Chlorin E6 Functionalized Silica Nanoparticles for Enhanced Removal of Antibiotic Resistant Bacteria from WWTPs

Adeola Sorinolu[1], Taraneh Barjesteh[2], Juan L. Vivero-Escoto[2], Mariya Munir[1]

[1]Department of Civil and Environmental Engineering, University of North Carolina at Charlotte, USA

[2]Department of Chemistry, University of North Carolina at Charlotte, USA

Introduction

- Wastewater treatment plants (WWTPs) play a role in the dissemination of antibiotic resistance (AR) in the environment (Fig. 1).
- Effective disinfection of secondary effluent is a means of reducing the spread of AR.
- Secondary effluent sometimes show an increase in the proportion of AR genes post-disinfection using conventional disinfection processes (e.g. chlorination, UV) [1].
- Non-toxic photosensitizers such as chlorin E6 plus harmless visible light can be an effective alternative to chlorine and UV disinfection [2].

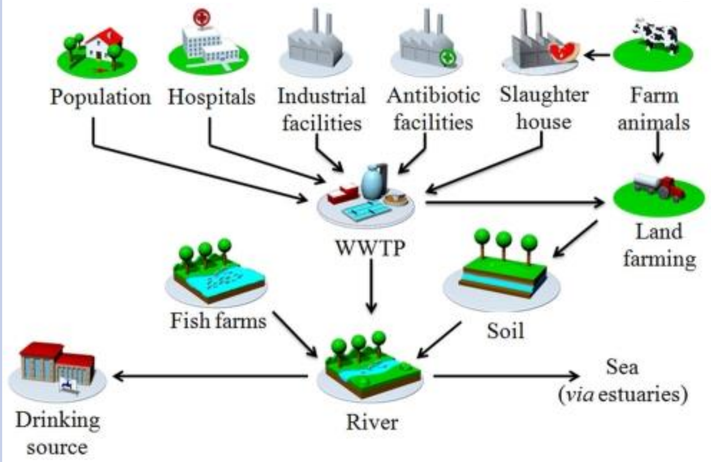


Fig 1: Wastewater treatment plants as sources of AR dissemination [3]

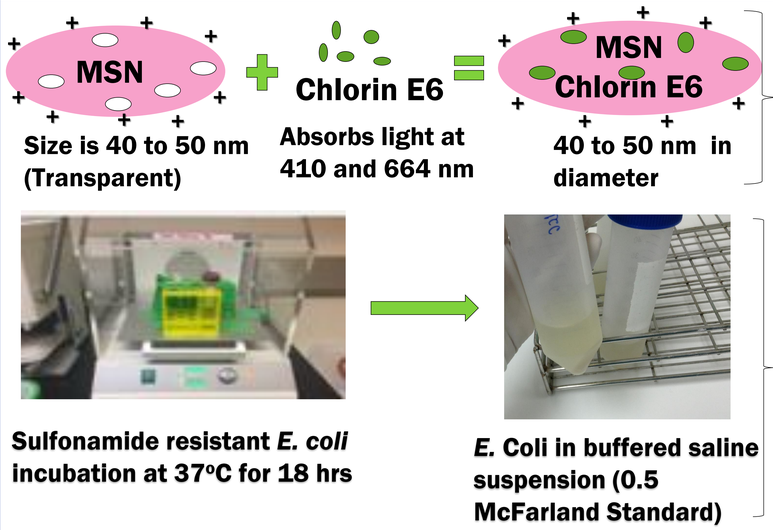
Hypotheses

- Reactive oxygen species (ROS) produced from light excited chlorin E6 (Ce6) will irreversibly inactivate antibiotic resistant bacteria (ARB) and degrade AR genes.
- Embedding chlorin E6 in mesoporous silica nanoparticle (MSN) will enhance the bacteria inactivation efficiency of chlorin E6.

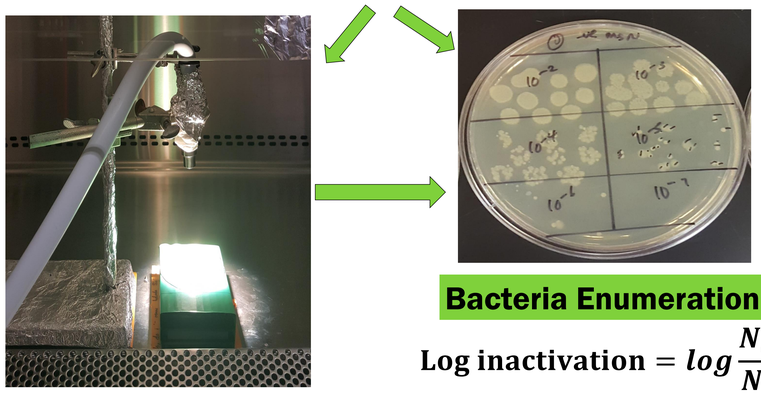
Aim

To assess the efficiency of chlorin E6 functionalized silica nanoparticles in the photodynamic inactivation of ARB in secondary effluent from WWTPs.

Methods



Bacteria + disinfectant incubation in the dark (30 mins)



Bacteria Irradiation

Light at 400 nm – 700 nm for 10 mins (0.036 W/cm^2)

Bacteria Enumeration

$$\text{Log inactivation} = log\frac{N_o}{N_i}$$

N_o = Number of bacteria without disinfectant

N_o = Number of bacteria after disinfectant

Results from Initial Trial

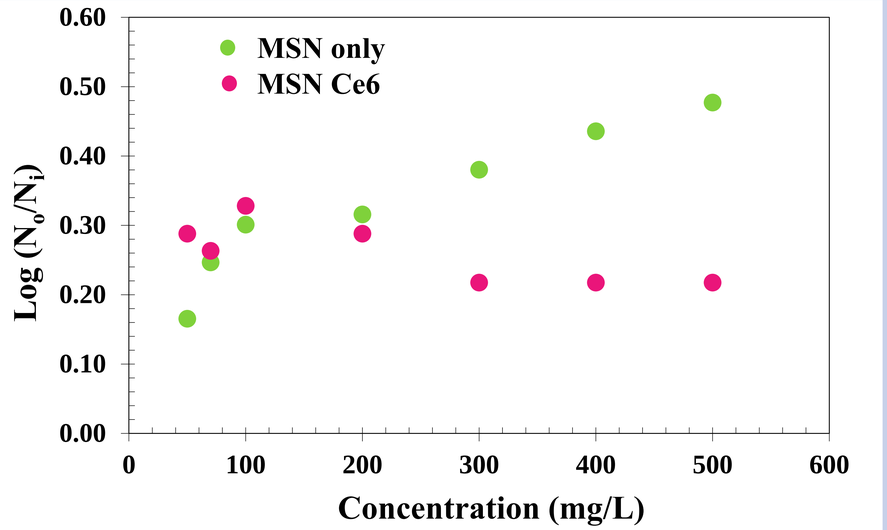


Fig 2: Log inactivation of sulphonamide resistant E. coli at different MSN concentrations

- MSN showed lethal effect on the antibiotic resistant *E. coli.*
- Bacterial inactivation decreases as MSN Ce6 concentration increases.

Future Work

1. Identify the influence of physicochemical properties of secondary effluent on ARB removal of MSN Ce6.
2. Compare the ARB inactivation achievable using MSN Ce6 with typical chlorine and UV doses.
3. Investigate the presence of post-inactivation repair mechanism in the resistant bacteria.

References

[1] Czekalski, N., Imminger, S., Salhi, E., Veljkovic, M., Kleffel, K., Drissner, D., Hammes, F., Bürgmann, H. and Von Gunten, U. *Environmental science & technology*, 2016, *50*(21), 11862-11871.

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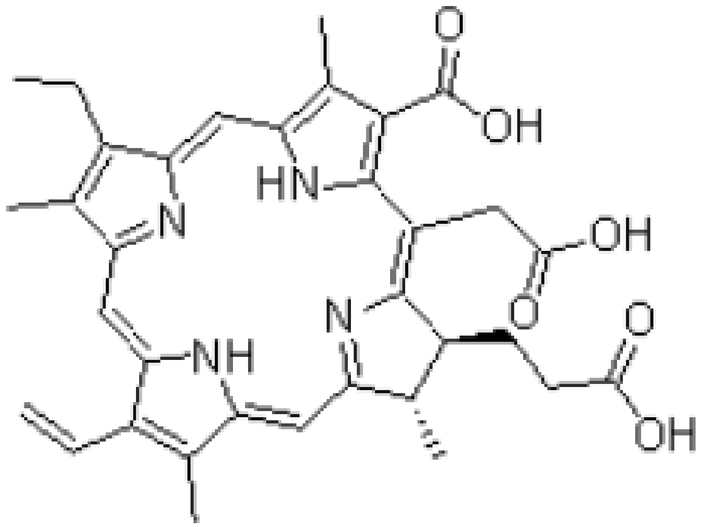
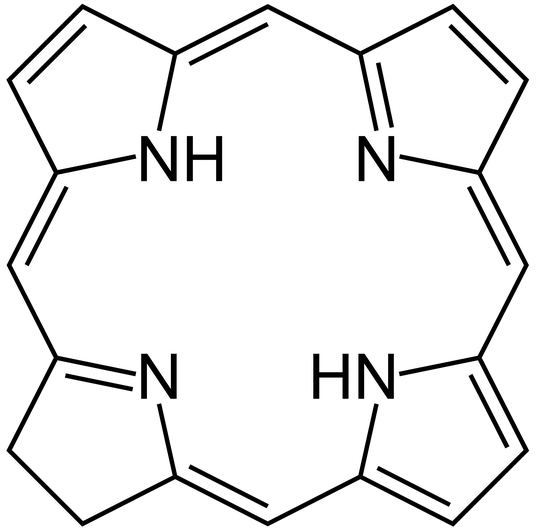
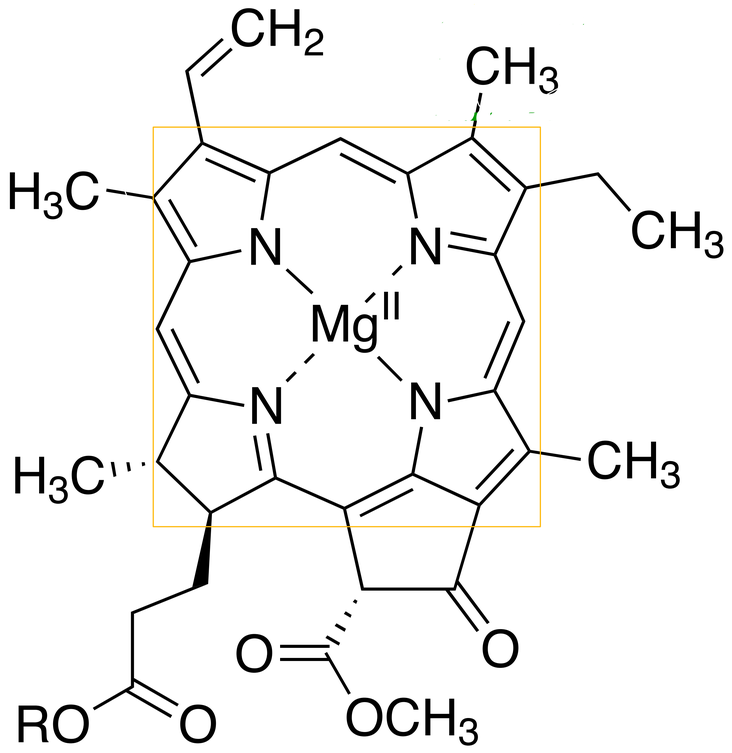


Chlorin e6



Chlorin



Chlorophyll a

UV-Vis spectroscopy