Advanced degradation of organic substance in water using no-ferric Fenton Reaction on Titania Nanotube

CAM — Center for Advanced Materials

Faculty and PostDocs Sciences and Engineering

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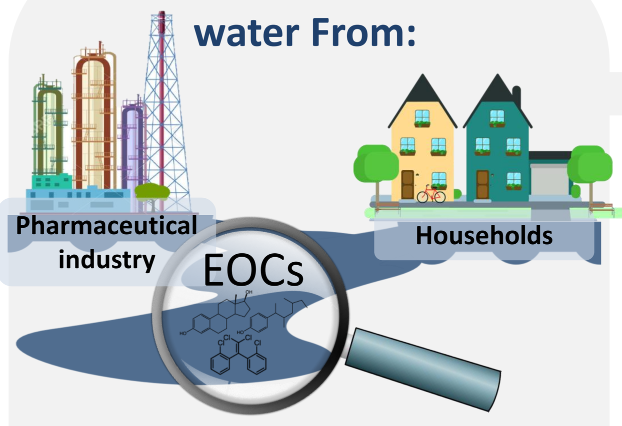
1 Introduction

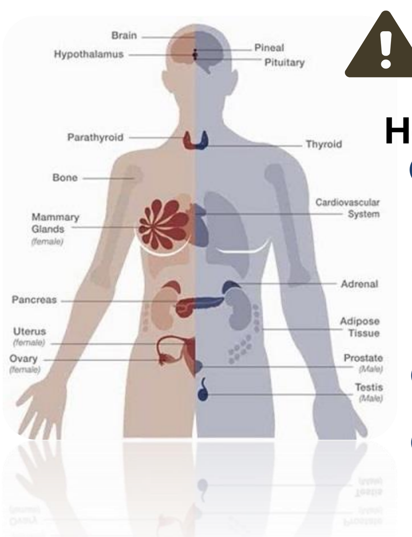
Main Issue



Emerging Organic Contaminants

Key organic contaminate

Endocrine Destructive chemicals



Affects the glands in the body

Health effects:

- Brain and behavioral Problems
- Impaired immune system
- Reproductive issues
- Various cancers

Treatment methodology

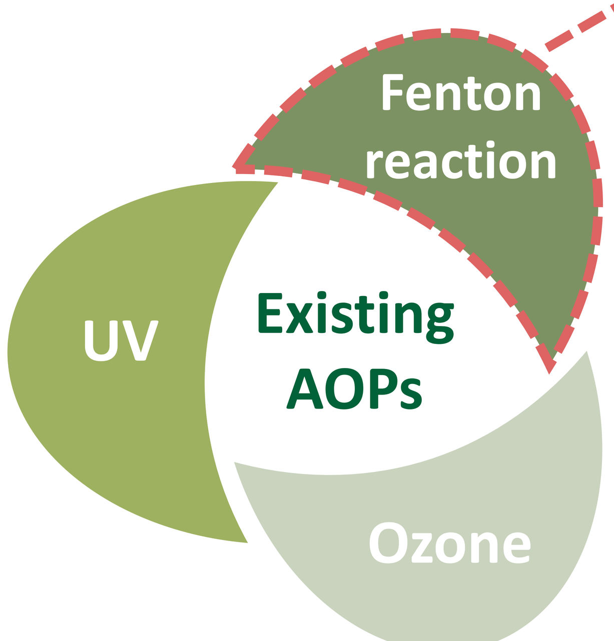
AOPs

Goal

Clean Drinking water

What are AOPs?

Advanced oxidation processes (AOPs) are clean, tertiary micropollutant treatment processes : they mineralize EOCs to CO_2 and H_2O



Most popular:

Fenton based activation of oxidant

Oxidant ⟶ H_2O_2

Why? Dose not generate Toxic by-products

$Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + HO\cdot + OH^-$

Generated OH· radical Oxidizes Organic contaminants

Application restricted because of:

- Rapid sludge formation
- Works under acidic conditions

Motivation for water treatment in Qatar:

- Cost effective Process
- Energy Saving
- Durable material
- Environmentally Green Technology

Selected Approach

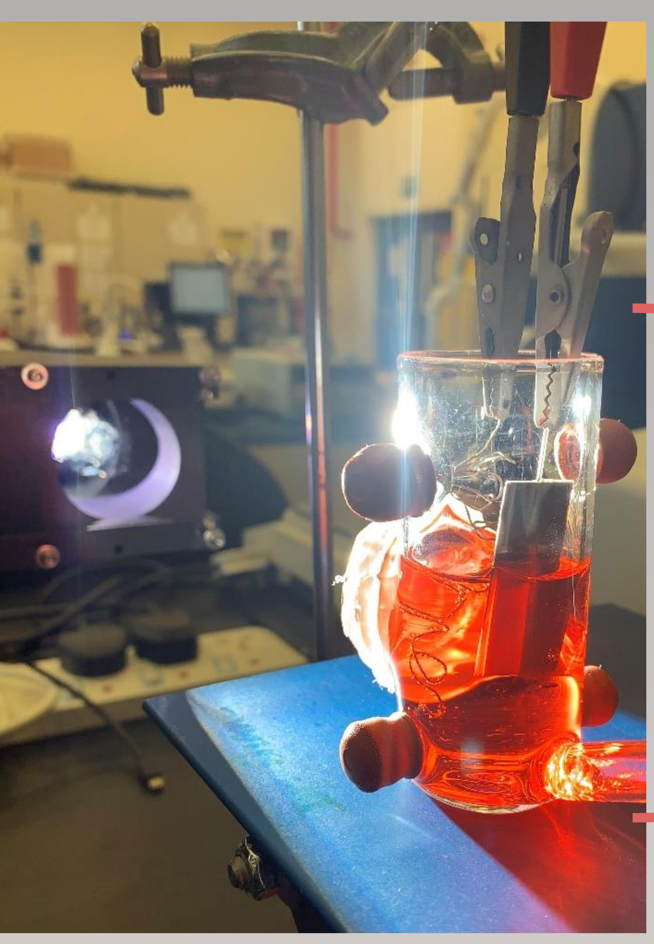
Photo-Oxidation of EOCs on Highly structured TiO2 Nanotubes

H_2O_2 activated by non-ferrous Photocatalyst → TiO_2 nanotube array (TNA) electrodes

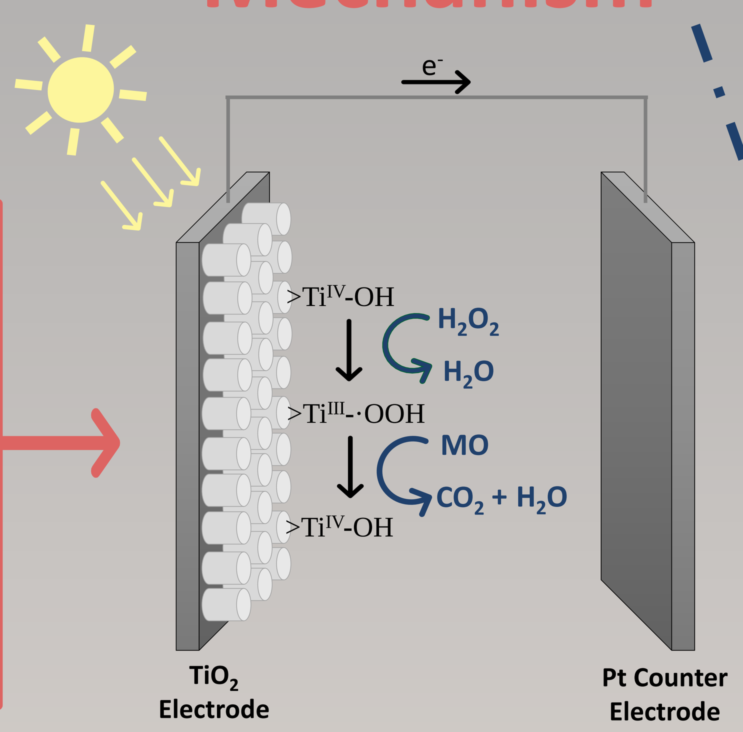
Advantages

- Use of Light absorbing material with large surface area to increase particle capacity.
- Dose not need further treatment. E.g. Sludge removal, TiO_2 powder separation.
- Dose not produce toxic or carcinogenic byproducts.

2 Experimental Setup and methodology

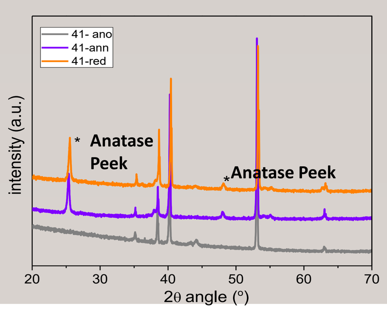


Mechanism

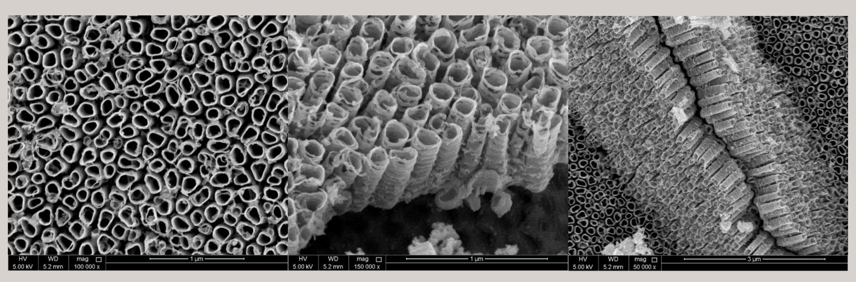


TNA Surface Morphology

X-ray diffraction XRD



Scanning electron microscopy (SEM)



3 Results

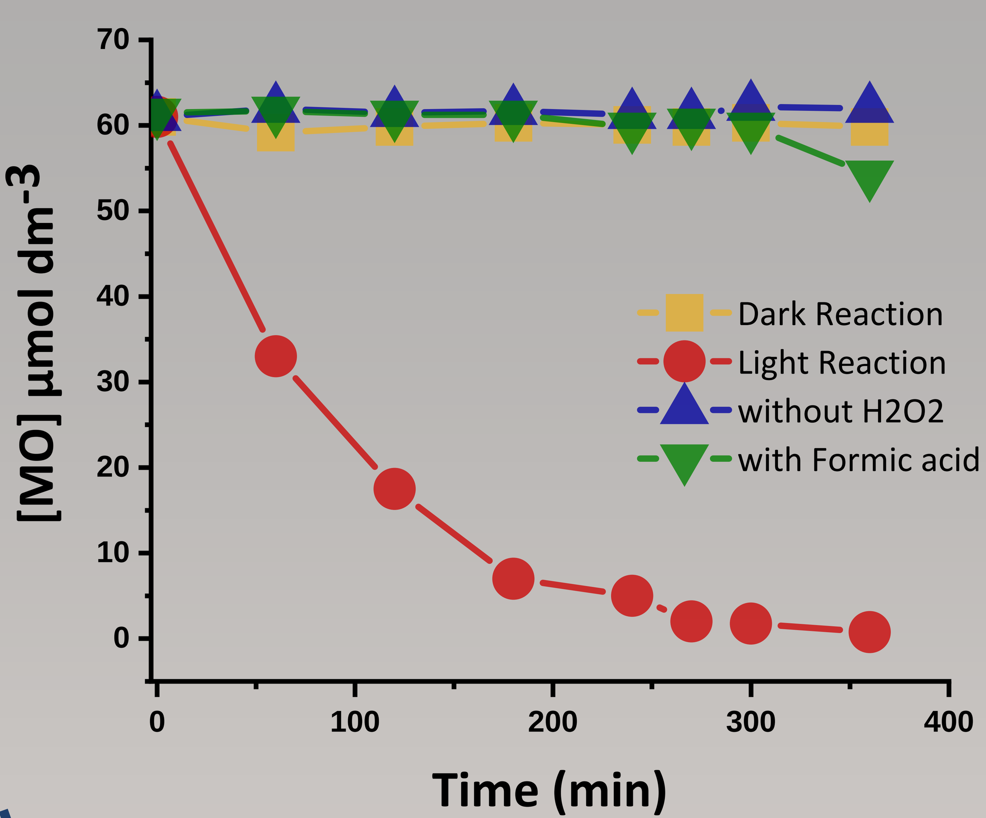


Figure 1. Time Profiles of MO Oxidation in the presence of TiO_2 photoelectrodes under various reaction conditions. [M]= 60μmol/dm³ at t=0min for all experiments.

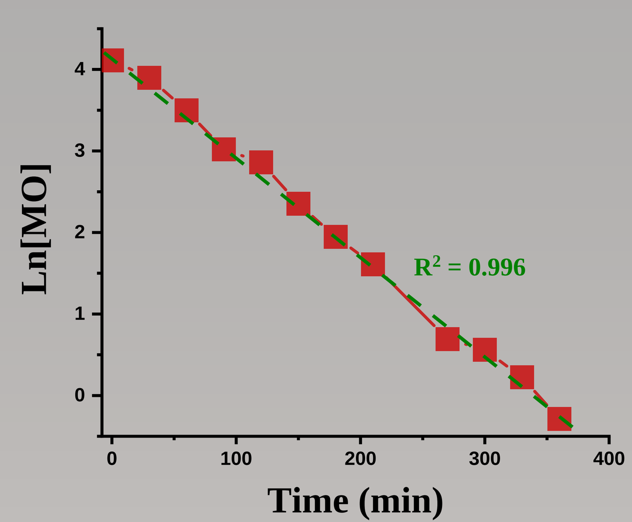


Figure 2. Photocatalytic Methyl orange degradation using TiO_2 Photoelectrodes in the presence of H_2O_2 fited to first order reaction model

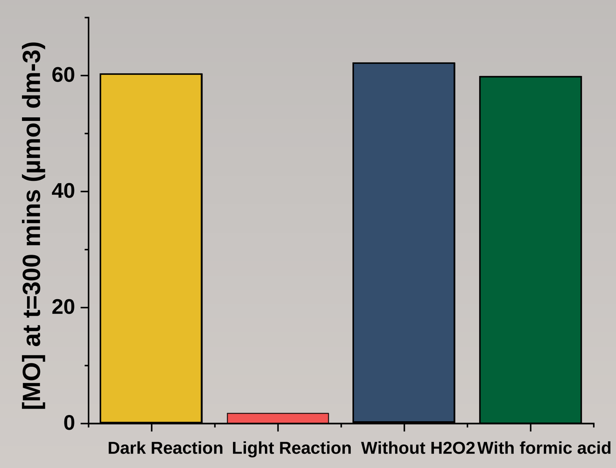


Figure 3. Concentration of MO dye after 5 hours for different reaction conditions.

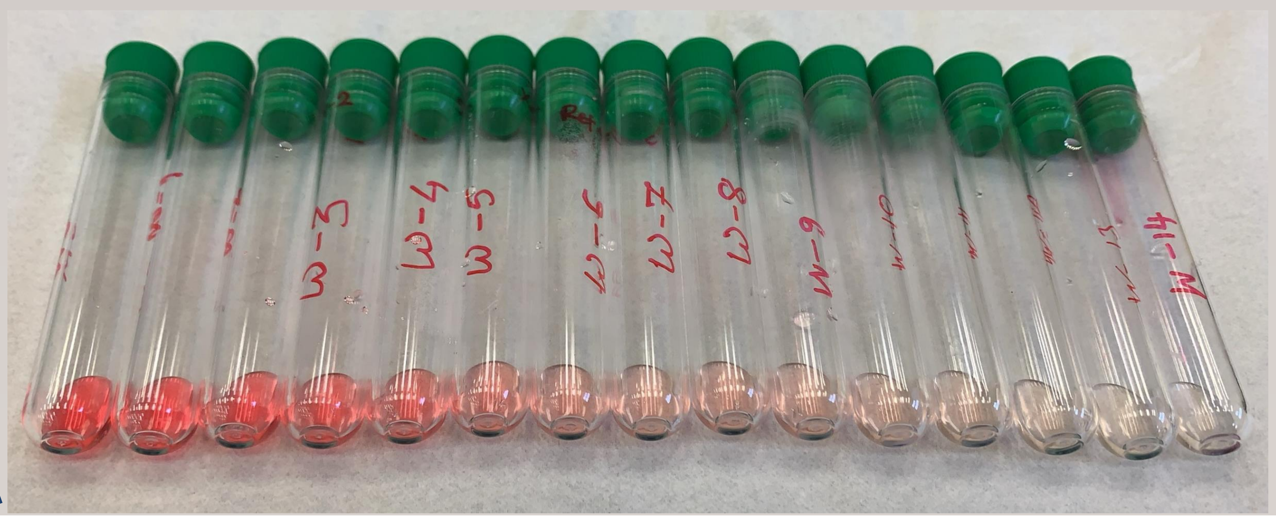


Figure 4. Complete removal of MO was achieved after six hours of exposure in AM 1.5 G light (equivalent to 1 sun intensity), where hydrogen peroxide accounted for only 1/200th of the amount of initial dye concentration.

4 Conclusion

a. The proposed degradation mechanism in the presence of TiO2 electrode, H2O2, and 1 sun intensity solar radiation showed complete oxidation of methyl orange (EOC representative in this system).

b. The Proposed approach follows first order reaction kinetics with rate constant k = 0.0124 min^{-1}

5 Significance

Prototype: The Proposed Photocatalytic TiO_2/H_2O_2 System

Scale up — Easily Scalable Electrode

Industrial level wastewater treatment

References

[1] Bokare, A. D.; Choi, W. *J. Hazard. Mater.* 2014, *275*, 121-135.

[2] Kim, D. H.; Bokare, A. D.; Koo, M. S.; Choi, W. *Environ. Sci. Technol*. 2015, *49*, 3506-3513.

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