

To improve the quality of MRI images, contrast media, a chemical substance, is injected into the patients' body. This treatment aids in the diagnosis of injury and diseases. However, side effects have been associated with their use. Thus, we have developed sugarbased molecules called sugar dots that attach to the contrast media to reduce its toxic properties while retaining and even enhancing their MRI properties. In contrast to traditional MRI techniques, we also show that sugar dots with contrast media emit visible and infrared light allowing for real-time tracking with or without drugs and genetic medicine during diagnosis and surgery.

### Manganese-nitrogen and gadolinium-nitrogen Co-doped graphene quantum dots as bimodal magnetic resonance and fluorescence imaging nanoprobes

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# MRI and its Contrast Agents

### • Gadolinium ions (Gd<sup>3+</sup>)

Off site accumulation in tissues and organsNephrogenic Systemic Fibrosis (NSF)

• Chelated (Protected) Gd<sup>3+</sup>

Leakage of Gd (III) associated via acidic environments and transmetallation with ions



Blaurock-Busch, E., *Chelation and Gadolinium: How Effective is it.* Diagn Pathol Open, 2019. **4**(151): p. 2476-2024.1000151.



Kuo, P.H., et al., *Gadolinium-based MR contrast agents and nephrogenic systemic fibrosis.* Radiology, 2007. **242**(3): p. 647-649.

### Graphene Quantum Dot Based Bimodal MR and Fluorescence Imaging Nanoprobe



Lee, B.H., et al., Manganese-Nitrogen and Gadolinium-Nitrogen Co-doped Graphene Quantum Dots as Bimodal Magnetic Resonance and Fluorescence Imaging Nanoprobes. Nanotechnology, 2020.

# Synthesis: Bottom-Up Approach



Hasan, M.T., et al., *Photo-and Electroluminescence from Nitrogen-Doped and Nitrogen–Sulfur Codoped Graphene Quantum Dots.* Advanced Functional Materials, 2018. **28**(42): p. 1804337.

# Physical Characterization: TEM and EDX

**Mn-NGQDs** 

#### **Gd-NGQDs**



Lee, B.H., et al., Manganese-Nitrogen and Gadolinium-Nitrogen Co-doped Graphene Quantum Dots as Bimodal Magnetic Resonance and Fluorescence Imaging Nanoprobes. Nanotechnology, 2020.

### **Optical Characterization: Fluorescence**



Lee, B.H., et al., Manganese-Nitrogen and Gadolinium-Nitrogen Co-doped Graphene Quantum Dots as Bimodal Magnetic Resonance and Fluorescence Imaging Nanoprobes. Nanotechnology, 2020.

# Cell Viability and Imaging in Healthy Cells



Lee, B.H., et al., Manganese-Nitrogen and Gadolinium-Nitrogen Co-doped Graphene Quantum Dots as Bimodal Magnetic Resonance and Fluorescence Imaging Nanoprobes. Nanotechnology, 2020.

### **MRI** Capabilities

• Types of contrast agents: Positive  $(T_1)$  is bright. Negative  $(T_2)$  is dark.



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# Discussion/Conclusion

- Single-step microwave assisted hydrothermal reaction
- Water-soluble nanomaterials
  3.9 nm (Mn-NGQDs)
  6.6 nm (Gd-NGQDs)
- High biocompatibility in healthy cells (HEK-293)
  1.3 mg/mL (Mn-NGQDs)
  1.5 mg/mL (Gd-NGQDs)
- hy cells (HEK-293)
- Dual Fluorescence (VIS/NIR) and MR Imaging Modality T1/T2 (Mn-NGQDs) T1 (Gd-NGQDs)
- Fluorescence-guided of drug delivery tracking in vitro
  MRI image-tracking in vivo for diagnostic and intraoperative imaging

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