# *In situ* modifications of porphyrin-conjugated magnetic nanoparticles for photodynamic inactivation of pathogens

**Milena B. Boarini, Sofia C. Santamarina, María E. Pérez, María E. Milanesio and Edgardo N. Durantini.**

*IDAS-CONICET, Departamento de Química, FCEFQYN, Universidad Nacional de Río Cuarto, Río Cuarto, Córdoba, Argentina*

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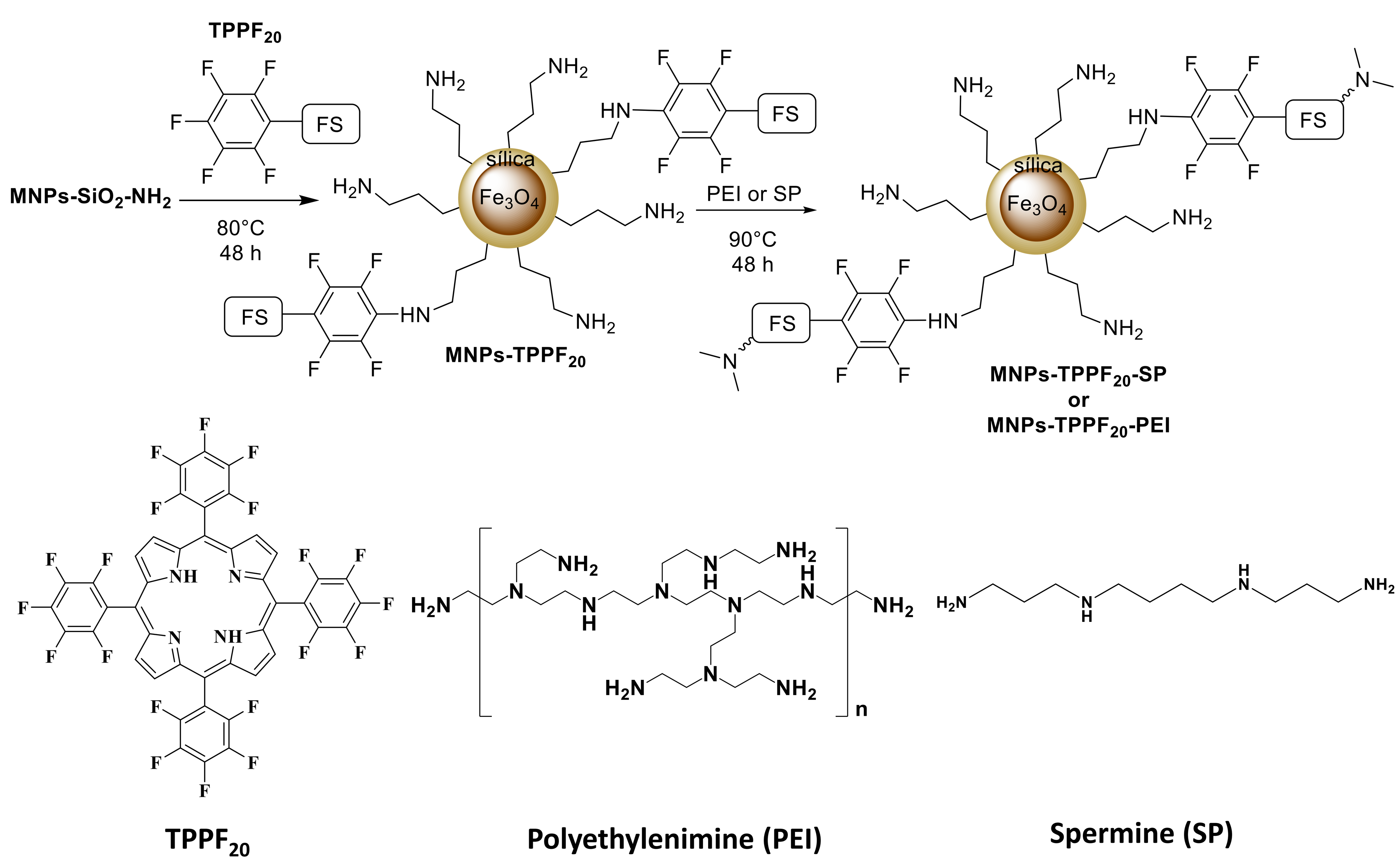
## INTRODUCTION

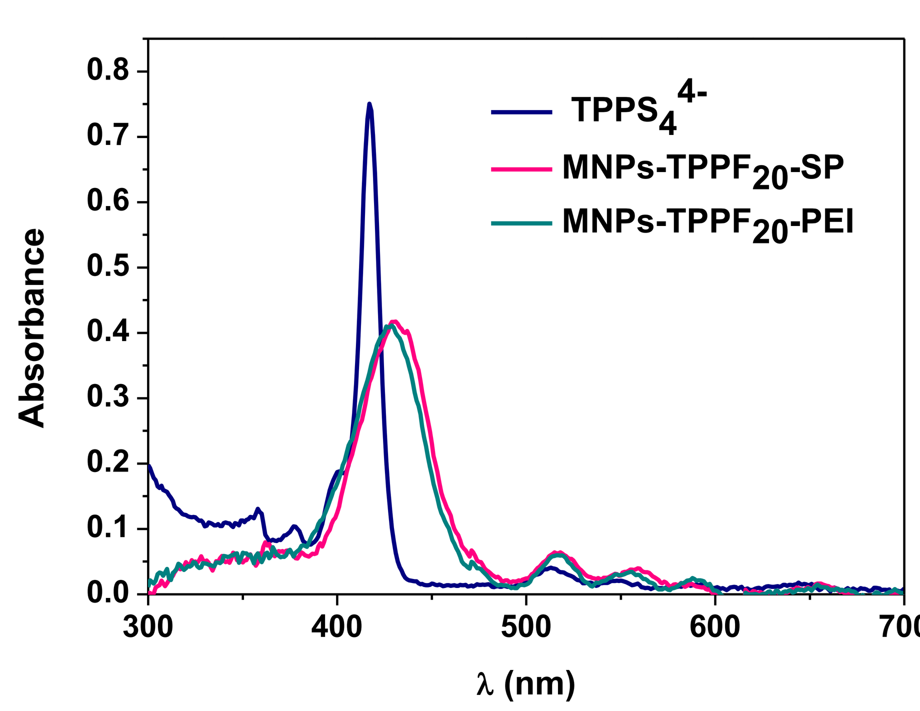
The spread of infectious diseases is a consequence of environmental contamination due to the presence of pathogenic agents in aqueous media. Therefore, it is of a vital importance the development of an economical and eco-friendly method to eradicate these microorganisms [1]. The use of photodynamic inactivation (PDI) with photosensitizers conjugated to magnetic nanoparticles (MNPs) has emerged as a successful approach for the rapid elimination of microorganisms [2].

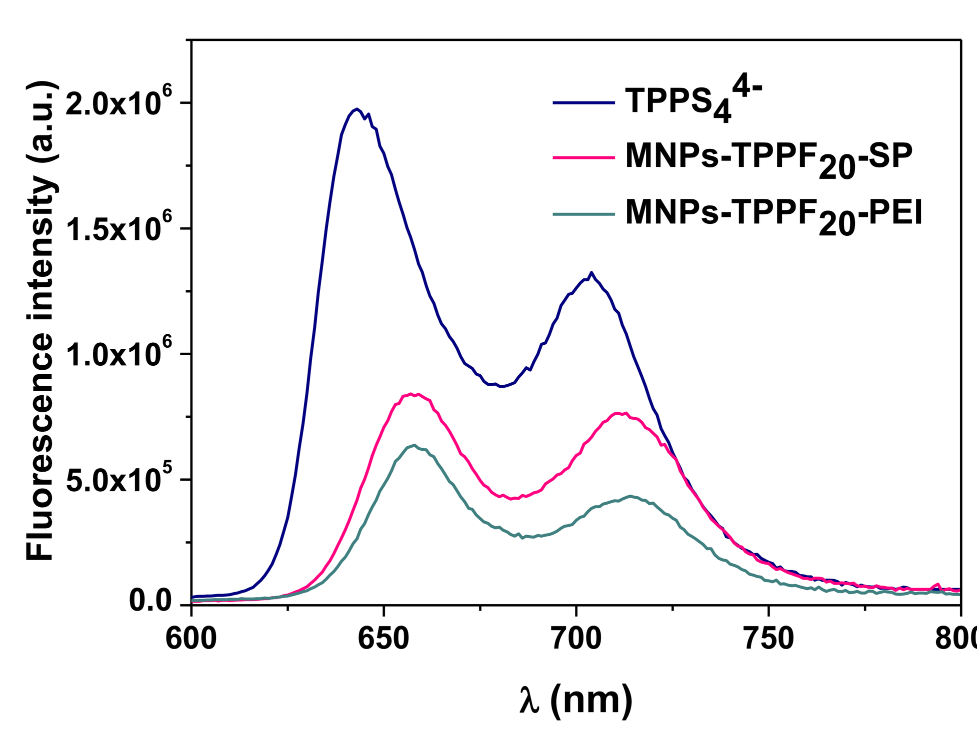
## SYNTHESIS

5,10,15,20-tetrakis(pentafluorophenyl)porphyrin ($TPPF_{20}$) was covalently immobilized on the MNPs by nucleophilic aromatic substitution reaction. Then, the remaining pentafluorophenyl groups of $TPPF_{20}$ attached to MNPs were substituted by polyethylenimine (PEI) or spermine (SP).




## SPECTROSCOPIC CHARACTERIZATION



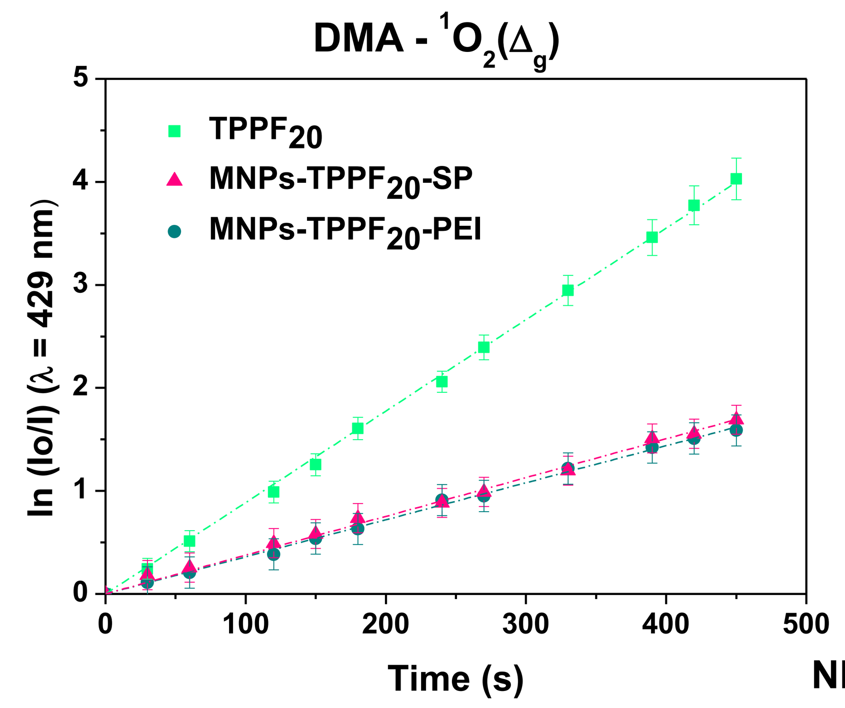



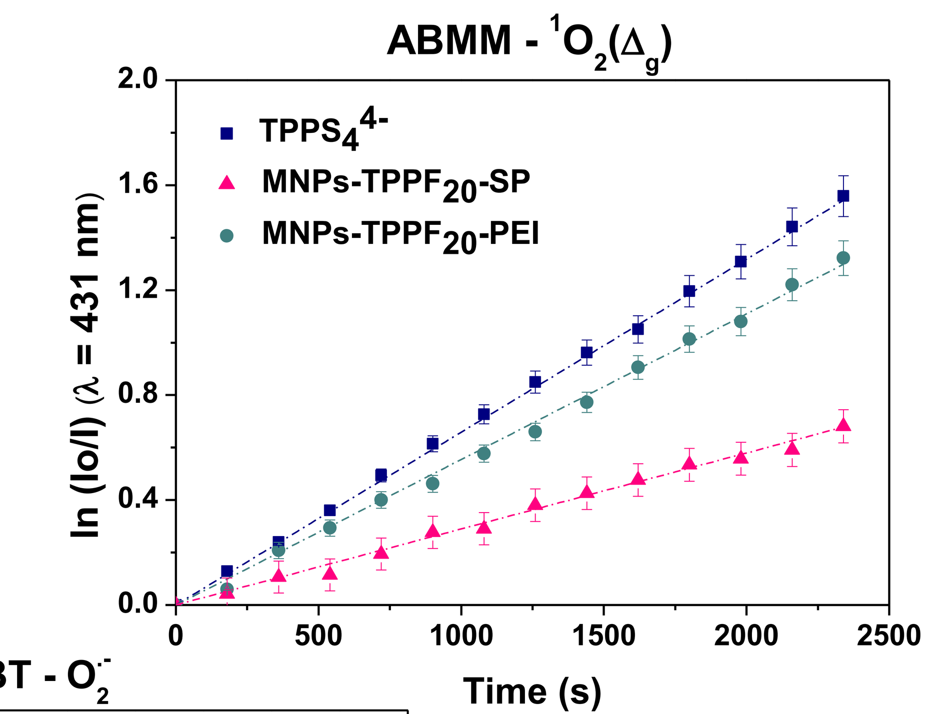

| FS | $\lambda_{máx}$ Abs (nm) | $\lambda_{máx}$ Em (nm) | $E_s$ (eV) | $(\Phi_F)^{Water}$ |
|---|---|---|---|---|
| $TPPS_4^{4-}$ | 413 | 643 | 1,93 | 0.08 |
| MNPs- $TPPF_{20}$-SP | 427 | 657 | 1,92 | 0.030 ± 0.003 |
| MNPs- TPPF20-PEI | 429 | 659 | 1,89 | 0.020 ± 0.002 |

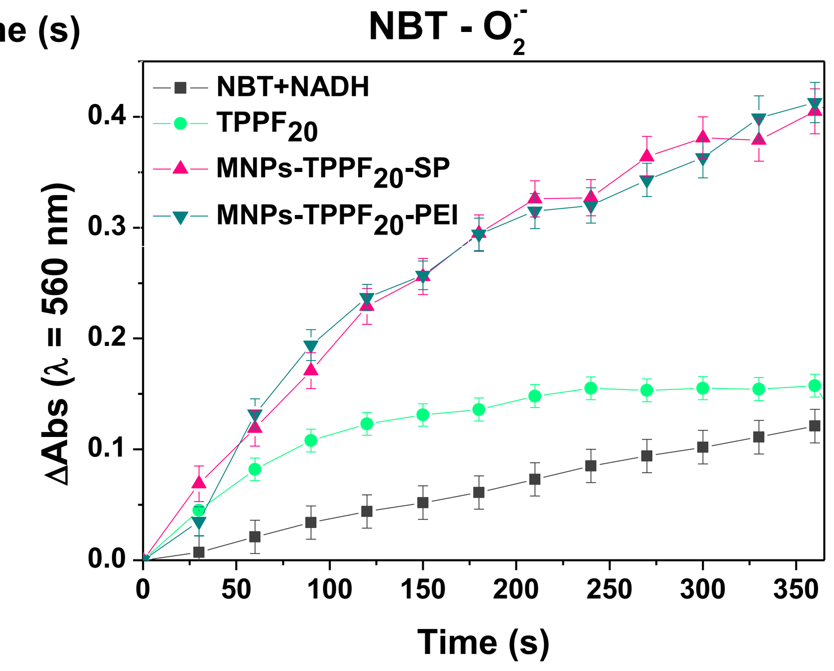
5,10,15,20-Tetrakis(4-sulfonatophenyl)porphyrin ($TPPS_4^{4-}$)

## PRODUCTION OF ROS

| FS | $k_{obs}^{DMA}$ | $k_{obs}^{ABMM}$ | $\Phi_\Delta^{DMF}$ | $\Phi_\Delta^{WATER}$ |
|---|---|---|---|---|
| $TPPF_{20}$ | (8.90 ± 0,05) x $10^{-3}$ | - | 0,80 | - |
| $TPPS_4^{4-}$ | - | (6.60 0,04) x $10^{-4}$ | - | 0.71 |
| MNPs-$TPPF_{20}$- SP | (3.70 ± 0,02) x $10^{-3}$ | (2.90 ± 0,02) x $10^{-4}$ | 0.34 ± 0,02 | 0.31 ± 0,01 |
| MNPs- $TPPF_{20}$-PEI | (3.62 ± 0,02) x $10^{-3}$ | (5.55 ± 0,03) x $10^{-4}$ | 0.33 ± 0,02 | 0.60 ± 0,03 |

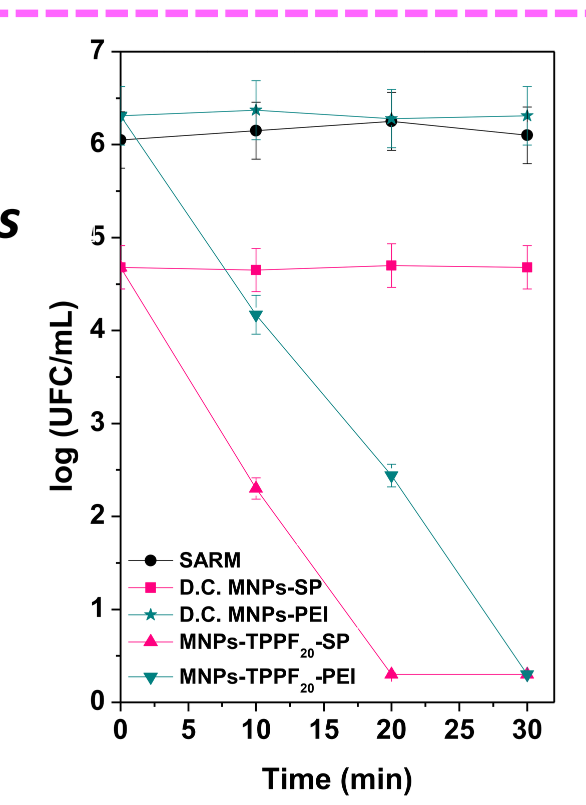


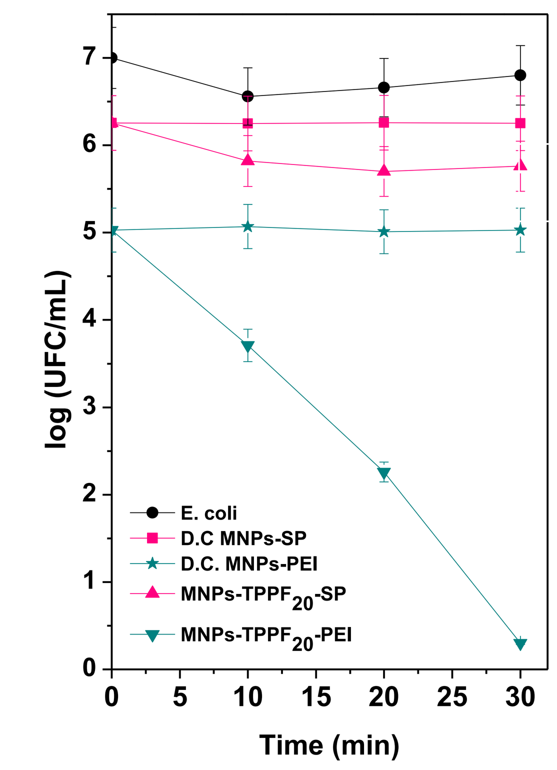




## PHOTOINACTIVATION OF BACTERIA

*S. aureus*




*E. coli*




## CONCLUSIONS

$Fe_3O_4$ MNPs coated with silica and functionalized with terminal amine groups were successfully synthesized. These were conjugated with $TPPF_{20}$ via covalent bonding, followed by further functionalization with PEI or SP. The resulting MNPs exhibited the characteristic absorption and fluorescence spectra of free-base porphyrins in water. Photodynamic studies demonstrated the ability of these materials to generate reactive oxygen species (ROS), such as singlet oxygen and superoxide anion radicals, under white light irradiation. Notably, these materials eradicated *Staphylococcus aureus* and *Escherichia coli* within 30 min of light exposure. The presence of basic amine groups provided positive charges at physiological pH, enhancing bacterial interaction, while the magnetic properties enabled efficient recycling. These findings highlight $TPPF_{20}$-conjugated MNPs as promising photodynamic agents for pathogen elimination.

## REFERENCES

[1] A. C. Scanone, et al., *ACS Appl. Bio Mater*. 3 (2020) 5930−5940.
[2] C. M. B. Carvalho, et al., *ACS Nano. 4* (2010) 7133-4140.

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