GD Doped Hollow Silica Shells for Tumor Ablation and MRI

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ABSTRACT

Recently, Hollow Silica Shells have been explored for various biomedical applications due to their biocompatibility. Hollow silica shells offer the flexibility to adjust their physical and mechanical properties (diameter, shell thickness, shell strength, etc.) as well as their chemical properties via elemental doping or surface chemical modification. Hollow silica shells are formed by a unique polymerization reaction between silicic acid into SiO_2, creating a layer covering a polystyrene beads as sacrificial templates. The template is then removed via solvent dissolution or heat, yielding a hollow SiO_2 shell.

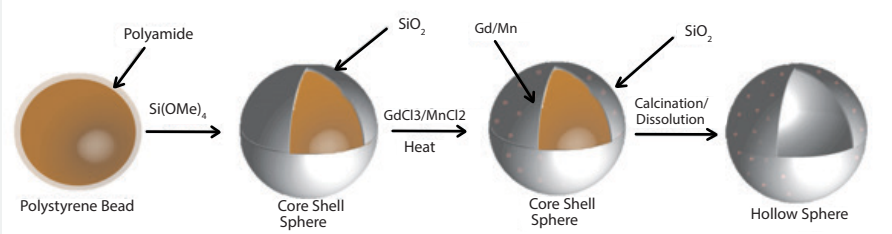

Figure 1. Diagram of shell synthesis process

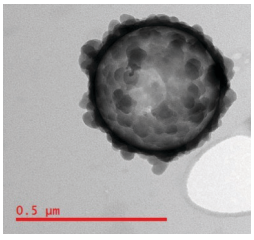

Figure 2.
A. TEM image of 2um hollow shells
B. Compositional map of Mn distribution
Image credit: Dr. Kim Moon and Dr. Lu Ning

At present, we are interested in developing shells that act as a sensitizing agent for High Intensity Focused Ultrasound (HIFU) therapy. This technique directs a focused high powered ultrasound wave at a region of tissue at the focal zone, creating thermal or mechanical damage. The goal of this therapy is to enable tumor removal without invasive surgery. Our goals are to improve the technique by allowing a lower ultrasound power to be used, and enabling more precise targeting. Hollow silica shells cavitate (gas bubble collapse) under HIFU. This allows the creation of a liquid cavity in the tissue while using reduced power HIFU, thus eliminating thermal damage to the surrounding tissue and yielding a cleaner excision. Another advantage of using hollow silica shells is that the ablated region can be imaged via ultrasound simultaneously, allowing for concurrent image-guided ablation.

In order to characterize the breakage of our shells under HIFU and explore multimodal imaging, we have synthesized shells doped with Gd (a material commonly used as an MRI sensitizing agent). The Gd will be released and work as a sensitizing agent once the shells are broken. This has allowed us to observe the area of ablation under MRI, an imaging technique which offers high spatial resolution. We have found that Hollow Silica Shells can act as a HIFU sensitizing agent, and have observed mechanical ablation occur, as the Gd released by shell breakage is visible under MRI. A further step is to develop particles that allow multimodal imaging (MRI, US) as well as ablative destruction of tumors, thus facilitating the non-invasive diagnosis and treatment of tumors. Ideally, one would be able to diagnose, characterize and then treat a tumor without surgical incision and in a single clinical session.

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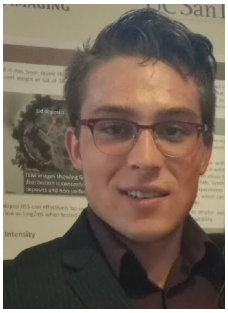

Adrian is a second year chemical engineer at Warren College. He grew up in Argentina, where he attended the Colegio Nacional de Buenos Aires, a prestigious public school. After graduation, he plans to pursue a Master's degree, and eventually a PhD. Adrian would like to work in the biomedical field and has an interest in drug delivery and medical diagnostics. He sees great promise in the exploration of how these fields interact with health and disease. He would also like to explore the area of drug discovery and design. Adrian believes that some of the most interesting science is developed at the confluence of disciplines, and he hopes that his career path reconciles these divergent fields. In his spare time, Adrian enjoys reading physiology and nutrition journals.

Q: What motivated you to get involved in the field of research?

A : I was most attracted by the ability to apply my knowledge in order to find solutions that would help a great number of people.

Q: What do you enjoy about doing research?

A : I enjoy having the resources and knowledge to establish hypothesis, test them, and evaluate the results independently.

Q: What is your typical day like?

A : My exact schedule varies, but I usually spend 1-2 hours a day playing hockey or weightlifting, about 4 hours on lab work and another 4 hours studying or in class.

Q: How do you define research?

A : There's a simple definition that states that it is simply the systematic accumulation of data or knowledge. I think research can't be described without the word curiosity. Curiosity is fundamental, and so is creativity. The ability to pose a question and systematically seek answers follows naturally from these.

Q: What is a book/podcast/show that you would recommend?

A : If you're interested in literature, I would suggest reading the original Don Quijote. The sociopolitical symbolism and intricate intertextuality make it a real eye opener when read in context.

Q: How does the theme of "exponential growth" relate to you?

A : I see knowledge as something that has the potential for exponential growth, in particular since the growth of internet access. I personally learned a lot online, and I hope that I will be able to share what I have learned and anything new I discover as well. Knowing that I'll have the opportunity to reach out to thousands in a tangible manner is a very satisfying and motivating feeling.

References

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