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Multifunctional Upconversion and Photocatalytic Nanoparticles for Cancer Theranostics

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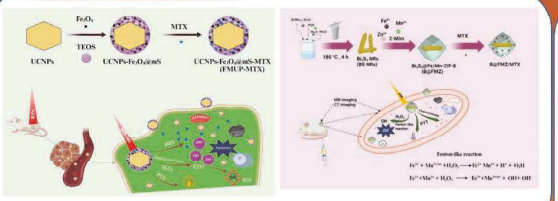
Abstract

Cancer is the most prevalent disease in global public health; hence, the discovery of breakthrough techniques and materials for treating cancer is very crucial. Multifunctional upconversion and photocatalytic nanoparticles have been considered great attention in cancer therapy. The upconversion nanoparticles (UCNPs) can convert near-infrared (NIR) light into ultraviolet/visible (UV/Vis) light that can absorbed by the photocatalytic nanoparticles to produce intense cytotoxic reactive oxygen species (ROS). Photocatalytic nanoparticles have been considered great attention in cancer therapy. Photocatalytic nanoparticles exhibit appropriate physical and chemical characteristics and possess high photocatalytic activity, photogenerated charge carriers' separation, biocompatibility, and strong absorption in the NIR region, which can result in generating ROS radicals. Hence, the use of these intense photocatalytic nanoparticles has the potential to augment therapeutic cancer treatment. Thus, this thesis summarizes the upconversion and various photocatalytic nanoparticle syntheses and evaluation their anticancer application through combinational therapeutic strategies, including photodynamic therapy (PDT), photothermal therapy (PTT), chemodynamic therapy (CDT), and chemotherapy for cancer treatment. These synergistic PTT/PDT/CDT/Chemotherapy therapeutic effects can effectively be accomplished to enhance antitumor efficacy. As a powerful clinical diagnostic, magnetic resonance imaging (MRI) and computed tomography (CT) are considered effective tools in cancer therapy. Therefore, upconversion and photocatalytic nanoparticles can be considered candidates for cancer theranostics.

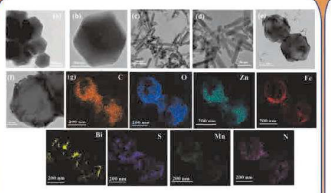
Introduction

Cancer is a pernicious disease all over the world and is the leading cause of global mortality and morbidity. Photothermal therapy (PTT) converts near-infrared (NIR) light energy into hyperthermia at the tumor site, resulting in tumor ablation. Photodynamic therapy (PDT) is a non-invasive therapeutic method that comprises a photosensitizer, light, and tissue oxygen, generating cytotoxic reactive oxygen species (ROS). Chemodynamic therapy can catalyze metal ions (Fe^{2+}, Cu^{2+}, and Mn^{2+}) to produce highly toxic hydroxyl radicals by reacting with overexpressed hydrogen peroxide in the tumor microenvironment. Chemotherapy is an efficient strategy for cancer treatment. Therefore, these combination therapeutic strategies have enormous potential to improve therapeutic efficiency in cancer treatment. Furthermore, imaging-guided synergistic therapeutics treatment, providing precise and personalized intervention in cancer therapy, has attracted considerable interest from researchers searching for efficient strategies against tumors. The upconversion and photocatalytic nanoparticles can be considered promising candidates for cancer theranostics. These nanoparticles possess strong absorption in the NIR region, superior electron-hole pair separation, and improved photocatalytic activity. Upconversion and photocatalytic nanoparticles can enhance theranostic cancer treatment due to their tunable optical properties, biocompatibility, and ability to be excited by infrared radiation. Thus, these composite nanoparticles exhibited enhanced antitumor effects through the synergistic therapeutic effects of imaging-guided under NIR laser irradiation in cancer therapy.

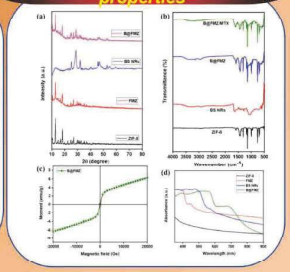
Experimental section



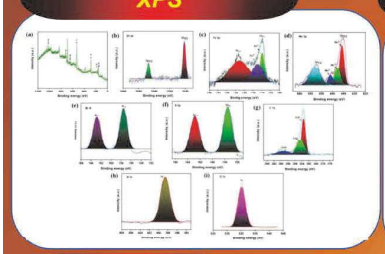
Morphology



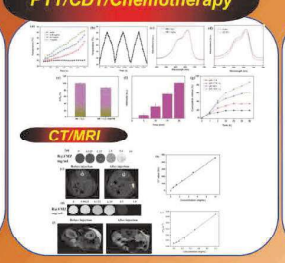
Structural and Magnetic properties



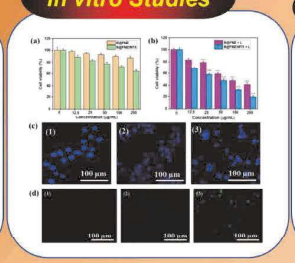
XPS



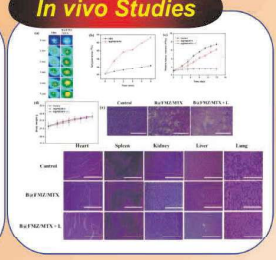
PTT/CDT/Chemotherapy



In vitro Studies



In vivo Studies



Conclusions

- ✓ UCNPs and photocatalytic nanoparticles were successfully fabricated.
- ✓ These composite nanoparticles possessed enhanced therapeutic efficiency of PTT, PDT, CDT, and chemotherapy for cancer treatment.
- ✓ Moreover, these nanoparticles performed excellent MRI and CT imaging that can utilized as intense MRI/CT contrast agents for cancer theranostics.
- ✓ Therefore, these UCNPs and photocatalytic nanoparticles can be considered promising candidates for cancer theranostics.

References

ADVANCED BIOMATERIALS LABORATORY

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