.Top. Appl. Phys. 2001. vol. 80, pp. 381–425.
- Baughman R. H., Zakhidov A. A., De Heer W. A. Carbon nanotubes—the route toward applications. // Science. 2002. Vol. 297, 787–792

- Yasuda E., Inagaki M., Kaneko K. et al. Carbon alloys: novel concept to develop carbon science and technology. // Elsevier. 2003. 1st edn, pp. 1–569.
- Zhao Q., Gan Z., Zhuang Q. Electrochemical Sensors Based on Carbon Nanotubes. // Electroanalysis. 2002. Vol. 14. pp. 1609-1613.
- S. Iijima. Helical microtubules of graphitic carbon. // Nature. 1991. Vol. 354. pp. 56-58.
- M.L.Cohen. CNT, nanoscience,nanotechnology. // Mater. Sci.Eng. C.2001. Vol.15. pp. 1-11
- Haruyama J., Takesue I., Kobayashi N. et al. Superconductivity in Entirely End-Bonded Multiwalled Carbon Nanotubes. // Phys. Rev. Lett. 2006. Vol. 5. pp. 96-99
- Zhao G. M., Wang Y. S. Possible superconductivity above 400 k in the carbon-based multiwall nanotubes. // Seven. 2001. Vol.1. pp. 5-9.
- Zhao G. M. Transport and magnetic properties in MWCNT ropes: Evidence for superconductivity above room temperature. // cond-mat.supr-con. 2002. Vol. 2. pp. 1-6.
- Kataura H., Kamazava Y., Maniwa Y. et. al. Optical properties of single-wall carbon nanotubes. // Synth. Met. 1999. vol. 103. pp. 2555-2258.
- L. Kavan, P. Rapta, L. Dunsch. et. al. Electrochemical Tuning of Electronic Structure of Single-Walled Carbon Nanotubes: In-situ Raman and Vis-NIR Study. // J. Phys. Chem. B. 2001. vol.105, pp 10764–10771.
- Bachilo S. M., Strano M. S., Kittrell C. et. al. Structure-Assigned Optical Spectra of Single-Walled Carbon Nanotubes. // Science. 2002. Vol. 298. pp. 2361- 2366
- VYTŘAS K., ŠVANCARA I., METELKA R. Carbon paste electrodes in electroanalytical chemistry. // J. Serb. Chem. Soc. 2009. Vol.74. pp. 1021–1033.
- Ensafi A. A., Maleh H. K. A Multiwall Carbon Nanotubes Paste Electrode as a Sensor and Ferrocenemonocarboxylic Acid as a Mediator for Electrocatalytic Determination of Isoproterenol. // Int. J. Electrochem. Sci. 2010. Vol. 5. pp. 1484 – 1495.
- Raoof J.B., Ojani R., Hosseinii S.R. Electrochemical fabrication of novel Pt./poly(m-toluidine)/Triton X-100 composite catalyst at the surface of carbon nanotube paste electrode and its application for methanol oxidation. // Int. J. Hydrogen Energy. 2011. Vol. 36. pp. 52-63.

- Beitollahi H., Sheikhshoaie I. Electrocatalytic and simultaneous determination of isoproterenol, uric acid and folic acid at molybdenum (VI) complex-carbon nanotube paste electrode. // Electrochim. Acta. 2011. Vol. 56. pp. 10259– 10263.
- Endo M., Nakamura J., Sasabe Y. et. al. Lithium secondary battery using vapor grown carbon fibers as a negative electrode and analysis of the electrode mechanism by TEM observation. // Trans. IEE Jpn A. 1995. Vol.115. pp. 349–356.
- Tatsumi K., Zaghib K., Abe H. et, al. A modification in the preparation process of a carbon whisker for the anode performance of lithium rechargeable batteries. // J. Power Sources. 1999. Vol. 54. pp. 425–427.
- Frackowiak E., Gautier S., Gaucher H. et. al. Electrochemical storage of lithium ion multiwalled carbon nanotubes. // Carbon. 1999. Vol. 37. pp. 61–69.
- Wu G. T., Wang C. S., Zhang X. B. et. al. Structure and lithium insertion properties of carbon nanotubes. // J. Electrochem. Soc. 1999. Vol.146. pp. 1696–1701
- Endo M., Hayashi T., Ahm Kim Y. et, al. Applications of carbon nanotubes in the twenty-first century. // Phil. Trans. R. Soc. Lond. A. 2004. Vol.362. pp. 2223–2238.
- Britto P. J., Santhanam K. S., Rubio A. et.al. Improved Charge Transfer at Carbon Nanotube Electrodes. //Adv. Mater. 1999. Vol. 11. pp. 154-157.
- Kongkanand A., Dominguez R.M., Kamat P.V. Single Wall Carbon Nanotube Scaffolds for Photoelectrochemical Solar Cells. Capture and Transport of Photo generated Electrons. // Nano Lett. 2007. Vol. 7. pp. 676-680.
- Trancik J.E., Barton S.C., Hone J. Transparent and Catalytic Carbon Nanotube Films. // Nano Lett. 2008. Vol. 8. pp. 982-987.
- Lee K.M., Hu C.W., Chen H.W., Ho K.C. Incorporating carbon nanotube in a low-temperature fabrication process for dye-sensitized TiO2 solar cells. // Sol. Energy Mater. Sol. Cells. 2008. Vol. 92. pp. 1628-1633.
- Umeyama T., Imahori H. Carbon nanotube-modified electrodes for solar energy conversion. // Energy Environ. Sci. 2008. Vol. pp. 120-133.