UNIVERSITY of HOUSTON | ENGINEERING
Department of Electrical & Computer Engineering

Graduate Office
Email: Ece_grad_admit@uh.edu
http://www.egr.uh.edu/ece/graduate

N308 Engineering Bldg. 1
Houston, TX 77204-4005

Tel: (713)743.8505 or (713)743.4400
Fax: (713) 743-4402

PhD Dissertation Announcement

RADIO-FREQUENCY ELECTROMAGNETIC CHARACTERIZATION OF BIOMATTER AND NANOPARTICLES FOR BIOMEDICAL APPLICATIONS

Rohit Pande

The influence of radio-frequency (*rf*) electromagnetic fields (EMF) on biological tissues plays a critical role in their diagnostic and therapeutic applications. These include hyperthermia and *rf* ablation procedures for cancer, in which cell temperatures are increased to 41-46ºC and above 56ºC respectively. This dissertation focuses on the interactions and applications of non-ionizing *rf* EMF on bio-samples combined with presence of nanoparticles, which can be classified as systems having linear/non-linear or thermal/non-thermal characteristics.

Investigations of nonlinear *rf* responses at kHz frequencies of bio-electrolytes and yeast samples were carried out in a frequency-adjustable LCR parallel-resonant circuit with a gold plated capacitor as a sample holder. Measurements were done using the intermodulation distortion technique. We used double layer (EDL) model to analyze the observed nonlinearities and their dependence on ionic concentration. Electrode-electrolyte interface polarization was found to be a predominant cause of this intrinsic nonlinearity and to be dependent on ionic concentrations.

The *rf* induced thermo-therapeutic procedures must be non-invasive and cell selective which is accomplished by surface functionalized nanoparticles. Characterization of heating performance for both magnetic and non-magnetic NPs was experimentally conducted and theoretically analyzed.

Rf losses due to interaction of NPs in aqueous media with both electric (E_{rf}) and magnetic (H_{rf}) fields were investigated using a low input power hyperthermia-setup designed with high quality factor LCR resonator to generate E_{rf} and H_{rf} fields up to 100 kV/m and 50 kA/m, in 12-50 MHz frequency range. Measurements of temperature changes versus time were performed to find following specific absorption rates (SAR) for gold, silica, and superparamagnetic iron oxide (SPIO) NP suspensions; Magnetic SAR for SPIO was calculated as 4 kW/kg and electric SARs for gold, silica and SPIO NPs were calculated as ~10^3, 2 and 27 kW/kg respectively. This shows that at MHz frequencies SARs for NPs were overestimated by previous studies, which ignored loss from ohmic heating due to ionic conduction. From the analysis of non-magnetic NPs, the enhanced dipole fields on gold were found three times higher than silica. The *rf* loss was strongly ascribed to the interaction of dipole fields with particle-electrolyte interface, which was confirmed by synergistic heat enhancement through EDL modification using physiologically relevant proteins.

Committee Chairs: Dr. Jarek Wosik & Dr. Wanda Wosik
Committee Members: Dr. Paul Ruchhoeft
Dr. Akhil Bidani
Dr. John H. Miller Jr.
Dr. Biana Godin

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