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PEI-PPIX and PEI-ZnPPIX conjugates as new photosensitizing agents for raw food surface decontamination

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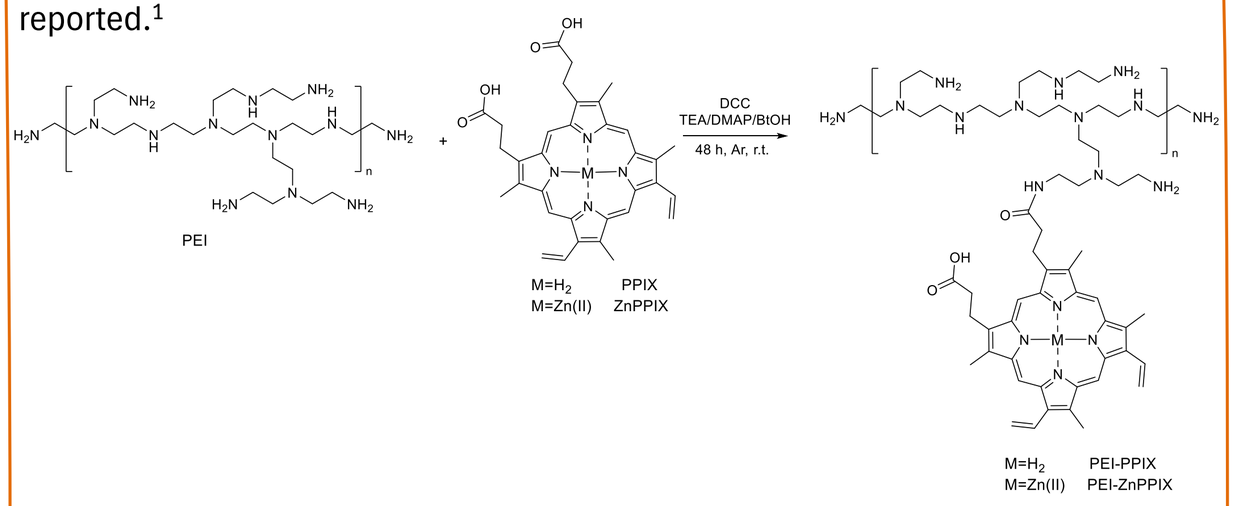
INTRODUCTION & AIM

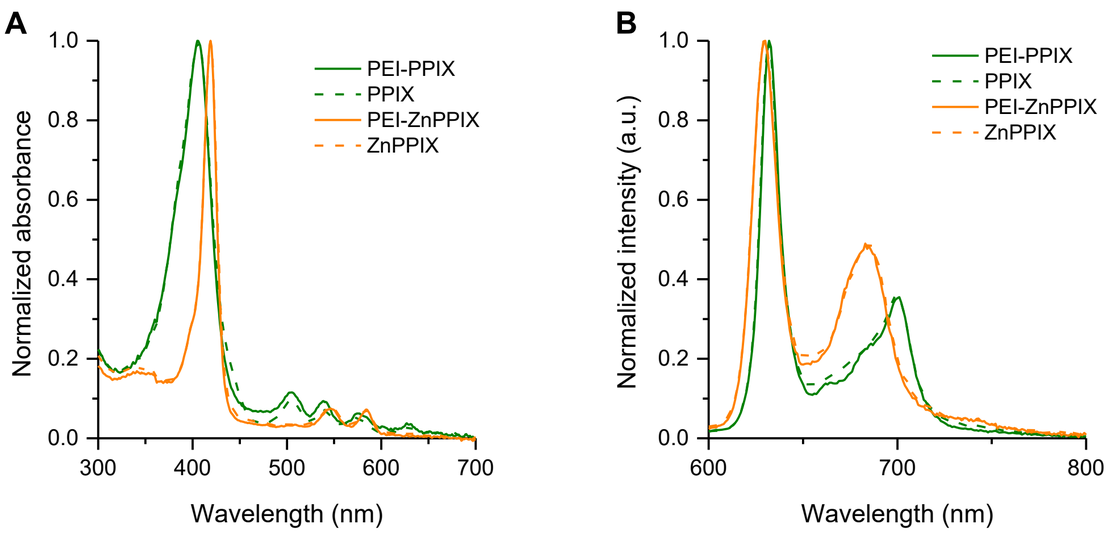
Ensuring microbiological safety is a growing concern in modern **food technology**, especially in response to consumer demand for minimally processed fruits and vegetables. In this study, two novel photosensitizer conjugates were synthesized by covalently linking **protoporphyrin IX** (PPIX) and its **Zn (II) complex** (ZnPPIX) to **polyethyleneimine** (PEI). The aim was to develop naturally derived polymeric materials capable of reducing microbial contamination on food surfaces through **photodynamic inactivation** (PDI) of pathogens.

METHOD

Conjugates, PEI-PPIX and PEI-ZnPPIX, were synthesized following the procedure reported.[1]

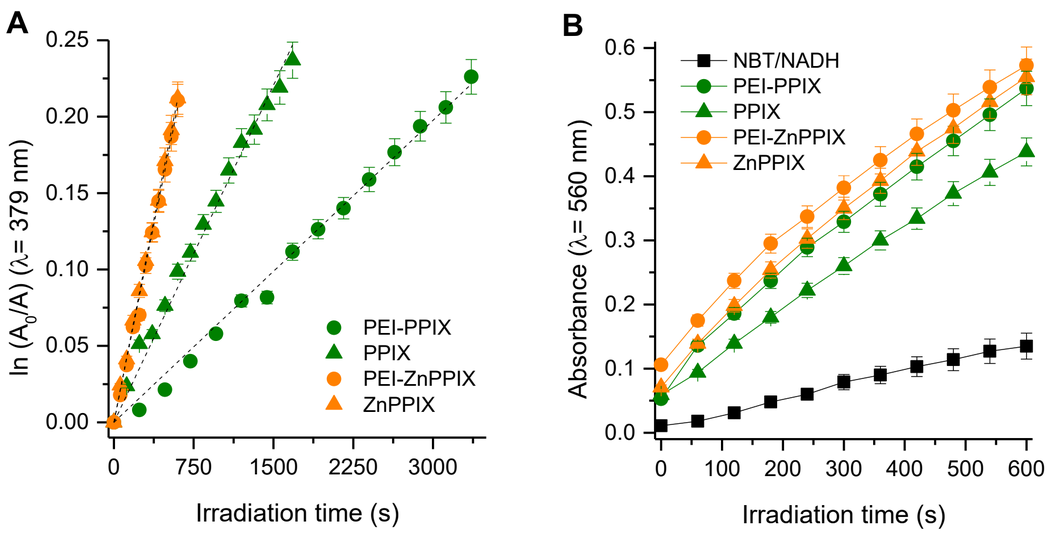


The conjugates were characterized by FT-IR spectroscopy, confirming successful covalent binding. Spectroscopic analysis indicated that the porphyrin chromophores retained their optical properties upon conjugation with PEI.



(A) Absorption and (B) emission spectra of the conjugates in DMF (λ_{exc}=505 nm for PEI-PPIX and PPIX; λ_{exc}=550 nm for PEI-ZnPPIX and ZnPPIX).

Both PEI–PPIX and PEI–ZnPPIX were able to generate singlet oxygen (Φ_Δ = 0.20 and 0.47, respectively)[2,3] and superoxide anion radicals in the presence of NADH.



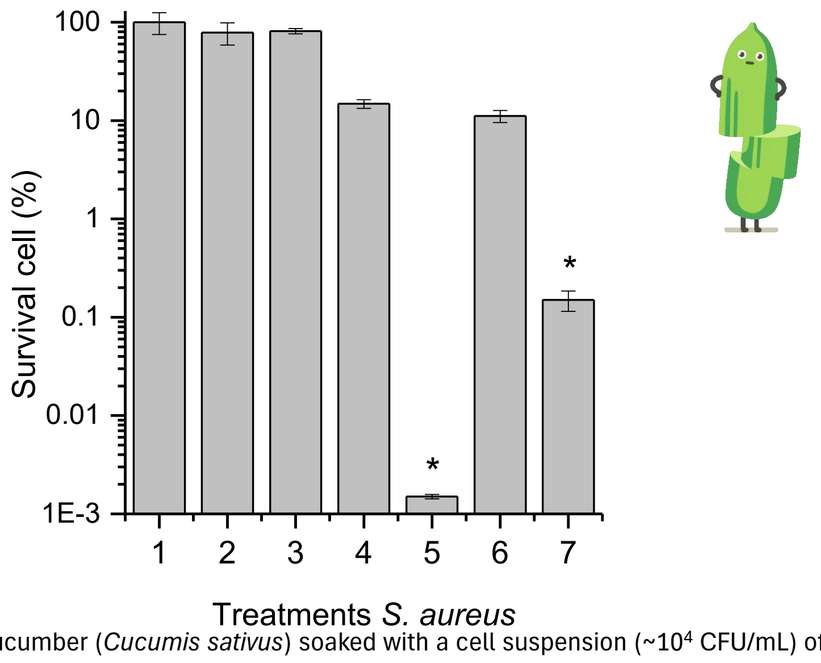
(A) Photooxidation of 9,10-dimethylanthracene (DMA) and (B) photoreduction of nitrotetrazolium (NBT) in DMF at different excitation and time or irradiation.

RESULTS & DISCUSSION

PDI assays demonstrated strong antimicrobial activity against *Staphylococcus aureus*, with both conjugates achieving >7 log reductions in bacterial viability, after 30 min of irradiation with white light.

S. aureus cell viability (~10^8 CFU/mL) after incubation with conjugates at different concentrations.

Cucumber *(Cucumis sativus)* surfaces were used as a representative raw food commonly found in salads. After microbial contamination, both photosensitizers showed effective pathogen eradication at low concentrations (0.1 nmol).



Decontamination of cucumber (*Cucumis sativus*) soaked with a cell suspension (~10^4 CFU/mL) of *S. aureus* and treated with 0.1 nmol of PEI-PPIX and PEI-ZnPPIX.

1) Cells in the dark
2) Cells on cucumber in the dark
3) Cells on cucumber irradiated
4) Cells on cucumber treated with PEI-PPIX
5) Cells on cucumber treated and irradiated with PEI-PPIX
6) Cells on cucumber treated with PEI-ZnPPIX
7) Cells on cucumber treated and irradiated with PEI-ZnPPIX

CONCLUSION

PEI–PPIX and PEI–ZnPPIX conjugates retained their photoactive properties after conjugation and efficiently generated reactive oxygen species against *S. aureus*. Both showed strong bactericidal activity even at low concentrations, demonstrating their potential as photosensitizers for the decontamination of fresh foods, specifically on cucumber.

FUTURE WORK / REFERENCES

[1] Larrea, G. *et al*. *ACS Food Sci. Technol.* **2024**, *4*, 207-217.
[2] Cormick, M. P. *et al. Eur. J. Med. Chem.* **2009**, *44*, 1592–1599.
[3] Santamarina, S. *et al*. *Polymers* **2022**, *14*, 4936.

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