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Antimicrobial photodynamic coating on glass surfaces for food preservation

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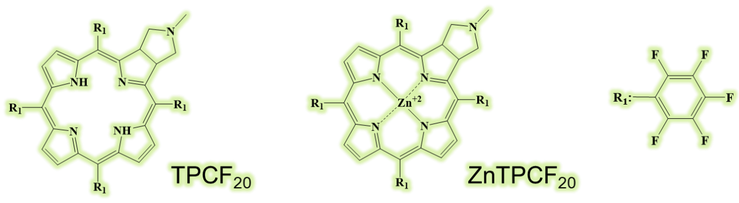
INTRODUCTION & AIM

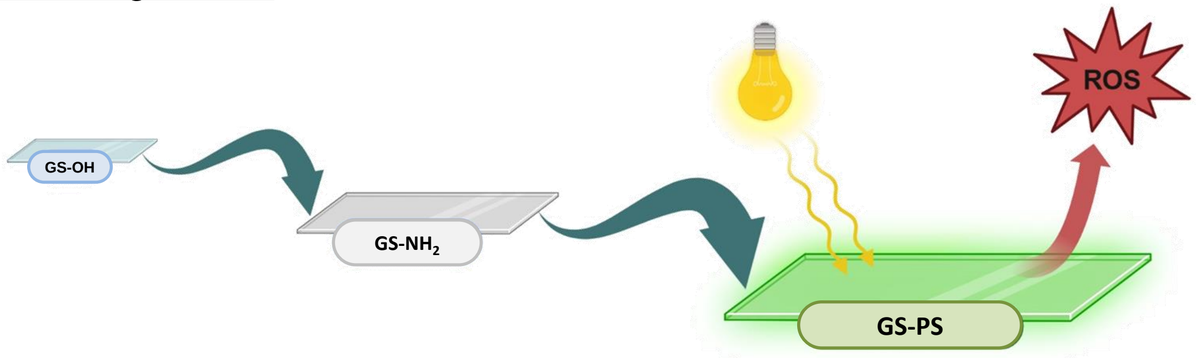
Glass surfaces contribute significantly to food preservation by maintaining food quality, ensuring safety, and enhancing shelf life through their inert, impermeable, and hygienic properties.

In this work, glass surfaces (GSs) were covalently coated with photosensitizers (GS-PS) to eliminate microbial contamination through the photodynamic inactivation of microorganisms (PDI). Thus, 5,10,15,20-tetrakis(pentafluorophenyl)-2,3-[methane(*N*-methyl)iminomethane]chlorine ($TPCF_{20}$) and its metal complex with Zn(II) ($ZnTPCF_{20}$) were used as photodynamic agents.



METHOD

Obtaining GS-PS:



1. Coverslips were cleaned H_2SO_4/H_2O_2, sonicated and rinsed. After, these were etched by NaOH solution and they were sonicated. The surfaces were rinsed with wáter and absolute ethanol and then dried using nitrogen flow to obtain GS-OH.
2. GS-OH surfaces were sumerged in a solution of APTS in anhydrous toluene and it was allowed to react at room temperature overnight, and sonicated in toluene to obtain a homogeneous layer with a frosted appearance. The surfaces were dried with a nitrogen flow, resulting in $GS\text{-}NH_2$.
3. Subsequently were immersed in solutions of $TPCF_{20}$ or $ZnTPCF_{20}$ in DMF. These compounds were allowed to react with the amine groups of $GS\text{-}NH_2$ to obtain GS-PS.

RESULTS & DISCUSSION

Morphological studies of GS-PS revealed a uniform distribution of the PS on the surfaces.

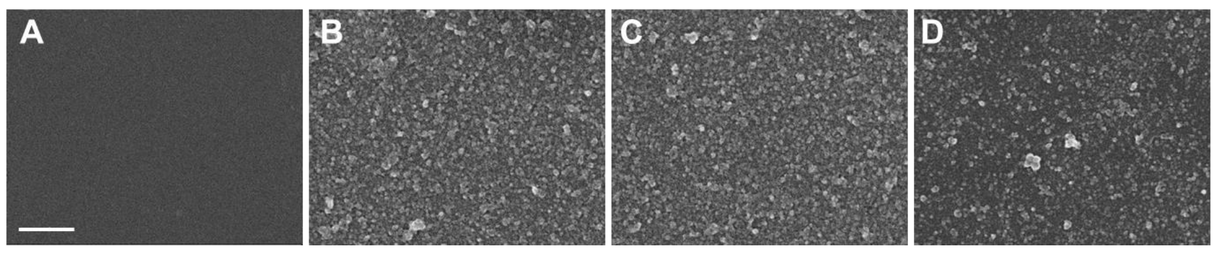


Figure 1. SEM images of (A) GS-OH, (B) $GS\text{-}NH_2$, (C) $GS\text{-}TPCF_{20}$, and (D) $GS\text{-}ZnTPCF_{20}$ surfaces (scale bar 400 nm).

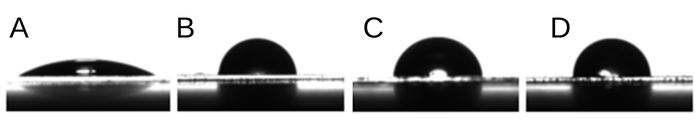


Figure 2. Images of water drop (A) GS-OH, (B) $GS\text{-}NH_2$, (C) $GS\text{-}TPCF_{20}$, and (D) $GS\text{-}ZnTPCF_{20}$ surfaces

The contact angles indicated an increase in the lipophilicity of the surfaces coated with the PS

The absorption and emission spectra of the GS-PS surfaces exhibited the characteristic bands of the corresponding monomers in solution.

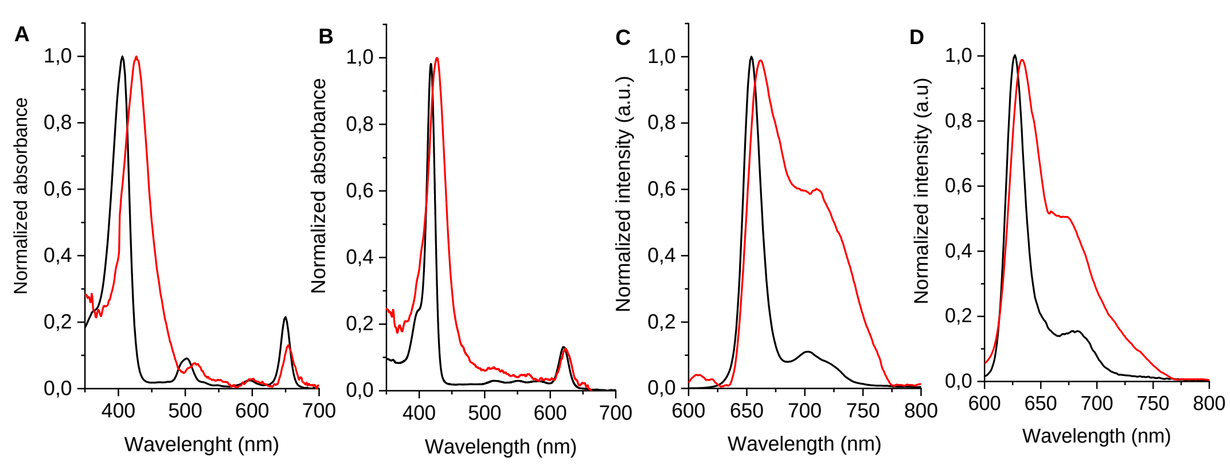


Figure 3. Absorption spectra of (A) $GS\text{-}TPCF_{20}$, (B) $GS\text{-}ZnTPCF_{20}$ (red lines) compared to the corresponding PS (black lines) in DMF. Fluorescence emission spectra of (C) GS-TPCF20, and (D) GS-ZnTPCF20 (red lines, λ_{exc} = 430 nm) compared to the corresponding PS (black lines, λ_{exc} = 412 nm) in DMF.

Photodynamic studies revealed that the GS-PS surfaces were capable of generating singlet molecular oxygen. The photoinactivation efficacy of these surfaces was assessed against *Staphylococcus aureus*. Bacterial cells on GS-PS surfaces were eradicated (over 6 log, >99.9999% reduction in survival) after 45 min of white light irradiation.

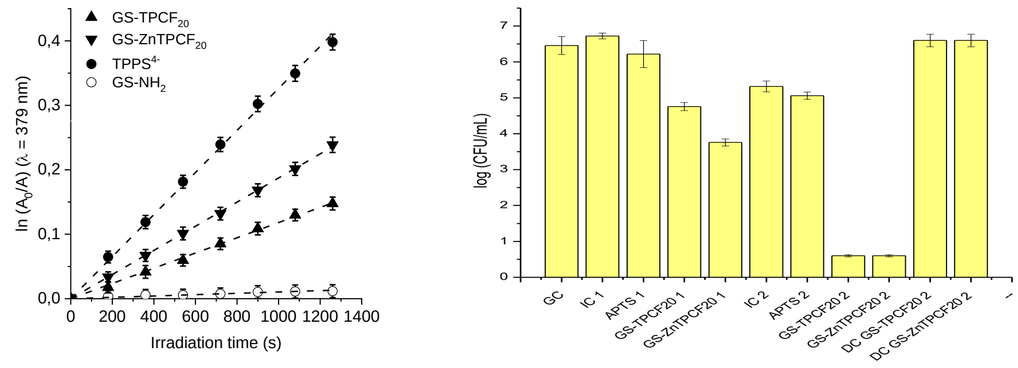


Figure 4. A) First-order plots for the photooxidation of DMA sensitized by $GS\text{-}TPCF_{20}$, $GS\text{-}ZnTPCF_{20}$, and $TPPS^{4-}$ in DMF. Control of $GS\text{-}NH_2$, λirr = 455-800 nm. **B)** CFU/mL in (GC) growth control, (IC 1) Irradiation control, (APTS 1) control of surface without PS, (GS-TPCF20 1) is the surface, (GS-ZnTPCF20 1) is the metalated surface, all at 30 min, (IC 2) Irradiation control, (APTS 1) control of surface without PS, (GS-TPCF20 1) is the surface, (GS-ZnTPCF20 1) is the metalated surface, all at 45 min, (DC GS-TPCF20 and DC GS-ZnTPCF20) are the dark controls of surfaces at 45 min of irradiation.

These surfaces were also effective in photoinactivating individual bacteria of *S. aureus* attached to the GS-PS

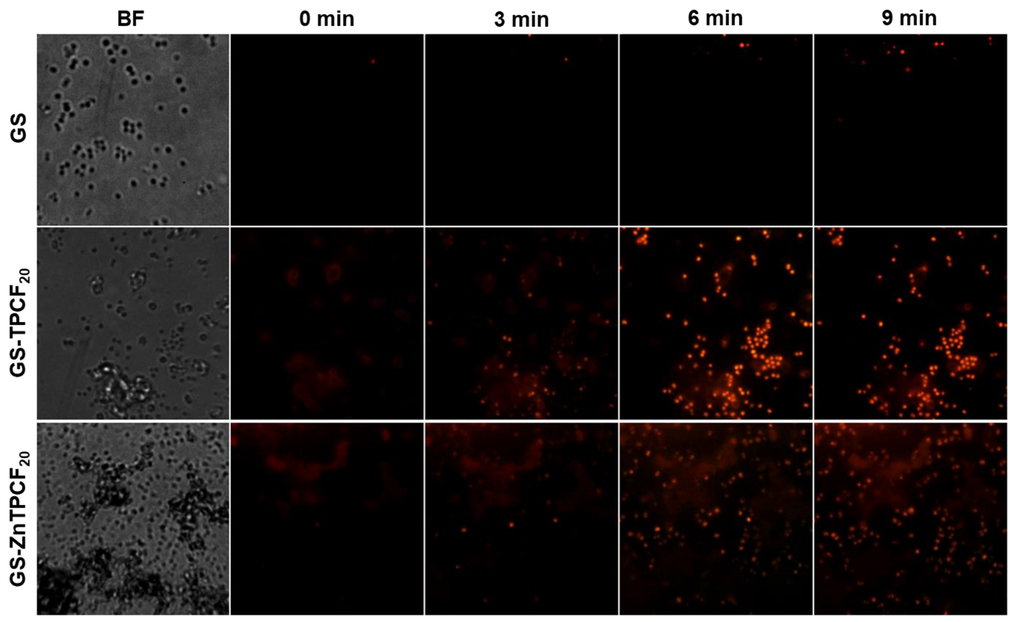


Figure 5. Microscopy images of S. aureus anchored on the GS-PS under bright field (BF) and red fluorescence emissions of PI (1 μM) after different irradiation times with white light (6.2 mW/cm^2), 40× microscope objective.

CONCLUSION

The GS-PS materials exhibited suitable properties to eliminate microbial contamination and maintain aseptic conditions for food preservation.

FUTURE WORK / REFERENCES

Lopez, M., Gsponer, N. S., Heredia, D. A., Durantini, E. N. Chlorine-based photodynamic antimicrobial glass surfaces to eradicate *Staphylococcus aureus*. Manuscript submitted.