Magnetic and Near Infrared Fluorescent Quantum Dots for Bioimaging

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Introduction

Multimodal nanoparticles act as contrast agents for multiple imaging modalities simultaneously. They are commonly employed to integrate the advantages of different imaging modalities into a single contrast agent. Optical and Magnetic Resonance Imaging (MRI) are examples of complimentary imaging techniques employed together to obtain structural and functional information with high resolution and sensitivity. Quantum dots (Qdots) offer excellent optical properties such as high quantum yields (QY), phototstability, large stokes shift, small size and tunable emission. The magnetic component is commonly added to Qdots by coating them with a magnetic shell; or silica containing paramagnetic gadolinium [1]. This results in increasing the particle size to more than 10nm, which restricts their applications such as tracking small viruses and stem cells. Herein we report the development of 5nm water dispersible CdTeS Qdots doped with Fe as ultrasmall multimodal particles. Fe-Qdots size, morphology, optical (NIR fluorescence, QY) and magnetic characterization (superconducting quantum interference device and MRI) results in phantom and in vivo experiments are presented.

Experimental

The synthesis and characterization of dilute magnetic semiconducting material have been described in detail elsewhere [2]. SQUID measurements were done at quantum design (MPMS-5S) SQUID at 10K and 300K. The MR data (T_2, T_2*) was collected using a 4.7 T, 11T Varian and 750Mz Bruker (AMRIS facility, UF). Optical imaging experiments were performed at CTAC core (UF).

Results and Discussion

Representative TEM images, Fig.1A shows monodisperse and crystalline character of ultrasmall ~ 5nm dilute magnetic semiconductor Qdots. Fig. 1B shows Qdots with increasing emission λ. Energy dispersive spectrum (EDX) Fig.1C clearly shows the presence of Fe and other elements of Qdots. SQUID measurements indicate superparamagnetic behavior at room temperature (Fig. 1D). Relaxivity measurements have been performed at 4.7T in phantom and *in vitro* studies. Fig. 1E Xenogen IVIS image shows Fe-Qdots labeled macrophages in mouse thigh muscle and corresponding MRI (Fig. 1F), Feridex as control.

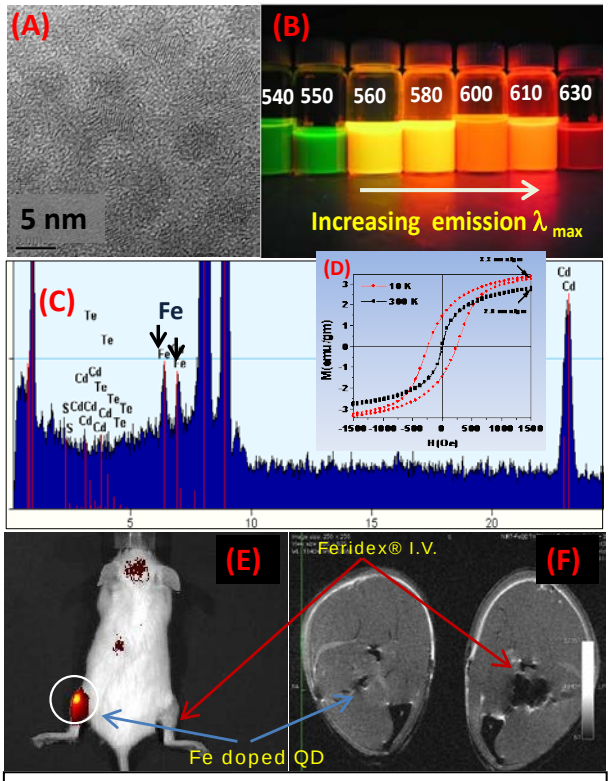

Figure1. (A) High resolution TEM of ~ 5nm Fe-CdTeS Qdots; **(B)** Qdots with increasing λ emission under UV excitation **(C)** EDX spectrum showing the presence of Fe dopant in CdTeS; inset **(D)** SQUID at 10K and 300K **(E)** IVIS image showing Fe-Qdots labeled macrophages in mouse thigh muscle; **(F)** corresponding MRI showing in vivo T_2 contrast without susceptibility blooming effects.

Conclusions

Ultra small, ~ 5nm dilute magnetically doped Qdots have been demonstrated as multimodal contrast agents for non-invasive imaging by NIR optical and MRI.

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References

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