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MDPI

MAGNETIC NANOVEHICLES FUNCTIONALIZED WITH CHLORINS FOR ANTIMICROBIAL PHOTODYNAMIC THERAPY

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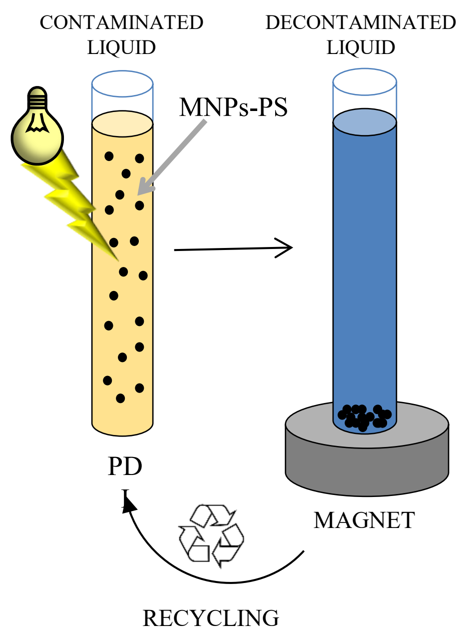
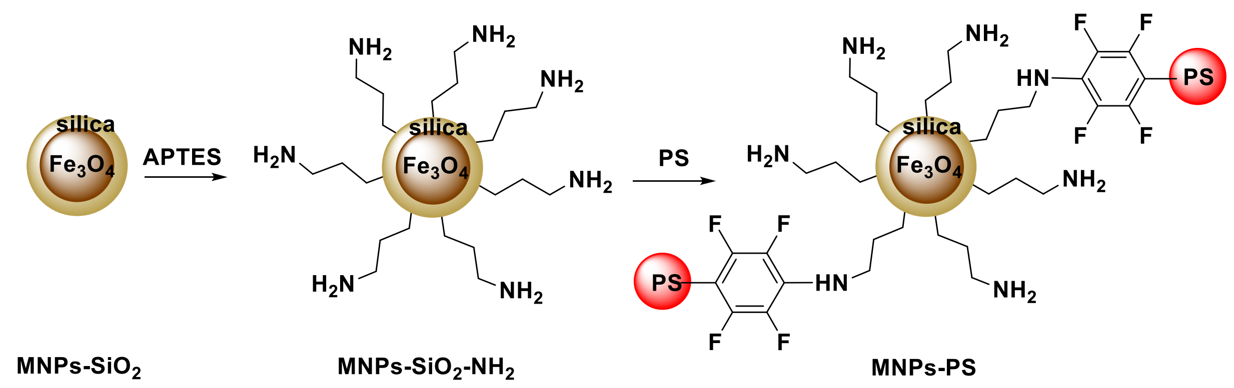
INTRODUCTION & AIM

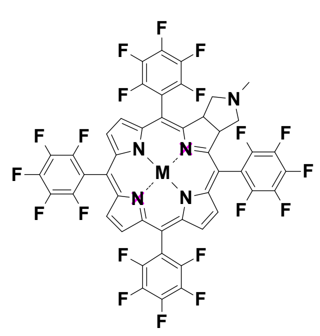
Efficient photodynamic inactivation (PDI) requires close interaction between photosensitizer (PS) and microbes, but many PSs are poorly dispersed in water, limiting their use in biological systems [1]. Magnetic nanoparticles (MNPs) can act as carriers to improve PS solubility and delivery [2]. In this work, we synthesize MNPs–PS conjugates with chlorins [3], characterize their photophysical and photochemical behavior, and evaluate their PDI performance in Gram-positive and Gram-negative bacteria.



METHOD

HOW WERE THE NANOCONJUGATES OBTAINED?





M: H2 for $TPCF_{20}$

M: Zn(II) for $ZnTPCF_{20}$

Magnetite nanoparticles were synthesized by coprecipitation and coated with silica. APTES was then added to introduce surface amine groups. Finally, the PSs ($TPCF_{20}$ and $ZnTPCF_{20}$) were anchored via S_NAr substitution on the *para*-fluorine of their perfluorophenyl groups.

RESULTS & DISCUSSION

HOW WERE THE NANOMATERIALS CHARACTERIZED?

Shape and size of the nanoconjugates was visualized using TEM (***Fig. 1***). Also, the characteristic chemical bonds were corroborated using IR spectroscopy.

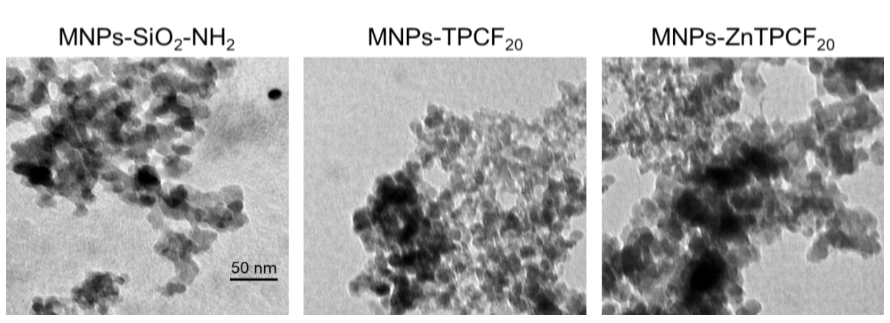


Figure 1. *SEM images of coated nanoparticles.*

DO THEY RETAIN THEIR PHOTOPHYSICAL AND PHOTOCHEMICAL PROPERTIES?

Nanoconjugates in water retain the absorption and emission properties of the monomers in DMF (***Fig. 2, Tab. 1***).

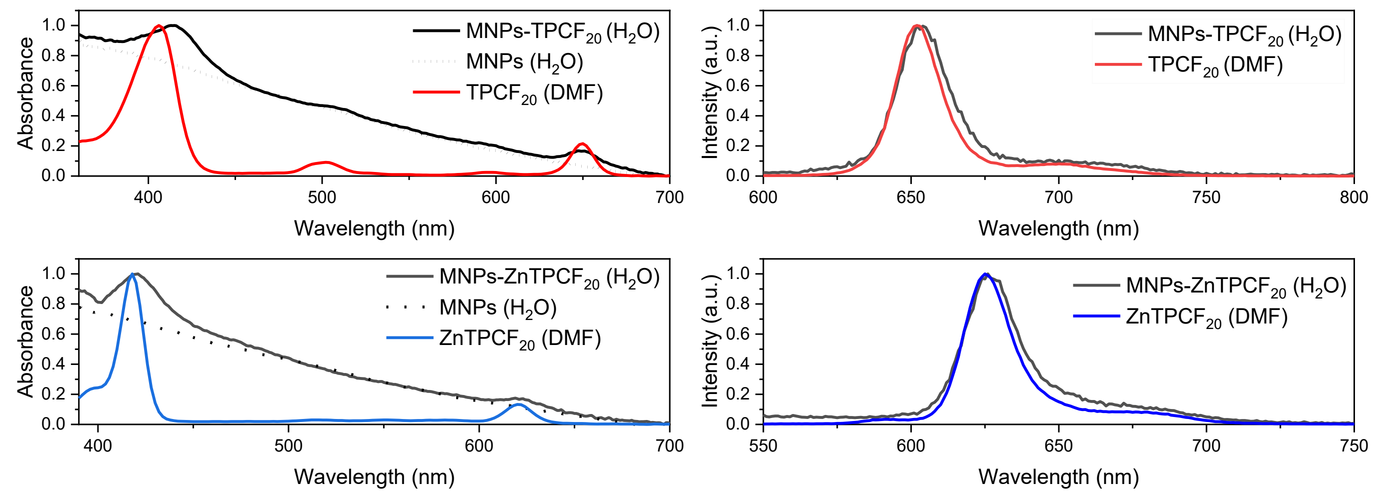


Figure 2. *Absorption and emission spectra of nanoconjugates.*

The photodynamic properties (***Tab. 1***) of the PS were preserved upon immobilization on MNPs, although modified by the paramagnetic environment. Singlet oxygen and superoxide anion radical production were evaluated (***Fig. 3 A, B***).

Table 1. *Spectroscopic and photodynamic properties of PS (DMF) and MNP-PS (water).*

FS	λ_{Soret} (nm)	ε ($M^{-1}cm^{-1}$)	λ_{Em} (nm)	Φ_F	Φ_Δ
$TPCF_{20}$	404	1,55 x10^5	654	0,16 ± 0,01	0,42 ± 0,02
MNPs-$TPCF_{20}$	414	-	655	0,060 ± 0,02	0,07 ± 0,01
$ZnTPCF_{20}$	418	1,52 x10^5	627	0,071 ± 0,004	0,82 ± 0,04
MNPs-$ZnTPCF_{20}$	419	-	628	0,032 ± 0,007	0,25 ± 0,04

CAN NANOCONJUGATES INACTIVATE BACTERIA?

Microbial inactivation under irradiation was significant. *S. aureus* MRSA showed a strong response, reaching 99.999% inactivation, while *E. coli* achieved 99.7%(***Fig 3. C, D***).

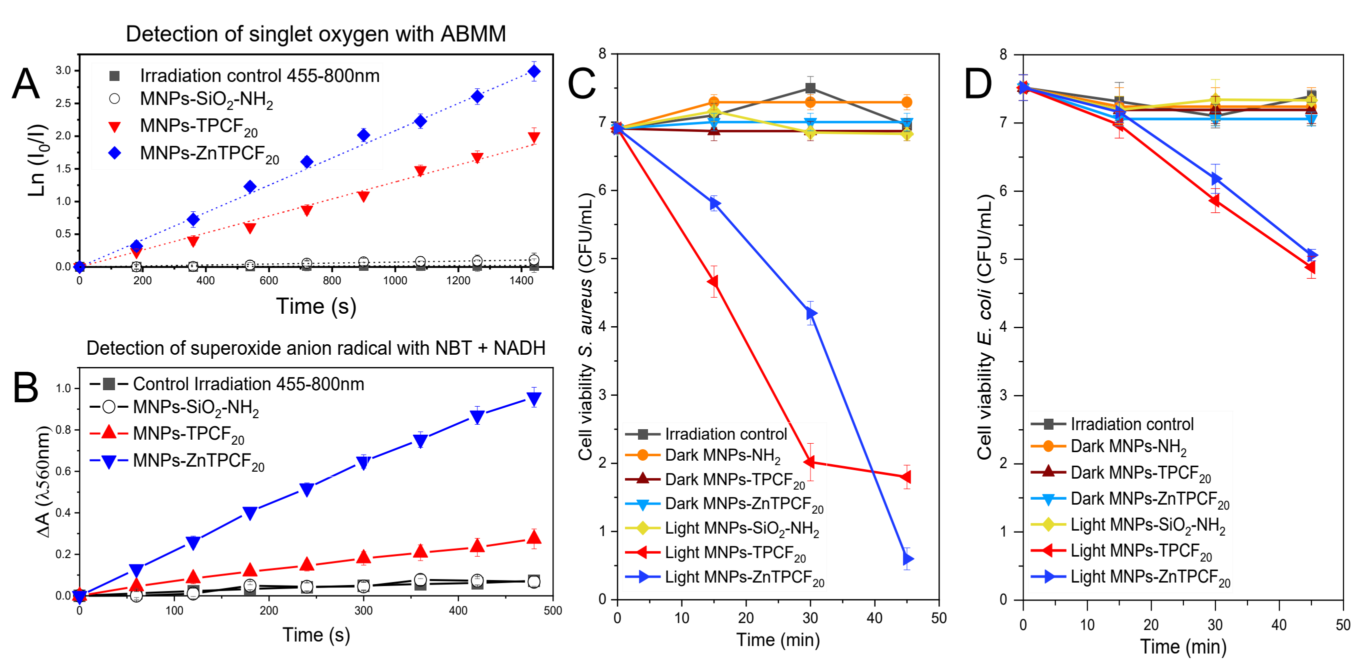


Figure 3. *A) Absorption decay kinetics of ABMM by singlet oxygen. B) Increase in the absorbance of diformazan (white light 455-800 nm filter 90 mW/cm²). C) Inactivation of S. aureus and D) E. coli using the nanoconjugates (2 and 4 µM PS, respectively, white light 90 mW/cm²).*

CONCLUSION

Magnetic nanomaterials based on MNPs–$TPCF_{20}$ and MNPs–$ZnTPCF_{20}$ are stable platforms that enable the dispersion of hydrophobic photosensitizers in aqueous media. The covalently bound PSs retain their visible-light absorption and emission, generate reactive oxygen species in water, and achieve significant photodynamic inactivation of bacteria under physiological conditions. In addition, the magnetic core allows easy recovery, recycling, and reuse of the nanoconjugates, minimizing environmental impact.

REFERENCES

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2. Scanone, A. C., Santamarina, S. C., Heredia, D. A., Durantini, E. N., Durantini, A. M. *ACS Applied Bio Materials.* 2020, **3**(2), 1061–1070.
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