Heavy Element X-ray Spectroscopy For Cancer Therapy and Diagnostics

Sara Lim[a], Sultana N. Nahar[b], Anil K. Pradhan[a,b], M. Montenegro[c], Rolf Barth[d], Claudio Tarrro[e], Robin Nakkula[d]

[a]*Biophysics Graduate Progam, The Ohio State University, Columbus, OH 43210, USA,*
[b]*Department of Astronomy, The Ohio State University, Columbus, OH 43210, USA,*
[c]*Universidad Catolica de Chile, Santiago, Chile,*
[d]*Department of Pathology, The Ohio State University, Columbus, OH 43210, USA,*
[e]*Department of Chemistry, The Ohio State University, Columbus, OH 43210, USA*

Abstract. Heavy high-Z (HZ) elements are commonly used in radiosensitizing agents for cancer diagnostics and treatment. The basic property of the HZ element being utilized is its interaction with the irradiating x-rays. Current x-ray sources in medical facilities, such as LINAC, produce broadband x-rays only part of which is absorbed by the reagent while the rest cause harm as they are absorbed and Compton scattered in the body tissue. Our proposed method *Resonant Nano-Plasma Theranostics*[1-3], or RT in short, implements the spectroscopic resonant interaction of the x-rays with the HZ element for more effective and safer therapy and diagnostics (Theranostics). The production of electron which is ejected by photoionization during interaction and cause the destruction of the malignant cell can be increased through monochromatic x-rays targeted at the resonant energy. We show that while cross sections for photoionization rapidly decrease after the K-edge; strong resonant absorption of x-rays occur below the K-edge. We determine the resonant energy which is mainly due to K-L transitions and corresponding resonant cross sections which cam be orders of magnitude higher than the background. Through initiation of Auger process by K-shell ionization, the process of theranostics could be enhanced considerably.

We will present study between X-ray radiotherapy in two energy ranges: (i) E <100 keV including HZ sensitization, and (ii) E > 100 keV where sensitization is inefficient. We perform Monte Carlo numerical simulations of tumor tissue embedded with platinum compound and compute radiation dose enhancement factors (DEF) upon irradiation with 100 kV, 170 kV and 6 MV sources. Our results demonstrate that the DEF peaks below 100 keV and fall sharply above 200 keV to very small values. Therefore most of the X-ray output from LINACs up to the MeV range is utilized very inefficiently. We also describe experimental studies for implementation of low energy x-rays with Pt reagents and selected cancer cell lines. Resultant radiation exposure to patients could be greatly reduced, yet still result in increased tumoricidal ability.

REFERENCES

1. A. K. Pradhan, S.. N. Nahar, M. Montenegro, Y. Yu, H.L. Zhang, C. Sur, M. Mrozik, R. Pitzer, J. Phys. Chem. A 113, 12356-12363 (2009)
2. M. Montenegro, S. N. Nahar, A. K. Pradhan, Y. Yu, K. Huang, J. Phys. Chem. A 113, 12364-12369 (2009)
3. S. N. Nahar, A. K. Pradhan, M. Montenegro, "RESONANT THERANOSTICS: A New Nano-Biotechnological Method for Cancer Treatment Using X-ray Spectroscopy of Nanoparticles" in *Simulations in Nanobiotechnology*, Edited by K Eom, CRC Press - Taylor \& Francis Group, 2011), p.305-330