Engineering novel theranostic devices for cancer treatment using an integrative experimental and simulation approach

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This proposal aims to synthesize novel theranostic devices for cancer treatment (i.e., devices that simultaneously perform diagnostic imaging and therapeutic functions) based on the unique drug delivery and imaging properties of polymeric patchy particles that we have developed in house. We will achieve this goal by using an integrative experimental and simulation approach. Our patchy particles are biocompatible and biodegradable nano-spheres that have anisotropic surface domains.

According to the American Society of Cancer, approximately 2 million people are diagnosed with cancer every year, demanding more effective diagnostics and treatments for this devastating disease. Recently, we discovered that our patchy particles are natural Photoacoustic (PA) contrast agents because of their remarkable optical properties. These patchy particles induce a relatively high PA signal in the near-infrared region, which is clinically relevant. These unparalleled physicochemical-optical properties enable advanced cancer treatments by offering a non-invasive medical procedure to image the distribution of the drug in the tumor while controlling the nanocarrier's drug-release kinetics, thus reducing the drug resistance phenomenon in cancer.

Currently, our theranostic device has two main limitations: the patchy particles do not yet possess high suspensibility properties in aqueous solution, and the PA signal emitted by them is not as strong at low doses in comparison to the one generated from standard PA contrast agents. Therefore, we aim to address these technical challenges using a multifactorial experimental and simulation approach.

This research project provides the possibility of pioneering computational fluid dynamics (CFD) in the area of polymer chemistry and as such enhances collaboration across departments (i.e., Bioengineering and College of Science) at GMU and with other universities such as VCU. This is a unique project that highlights the cutting edge research that GMU is currently conducting in the Biomedical Translational field. This fundamental and clinical translational work will allow us to obtain preliminary results that we will include in a R01 proposal that we are planning to submit to the Image-guided Drug Delivery in Cancer solicitation (PAR-13-185). The results of this project will be disseminated in peer-reviewed papers, national and international conferences, and seminars at GMU.