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PHOTOTHERMAL THERAPY OF CANCER BY LASER LIGHT WITH NANOPARTICLES INDUCTION: SIMULATION AND PREDICATIONS

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ABSTRACT

Accurate simulation of temperature distribution in tumors induced by gold nanoparticles during laser photothermal therapy relies on precise measurements of thermal distribution of temperature on the tumor region. We find that there is effect of laser intensity on the changing the temperature .This behavior is predicated to control on the temperature distribution in at the tumor. The simulation of the photothermal treatment processes is achieved by using mat-lab program with using the numerical method is called as(Finite difference method).

KEYWORDS: Photothermal Therapy, Gold Nanoparticles, Modeling of Bioheattransfer, Finite Difference Method

INTRODUCTION

Recent years, laser photothermal therapy processes by using gold nanoparticles have been studied as a hyperthermia approach due to its capability to control and confine adequate thermal dosage to tumors[1].The computational simulation may give a detailed description of temperature distribution in the tumor and help obtain a better understating of the one-dimensional heat transfer in tumors during laser photothermal therapy[2].Modeling laser-tissue interaction is beneficial for analyses and optimization of the parameters determining laser energy absorption[1-3].

The tumors are heated byusing laser incident on the top surface of the tumor. The investigation of the effect of laser light is enhanced by the presence of nanostructures is limited [4]. Our study has attempted to find the relation between temperature variation with depth under limit time and the effect of laser intensity on the temperature translation in the tissue of cancer.

THEORY

There are many dynamics and mechanism that are noticed in the photothermal therapy by laser of tumor. Laser irradiation on the tissue is the first factor in these processes.The surface of the tumor with the nanoparticles injection was then irradiated by the laser operating at a wavelength of visible light [1]. Thelaser light at the tumor surface was fixed at powerof Watts for many minutes. Then the heating protocolin this that lead to treatment of the tumor. Laser use in thermal therapy has long held great promise, but has never been carried out with great success. Tissue penetration, inability to selectively heat the target, and alack of predictive heat control have prevented its widespread clinical use[4,5]. Recently, goldnanoparticles (GNPs) have been proposed to enhance the treatment efficacy of photo-thermal treatment by laser[7-10].When electrons in matter are exposed to light, they are set in motion by the electric field[11,12]. If the frequency of light matches the natural frequency of oscillation of the particles, theyabsorb significant energy[8-10]. Therefore, the

intensity of the incident light field is attenuatedas it passes through the medium, depositing energy throughout. There are a multitude of effects on matter that can occur when laser light is applied to biological tissues [8,9]. The type of effects that actually occur are not only heavily dependent ontissue properties but also on various laser parameters: power, focal spot size, wavelength,and exposure time. These effects are categorized into: photo-ablation, photo-disruption,photochemical interactions, plasma-induced ablation, and thermal interactions [6].Figure (1) represents the photo-thermal processes to treatment the cancer cells[8].

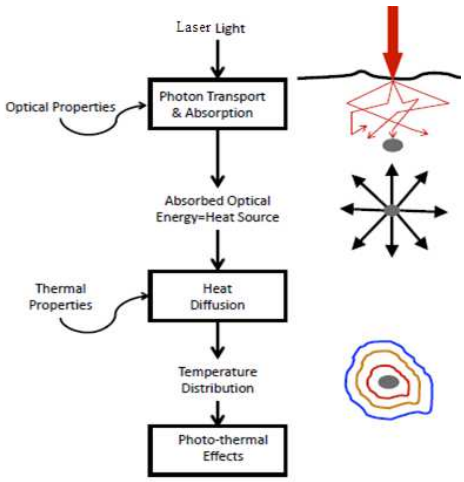

Figure 1: Photo-Thermal Processes [8]

Photo-Thermal Effects

Photo-thermal effects are one of the first laser-tissue interactions to be studied, as it doesnot require short laser pulses [1]. Photo-thermal effectsare unique among other effects as there is no specific reaction pathway required to achievedamage; heat can be absorbed by any biomolecule and lead to tissue damage. Photothermaleffects are also unique in the sense that tissue damage is only dependent on thetemperature that is reached and the duration at which it remains at that temperature[10-12].The Pennesbioheat equation is used to simulate the variation for temperature fields of the tumors. This equation with effect of laser on the tumor is given by[8,10-11]:

$$\rho C_p \frac{\partial T}{\partial t} = \nabla \cdot (k \nabla T) + \rho_b C_{p,b} \omega_b (T_b - T) + Q_1$$

where ρ C_p and k correspond to the density , specific heat, and thermal conductivityof the medium, respectively. ρ_b, $C_{p,b}$, and ω_b correspond to the density, specific heat, and perfusion rate of blood, respectively. T_b and T correspond to the arterial blood temperature (°C) and temperature (°C), respectively.

$$T_b = 300K$$

and

$$Q_l = I(1-10^{-A_\lambda})\eta$$

Where $A_\lambda = l_{opt}.C.\varepsilon$, l_{opt} is the optical path, C is the molar concentration for gold nanoparticles and ε is the molar extinction coefficient.

The cross section of nanoparticle is given by:

$$\sigma_{particles} = \frac{\varepsilon}{N_A}.10^8$$

RESULTS AND DISCUSSIONS

The parameters of the results of this paper are summarized on Table (1) and table (2). We study the variationof the temperature under depth of tumor with different times as shown in figure (2) and figure(3).Figure(4) represent the effect of variation of temperature with time at the same parameters as shown in table(1) and table(2) .The effect of intensity of laser light (I (W/cm-2)) for the behavior of temperature with depth that appears on figure(5) and the variation of temperature with time for the same limits (figure(6)).

Table 1: The Physical Properties Parameters Model [10-11]

	Density kg/m^3	**Specific Heat(C)** $J/kg.K$	**Thermal Conductivity (K)** $W/m.K$
Lung	1000	3500	0.28
Blood	1000	4200	0.6

Table 2: Simulation Parameters Absorption Processes

Intensity of Laser Light (W/cm^{-2})	A_λ	η
50	0.0127	0.98

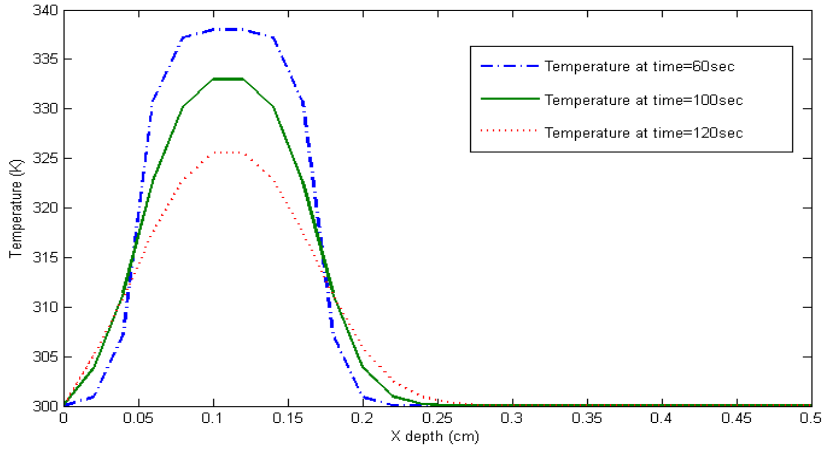

Figure 2: Variation of the Temperature under Depth of Tumor with Different Times

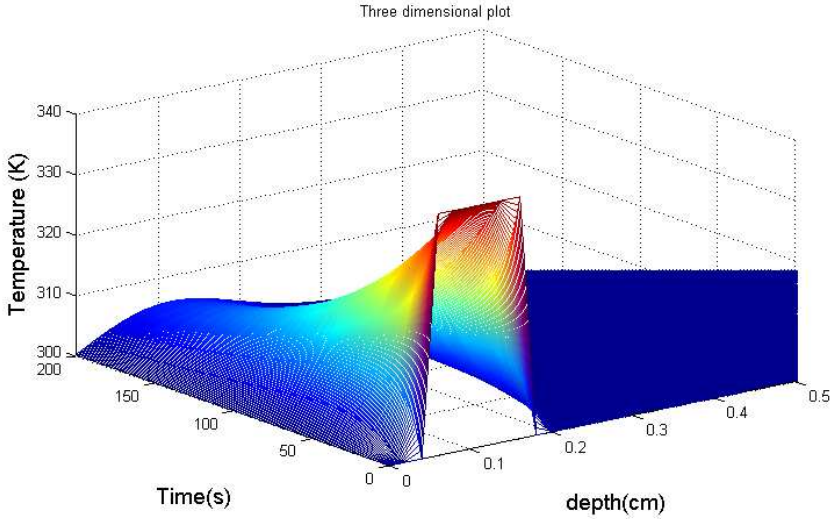

Figure 3: Three Dimensional Plot (Variation of the Temperature under Depth of Tumor with Different Times)

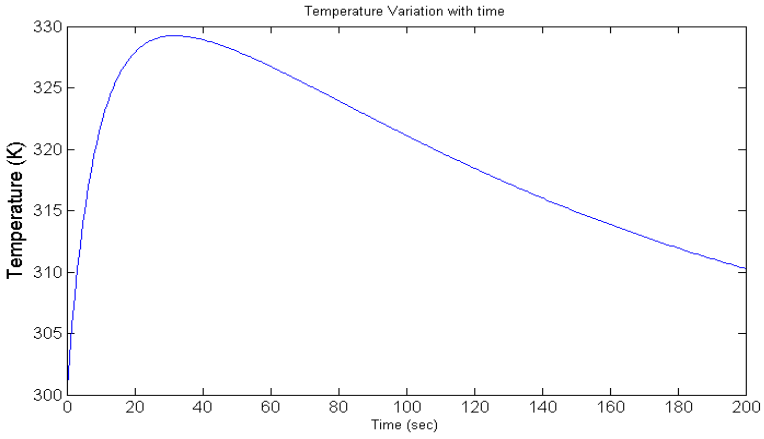

Figure 4: Variation of the Temperature with Time

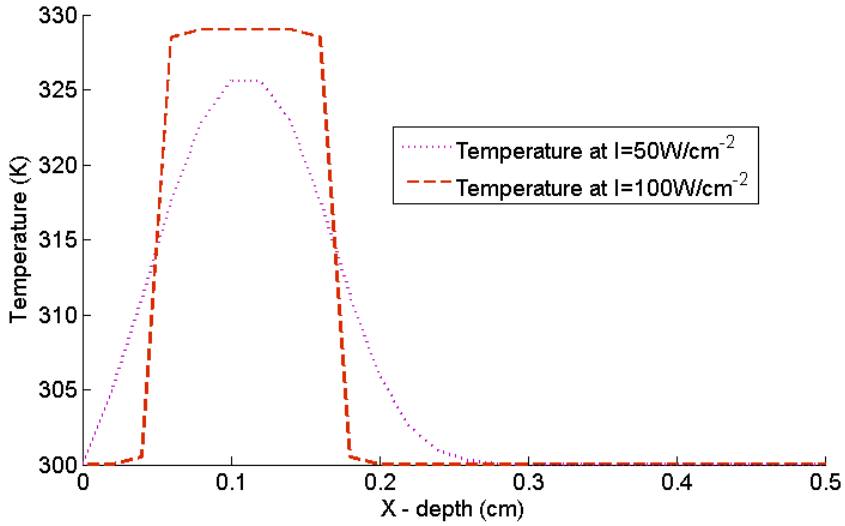

Figure 5: Variation of the Temperature under Depth of Tumor on the Different Values of Intensity of Laser Light

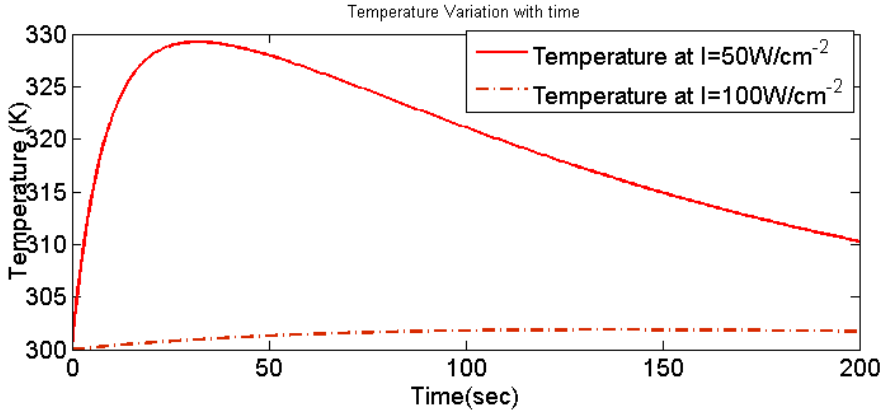

Figure 6: Variation of the Temperature with Timeon the Different Values of Intensity of Laser Light

CONCLUSIONS

The simulation of photon propagation in a spherical tumor to examine the effects of the absorption and scattering coefficients of PC3 tumors on the generated heating pattern in spherical tumors. The laser generated energy deposition distribution is then incorporated into 1-Dimension -finite difference lung tumors implanted on its flanks to simulate temperature elevations during laser photothermal therapy using gold nanoparticles. In the previous results we observed the effect of the intensity of laser light and the behavior of temperature as a function of time and depth.

REFERENCES

1. Welch, A. J., and van Gemert, M. J. C., 1995, “Optical-Thermal Response of Laser-Irradiated Tissue,” A. J. Welch and M. J. C. van Gemert ed., New York: Plenum Press.
2. Engin, K., 1994, “Biological Rationale for Hyperthermia in Cancer Treatment (II),” Neoplasma, 41(5), pp. 277-283.

3. Dewhirst, M. V., Vujaskovic, Z., Jones, E., and Thrall, D., 2005, “Resetting the Biologic Rationale for Thermal Therapy,” International Journal of Hyperthermia, 21(8), pp. 779-790.
4. El-Sayed, I. H., Huang, X., and El-Sayed, M. A., 2006, “Selective Laser Photo Thermal Therapy of Epithelial Carcinoma Using Anti-EGFR Antibody Conjugated Gold Nanoparticles,” Cancer Letter, 239, pp. 129-135.
5. O’Neal, D. P., Hirsch, L. R., Halas, N. J., Payne, J. D., and West, J. L., 2004, “Photo Thermal Tumor Ablation in Mice Using Near Infrared-Absorbing Nanoparticles,” Cancer Letter, 209, pp. 171-176.
6. Xie, H., Gill-Sharp, K. L., and O’Neal, D. P., 2007, “Quantitative Estimation of Gold Nanoshell Concentrations in Whole Blood Using Dynamic Light Scattering,” Nanomedicine: Nanotechnology, Biology, and Medicine, 3, pp. 89-94.
7. Weissleder, R., 2001, “A Clearer Vision for in Vivo Imaging” Nat. Biotechnol., 19(4), pp. 316-317.
8. Francisco J. Reynoso, MODELING OF NEAR INFRARED LASER-MEDIATED PLASMONIC HEATING WITH OPTICALLY TUNABLE GOLD NANOPARTICLES FOR THERMAL THERAPY ,Georgia Institute of Technology 2011.
9. Huang, X. W., Jain, P. K., El-Sayed, I. H., and El-Sayed, M. A., 2008, “PlasmonicPhotothermal Therapy (PPTT) Using Gold Nanoparticles”, Lasers in Medical Science, 23, pp. 217-228.
10. Ravi Kumar Kannadorai and QuanLiua, Optimization in interstitial plasmonicphotothermal therapy for treatment planning, 103301-1, 2013.
11. Ballou, B. L., Lagerholm, C., Ernst, L. A., Bruchez, M. P., and Waggoner, A. S., 2004, “Non-invasive Imaging of Quantum Dots in Mice,” Bioconjug. Chem., 15, pp. 79-86.
12. Manuchehrabadi, N., Attaluri, A., Cai, H., Edziah, R., Lalanne, E., Bieberich, C., Ma, R., Johnson, A. M., and Zhu, L., 2013, “Tumor Shrinkage Studyies and Histological Analyses after Laser Photothermal Therapy Using Gold Nanorods,” International Journal of Biomedical Engineering Technology, in press.