International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 5 Issue 3, March - 2021, Pages: 34-41

# Optical Properties of Carbon Nanotubes Doping by Titanium Dioxide Ti $O_2$ at Different Molar

**[1]Mona Ali .A, [2]Rawia Abd Elgani Elobaid, [3]Abdalsakhi S, [4]M.H &Ali Soliman , [5]Nafisa Badar Eldeen ,[6]Mubarak Dirar, ,.**

*[1,2,5] Sudan University of Science &Technology-College of Science-Department of Physics-Khartoum- Sudan*
*[3] Al-Neenlen University – Faculty of Science and Technology Department of Physics- Khartoum- Sudan*
*[4]Department of Physics, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan.*
*[6]International University of Africa- College of Science-Department of Physics & Sudan University of Science &Technology-College of Science-Department of Physics- Khartoum-Sudan*

***Abstract:*** *In this work, carbon nanotubes were prepared by chemical vapor deposition (CVD) and doping by different molarity of titanium dioxide Ti $O_2$ (0.00, 0.05 and 1.5) molar. UV/VIS spectrophotometer technique was used to investigate the optical characteristics of all samples. The maximum absorbance value is 1.82 ( a.u ) for carbon + Ti $O_2$ (1.5 molar )and the minimum value is 0.99 ( a.u ) for carbon + Ti $O_2$ (0.00 molar ) , absorbance of CNT samples that treatment by Titanium dioxide was increased due to Ti $O_2$ molarity increased at 258 nm . The maximum value of refractive index is (2.79) for all samples that made at wave length range (345 -368) nm. The samples have a direct electronic transition, and the optical energy gab decreased with molarity increased. This results leads to that Titanium dioxide is a good material to enhance the optical properties of carbon nanotubes.*

**Keyword**: *Carbon Nanotubes, Titanium Dioxide, Optical Characteristics, Energy Gab*

## Introduction

Carbon nanotubes (CNT) are the basis of nanotechnology. Carbon with an atomic number of 6 plays a pivotal role in nanotechnology. They were discovered by Iijima accidentally while studying the surface of graphite electrode used in electric arc discharge [1]. A carbon nanotube (CNT) is a hexagonal array of carbon atoms rolled up into a long, thin, hollow cylinder and are known for their size, shape, and remarkable physical properties. They can be manipulated chemically and physically for their application in material science, electronics, energy management, biomedical application and many more [2]. Carbon nanotubes (CNTs) are one dimensional carbon materials with aspect ratio greater than 1000. They are cylinders composed of rolled-up graphite planes with diameters in nanometer scale [3]. The cylindrical Nano tube usually has at least one end capped with a hemisphere of fullerene structure. Depending on the process for CNT fabrication, there are two types of CNTs: single-walled CNTs (SWCNTs) and multi walled CNTs (MWCNTs). SWCNTs consist of a single graphene layer rolled up into a seamless cylinder whereas MWCNTs consist of two or more concentric cylindrical shells of graphene sheets coaxially arranged around a central hollow core with Vander Waals forces between adjacent layers [4]. According to the rolling angle of the graphene sheet, CNTs have three chirality's: armchair, zigzag and chiral one[5] .Carbon nanotubes are represent a promising material due to their unique physicochemical properties: their nanoscale needle shape, high chemical stability, thermal conductivity, and mechanical strength, which confer an advantage in the fabrication of field emitters [7] .CNTs have amazing properties, which make them potential candidates for a wide range of applications, such as electro catalytic electrodes, molecular channels for water and protons transparent conductive films, electrostatically dissipative materials, in photo catalysis, in electronics (diodes, transistors, FETs, logic gates), thermoelectric, chemical and biological sensors, thermal interface materials (TIMs), magnetic storage devices , reinforcement in polymer nanocomposites ,smart materials, biocompatible devices, in battery storage, and elsewhere [8,9].

## Method

Samples were prepared by adding 5g of graphite powder to mixture of 50 ml of sulfuric acid and (25 ml) of nitric acid. Due to the acid reaction, the solution was cooled down up to 5 $^oC$ using an ice bath. 25$g$ of sodium chlorate was added to solution in addition to the doping elements which were titanium(0.00, 0.05 and 1.5) molar .The solution was heated up to 70 $^oC$ in water bath for 24 hours then placed in the air for 3 days. Most graphite percolated in the bottom but some carbons were floating. The floating carbon materials were transferred to 1 $l$ of Deionized water (DI). After stirring for 1 hour the solution was filtered and dried. The optical properties were investigating using UV/VIS Spectrophotometer at ranged (200 – 800) nm.

## Results & Discussion

After carbon nanotubes were prepared by chemical vapor deposition (CVD) and doping by different molarity of titanium dioxide Ti $O_2$ ,and used UV/VIS spectrophotometer to investigate the some optical characteristics and electrical conductive as showing blow .

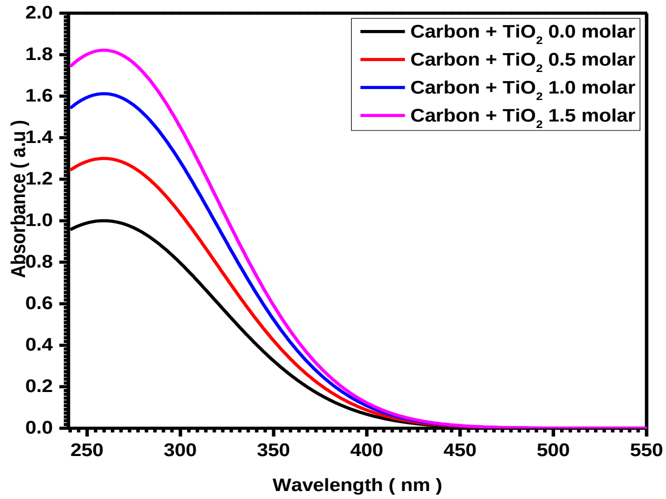


Fig (1) absorption curve of carbon sample $+TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

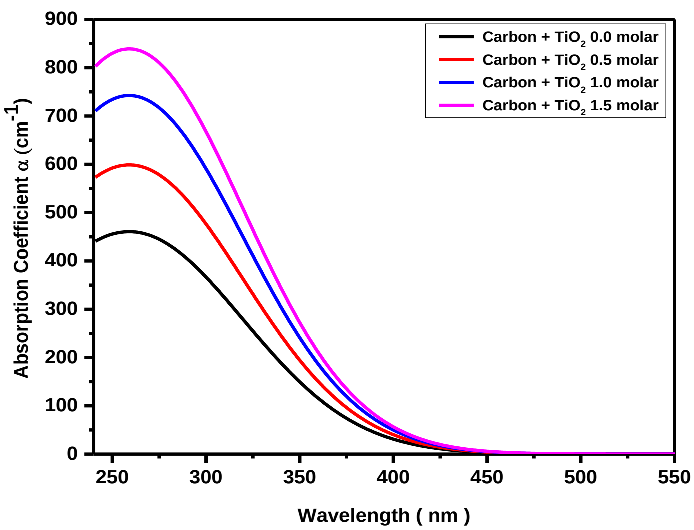


Fig (2) absorption coefficient curve of carbon sample $+TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

.

.

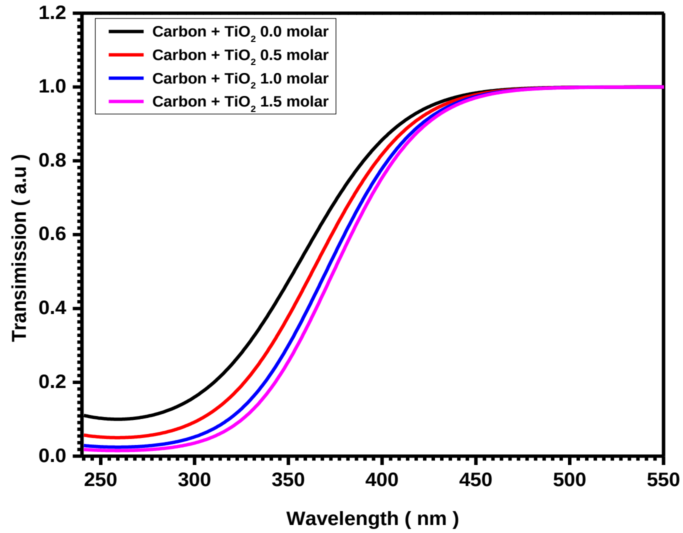


Fig (3) transmission curve of carbon sample +$TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

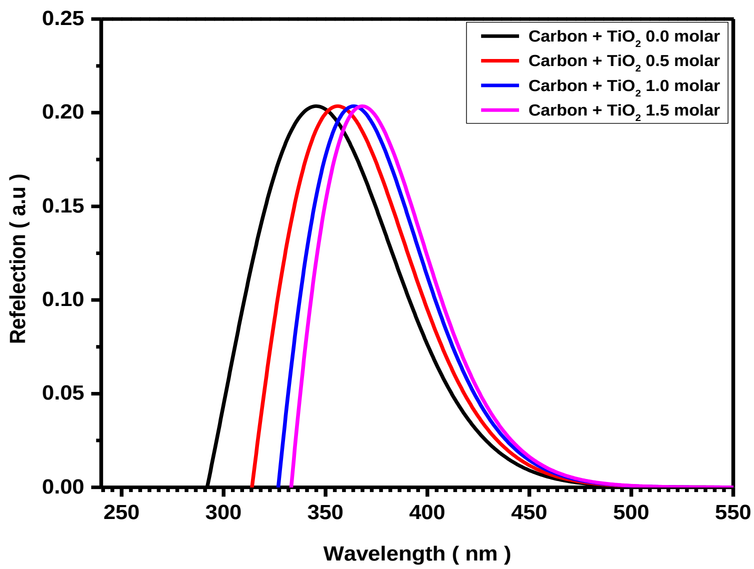


Fig (4) reflection curve of carbon sample +$TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

**International Journal of Academic and Applied Research (IJAAR)**
**ISSN: 2643-9603**
**Vol. 5 Issue 3, March - 2021, Pages: 34-41**

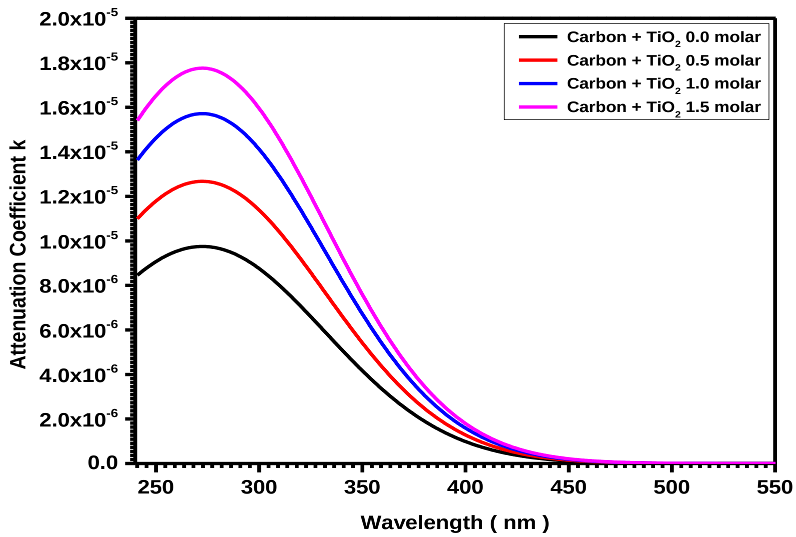


Fig (5) attenuation coefficient curve of carbon sample +$TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

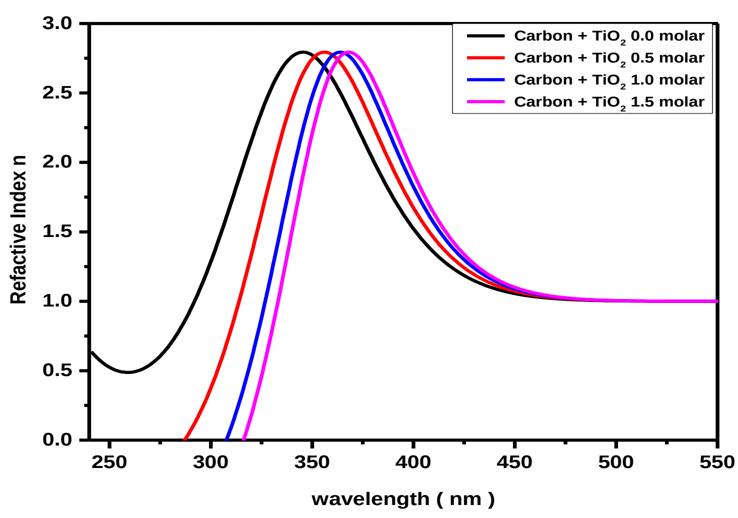


Fig (6) refractive index curve of carbon sample +$TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

**International Journal of Academic and Applied Research (IJAAR)**
**ISSN: 2643-9603**
**Vol. 5 Issue 3, March - 2021, Pages: 34-41**

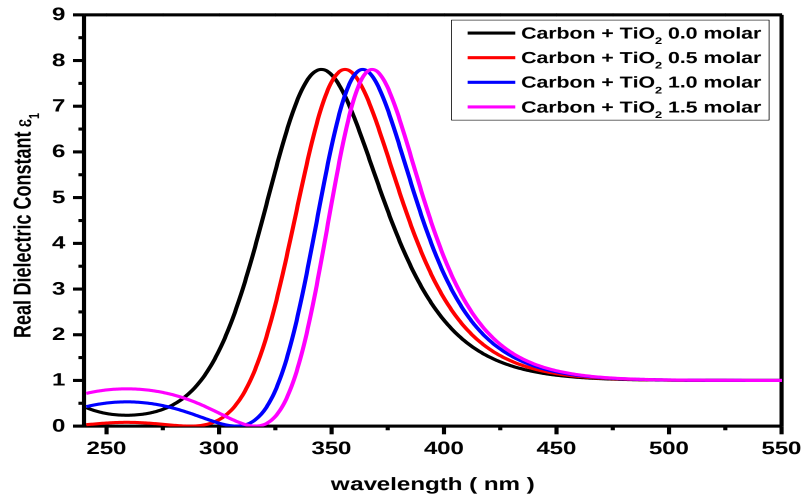


Fig (7) rail dialectical constants curve of carbon sample $+TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

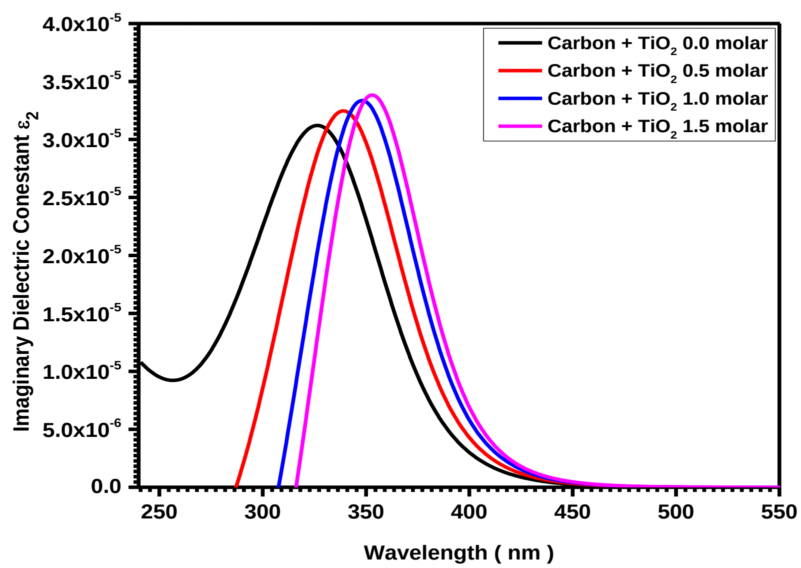


Fig (8) imaginary dialectical constants curve of carbon sample $+TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 5 Issue 3, March - 2021, Pages: 34-41

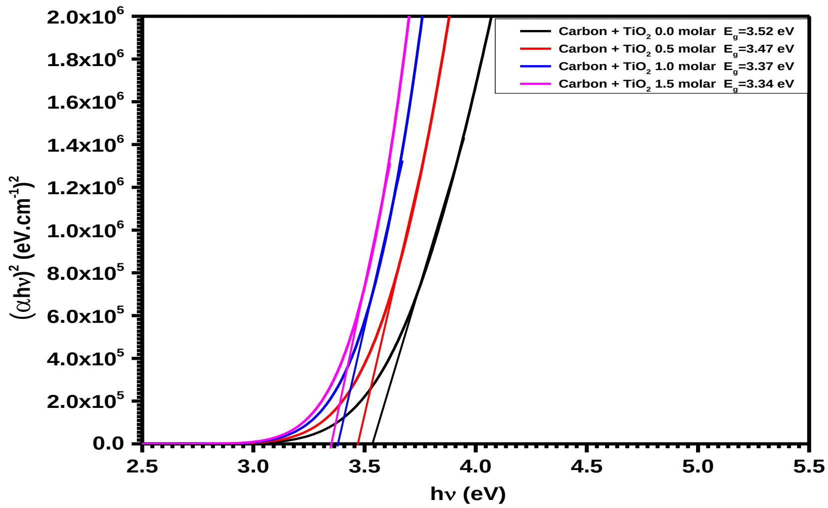


Fig (9) optical energy band gap curve of carbon sample $+TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

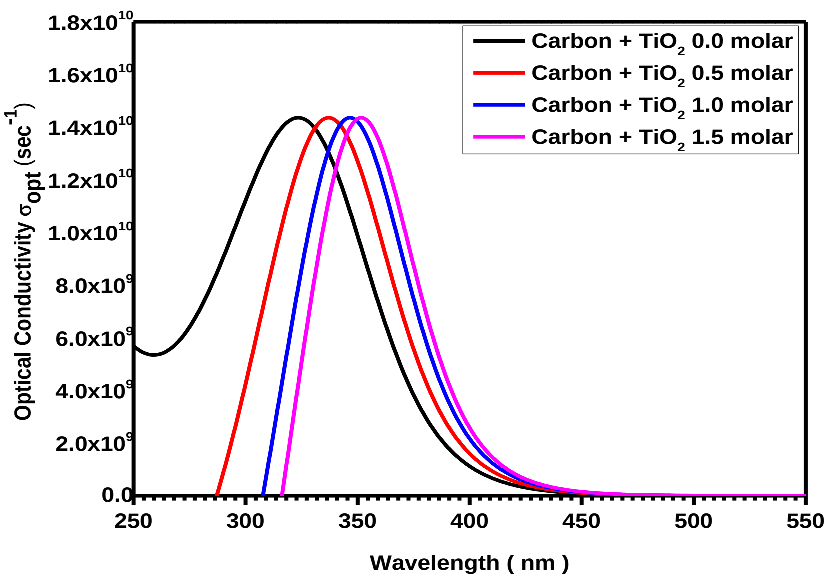


Fig (10) optical conductivity curve of carbon sample $+TiO_2$ in different molar (0.00, 0.5, 1.0 and 1.5).

In figure (1) shows the absorbance of carbon sample doping by $TiO_2$ in different molar were in the wavelength range (250 – 550) nm, the maximum value of absorbance is 1.82 (a.u) at wavelength (258) nm corresponding photon energy 4.8 eV for carbon +$TiO_2$ (1.5 molar) and the minimum value is 0.99 (a.u) at the same wavelength for carbon +$TiO_2$ (0.00 molar). The absorption coefficient (α) of carbon sample doping by $TiO_2$ in different molar showing in figure (2), that has been calculated using the formula $\alpha = \frac{(2.303*A)}{l}$ where (A) is Absorbance, (l) is Optical length on the sample, the maximum value of $(\alpha)$ is $(2.4\times10^2)$ $cm^{-1}$ for carbon +$TiO_2$ (1.5 molar) and for carbon +$TiO_2$ (0.00 molar) the value is $(4.6\times10^2)$ $cm^{-1}$ at the same wavelength, also in fig(2) show that the value of absorption coefficient ($\alpha$) increase when molar rated increase . And in figure (3) shows the transmission (T) of all sample that treatment by the carbon and $TiO_2$ in different molar, the treatment at range of (300-476) nm, and the value of transmission increase by molarity decrease. For the reflection of carbon sample doping by $TiO_2$ in different molar show the results in figure (4) that has been calculated using this formula $R = 1 - A - T$, the maximum value of (R) equal 0.2 (a.u) for all samples at the wavelength 345 nm for carbon +$TiO_2$ (0.00 molar) and 365 nm for carbon +$TiO_2$ (1.5 molar) in this wavelengths the sample has be mirror. In figure (5) shows the Extinction coefficient (Attenuation Coefficient) (K) of carbon samples doping by $TiO_2$ in different molar, it was calculated using formula $k = \frac{\alpha\lambda}{4\pi}$ , the maximum value of (k) equal ($1.77\times10^{-5}$) at 271 nm for carbon +$TiO_2$ (1.5 molar) and the minimum value is ($9.82\times10^{-5}$) for carbon +$TiO_2$ (0.00 molar) at the same wavelength. In figure (6) shows the refractive index (n) of the sample that we have study, (n) is defined as the ratio between the speeds of light in a vacuum to its speed in material, and it has been calculated using formula $\left[\left(\frac{1+R}{1-R}\right)^2 - (1+k^2)\right]^{0.5} + \left(\frac{1+R}{1-R}\right)$ .The value of (n) equal (2.79) for all samples at wave length range (345 nm) for the carbon +$TiO_2$ (0.00 molar) sample and at 368 nm for the carbon +$TiO_2$ (1.5 molar) sample. The real $\varepsilon_1$ and imaginary $\varepsilon_2$ dielectric constants of carbon samples doping by $TiO_2$ in different molar showing in figure (7) and figure (8) that have been calculated using this formulas $\varepsilon_1 = n^2 - k^2$ for real dielectric constants, $\varepsilon_2 = 2nk$ for imaginary dielectric, the value of $\varepsilon_1$ equal 781 at wavelength 345 nm for carbon +$TiO_2$ (0.00 molar) , the same value at 368 nm for carbon +$TiO_2$ (1.5 molar), the effect of molar in the value of ($\varepsilon_1$) when the molar increases the wavelength in the red shift . The value of $\varepsilon_2$ equal ($3.38\times10^{-5}$) at 352 nm for carbon +$TiO_2$ (1.5) molar, but for carbon +$TiO_2$ (0.00 molar) sample equal ($3.13\times10^{-5}$) at 326 nm. The optical energy band gab which has been calculated using the relation $(\alpha h\nu)^n = C(h\nu = (h\nu - E_g)$ where C = constant and n = type of transition, and the optical energy gap has been obtained by plotting $(\alpha h\nu)^n$ vs photon energy (hν) that as show figure (9) the optical energy band gap of carbon samples doping by $TiO_2$ in different molar, the value of $E_g$ is 3.52 eV for carbon +$TiO_2$ (0.00 molar) and 3.34 eV carbon +$TiO_2$ (1.5 molar), this means the energy gab increase with molarity decrease. At last the optical and electrical conductivity have been calculated using relations $\sigma_{opt} = \frac{\alpha nc}{4\pi}$ for optical conductivity and $\sigma_{elec} = \left(\frac{2\lambda\,\sigma_{opt}}{\alpha}\right)$ for electrical conductivity as showing in Figure (10) and (11),the value of optical conductivity ($\sigma_{opt}$) is $1.43\text{x}10^{10}$ $Sec^{-1}$ at 323.3 nm for carbon +$TiO_2$ (0.00) molar and the same value at 352.4 nm for carbon + $TiO_2$ (1.5) molar. And for the electrical conductivity the maximum value equal 49.3 $(\Omega.cm)^{-1}$ for carbon + $TiO_2$ (1.5) molar at 370 nm and the minimum value is 46.3 $(\Omega.cm)^{-1}$ at 349 nm for carbon +$TiO_2$ (0.00) molar .

**Conclusion**

The value of absorbance and absorption coefficient were increased due to $TiO_2$ molar increase. Reflection value was 0.2 (a.u) for all samples at wavelength range (345 to 268) nm. Maximum refractive index (n) value is (2.79) for all samples .And the optical conductivity ($\sigma_{opt}$) value equal $1.43\text{x}10^{10}$ $Sec^{-1}$ for all carbon nanotube that treatment samples .The maximum value of electrical conductivity ($\sigma_{elec}$) = 49.3 and the minimal value equal 46.3 $(\Omega.cm)^{-1}$ . The energy band gab increase from (3.34 to 3.52) eV due to molarity decrease. For all this results Titanium dioxide is a good material to enhance the optical characteristics of carbon nanotubes.

**References**

[1] Sonia Khanna and Nazmul Islam, Carbon Nanotubes-Properties a Applications, Organic & Medicinal Chemistry, International Journal, Jupiner Publisher.2018.
[2] Saeedeh Rafiei, Foundations of Nanotechnology, Mechanics of Carbon Nanotubes, Volume 3, Taylor & Francis Group, 2015.
[3] Muc, A. (2011). Modelling of Carbon Nanotubes Behaviour with the Use of a Thin Shell Theory, Journal of Theoretical and Applied Mechanics, 49, 531–540.
[4] Muc, A. Design and Identification Methods of Effective Mechanical Properties for Carbon Nanotubes, Materials & Design, 31(4), 1671–1675, (2010).
[5] Muc, A., Banas, A., & lgorzata, M. Chwa, Free Vibrations of Carbon Nanotubes with Defects, Mechanics and Mechanical Engineering, 17(2), 157–166,(2013).
[6] Bharat Bhushan, Handbook of Nanotechnology, Springer-Verlag GmbH Germany, 2017.
[7] Ibtehag Ali Sanosy, Khalid Mohammed. Haroun, Abdalsakhi Suliman Mohammed Hamed, Adam Mohammed Adam Bakheet, Optical Properties of Barium Borate (BaB2O4) Compound for Current Optoelectronic Applications, Journal of Materials & Metallurgical Engineering, 2020.
[8] Mohammed Muzibur Rahman and Abdullah Mohamed Asiri, Carbon Nanotubes and Their Applications, published by Intechopen, 2018.
[9] Filipe V. Ferreira, Wesley Franceschi, Beatriz R.C. Menezes,Audrey F.Biagion , Aparecido R. Coutinho and Luciana S. Cividanes, Synthesis, Characterization, and Applications of Carbon Nanotubes, Elsevier Inc, 2019.
[10] Rajendra Kumar Goyal, Nanomaterials and Nanocomposites Synthesis, Properties, Characterization Techniques, and Applications, Taylor & Francis Group, 2018.