Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

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Abstract
In the current research, annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations is investigated. The calculation of thickness and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations produced using sol-gel method over glassy medium through a single reflection spectrum is presented. To obtain an appropriate fit for reflection spectrum, the classic Drude-Lorentz model for parametric di-electric function is used. The best fitting parameters are determined to simulate the reflection spectrum using Lovenberg-Marquardt optimization method. The simulated reflectivity from the derived optical constants and thickness are in good agreement with experimental results.

Keywords: Annealing, Interband Transition; Optical Constants; Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄); Nano Thin Films; Cancer Cells; Tissues and Tumors; Synchrotron and Synchrocyclotron Radiations
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Annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations are produced over glassy medium in sol-gel laboratory, Faculty of Chemistry, BioSpectroscopy Core Research Laboratory and Cancer Research Institute (CRI) at California South University, Irvine, California, USA, under similar conditions. Measurement of thin films are

Introduction

Annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations is investigated. Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) are a semi-conductor of type n which its 3d level is filling up [1-67] and it belongs to a group of smart materials that reacts to variations of temperature, electrical or magnetic fields and pressure. This oxide can be used as thin films for a wide range of applications including electrical and or optical-thermal switching tools and energy storing covers [67-103]. Therefore, determining optical constants (refractive coefficient, n, and extinction coefficient, k) of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) thin films is essential for designing optoelectronical and optical tools for producing optical covers and similar tools such as multilayer covers and filters [104-184]. The measured experimental parameters including optical reflectivity are used as a function of wavelength to determine optical parameters of thin layers [185-257]. For determining optical parameters, various physical models such as Kuschi, Frouhi-Blumber and Tawk-Lorentz have been suggested to calculate refractive coefficient, n, and extinction coefficient, k. for any thin layer, an appropriate optical model should be selected and used for estimation of real and imaginary di-electric function according to its physical condition [258-313]. To do this, an initial guess is needed for parameters of di-electric function and thickness which is defined as a range regarding physical characteristics of thin film and the available results in the literature. Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄)-annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations are produced over glassy medium in sol-gel laboratory, Faculty of Chemistry, BioSpectroscopy Core Research Laboratory and Cancer Research Institute (CRI) at California South University, Irvine, California, USA, under similar conditions. Measurement of thin films are
performed on four samples of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) as annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations with mole ratio of 0.5, 1 and 1.5% of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) [314-467]. Simulation of experimental spectra are performed using a single reflection spectrum of thin films and through Drude-Lorentz physical model in optimization process of Lovenberg-Marquardt. Optical constants such as reflection coefficient, n, extinction coefficient, k, and layer thickness are simultaneously determined at wavelength of 400-1100 (nm).

Modeling, Simulation and Calculation Method

A usual method for describing optical constants of thin films is utilizing classic dispersion relationships based on di-electric function. One of the oldest and most applicable dispersion relationships is Drude-Lorentz di-electric equation which is based on the interaction between light and material. This relationship is shown in Eq. (1):

\[
\varepsilon = \varepsilon_\infty + \sum_{j=1}^{g} \frac{f_j E_{0j}}{E_{0j}^2 - E^2 - i \Gamma_j E} + \frac{E_p^2}{E^2 + iE_cE}
\]

(1)

Where \( \varepsilon_\infty \), \( f_j \), \( E_0 \) and \( \Gamma_j \) are di-electric constant at high frequencies, resonance amplitude, power and resonance width-band which are recognized as the reason for damping. Damping is due to absorption process which includes transition between two states. The third term is related to Drude model. \( E_p \) is density of Plasma energy and \( E_c \) is incident energy [4]. The complex di-electric function as \( \varepsilon = \varepsilon_\infty + i\varepsilon_2 \) which describes the reaction of material with electromagnetic waves as a function of photon energy, \( E \), or wavelength, \( \lambda \), has a real part \( \varepsilon_1 \) and an imaginary part \( \varepsilon_2 \). Real and imaginary parts of complex reflection coefficient, namely \( n(\lambda) \) and \( k(\lambda) \) are related to di-electric function as Eq. (2) [5]:

\[
n(\lambda) = \left( \frac{\varepsilon_1 + \left(\varepsilon_1^2 + \varepsilon_2^2\right)^{1/2}}{2} \right)^{1/2}
\]

(2)

\[
k(\lambda) = \left( \frac{-\varepsilon_1 + \left(\varepsilon_1^2 + \varepsilon_2^2\right)^{1/2}}{2} \right)^{1/2}
\]

Reflection spectrum (R) of samples for normal incident is a function of film thickness \( d \), medium reflection coefficient \( S \), incident light wavelength \( \lambda \), reflection coefficient \( n(\lambda) \) and extinction coefficient \( k(\lambda) \). Simulation of the measured reflection data using optimization of objective function, which is the square of difference between the measured reflection spectrum and the calculated one, is defined as:

\[
O = \left( \varepsilon_n f_j, \Gamma, E_0, E_p, E_r, d \right) = \sum \left( R_{\text{meas}} - R_{\text{calc}} \right)^2
\]

(3)

Where, \( R_{\text{meas}} \) and \( R_{\text{calc}} \) are the measured and theoretical reflection spectrum, respectively. using the fitting parameters obtained from minimization of objective function, dispersion curves of reflection and extinction coefficients can be estimated.

Results and Discussion

The measured and simulated reflection spectra with fitting parameters of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄)-annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations at various concentrations of 0.5, 1 and 1.5%, named as a, b, and c, and annealing effects on the interband
transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations sample, named as p, are shown in Figure (1) in wavelength range of 400-1100 (nm) (visible regions close to infrared) using Drude-Lorentz model for air, film, medium, air system.

Figure 1: Results of simulating the reflection spectrum for Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄)-annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations at concentrations of (a) 0.5%, (b) 1%, (c) 1.5% and (p) non-doped.

Comparison of the results were shown that the sample containing 0.5% of Ru (sample a) has shown more reflectivity than samples containing 1% and 1.5% of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) (samples b and c). As can be seen in Figure (1), the reflection of thin films is decreased by increase in mole concentration of Ru to Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄). This reduction can be attributed to various reasons such as increasing roughness, increasing thickness and increasing the concentration of contaminant. The results of investigation about surface roughness using AFM method confirms the increasing of roughness by increasing the concentration of Ru. Therefore, dispersion of incident light is increased in thin films. Variation of thickness of thin film by increasing the percentage of Ru is effective in variation of reflectivity of thin films which is due to sol viscosity. Changing the crystalline structure and chemical composition of thin films induced by penetration of Ru ions into the crystalline lattice of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) is another effective factor which leads to changing the reflection spectrum. The results of structural analysis using XRD confirms the tendency to be amorphous by increasing the concentration of contaminant. The best fitting parameters obtained from optimization process and experimental data fitting are listed in Table (1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pure</th>
<th>0.5% Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄)</th>
<th>1% Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄)</th>
<th>1.5% Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ε∞</td>
<td>4.4</td>
<td>3.4</td>
<td>2.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Eρ</td>
<td>1.84</td>
<td>1.74</td>
<td>1.64</td>
<td>1.54</td>
</tr>
<tr>
<td>Eτ</td>
<td>0.44</td>
<td>0.43</td>
<td>0.34</td>
<td>0.24</td>
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<tr>
<td>f</td>
<td>0.34</td>
<td>0.24</td>
<td>0.14</td>
<td>0.04</td>
</tr>
<tr>
<td>E₀</td>
<td>2.1</td>
<td>1.9</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Γ</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>d (nm)</td>
<td>205</td>
<td>305</td>
<td>405</td>
<td>505</td>
</tr>
</tbody>
</table>

Table 1: Fitting parameters of dielectric function of DL model.
As can be seen in Table (1), more increase in Ru leads to increase in Γ, f, E₀ and d and decrease in other parameters as crystalline structure and inter-atom distance changes in lattice of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) thin film. According to [7], E₀ in the range of 2.9-3.1 (eV) shows optical transition capacity band to displaced state of conducting band which according to the data of Table (1), it can be concluded that optical transition energy (gaff energy) increases with increase in Ru concentration. The calculation results of optical constants including reflection coefficient and extinction coefficient using the parameters of obtained dielectric function from the optimization process of thin films at various concentrations of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) as 0.5% (sample a), 1% (sample b) and 1.5% (sample c) are shown in Figures (2) and (3), respectively.

As can be seen in Figure (2), reflection coefficient of samples at 500-1100 (nm) are the same and are decreased by increasing wavelength. By increasing the concentration of Ru, reflection coefficient is totally reduced which is in good agreement with the results related to variations of reflectivity in Figure (1) in which, increasing roughness leads to increase in dispersion and hence, reducing the amount of reflection spectrum. It can be seen in Figure (3) that k(λ) for two samples of p and a are of increasing rate at wavelength range of 400-500 (nm). Further, all samples are of decreasing rate at the range of 500-800 (nm). Totally, k(λ) is reduced by increase in Ru concentration. In other words, optical absorption is reduced in this range and the emerged peaks at extinction coefficient are in agreement with parameters of Drude-Lorentz obtained from the optimization algorithm.

Conclusions, Summary, Recommendations, Perspectives, Useful Suggestions and Future Studies

The results of optimization algorithm of Lovenberg-Marquardt with physical model of
Drude-Lorentz for determining optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) annealing effects on the interband transition and optical constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) nano thin films in cancer cells, tissues and tumors under synchrotron and synchrocyclotron radiations.

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References


18. Heidari A. 2016. Measurement the Amount of Vitamin D2 (Ergocalciferol), Vitamin D3 (Cholecalciferol) and Absorbable Calcium (Ca2+), Iron (II) (Fe2+), Magnesium (Mg2+), Phosphate (PO4-) and Zinc (Zn2+) in Apricot Using High-Performance Liquid Chromatography (HPLC) and Spectroscopic Techniques. J Biom Biostat. 7: 292.

19. Heidari A. 2016. Spectroscopy and Quantum Mechanics of the Helium Dimer (He2+), Neon Dimer (Ne2+), Argon Dimer (Ar2+), Krypton Dimer (Kr2+), Xenon Dimer (Xe2+), Radon Dimer (Rn2+) and Ununoctium Dimer (Uuo2+) Molecular Cations. Chem Sci J. 7: 112.


27. Heidari A. 2016. Discriminate between Antibacterial and Non-Antibacterial Drugs
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.11001

Artificial Neutral Networks of a Multilayer Perceptron (MLP) Type Using a Set of Topological Descriptors. J Heavy Met Toxicity Dis. 1: 2.


42. Heidari A. 2016. Cheminformatics and System Chemistry of Cisplatin, Carboplatin,
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

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DOI: https://doi.org/10.36811/ijho.2021.11001

IJHO: August-2021: Page No: 61-105


69. Heidari A. 2017. Polymorphism in Nano-Sized Graphene Ligand-Induced Transformation of Au38-xAgx/xCu(x(SPhtBu)24 to Au36-xAgx/xCu(x(SPhtBu)24 (x = 1-12) Nanomolecules for Synthesis of Au144-xAgx/xCu(x(SR)60, (SC4)60, (SC6)60, (SC12)60, (PET)60, (m-MBA)60, (F)60, (Cl)60, (Br)60, (I)60, (At)60, (Uus)60 and (SC6H13)60] Nano Clusters as Anti-Cancer Nano Drugs. J Nanomater Mol Nanotechnol. 6: 3.


82. Heidari A. 2017. Treatment of Breast Cancer Brain Metastases through a Targeted Nanomolecule Drug Delivery System Based on Dopamine Functionalized Multi-Wall Carbon Nanotubes (MWCNTs) Coated with Nano Graphene Oxide (GO) and Protonated Polyaniline (PANI) in Situ During the Polymerization of Aniline Autogenic Nanoparticles for the Delivery of Anti-Cancer Nano Drugs under Synchrotron Radiation. Br J Res. 4: 16.


95. Heidari A. 2017. Potency of Human Interferon β-1a and Human Interferon β-1b in
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.11001

Enzymotherapy, Immunotherapy, Chemotherapy, Radiotherapy, Hormone Therapy and Targeted Therapy of Encephalomyelitis Disseminate/Multiple Sclerosis (MS) and Hepatitis A, B, C, D, E, F and G Virus Enter and Targets Liver Cells. J Proteomics Enzymol. 6: 1.


106. Heidari A. 2017. Electron Phenomenological Spectroscopy, Electron Paramagnetic Resonance (EPR) Spectroscopy and Electron Spin Resonance (ESR) Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under...
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.11001

IJHO: August-2021: Page No: 61-105

1 Synchrotron Radiation. Austin J Anal Pharm Chem. 4: 1091.


111 Heidari A. 2017. Vibrational Decihertz (dHz), Centihertz (cHz), Millihertz (mHz), Microhertz (µHz), Nanohertz (nHz), Picohertz (pHz), Femtohertz (fHz), Attohertz (aHz), Zeptohertz (zHz) and Yoctohertz (yHz) Imaging and Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation. International Journal of Biomedicine. 7: 335-340.


116 Heidari A. 2017. Vibrational Decahertz (daHz), Hectohertz (hHz), Kiloherzt (kHz), Megahertz (MHz), Gigahertz (GHz), Terahertz (THz), Petahertz (PHz), Exahertz (EHz), Zettahertz (ZHz) and Yottahertz (YHz) Imaging and Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation. Madridge J Anal Sci Instrum. 2: 41-46.


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Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.110011


119. Heidari A. 2018. Infrared Photo Dissociation Spectroscopy and Infrared Correlation Table Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time. Austin Pharmacol Pharm. 3: 1011.


129. Heidari A. 2018. Heteronuclear Correlation Experiments such as Heteronuclear Single-Quantum Correlation Spectroscopy (HSQC), Heteronuclear Multiple-Quantum Correlation Spectroscopy (HMQC) and Heteronuclear Multiple-Bond Correlation Spectroscopy (HMBC) Comparative Study on Malignant and Benign Human Endocrinology and Thyroid Cancer Cells and Tissues under Synchrotron Radiation. J Endocrinol Thyroid Res. 3: 555603.

130. Heidari A. 2018. Nuclear Resonance Vibrational Spectroscopy (NRVS), Nuclear Inelastic Scattering Spectroscopy (NISS), Nuclear Inelastic Absorption Spectroscopy
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.11001


5. Heidari A. 2018. Correlation Spectroscopy, Exclusive Correlation Spectroscopy and Total Correlation Spectroscopy Comparative Study on Malignant and Benign Human AIDS-Related Cancers Cells and Tissues with the Passage of
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

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Incorporation into the Nano Polymeric Matrix (NPM) by Immersion of the Nano Polymeric Modified Electrode (NPME) as Molecular Enzymes and Drug Targets for Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron and Synchrocyclotron Radiations. Nanomed Nanotechnol. 3: 138.


Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations


165. Heidari A. 2018. Cadaverine (1,5-Pentanediamine or Pentamethylenediamine), Diethyl Azodicarboxylate (DEAD or DEADCAT) and Putrescine (Tetramethylenediamine) Nano Molecules Incorporation into the Nano Polymeric Matrix (NPM) by Immersion of the Nano Polymeric Modified Electrode (NPME) as Molecular Enzymes and Drug Targets for Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron and Synchrocyclotron Radiations. Hiv and Sexual Health Open Access Open Journal. 1: 4-11.


170. Heidari A. 2018. Uranocene (U(C8H8)2) and Bis (Cyclooctatetraene)Iron (Fe(C8H8)2 or Fe (COT)2)-Enhanced Precatalyst Preparation Stabilization and Initiation (EPPSI) Nano Molecules. Chemistry Reports. 1: Pages 1-16.


Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.11001


186. Heidari A. 2018. Fucitol, Pterodactyladiene, DEAD or DEADCAT (DiEthyl AzoDiCarboxyTe), Skatole, the NanoPutians, Thebacon, Pikachurin, Tie Fighter, Spermidine and Mirasorvone Nano Molecules Incorporation into the Nano Polymeric Matrix (NPM) by Immersion of the Nano Polymeric Modified Electrode (NPME) as Molecular Enzymes and Drug Targets for Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron and Synchrocyclotron Radiations. Parana Journal of Science and Education. 6: 46-67.


188. Heidari A, Gobato R. 2018. First-Time Simulation of Deoxyuridylate Monophosphate (dUMP) (Deoxyuridylic Acid or Deoxyuridylate) and Vomitoxin (Deoxyxidvalenol (DON)) ((3α,7α)-3,7,15-Trihydroxy-12,13-Epoxytrichothec-9-En-8-One)-Enhanced Precatalyst Preparation Stabilization and Initiation (EPPSI) Nano Molecules Incorporation into the Nano Polymeric Matrix (NPM) by Immersion of the Nano Polymeric Modified Electrode (NPME) as Molecular Enzymes and Drug Targets for Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron and Synchrocyclotron Radiations. Parana Journal of Science and Education. 6: 46-67.

189. Heidari A. 2018. Buckminsterfullerene (Fullerene), Bullvalene, Dickite and Josiphos Ligands Nano Molecules Incorporation into the Nano Polymeric Matrix (NPM) by Immersion of the Nano Polymeric Modified Electrode (NPME) as Molecular Enzymes and Drug Targets for Human Hematology and Thromboembolic Diseases Prevention, Diagnosis and Treatment under Synchrotron and Synchrocyclotron Radiations. Glob Imaging Insights, Volume. 3: 1-7.


199. Heidari A. 2018. Two-Dimensional (2D) 1H or Proton NMR, 13C NMR, 15N NMR and 31P NMR Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation with the Passage of Time. Glob Imaging Insights. 3: 1-8.


204. Heidari, A. 2018. 2-Amino-9-(((1S, 3R, 4R)-4-Hydroxy-3-(Hydroxymethyl)-2-Methylenecyclopentyl)-1H-Purin-6(9H)-One, 2-Amino-9-(((1R, 3R, 4R)-4-Hydroxy-3-(Hydroxymethyl)-2-Methylenecyclopentyl)-1H-Purin-6(9H)-One, 2-Amino-9-(((1R, 3R, 4S)-4-Hydroxy-3-(Hydroxymethyl)-2-Methylenecyclopentyl)-1H-Purin-6(9H)-One and 2-Amino-9-(((1S, 3R, 4S)-4-Hydroxy-3-(Hydroxymethyl)-2-Methylenecyclopentyl)-1H-Purin-6(9H)-One-Enhanced Precatalyst Preparation Stabilization and Initiation Nano Molecules. Glob Imaging Insights. 3: 1-9.


Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

DOI: https://doi.org/10.36811/ijho.2021.11001


221. Heidari A. 2019. The Hydrolysis Constants of Copper (I) (Cu+) and Copper (II) (Cu2+) in Aqueous Solution as a Function of pH Using a Combination of pH Measurement and Biospectroscopic Methods and Techniques. Glob Imaging Insights. 4: 1-8.


228. Heidari A, Esposito J, Caissutti A. 2019. The Importance of Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) and Raman Bio-spectroscopy of Single-Walled Carbon Nanotubes (SWCNT) and Multi-Walled Carbon Nanotubes (MWCNT) in Interpreting Infrared and Raman...
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DOI: https://doi.org/10.36811/ijho.2021.11001


365. Heidari A. 2019. 16th International Conference on Advance Material &
Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations

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DOI: https://doi.org/10.36811/ijho.2021.110011

and Nano-Enhanced Drug Delivery and Therapeutic in Cancer Treatment and Beyond under Synchrotron Radiation. Parana Journal of Science and Education. 6: 8-50.


Annealing Effects on the Interband Transition and Optical Constants of Ruthenium (IV) Oxide (RuO₂) and Ruthenium (VIII) Oxide (RuO₄) Nano Thin Films in Cancer Cells, Tissues and Tumors under Synchrotron and Synchrocyclotron Radiations


462. Heidari A, Gobato R. 2021. Integrated Analysis of the Conformation of a DNA/RNA-Linked Spin Label by Combining NMR Ensembles and Molecular Dynamics Simulations Provides More Realistic Models of DNA/RNA Structures in Gum Cancer Cells Using Optimization of NMR Spectroscopy of...

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Theoretical Chemistry, Mathematical Chemistry, Computational Chemistry, Vibrational Spectroscopy, Molecular Modelling, Ab initio & Density Functional Methods, Molecular Structure, Biochemistry, Molecular Simulation, Pharmaceutical Chemistry, Medicinal Chemistry, Oncology, Synchrotron Radiation, Synchrocyclotron Radiation, LASER, Anti-Cancer Nano Drugs, Nano Drugs Delivery, ATR-FTIR Spectroscopy, Raman Spectroscopy, Intelligent Molecules, Molecular Dynamics, Biosensors, Biomarkers, Molecular Diagnostics, Numerical Chemistry, Nucleic Acids, DNA/RNA Monitoring, DNA/RNA Hypermethylation & Hypomethylation, Human Cancer Tissues, Human Cancer Cells, Tumors, Cancer Tissues, Cancer Cells, etc. He has participated at more than five hundred reputed international conferences, seminars, congresses, symposiums and forums around the world as yet. Also, he possesses many published articles in Science Citation Index (SCI)/International Scientific Indexing (ISI), Medline/PubMed and Scopus Journals. It should be noted that he has visited many universities or scientific and academic research institutes in different countries such as United States, United Kingdom, Canada, Australia, New Zealand, Scotland, Ireland, Netherlands, Belgium, Denmark, Luxembourg, Romania, Greece, Russia, Estonia, Ukraine, Turkey, France, Swiss, Germany, Sweden, Norway, Italy, Austria, Czech Republic, Hungary, Poland, South Africa, Egypt, Brazil, Spain, Portugal, Mexico, Japan, Singapore, Malaysia, Indonesia, Thailand, Taiwan, Hong Kong, Philippines, South Korea, China, India, Kingdom of Saudi Arabia, Jordan, Qatar, United Arab Emirates, etc. as research fellow, sabbatical and volunteer researcher or visitor and so on heretofore. He has a history of several years of teaching for college students and various disciplines and trends in different universities. Moreover, he has been a senior advisor in various industry and factories. He is expert in many computer programs and programming languages. Hitherto, he has authored more than twenty books and book chapters in different fields of Chemistry. Syne, he has been awarded more than one thousand reputed international awards, prizes, scholarships and honors. Heretofore, he has multiple editorial duties in many reputed international and peer-reviewed journals, books and publishers. Hitherward, he is a member of more than five hundred reputed international academic-scientific-research institutes around the world. It should be noted that he is currently the President of the American International Standards Institute (AISI), Irvine, California, USA and also Head of Cancer Research Institute (CRI) and Director of the BioSpectroscopy Core Research Laboratory at California South University (CSU), Irvine, California, USA.

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