Computational approach to interaction between synchrotron radiation emission as a function of the beam energy and ruthenium nanoparticles in human gum cancer cells, tissues and tumors treatment

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Abstract

In the current study, thermoplasmonic characteristics of Ruthenium nanoparticles with spherical, core–shell and rod shapes are investigated. In order to investigate these characteristics, interaction of synchrotron radiation emission as a function of the beam energy and Ruthenium nanoparticles were simulated using 3D finite element method. Firstly, absorption and extinction cross sections were calculated. Then, increases in temperature due to synchrotron radiation emission as a function of the beam energy absorption were calculated in Ruthenium nanoparticles by solving heat equation. The obtained results show that Ruthenium nanorods are more appropriate option for using in optothermal human cancer cells, tissues and tumors treatment method.

Introduction

In recent decade, metallic nanoparticles have been widely interested due to their interesting optical characteristics [1-8]. Resonances of surface Plasmon in these nanoparticles lead to increase in synchrotron radiation emission as a function of the beam energy scattering and absorption in related frequency [9,10]. Synchrotron radiation emission as a function of the beam energy absorption and induced produced heat in nanoparticles has been considered as a side effect in plasmonic applications for a long time [11-15]. Recently, scientists find that thermoplasmonic characteristic can be used for various optothermal applications in cancer, nanoflows and photonic [16-22]. In optothermal human cancer cells, tissues and tumors treatment, the descendent laser light stimulate resonance of surface Plasmon of metallic nanoparticles and as a result of this process, the absorbed energy of descendent light converge to heat in nanoparticles [23-25]. The produced heat devastates tumor tissue adjacent to nanoparticles without any hurt to sound tissues [26,27]. Regarding the simplicity of ligands connection to Ruthenium nanoparticles for targeting cancer cells, these nanoparticles are more appropriate to use in optothermal human cancer cells, tissues and tumors treatment method.
and tumors treatment [28-74]. In the current paper, thermoplasmonic characteristics of spherical, core-shell and rod Ruthenium nanoparticles are investigated.

**Heat generation in synchrotron radiation emission as a function of the beam energy–ruthenium nanoparticles interaction**

When Ruthenium nanoparticles are subjected to descendent light, a part of light scattered (emission process) and the other part absorbed (non-emission process). The amount of energy dissipation in non-emission process mainly depends on material and volume of nanoparticles and it can be identified by absorption cross section. At the other hand, emission process which its characteristics are depend on volume, shape and surface characteristics of nanoparticles explains by scattering cross section. Sum of absorption and scattering processes which lead to light dissipation is called extinction cross section [75-123].

Ruthenium nanoparticles absorb energy of descendent light and generate some heat in the particle. The generated heat transferred to the surrounding environment and leads to increase in temperature of adjacent points to nanoparticles. Heat variations can be obtained by heat transfer equation [124-202].

**Simulation**

To calculate the generated heat in Ruthenium nanoparticles, COMSOL software which works by Finite Element Method (FEM) was used. All simulations were made in 3D. Firstly, absorption and scattering cross section areas were calculated by optical module of software. Then, using heat module, temperature variations of nanoparticles and its surrounding environment were calculated by data from optical module [203-283]. In all cases, Ruthenium nanoparticles are presented in water environment with dispersion coefficient of 1.84 and are subjected to flat wave emission with linear polarization. Intensity of descendent light is 1 mW/μm². Dielectric constant of Ruthenium is dependent on particle size [284-442].

Firstly, calculations were made for Ruthenium nanospheres with radius of 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 nanometers. The results show that by increase in nanoparticles size, extinction cross section area increases and maximum wavelength slightly shifts toward longer wavelengths. The maximum increase in temperature of nanospheres in surface Plasmon frequency is shown in Figure 1.

According to the graph, it can be seen that the generated heat is increased by increase in nanoparticles size. For 100 (nm) nanoparticles (sphere with 50 (nm) radius), the maximum increase in temperature is 83 (K). When nanoparticles size reaches to 150 (nm), increase in temperature is increased in spite of increase in extinction coefficient. In order to find the reason of this fact, ratio of absorption to extinction for various nanospheres in Plasmon frequency is shown in Figure 2.

Figure 2 shows that increasing the size of nanospheres leads to decrease in ratio of light absorption to total energy of descendent light so that for 150 (nm) nanosphere, scattering is larger than absorption. It seems that although increase in nanoparticles size leads to more dissipation of descendent light, the dissipation is in the form of scattering and hence, it cannot be effective on heat generation.

Heat distribution (Figure 3) shows that temperature is uniformly distributed throughout the nanoparticles which are due to high thermal conductivity of Ruthenium.

In this section, core-shell structure of Ruthenium and silica is chosen. The core of a nanosphere with 45 (nm) radius and silica layer thickness of 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 nanometers are considered. The results show that increase in silica thickness leads to increase in extinction coefficient and shift in Plasmon wavelength of nanoparticles, to some extent.
According to Figure 4, silica shell causes to considerable increase in temperature of Ruthenium nanoparticles but by more increase in silica thickness, its effects are decreased. Heat distribution (Figure 5) shows that temperature is uniformly distributed throughout metallic core as well as silica shell. However, silica temperature is considerably lower than core temperature due to its lower thermal conductivity. In fact, silica layer prohibits heat transfer from metal to the surrounding aqueous environment due to low thermal conductivity and hence, temperature of nanoparticles has more increase in temperature. Increasing the thickness of silica shell leads to increase in its thermal conductivity and hence, leads to attenuate in increase in nanoparticles temperature.

Figure 6 is drawn. This graph shows that variation of nanorod dimension ratio leads to considerable shift in Plasmon wavelength. This fact allows regulating the Plasmon frequency to place in near IR zone. Light absorption by body tissues is lower in this zone of spectrum and hence, nanorods are more appropriate for optothermal human cancer cells, tissues and tumors treatment methods.

Variations of temperature in Ruthenium nanorods with two effective radius and various dimension ratios are shown in Figure 7. By increase in length (a) to radius (b) of nanorod, temperature is increased.

**Conclusion and summary**

The calculations showed that in Ruthenium nanoparticles, light absorption in Plasmon frequency causes to increase in temperature of the surrounding environment of nanoparticles. In addition, it showed that adding a thin silica layer around the Ruthenium nanospheres increases their temperatures. Calculations of nanorods showed that due to ability for shifting surface Plasmon frequency toward longer wavelength as well as more increase in temperature, this nanostructure is more appropriate for medical applications such as optothermal human cancer cells, tissues and tumors treatments.

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Figure 5. Maximum increase in temperature for core–shell nanoparticles with radius of 45 (nm) and silica thickness of 10 (nm) at Plasmon wavelength of 701 (nm)

Figure 6. Extinction cross section area for Ruthenium nanorods with effective radius of 45 (nm) and various dimension ratios

Figure 7. Maximum increase in temperature for nanorods with effective radius of 20 and 45 (nm) and various dimension ratios
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References

1. Yu, P.; Wu, J.; Liu, S.; Xiong, J.; Jagadish, C.; Wang, Z. MDesign and Fabrication of Silicon Nanowires towards Efficient Solar Cells NanoToday2016, 11, 704-737, 10.1016/j.jantod201610001
2. Sandhu, S.; Fan, S. Current-Voltage Enhancement of a Single Coaxial Nanowire Solar Cell ACS Photonics2015, 2, 1698-1704, 10.1021/acsphotonics.5b00236
3. van Dam, D.; Van Hoof, N.J.J.; Cui, Y.; van Veldhoven, P.J.; Bakkers, E.P.M.; Gómez Rivas, J.; Haverkort, J. E.; High-Efficiency Nanowire Solar Cells with Orbitally Directed Enriched Absorption Due to Self-Admixed Indium-Tin-Oxide Mie Scatters Arcs CANano2016, 10, 11414-11419, 10.1012/acsnano.201608674
4. Luo, S.; Yu, W.; B.; He, Y.; Ouyang, GSizese-Dependent Optical Absorption Modulation of Si and GeSi CoreShell Nanowires with Different Cross-Sectional Geometries Nanotechnology2015, 26, 085702, 10.1088/0957-4484/26/8/085702
5. Yu, P.; Yao, W.; Yu, J.; Niu, X.; Rogach, L.; Wang, Z. Effects of Plasmonic Metal Core-Dielectric Shell Nanoparticles on the Broadband Light Absorption Enhancement in Thin Film Solar Cells Sci Rep2017, 7, 7696, 10.1038/s41598-017-08077-9
6. Gouda, M.; Allam, N. K.; Swillam, M. Efficient Fabrication Methodology of Wide Angle Black Silicon for Energy Harvesting Applications RSC Adv2017, 7, 26974-26982, 10.1039/C7RA03568C
7. Branz, H. M.; Yost, V. E.; Ward, S.; Jones, K. M.; To, B.; Stradins, PTunable Black Silicon and the Optical Response of Graded-Density Gratings Surf. Sci Appl Phys Lett2009, 94, 23112, 10.1016/j.surfsci.2012.11.024
8. Fazio, B.; Artoni, P.; Antonia Iatti, M.; D’Andrea, C.; Lo Faro, M. J.; Del Sorbo, S.; Pirrotta, S.; Giuseppe Gucciardi, P.; Musumeci, P.; Salvatore Vasi, C.; Saini, R.; Galli, M.; Prisolo, F.; Ierri, A.; Strongly Enhanced Light Trapping in a Two-Dimensional Silicon Nanowire Random Fractal Array Light: SciAppl2016, 5, e16062, 10.1038/srep12066
9. Ko, M-D.; Rim, T.; Kim, K.; Meyyappan, M.; Baek, C.-High Efficiency Silicon Solar Cell Based on Asymmetric Nanowire Sci Rep2015, 5, 11646, 10.1038/srep11646
10. Oh, J.; Yuan, H. C.; Branz, H. MAverage 18%-Efficient Black Silicon Solar Cell Achieved through Control of Carrier Recombination in Nanostructures Nat NanoTech2012, 7, 743-748, 10.1038/nnano.2012.166
11. Lin, H.; Xu, F.; Mang, F.; Yang, S.; Cheung, H. Y.; Wang, F.; Han, N.; Chan, K. S.; Wong, C. Y.; He, J. CRational Design of Inverted Nanopillar Arrays for Cost-Effective, Broadband, and Omnidirectional Light Harvesting ACS Nano2014, 8, 3752-3760, 10.1021/nn405041x
12. Garnett, E.; Yang, P. Light Trapping in Silicon Nanowire Solar Cells Nano Lett2010, 10, 1082-1087, 10.1021/nl101611z
13. Misra, S.; Yu, L.; Foldyna, M.; Roca I Cabarrocas, P.; Razek, S.; Swillam, M. High Efficiency and Stable Absorption and Carrier Collection in Si Arrays for Photovoltaic Applications Nat Phys2012, 8, 1045-1050, 10.1038/nphys2337
14. Kelzenberg, M. D.; Boettcher, S. W.; Petykiewicz, J.; C.; Warren, E. L.; Spurgeon, J. M.; Briggs, R. M.; Lewis, N. S.; Atwater, H. A.; Enhanced Electron Field Transfer Problem J Appl Phys2007, 101, 094301, 10.1063/12720185
15. Jin, S.; Hong, S.; Mativenga, M.; Kim, B.; Shin, H. P.; Park, J. K.; Kim, T.; Wang, J.; Low Temperature Poly crystalline Silicon with Single Orientation on Glass by Blue Laser Annealing Thin Solid Films2016, 616, 838-841, 10.1016/j.tsf.201610026
16. Pedraza, J.; Fowkels, J. D.; Lowndes, D. HSilicon Microcolumn Arrays Grown by Nanosecond Pulsed-Excimer Laser Irradiation Appl Phys Lett1999, 74, 2322-2324, 10.1063/1123838
17. Pedraza, J.; Fowkels, J. D.; Jesse, S.; Mao, C.; Lowndes, D. H. Silicon Micro-Structuring of Silicon by Excimer-Laser Irradiation in Reactive Atmospheres Surf SciSc2000, 168, 251-257, 10.1016/S0169-4332(00)00611-5
18. Porte, H. P.; Turchinnovich, D.; Persheyev, S.; Fan, Y.; Rose, M.; Jepsen, P. UOltrafast Photocurrent Dynamics and Crystallinity of Black Silicon IEEE Trans Terahertz SciTech2013, 3, 331-341, 10.1109/TTHz.2013.2255917
19. Georgiev, D. G.; Baird, R. J.; Avrutsky, I.; Auner, G.; Newaz, G.; Controllable Excimer-Laser Fabrication of Conical Nano-Tips on Silicon Thin Films Appl Phys Lett2004, 84, 4881-4883, 10.1063/11762978
20. Eizenkop, J.; Avrutsky, I.; Georgiev, D. G.; Chaudhary, V.; Single-Pulse Excimer Laser Nanostructuring of Silicon: A Heat Transfer Problem and Surface Morphology J Appl Phys2008, 103, 094311, 10.1063/12910196
21. Eizenkop, J.; Avrutsky, I.; Auner, G.; Georgiev, D. G.; Chaudhary, V.; Single Pulse Excimer Laser Nanostructuring of Thin Silicon Films: Nanophor Cones Formation and a Heat Transfer Problem J Appl Phys2007, 101, 094301, 10.1063/12720185
22. Hong, I.; Wang, X. C.; Cheng, H. Y.; He, L.; Wang, H.; Yu, H. Y.; Rudi;Femtosecond Laser Induced Nanocore Structure and Simultaneous Crystallization of 16 µM Amorphous Silicon Thin Film for Photovoltaic Application J Phys D Appl Phys2013, 46, 195109, 10.1088/0022-3727/46/19/195109
23. Hong, I.; Wang, X.; Rudi; Zheng, H.; Yu, H.; Y.; Hucz; and Surface Crystallization and Surface Texturing of Amorphous-Si Induced by UV Laser for Photovoltaic Application J Appl Phys2012, 111, 043516, 10.1063/13666612
24. Magdi, S.; Swillam, M.; Broadband Absorption Enhancement in Amorphous Si Solar Cells Using Metal Gratings and Surface Texturizing Proc SPIE2017, 10099, 1009912, 10.1117/12225326
25. Diederhofen, S. L.; Janssen, O. T.; Greyla, G.; Bakkers, E. P. M.; Gómez Rivas, I.; Strong Geometrical Dependence of the Absorption in Arrays of Semiconductor Nanowires ACS Nano2011, 5, 2316-2323, 10.1021/n103596n
26. Jäger, S. T.; Strehe, S.; Design Parameters for Enhanced Photon Absorption in Vertically Aligned Silicon Nanowire Arrays Nanoscale Res Lett2014, 9, 511, 10.1186/1556-276X-9-511

Dent Oral Maxillofac Res, 2019 doi: 10.15761/DOMR.1000322

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Heidari A (2019) Computational approach to interaction between synchrotron radiation emission as a function of the beam energy and ruthenium nanoparticles in human gum cancer cells, tissues and tumors treatment

Dent Oral Maxillofac Res, 2019 doi: 10.15761/DOMR.1000322

Volume 5: 5-18
61. Schäfer, S; Kickelbick, G Self-Healing Polymer Nanocomposites based on Diels-Alder
60. 58. 57. 53. Engel, T; Kickelbick, G Furan-Modified Spherosilicates as Building Blocks for Self-
56. 49. Roszairi, H; Rahman, S High Deposition Rate Thin Film Hydrogenated Amorphous
55. 46. 42. Magdi, S; Swillam, M Optical Analysis of Si-Tapered Nanowires/low Band Gap
54. 43. 40. Gouda, M; Elsayed, M Y; Khalifa, E; Ismail, Y; Swillam, M Lithography-Free Wide- 
Angle Antireflective Self-Cleaning Silicon Nanocones Opt Lett2016, 41, 3575, 101364/DL14003575
41. Gouda, M; Elsayed, M Y; Khalifa, E; Ismail, Y; Swillam, M Lithography-Free Wide- 
40. Magdi, S; Swillam, M Optical Analysis of Si-Tapered Nanowires/low Band Gap
39. Park, J S; Darlington, T; Starr, F; Takahashi, K; Riedeau, J; Thomas Hahn, H Multiple
38. Frison, R; Cerruto, G; Cervellino, Z; Zabarko, O; Colonna, G M; Guagliardi, ; Masicocchi, NMagneticite-Maghemite Nanoparticles in the 5–15 nm Range: Correlating the Core-
37. Yao, J; Gong, X; Qin, R; Liu, H; Xia, C; Ma, HEfficiency Enhancement Mechanism for
36. 35. Li, J; Liang, J; Li, L; Ben, F; Hu, W; Li, J; Qi, S, Pei Qiao H-Gelative Capacitive Touch Screen
34. 33. Frison, R; Cerruto, G; Cervellino, Z; Zabarko, O; Colonna, G M; Guagliardi, ; Masicocchi, NMagneticite-Maghemite Nanoparticles in the 5–15 nm Range: Correlating the Core-Shell Composition and the Surface Structure to the Magnetic Properties A Total Scattering Study Chem Mater2013, 25, 4820–4827, 101021/cm03360f
32. Santoyo Salazar, J; Perez, L; de, A; Abril, O; Truong Phuoc, L; Ihiawakrim, D; Vazquez, M; Grenache, J-M; Begin-Colin, S; Pourry, GMagnetic Iron Oxide Nanoparticles in 10–40 nm Range: Composition in Terms of Magnetic/ Maghemite Ratio and Effect on the Magnetic Properties Chem Mater2011, 23, 1379–1386, 101021/cm01318a
31. Guerrero, G; Mutin, P H; Voux, Anchoring of Phosphonate and Phosphonate Coupling 
Molecules on Titania Particle Chem Mater2001, 13, 4367–4373, 101021/cm001253u
30. Babu, K; Dhamdharan, R Grafting of Poly(methyl methacrylate) Brushes from Magnetic Nanoparticles Using a Phosphonic Acid Based Initiator by Ambient Temperature Atom Transfer Radical Polymerization (ATA TRP) Nanoscale Res Lett2008, 3, 109–117, 101007/s11671-008-9121-9
29. Mohapatra, S; Pramanik, PSynthesis and Stability of Functionalized Iron Oxide Nanoparticles using Organophosphorous Coupling Agents Colloids Surf A2011, 39, 35–42, 101016/jcol200910009
28. Larsen, B ; Hurst, K M; Ashurst, W R; Serkova, N J; Stöhl, C RMono- and Dialkoxysilane Surface Modification of Superparamagnetic Iron Oxide Nanoparticles for Application as Magnetic Resonance Imaging Contrast Agents J Mater Res2012, 27, 1846–1852, 101557/jmr20121610
27. Davis, K; Qi, B; Witmer, M; Kitchens, C; Ll; Powell, B ; Mefford, O TQuantitative Infrared Spectra of Alkylphosphonic Acid Bound to Aluminium Surfaces Macromol Symp2007, 254, 248–253, 101002/chem201103256
26. Lu, C; Bhatt, L R; Jun, H Y; Park, S H; Chai, K VCyclopolylthiyloxyPolyglycol– 
Phosphoric Acid: A Ligand for highly stabilized Iron Oxide Nanoparticles J Mater Chem2012, 22, 19086–19811, 101393/cj20134327b
25. Patula, V; Kosinova, L; Lovric, M; Ferhatovic Hamzic, L; Rabyk, M; Konefal, R; Patsula, V; Kosinova, L; Lovric, M; Ferhatovic Hamzic, L; Rabyk, M; Konefal, R; Paruzel, J; Slouf, M; Herynek, V; Gajovic, S; Horak, D DSuperparamagnetic Fe3O4 Nanoparticles: Synthesis by Thermal Decomposition of Iron(III) Glucuronate and Application in Magnetic Resonance Imaging ACS Appl Mater Interfaces2016, 8, 7238–7247, 101021/acsmi5b06903
24. Pothayee, N; Balasubramaniam, S; Davis, R M; Riffe, J S; Carroll, M J; Woodward, R C; St Pierre, T GSynthesis of ‘read-to-adsorb’ Polymeric Nanoshells for Magnetic Iron Oxide Nanoparticles via Atom Transfer Radical Polymerization Polymer2011, 52, 1356–1366, 101002/acspolymer201101047
23. Daou, J; Begin-Colin, S; Grenèche, J M; Thomas, F; Derovy, ; Bernhardt, P; Legaré, P; Pourry, GMagnetic Phosphonic Acid Adsorption Properties of Magnetic-Base Nanoparticles Chem Mater2007, 19, 4494–4505, 101021/cm071046v
22. Breucker, L; Landefaster, K; Tuden, Phosphoric Acid-Functionalized Polypyrrole Dispersions with Improved Adhesion Properties ACS Appl Mater Interfaces2015, 7, 2464–24648, 101021/acsmi5b06903
21. Sahoo, Y; Pizmem, H; Fried, T; Goldnitsky, D; Burstein, L; Sukenik, C; N Markovich, GAKyl Phosphonate/Phosphate Coating on Magnetic Nanoparticles: A Comparison with Fatty Acids Langmuir2001, 17, 7907–7911, 101021/la107030+3
20. Longo, R C; Cho, K; Schmidt, W G; Chabu, Y J; Thiessen, P Monolayer Doping via Phosphonic Acid Grafting on Silicon: Microscopic Insight from Infrared Spectroscopy and Density Functional Theory Calculations Adv Funct Mater2013, 23, 3471–3477, 101002/adfm201202808
19. Lutschinrez, R; Seifert, G; Jaebne, E; Adler, H JPlaspared Spectra of Alkylphosphonic 
Acid Bound to Aluminium Surfaces Macromol Symp2007, 249, 248–253, 101021/ masy200750837
18. Volume 5: 6-18
Heidari, A (2019) Computational approach to interaction between synchrotron radiation emission as a function of the beam energy and ruthenium nanoparticles in human gum cancer cells, tissues and tumors treatment

120. Heidari, “Discriminate between Antibacterial and Non-Antibacterial Drugs Artificial Neural Networks of a Multilayer Perceptron (MLP) Type Using a Set of Topological Descriptors”, J Heavy Met Toxicity Dis 1: 2, 2016

121. Heidari, “Combined Theoretical and Computational Study of the Belousov-Zhabotinsky Chaotic Reaction and Curtius Rearrangement for Synthesis of Methyleneamine, Cisplatin, Streptozocin, Cyclophosphamide, Melphalan, Busulphan and BCNU as Anti-Cancer Drugs”, Insights Med Phys 1: 2, 2016

122. Heidari, “A Translational Biomedical Approach to Structural Arrangement of Amoebic Acids’ Complexes: A Combined Theoretical and Computational Study”, Transl Biomed 7: 2, 2016

123. Heidari, “Ab Initio and Density Functional Theory (DFT) Studies of Dynamic NMR Shielding Tensors and Vibrational Frequencies of DNA/RNA and Cadmium Oxide (CdO) Nanoparticles Complexes in Human Cancer Cells”, J Nanomedicine Biotherapeutic Discov 6: e144, 2016

124. Heidari, “Molecular Dynamics and Monte-Carlo Simulations for Replacement Sugars in Insulin Resistance, Obesity, LDL Cholesterol, Triglycerides, Metabolic Syndrome, Type 2 Diabetes and Cardiovascular Disease: A Glycobiological Study”, J Glycobiol 5: e111, 2016

125. Heidari, “Synthesis and Study of 5-[(Phenylsulfonyl)amine]-1,3,4-Thiadiazolo-2-Sulfonamide as Potential Anti-Pertussis Drug Using Chromatography and Spectroscopy Techniques”, Transl Med (Sunnyvale) 6: e138, 2016

126. Heidari, “Nitrogen, Oxygen, Phosphorus and Sulphur Heterocyclic Anti-Cancer Nano Drugs Separation in the Supercritical Fluid of Ozone (O3) Using Soave-Redlich-Kwong (SRK) and Pang-Robinson (PR) Equations”, Electronic J Biol 12: 4, 2016

127. Heidari, “An Analytical and Computational Infrared Spectroscopic Review of Vibrational Modes in Nucleic Acids”, Austin J Anal Pharm Chem 3 (1): 1058, 2016

128. Heidari, C Brown, “Phase, Composition and Morphology Study and Analysis of Os-Pd/Hc Nanocomposites”, Nano Res Appl 2: 1, 2016

129. Heidari, C Brown, “Vibrational Spectroscopic Study of Intensities and Shifts of Symmetric Vibration Modes of Ozone Diluted by Cumene”, International Journal of Advanced Chemistry, 4 (1) 5-9, 2016

130. Heidari, “Study of the Role of Anti-Cancer Molecules with Different Sizes for Decreasing Corresponding Bulk Tumor Multiple Organs or Tissues”, Arch Can Res 4: 2, 2016

131. Heidari, “Genomics and Proteomics Studies of Zolpidem, Nocpepidom, Alpidem, Saripidem, Miroprofen, Zolimidine, Oxpromine and Abafungin as Anti-Tumor, Peptide Antibiotics, Antiviral and Central Nervous System (CNS) Drugs”, J Data Mining Genomics & Proteomics 7: e125, 2016

132. Heidari, “Pharmacogenomics and Pharmacoproteomics Studies of Phosphodiesterase-5 (PDE5) Inhibitors and Paclitaxel Albumin-Stabilized Nanoparticles as Sandwiched Anti-Cancer Nano Drugs between Two DNA/RNA Molecules of Human Cancer Cells”, J Pharmacogenomics Pharmacoproteomics 7: e153, 2016

133. Heidari, “Biotranslational Medical and Biospectroscopic Studies of Cadmium Oxide (CdO) Nanoparticles-DNA/RNA Straight and Cycle Chains Complexes as Potential Anti-Viral, Anti-Tumor and Anti-Microbial Drugs: A Clinical Approach”, Transl Biomed 7: 2, 2016

134. Heidari, “A Comparative Study on Simultaneous Determination and Separation of Adsorbed Cadmium Oxide (CdO) Nanoparticles on DNA/RNA of Human Cancer Cells Using Biospectroscopic Techniques and Deicthrophoresis (DEP) Methods”, Arch Can Res 4: 2, 2016

135. Heidari, “Cheminformatics and System Chemistry of Cisplatin, Carboplatin, Nedaplatin, Oxaliplatin, Hepatplatin and Lobaplatin as Anti-Cancer Nano Drugs: A Combined Computational and Experimental Study”, J Inform Data Min 1: 3, 2016

136. Heidari, “Linear and Non-Linear Quantitative Structure–Anti-Cancer–Activity Relationship (QSACAR) Study of Hydrous Ruthenium (IV) Oxide (RuO2) Nanoparticles as Non-Nucleoside Reverse Transcriptase Inhibitors (NRTIs) and Anti-Cancer Nano Drugs”, J Integr Oncol 5: e110, 2016

137. Heidari, “Synthesis, Characterization and Biospectroscopic Studies of Cadmium Oxide (CdO) Nanoparticles-Nucleic Acids Complexes Absence of Soluble Polymer as a Protective Agent Using Nucleic Acids Condensation and Solution Reduction Method”, J Nanosci Curr Res 1: e101, 2016

138. Heidari, “Copolymerization, Chlorination and Cellulose of 4’-Dino—2.2-2’—Bithiazole in One Domain of Bleomycin and Penicillarginine as Possible for Binding of Cadmium Oxide (CdO) Nanoparticles to DNA/RNA Bidentate Ligands as Anti-Tumor Nano Drug”, Int J Drug Dev & Res 8: 007—008, 2016

139. Heidari, “A Pharmacovigilance Study on Linear and Non-Linear Quantitative Structure (Chromatographic) Retention Relationships (QSSR) Models for the Prediction of Retention Time of Anti-Cancer Nano Drugs under Synchrotron Radiations”, J Pharmacovigil 4: e161, 2016

140. Heidari, “Nanotechnology in Preparation of Semipermeable Polymers”, J Adv Chem Eng 6: 157, 2016

141. Heidari, “A Gastrointestinal Study on Linear and Non-Linear Quantitative Structure (Chromatographic) Retention Relationships (QSSR) Models for Analysis 5-Aminosalicylates Nano Particles as Digestive System Nano Drugs under Synchrotron Radiations”, J Gastrointest Dig Syst 6: e119, 2016

142. Heidari, “DNA-RNA Fragmentation and Cytolysis in Human Cancer Cells Treated with Diphthamide Nano Particles Derivatives”, Biomedical Data Mining 5: e102, 2016

143. Heidari, “A Successful Strategy for the Prediction of Solubility in the Construction of Quantitative Structure–Activity Relationship (QSAR) and Quantitative Structure–Property Relationship (QSPR) under Synchrotron Radiations Using Genetic Function Approximation (GFA) Algorithm”, J Mol Biol Biotechnol 1: 1, 2016

144. Heidari, “Computational Study on Molecular Structures of C20, C60, C240, C540, C960, C2160 and C3840 Fullerene Nano Molecules under Synchrotron Radiations Using Fuzzy Logic”, J Material Sci Eng 5: 282, 2016

145. Heidari, “Graph Theoretical Analysis of Zika Polyhexamethylene Biguanide, Polyhexamethylene Adipamide, Polyhexamethylene Biguanide Gauze and Polyhexamethylene Biguanide Hydrochloride (PFBH) Amorphous Boron Nitride Nanotubes (BNNTs), Amorphous Boron Nitride Nanotubes (a-BNNTs) and Hexagonal Boron Nitride Nanotubes (h-BNNTs)”, J Appl Comput Math 5: e143, 2016

146. Heidari, “The Impact of High Resolution Imaging on Diagnosis”, Int J Clin Imaging 3: 1006e101, 2016

147. Heidari, “A Comparative Study of Conformational Behavior of Isotretinoin (13-Cis Retinoic Acid) and Tretinoin (All-Trans Retinoic Acid (ATRA)) Nano Particles as Anti-Cancer Nano Drugs under Synchrotron Radiations Using Hartree-Fock (HF) and Density Functional Theory (DFT) Methods”, Insights in Biomed 1: 2, 2016

148. Heidari, “Advances in Logic, Operations and Computational Mathematics”, J Appl Comput Math 5: 5, 2016

149. Heidari, “Mathematical Equations in Predicting Physical Behavior”, J Appl Comput Math 5: 5, 2016

150. Heidari, “Chemotherapy a Last Resort for Cancer Treatment”, Chemo Open Access 5: 4, 2016

151. Heidari, “Separation and Pre-Concentration of Metal Cations-DNA/RNA Chelates Using Molecular Beam Mass Spectrometry with Tunable Vacuum Ultraviolet (VUV) Synchrotron Radiation and Various Analytical Methods”, Mass Spectrom Purif Tech 2: e130, 2016

152. Heidari, “Yoctosecond Quantitative Structure–Activity Relationship (QSAR) and Quantitative Structure–Property Relationship (QSPR) under Synchrotron Radiations Studies for Prediction of Solubility of Anti-Cancer Nano Drugs in Aqueous Solutions Using Genetic Function Approximation (GFA) Algorithm”, Insight Pharm Res 1: 1, 2016

153. Heidari, “Cancer Risk Prediction and Assessment in Human Cells under Synchrotron Radiations Using Quantitative Structure Activity Relationship (QSSAR) and Quantitative Structure Properties Relationship (QSPR) Studies”, Int J Med Imaging 3: 516, 2016

154. Heidari, “A Novel Approach to Biology”, Electronic J Biol 12: 4, 2016

155. Heidari, “Innovative Biomedical Equipment’s for Diagnosis and Treatment”, J Bioengineer & Biomedical Sci 6: 2, 2016

156. Heidari, “Integrating Precision Cancer Medicine into Healthcare, Medicare Reimbursement Changes and the Practice of Oncology: Trends in Oncology Medicine and Practices”, J Oncol Med & Pract 2: 1, 2016

157. Heidari, “Promoting Convergence in Biomedical and Biomatertials Sciences and Silk Proteins for Biomedical and Biomatertials Applications: An Introduction to Materials in Medicine and Bioengineering Perspectives”, J Bioengineer & Biomedical Sci 6: 3, 2016

158. Heidari, “X-Ray Fluorescence and X-Ray Diffraction Analysis on Discrete Element Modeling of Nano Powder Metallurgy Processes in Optimal Container Design”, J Powder Metall Min 6: 1, 2016

159. Heidari, “Biomoelastic Spectroscopy and Dynamics of Nano-Sized Molecules and Clusters as Cross-Linking-Induced Anti-Cancer and Immune-Oncoology Nano Drugs Delivery in DNA/RNA of Human Cancer Cells’ Membranes under Synchrotron Radiations: A Payload-Based Perspective”, Arch Chem Res 1: 2, 2017
DNA/RNA to Targeted Nano Drugs for Enhanced Anti-Cancer Efficacy and Targeted Cancer Therapy Using Nano Drugs Delivery Systems”, Ann Adv Chem 1 (2): 061–069, 2017.

Heidari, “High Resolution Simulations of Human Brain Cancer Translational Nano Drugs Delivery Treatment Process under Synchrotron Radiation”, J Transl Res 1 (3): 1–3, 2017.

Heidari, “Investigation of Anti-Cancer Nano Drugs’ Effects’ Trend on Human Pancreas Cancer Cells and Tissues Prevention, Diagnosis and Treatment Process under Synchrotron and X-Ray Radiations with the Passage of Time Using Mathematica”, Current Trends Anal Bioanal Chem, 1 (3): 36–41, 2017.

Heidari, “Pros and Cons Controversy on Molecular Imaging and Dynamics of Dopamine-Standard DNA/RNA of Human Preserving Stem Cells-Binding Nano Molecules with Androgens/Ambolic Steroids (AAS) or Testosterone Derivatives through Tracking of Helium-4 Nucleus (Alpha Particle) Using Synchrotron Radiation”, Arch Biotechnol Biochem 1 (1): 067–0100, 2017.

Heidari, “Visualizing Metabolic Changes in Probing Human Cancer Cells and Tissues Metabolism Using Vivo 1H or Proton NMR, 13C NMR, 15N NMR and 31P NMR Spectroscopy and Self-Organizing Maps under Synchrotron Radiation”, SOJ Mater Sci Eng 5 (2): 1–6, 2017.

Heidari, “Cavity Ring-Down Spectroscopy (CRDS), Circular Dichroism Spectroscopy, Cold Vapour Atomic Fluorescence Spectroscopy and Correlation Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Enlivin: Challenges Cancer Detect Ther 4 (2): e091, 2017.

Heidari, “Laser Spectroscopy, Laser-Induced Breakdown Spectroscopy and Laser-Induced Plasma Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Int J Hepatol Gastroenterol, 3 (4): 079–084, 2017.

Heidari, “Time-Resolved Spectroscopy and Time-Stretch Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Enlivin: Pharmacovigilance and Drug Safety 4 (2): e091, 2017.

Heidari, “Overview of the Role of Vitamins in Reducing Negative Effect of Decapeteyl (Triptorelin Acetate or Pamoato Salts) on Prostate Cancer Cells and Tissues in Prostate Cancer Treatment Process through Transformation of Malignant Prostate Tumors into Benign Prostate Tumors under Synchrotron Radiation”, Open J Anal Bioanal Chem 1 (1): 021–026, 2017.

Heidari, “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 Synchrotron Radiation”, Austin J Anal Pharm Chem 4 (3): 1091, 2017.

Heidari, “Therapeutic Nanomedicine Different High-Resolution Experimental Images and Computational Simulations for Human Brain Cancer Cells and Tissues Using Nanocarriers Deliver DNA/RNA to Brain Tumors under Synchrotron Radiation with the Passage of Time Using Mathematica and MATLAB”, Madridge J Nano Tech Sci 2 (2): 77–83, 2017.

Heidari, “A Consensus and Prospective Study on Restoring Cadmium Oxide (CdO) Nanoparticles Sensitivity in Recurrent Ovarian Cancer by Extending the Cadmium Oxide (CdO) Nanoparticles-Free Interval Using Synchrotron Radiation Therapy as Antibody-Drug Conjugate for the Treatment of Limited-Stage Small Cell Diverse Epithelial Cancers”, Cancer Clin Res Rep 1; 2, e001, 2017.

Heidari, “A Novel and Modern Experimental Imaging and Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under White Synchrotron Radiation”, Cancer Sci Res Open Access 4 (2): 1–8, 2017.

Heidari, “Different High-Resolution Simulations of Medical, Medicinal, Clinical, Pharmaceutical and Therapeutics Oncology of Human Breast Cancer Translational Nano Drugs Delivery Treatment Process under Synchrotron and X-Ray Radiations”, J Oral Cancer Res 1 (1): 12–17, 2017.

Heidari, “Vibrational Deciheritz (dHz), Centihertz (cdHz), Millihertz (mHz), Microhertz (μHz), Nanohertz (nHz), Picohertz (pHz), Femtohertz (fHz), Attohertz (aHz), Zephtohertz (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 (4), 335–340, 2017.

Heidari, “Force Spectroscopy and Fluorescence Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, EC Cancer, 2 (5), 239–246, 2017.

Heidari, “Photoacoustic Spectroscopy, Photoemission Spectroscopy and Photothermal Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, BAOJ Cancer Res Ther, 3; 3, 045–052, 2017.

Heidari, “J-Spectroscopy, Exchange Spectroscopy (EXSY), Nuclear Overhauser Effect Spectroscopy (NOESY) and Total Correlation Spectroscopy (TOSCY) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, EMS Eng Sci, 1 (2): 006–013, 2017.

Heidari, “Neutron Spin Echo Spectroscopy and Spin Noise Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Int J Biopharm Sci, 1: 103–107, 2017.

Heidari, “Vibrational Deciheritz (dHz), Centihertz (cdHz), Millihertz (mHz), 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 (3): 41–46, 2017.

Heidari, “Two-Dimensional Infrared Correlation Spectroscopy, Linear Two-Dimensional Infrared Spectroscopy and Non-Linear Two-Dimensional Infrared Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time”, J Mater Sci Nanotechnol 6 (1): 101, 2018.

Heidari, “Fourier Transform Infrared (FTIR) Spectroscopy, Near-Infrared Spectroscopy (NIRS) and Mid-Infrared Spectroscopy (MIRS) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time”, Int J Nanotechnon Nanomed, Volume 3, Issue 1, Pages 1–6, 2018.

Heidari, “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”, Austen Pharmacol Pharm, 3 (1): 1011, 2018.

Heidari, “Novel and Transcendental Prevention, Diagnosis and Treatment Strategies for Investigation of Interaction among Human Blood Cancer Cells, Tissues, Tumors and Metastases with Synchrotron Radiation under Anti-Cancer Nano Drugs Delivery Efficacy Using MATLAB Modeling and Simulation”, Madridge J Nov Drug Res, 1 (1): 18–24, 2017.

Heidari, “Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Open Access J Trans Med Res, 2 (1): 00026-00032, 2018.

M R R Gobato, R Gobato, Heidari, “Planting of Jaboticaba Trees for Landscape Repair of Degraded Area”, Landscape Architecture and Regional Planning, Vol 3, No 1, 2018, Pages 1–9, 2018.

Heidari, “Fluorescence Spectroscopy, Phosphorescence Spectroscopy and Luminescence Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time”, SM J Clin Med Imaging, 4 (1): 1018, 2018.

Heidari, “Nuclear Inelastic Scattering Spectroscopy (NISS) and Nuclear Inelastic Absorption Spectroscopy (NIAS) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Int J Pharm Sci, 2 (1): 1–14, 2018.

Heidari, “X-Ray Diffraction (XRD), Powder X-Ray Diffraction (PXRD) and Energy-Dispersive X-Ray Diffraction (EDXRD) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, J Oncol Res; 2 (1): 1–14, 2018.

Heidari, “Correlation Two-Dimensional Nuclear Magnetic Resonance (NMR) (2D-NMR) (COSY) Imaging and Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, EMS Can Sci, 1: 1–001, 2018.

Heidari, “Thermal Spectroscopy, Photothermal Spectroscopy, Thermal Microspectroscopy, Photothermal Microspectroscopy, Thermal Macrospectroscopy and Photothermal Macrospectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, SM J Biometrics Biostat, 3 (3): 1024, 2018.

Heidari, “A Modern and Comprehensive Experimental Biospectroscopic Comparative Study on Human Common Cancers’ Cells, Tissues and Tumors before and after Synchrotron Radiation Therapy”, Open Acc J Oncol Med 1 (1), 2018.

Heidari, “Heteronuclear Correlation Experiments such as Heteronuclear Single–Quantum Correlation Spectroscopy (HSQC), Heteronuclear Multiple–Quantum Correlation Spectroscopy (HMQC) and Heteronuclear Multiple–Bond Correlation Spectroscopy (HMBC)”, SOJ Nano Tech Sci 2 (2): 77–83, 2017.
Heidari A (2019) Computational approach to interaction between synchrotron radiation emission as a function of the beam energy and ruthenium nanoparticles in human gum cancer cells, tissues and tumors treatment

Dent Oral Maxillofac Res, 2019        doi: 10.15761/DOMR.1000322

- Heidari, “Vivo 1H or Proton NMR, 13C NMR, 15N NMR and 31P NMR Spectroscopy
- Heidari, “Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Imaging J Clin Medical Sci 5 (1): 001–007, 2018
- Heidari, “Small–Angle Neutron Scattering (SANS) and Wide–Angle X–Ray Diffraction (WAXD) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Int J Biochem Mol Biol 6 (2): 1–6, 2018
- Heidari, “Investigation of Cancer Types Using Synchrotron Technology for Proton Beam Therapy: An Experimental Biopsoscopic Comparative Study”, European Modern Studies Journal, Vol 2, No 1, 3–29, 2018
- Heidari, “Saturated Spectroscopy and Unsaturated Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Imaging J Clin Medical Sci 5 (1): 001–007, 2018
- Heidari, “Small–Angle Neutron Scattering (SANS) and Wide–Angle X–Ray Diffraction (WAXD) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Int J Biochem Mol Biol 6 (2): 1–6, 2018
- Heidari, “Investigation of Bladder Cancer, Breast Cancer, Colorectal Cancer, Endometrial Cancer, Kidney Cancer, Leukemia, Liver, Lung Cancer, Melanoma, Non–Hodgkin Lymphoma, Pancreatic Cancer, Prostate Cancer, Thyroid Cancer and Non–Melanoma Skin Cancer Using Synchrotron Technology for Proton Beam Therapy: An Experimental Biopsoscopic Comparative Study”, Ther Res Skin Dis 1 (1), 2018
- Heidari, “Attenuated Total Reflectance Fourier Transform Infrared (ATR–FTIR) Spectroscopy, Micro–Attenuated Total Reflectance Fourier Transform Infrared (Micro–ATR–FTIR) Spectroscopy and Micro–Attenuated Total Reflectance Fourier Transform Infrared (Micro–ATR–FTIR) Spectroscopic Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time”, International Journal of Chemistry Papers, 2 (1): 1–12, 2018
- Heidari, “Mössbauer Spectroscopy, Mössbauer Emission Spectroscopy and 57Fe Mössbauer Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Acta Scientific Cancer Biology 23: 17–20, 2018
- Heidari, “Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time”, Organic & Medicinal Chem J 6 (1): 555676, 2018
- Heidari, “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 Time under Synchrotron Radiation”, Int J Biostat Biom 2 (1): 001–007, 2018
- Heidari, “Biomedical Instrumentation and Applications of Biopsoscopic Methods and Techniques in Malignant and Benign Human Cancer Cells and Tissues Studies under Synchrotron Radiation and Anti–Cancer Nano Drugs Delivery”, Am J Nanotech Nanomed 1 (1): 001–009, 2018
- Heidari, “Vivo 1H or Proton NMR, 13C NMR, 15N NMR and 31P NMR Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Ann Biomater Biostat 1 (1): 100, 2018
- Heidari, “Grazing–Incidence Small–Angle Neutron Scattering (GISANS) and Grazing–Incidence X–Ray Diffraction (GIXD) Comparative Study on Malignant and Benign Human Cancer Cells, Tissues and Tumors under Synchrotron Radiation”, Ann Cardiovasc Surg 1 (2): 1006, 2018
- Heidari, “Adsortion Isethorns and Kinetics of Multi–Walled Carbon Nanotubes (MWCNTs), Boron Nitride Nanotubes (BNNTs), Amorphous Boron Nitride Nanotubes (a–BNNTs) and Hexagonal Boron Nitride Nanotubes (h–BNNTs) for Eliminating Carcinoma, Sarcoma, Lymphoma, Leukemia, Germ Cell Tumor and Blasoma Cancer Cells and Tissues”, Clin Med Rev Case Rep 5: 201, 2018
- Heidari, “Correlation Spectroscopy (COSY), Exclusive Correlation Spectroscopy (ECOSY), Total Correlation Spectroscopy (TOCSY), Incredible Natural–Abundance Double–Quantum Transfer Experiment (INADEQUATE), Heteronuclear Single–Quantum Correlation Spectroscopy (HSQC), Heteronuclear Multiple–Bond Correlation Spectroscopy (HMBC), Nuclear Overhauser Effect Spectroscopy (NOESY) and Rotating Frame Nuclear Overhauser Effect Spectroscopy (ROESY) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Acta Scientific Pharmaceutical Sciences 25: 30–35, 2018
- Heidari, “Small–Angle X–Ray Scattering (SAXS), Ultra–Small–Angle X–Ray Scattering (USAXS), Diffusion–X–Ray Scattering (FXS), Wide–Angle X–Ray Scattering (WAXS), Grazing–Incidence Small–Angle X–Ray Scattering (GISAXS), Grazing–Incidence Wide–Angle X–Ray Scattering (GIXD), Small–Angle Neutron Scattering (SANS), Grazing–Incidence Small–Angle Neutron Scattering (GISANS), X–Ray Diffraction (XRD), Powder X–Ray Diffraction (PXRD), Wide–Angle X–Ray Diffraction (WAXD), Grazing–Incidence X–Ray Diffraction (GIXD) and Energy–Dispersive X–Ray Diffraction (EDXRD) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Oncol Res Rev, Volume 1 (1): 1–10, 2018
- Heidari, “Pump–Probe Spectroscopy and Transient Grating Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Adv Mater Sci Engg, Volume 2, Issue 1, Pages 1–7, 2018
- Heidari, “Grazing–Incidence Small–Angle X–Ray Scattering (GISAXS) and Grazing–Incidence Wide–Angle X–Ray Scattering (GIXS) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Int J Bioorg Chem Mol Biol 6 (2): 1–6, 2018
- Heidari, “Acoustic Spectroscopy, Acoustic Resonance Spectroscopy and Auger Spectroscopy Comparative Study on Anti–Cancer Nano Drugs Delivery in Malignant and Benign Human Cancer Cells and Tissues with the Passage of Time under Synchrotron Radiation”, Nanosci Technol 5 (1): 1–9, 2018
- Heidari, “Niosium, Technetium, Ruthenium, Rhodium, Hafnium, Rheium, Osmium and Iridium Ions Incorporation into the Nano Polymeric Matrix (NPM) by Immersion of the Nano Polymeric Modified Electode (NPM) as Molecular Enzymes and Drug Targets for Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron and Synchrocyclotron Radiations”, Nanomed Nanotechnol, 3 (2): 000138, 2018
- Heidari, “Homonuclear Correlation Experiments such as Homonuclear Single–Quantum Correlation Spectroscopy (HSQC), Homonuclear Multiple–Quantum Correlation Spectroscopy (HMQC) and Homonuclear Multiple–Bond Correlation Spectroscopy (HMBC) Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, Aust J Proteomics Bioinform & Genomics 5 (1): 1024, 2018
- Heidari, “Atomic Force Microscopy Based Infrared (AFM–IR) Spectroscopy and Nuclear Resonance Vibrational Spectroscopy Comparative Study on Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation with the Passage of Time”, J Appl Biotechnol Bioeng 5 (3): 142–148, 2018
- Heidari, “Time–Dependent Vibrational Spectral Analysis of Malignant and Benign Human Cancer Cells and Tissues under Synchrotron Radiation”, J Cancer Oncol, 2 (2): 000124, 2018
- Heidari, “Palamunine and Olypiamidine 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”, Arc Org Inorg Chem Sci 3 (1), 2018
- R Gobato, Heidari, “Infrared Spectrum and Sites of Action of Sanguinarine by Molecular Mechanics and ab initio Methods”, International Journal of Atmospheric and Oceanic Sciences Vol 2, No 1, pp 1–9, 2018
- Heidari, “Angelic Acid, Diabolic Acids, Draculin and Miraculin Nano Molecules as Molecular Enzymes and Drug Targets for Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron and Synchrocyclotron Radiations”, Med & Analy Chem Int J, 2 (2): 000111, 2018
- Heidari, “Gamma Linolenic Methyl Ester, 5–Heptadecane–5,8–11–Trienyl 1,3,4– Oxadazole–2–Thiol, Sulphoquinovosid Diacyl Glycerol, Rosucogenin, Nocturnoside B, Protodioscine B, Pariquoiside–B, Leicarpinoside, Nanargenin, 7–Methoxy
Heidari A (2019) Computational approach to interaction between synchrotron radiation emission as a function of the beam energy and ruthenium nanoparticles in human gum cancer cells, tissues and tumors treatment

409. Heidari, J Esposito, Caissutti, “Diphtheria Toxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis: A Spectroscopic Study on an Anti–Cancer Drug”, Clin Case Studie Rep, Volume 2 (3): 1–14, 2019

410. Heidari, J Esposito, Caissutti, “Symbiodinolide Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Clin Case Study Rep, Volume 2 (3): 1–14, 2019

411. Heidari, J Esposito, Caissutti, “Saxitoxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Am J Exp Clin Res 6 (4): 364–377, 2019

412. R Gobato, M R R Gobato, Heidari, Mitra, “Hartree–Fock Methods Analysis Protonated Rhodochrosite Crystal and Potential in the Elimination of Cancer Cells through Synchrotron Radiation”, Vol 5, No 3, pp 27–36, 2019

413. R Gobato, I K Dosh, Heidari, Mitra, M R R Gobato, “Perspectives on the Elimination of Cancer Cells Using Rhodochrosite Crystal Through Synchrotron Radiation, and Absorption the Tumoral and Non–Tumoral Tissues”, Arch Biomed Eng & Biotechnol 3 (2): 1–2, 2019

414. R Gobato, M R R Gobato, Heidari, Mitra, “Unrestricted Hartree–Fock Computational Simulation in a Protonated Rhodochrosite Crystal”, Phys Astron Int J 3 (6):220–228, 2019

415. Heidari, K Schmitt, M Henderson, E Besana, “Perspectives on Sub–Nanometer Level of Electronic Structure of the Synchrotron with Mendelevium Nanoparticles for Elimination of Human Cancer Cells, Tissues and Tumors Treatment Using Mathematica 120”, Journal of Energy Conservation, Volume 1, Issue 2, Pages 46–73, 2019

416. Heidari, K Schmitt, M Henderson, E Besana, “Simulation of Interaction of Synchrotron Radiation Emission as a Function of the Beam Energy and Bohrium Nanoparticles Using 3D Finite Element Method (FEM) as an Optothermal Human Cancer Cells, Tissues and Tumors Treatment”, Current Research in Biochemistry and Molecular Biology, 1 (3), 17–44, 2019

417. Heidari, K Schmitt, M Henderson, E Besana, “Investigation of Interaction between Synchrotron Radiation and Thulium Nanoparticles for Human Cancer Cells, Tissues and Tumors Treatment”, European Journal of Scientific Exploration, Volume 2, Issue 3, Pages 1–8, 2019

418. Heidari, K Schmitt, M Henderson, E Besana, “The Effectiveness of the Treatment Human Cancer Cells, Tissues and Tumors Using Darmstadtium Nanoparticles and Synchrotron Radiation”, International Journal of Advanced Engineering and Science, Volume 9, Number 1, Pages 9–39, 2020

419. Heidari, K Schmitt, M Henderson, E Besana, “Using 3D Finite Element Method (FEM) as an Optothermal Human Cancer Cells, Tissues and Tumors Treatment in Simulation of Interaction of Synchrotron Radiation Emission as a Function of the Beam Energy and Uranium Nanoparticles”, Nano Prog, 1 (2), 1–6, 2019

420. Heidari, K Schmitt, M Henderson, E Besana, “A New Approach to Interaction between Beam Energy and Erbium Nanoparticles”, Saudi J Biomed Res, 4 (11): 372–396, 2019

421. Heidari, K Schmitt, M Henderson, E Besana, “Consideration of Energy Functions and Wave Functions of the Synchrotron Radiation and Samarium Nanoparticles Interaction During Human Cancer Cells, Tissues and Tumors Treatment Process”, Sci Int (Lahore), 31 (6), 885–908, 2019

422. Heidari, K Schmitt, M Henderson, E Besana, “An Outlook on Optothermal Human Cancer Cells, Tissues and Tumors Treatment Using Lanthanum Nanoparticles under Synchrotron Radiation”, Journal of Materials Physics and Chemistry, Vol 7, No 1, 29–45, 2019

423. Heidari, K Schmitt, M Henderson, E Besana, “Effectiveness of Einsteinium Nanoparticles in Optothermal Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron Radiation”, Journal of Analytical Oncology, 8, 1, 43–62, 2019

424. Heidari, K Schmitt, M Henderson, E Besana, “Study of Relation between Synchrotron Radiation and Dubnium Nanoparticles in Human Cancer Cells, Tissues and Tumors Treatment Process”, Int Res J Applied Sci, Volume 1, Number 4, Pages 1–20, 2019

425. Heidari, K Schmitt, M Henderson, E Besana, “A Novel Prospect on Interaction of Synchrotron Radiation Emission and Europium Nanoparticles for Human Cancer Cells, Tissues and Tumors Treatment”, European Modern Studies Journal, 3 (5), 11–24, 2019

426. Heidari, K Schmitt, M Henderson, E Besana, “Advantages, Effectiveness and Efficiency of Using Neodymium Nanoparticles by 3D Finite Element Method (FEM) as an Optothermal Human Cancer Cells, Tissues and Tumors Treatment under Synchrotron Radiation”, International Journal of Advanced Chemistry, 7 (2) 119–135, 2019

427. Heidari, K Schmitt, M Henderson, E Besana, “Role and Applications of Promethium Nanoparticles in Human Cancer Cells, Tissues and Tumors Treatment”, Scientific Modelling and Research, 4 (1): 8–14, 2019

428. Heidari, J Esposito, Caissutti, “Maitotoxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis: A Spectroscopic Study on an Anti–Cancer Drug”, Glob Imaging Insights 4 (2), 1–13, 2019

429. Heidari, J Esposito, Caissutti, “Biotoxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Glob Imaging Insights 4 (2), 1–14, 2019

430. Heidari, J Esposito, Caissutti, “Time–Resolved Resonance FT–IR and Raman Spectroscopy and Density Functional Theory Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra of Nanopolypeptide Macromolecules by the Multi–Dimensional Franck–Condon Integrals Approximation and Density Matrix Method”, Glob Imaging Insights 4 (2), 1–14, 2019

431. Heidari, J Esposito, Caissutti, “Cholera Toxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Glob Imaging Insights 4 (2), 1–14, 2019

432. Heidari, J Esposito, Caissutti, “Nodularin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Glob Imaging Insights 4 (2), 1–14, 2019

433. Heidari, J Esposito, Caissutti, “Cangitoxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Glob Imaging Insights 4 (2), 1–13, 2019

434. Heidari, J Esposito, Caissutti, “Ciguatoxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Glob Imaging Insights 4 (2), 1–14, 2019

435. Heidari, J Esposito, Caissutti, “Brevetoxin (a) and (b) Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Glob Imaging Insights 4 (2), 1–13, 2019

436. Heidari, J Esposito, Caissutti, “Cobrotoxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Trends in Res 3 (1), 1–13, 2019

437. Heidari, J Esposito, Caissutti, “Cylindropermopsin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Trends in Res 3 (1), 1–14, 2019

438. Heidari, J Esposito, Caissutti, “Anthrax Toxin Time–Resolved Absorption and Resonance FT–IR and Raman Biospectroscopy and Density Functional Theory (DFT) Investigation of Vibronic–Mode Coupling Structure in Vibrational Spectra Analysis”, Trends in Res 3 (1), 1–14, 2019

439. Heidari, K Schmitt, M Henderson, E Besana, “Investigation of Moscovium Nanoparticles as Anti–Cancer Nano Drugs for Human Cancer Cells, Tissues and Tumors Treatment”, Elsevier Appl Chem 137A, 53943–53963, 2019

440. Heidari, K Schmitt, M Henderson, E Besana, “Study of Function of the Beam Energy and Holmium Nanoparticles Using 3D Finite Element Method (FEM) as an Optothermal Human Cancer Cells, Tissues and Tumors Treatment”, European Journal of Advances in Engineering and Technology, 6 (12): 34–62, 2019
Heidari A (2019) Computational approach to interaction between synchrotron radiation emission as a function of the beam energy and ruthenium nanoparticles in human gum cancer cells, tissues and tumors treatment

441. Heidari, K Schmitt, M Henderson, E Besana, “Human Cancer Cells, Tissues and Tumors Treatment Using Dysprosium Nanoparticles”, Asian J Mat Chem 4 (3–4), pp 47-51, 2019

442. Heidari, K Schmitt, M Henderson, E Besana, “Simulation of Interaction of Synchrotron Radiation Emission as a Function of the Beam Energy and Plutonium Nanoparticles Using 3D Finite Element Method (FEM) as an Optothermal Human Cancer Cells, Tissues and Tumors Treatment”, J Cancer Research and Cellular Therapeutics, Volume 2 (4), Pages 1–19, 2019.

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