

THE VISION OF THE INTERNATIONAL INSTITUTE OF NANO AND MOLECULAR MEDICINE (I²NM²)

M. Frederick Hawthorne, Mark. W. Lee, Peter Kueffer, Li Fang, Shuo Yang,
Satish S. Jalisatgi, Michael Lewis, Varyanna Ruthengael

The International Institute of Nano and Molecular Medicine

The translational research effort in boron neutron capture therapy (BNCT) described below and recently initiated at the University of Missouri International Institute of Nano and Molecular Medicine and the University of Missouri Research Reactor would benefit from collaboration with a research group knowledgeable in modeling human tumors using small animal hosts and cellular biology as it relates to therapeutic results and the treatment of experimental data.

The boron-10 (^{10}B) isotope is unique among light elements for its high neutron cross-section and low inherent toxicity. When subjected to relatively benign thermal neutrons, the ^{10}B nucleus undergoes a neutron capture reaction forming an excited ^{11}B species. This unstable nucleus subsequently undergoes essentially instantaneous fission to release 2.4 MeV of kinetic energy in the form of a pair of $^7\text{Li}^{3+}$ and $^4\text{He}^{2+}$ ions, which are confined to the volume of about one cell. Therefore, preferential accumulation of ^{10}B -containing structures within cancerous cells can lead to selective destruction of these cells. This process is more commonly known as Boron Neutron Capture Therapy (BNCT) for cancer. The key to the implementation of this potentially powerful and selective therapy is the delivery of at least 30 parts per million (ppm) of ^{10}B within the tumor tissue while minimizing superfluous ^{10}B within the surrounding healthy tissue. This

difference in ^{10}B concentration is often denoted through the boron concentration in tumor to boron concentration in blood ratio, with a higher ratio being preferable. Herein we describe the synthesis and results of biodistribution experiments with two nano-scale boron delivery agents: liposomes and oligomeric phosphate diesters (OPDs). Liposomes, containing both amphiphilic ($\text{KC}_2\text{B}_9\text{H}_{11}(\text{CH}_2)_{15}\text{CH}_3$, MAC) and hydrophilic ($\text{Na}_3\text{B}_{20}\text{H}_{17}\text{NH}_3$, TAC) components and ranging in diameter from 30 to 100 nm, showed tumor boron accumulations as high as 50 ppm and tumor to blood ratios over 8. OPDs, ranging in size from 1 to 5 nm in diameter, also exhibited preferential tumor accumulations of 30 ppm at tumor to blood ratios as high as 35 to 1. In both cases, liposomes and OPDs greatly outperformed currently available small boron-containing pharmaceuticals at the same injected dose of ^{10}B . Studies in which OPDs were fluorescently labeled proved their localization within the cellular nucleus, increasing the relative efficacy of these species due to their proximity to the DNA target. In conclusion, both liposomes and OPDs show great promise as nano-sized delivery vehicles for BNCT.