Development of theranostic silica nanoparticles for quantitative ^{19}F MRI and Boron Neutron Capture Therapy (BNCT) against cancer.

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Cancer remains one of the leading causes of death worldwide. Despite significant advances in treatment quality, conventional therapies still face practical limitations and side effects that restrict their suitability for all patients. Recently, there has been a resurgence of interest in Boron Neutron Capture Therapy (BNCT) as a potential solution to these challenges. **[1]**

BNCT is a form of radiotherapy that uses neutrons instead of X-rays. This therapy relies on administering molecules containing the ^{10}B isotope, which absorb irradiated slow neutrons and release short-range ionizing radiation. This radiation selectively destroys cancer cells that have accumulated the boronated compound, sparing healthy tissues. However, the effectiveness of BNCT is currently hindered by the insufficient tumor accumulation of approved boron compounds. This shortfall underscores the critical need for innovative boron-based drugs that achieve higher tumor specificity and enable non-invasive monitoring of their distribution via medical imaging. **[2]**

To address these challenges, we are developing a nanoplatform (NP) based on mesoporous silica nanoparticles (MSN) encapsulating a PFCE emulsion (Perfluoro crown-ether), which provides a quantifiable ^{19}F MRI signal. The project consists of the functionalization of the MSN with boron-containing molecules (borocaptate $B_{12}H_{12}S$) and an RGD peptide targeting integrins commonly overexpressed in cancer cells. **[3]**

The initial phase of this project focuses on synthesizing raw silica nanoparticles containing PFCE. We are adjusting the synthesis parameters to produce stable MSN with a suitable size for biological applications and sufficient fluorine content for ^{19}F MRI. The nanoparticles' physicochemical properties are being assessed by using techniques such as Dynamic Light Scattering (DLS), Transmission Electron Microscopy (TEM), ^{1}H and ^{19}F Nuclear Magnetic Resonance (NMR), and Infrared Spectroscopy (FTIR).

Subsequent phases will involve functionalizing the nanoparticle surfaces with boron and targeting peptides, followed by *in vitro* studies of cellular internalization, *in vitro* neutron irradiation experiments, and *in vivo* biodistribution analyses using murine models.

In conclusion, this project aims to establish the feasibility of our multifunctional nanoparticles for BNCT. By combining precise tumor targeting, enhanced boron delivery, and real-time imaging capabilities, this approach could offer a new type of cancer treatment with reduced side effects and improved outcomes.

References

[1] Majeed H. and Gupta V., Adverse Effects of Radiation Therapy, StatPearls Publishing, 2023.
[2] International Atomic Energy Agency, Advances in Boron Neutron Capture Therapy, IAEA, Vienna, 2023.
[3] Gu Y., Dong B., He X., Qiu Z., Zhang J., Zhang M., Liu M., Pang X., Cui Y., The challenges and opportunities of αvβ3-based therapeutics in cancer: From bench to clinical trials, Pharmacological Research, 189, 2023.