Disinfection of Waters/Wastewaters by Solar Photocatalysis

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Thematic Session 2: Waste water treatment

Project Description:
“Scale-up of solar-active, stable photocatalysts for pathogens elimination and wastewater treatment”
Past Expertise relevant to the topic:

- A. Inactivation of Staphylococcus aureus in water by means of solar photocatalysis using metal doped TiO₂ semiconductors
  
  D. Venieri et al, 
  Journal of Chemical Technology and Biotechnology, 92 (2017), p.43–51

- B. Inactivation of bacteriophage MS2 in real wastewater by means of solar photocatalysis using metal doped TiO₂ semiconductors
  
  D. Venieri et al, 
  Applied Catalysis B: Environmental 178 (2015) 54–64
Environmental problem

- Chemical pollution
- Induction of antibiotic resistant bacteria (ARBs) & antibiotic resistance genes (ARGs)
  - acquisition of genes encoding enzymes, that destroy the antibacterial agent / mutations / new metabolic pathways

Concerns:
- Threat to public health
- Economic impact
- **How far wastewater disinfection and in general biological and chemical processes are part of a sanitary illusion?**
- **Are these processes capable to eliminate ARB & ARGs during wastewater treatment?**
Expertise relevant to the topic:

- Metal doped (Mn-, Co- and Mn/Co- binary doped) titania for the inactivation of *K. pneumoniae* in real wastewater by simulated solar irradiation
- Assessment of catalysts potential to purify real wastewater samples in terms of *K. pneumoniae* removal
- Assessment of antibiotic resistance
- Study of changes in bacterial antibiotic resistance profile through treatment
K. pneumoniae inactivation under simulated solar irradiation in the presence of Mn-, Co- and Mn/Co co-doped TiO₂ catalysts and the commercially available TiO₂ (P25, Evonik).

*Catalyst concentration: 250 mg/L.*

- Binary dopant ⇒ equal performance to Co-titania, despite the lower concentration of the dopant (0.04 wt%).
- Enhanced activity of composite dopants ⇒ induced synergistic effect.
Antibiotics profiles – MIC (Minimum Inhibitory Concentration, defined as the lowest concentration of an antimicrobial that will inhibit the visible growth of a microorganism after overnight incubation)

1. Tetracycline

- **P25 (solar)**: 2
- **0.04% Mn/Co:TiO2 (solar)**: 2
- **0.1% Co:TiO2 (solar)**: 2
- **0.1% Mn:TiO2 (solar)**: 2

**Klebsiella pneumoniae (intact cells)**

MIC (\(\mu g/mL\))

2. Sulfamethoxazole (bacteriostatic antibiotic)

- **P25 (solar)**
- **0.04% Mn/Co:TiO2 (solar)**: 4
- **0.1% Co:TiO2 (solar)**
- **0.1% Mn:TiO2 (solar)**

**Klebsiella pneumoniae (intact cells)**

MIC (\(\mu g/mL\))
3. Cefaclor (β lactams)

Suitable approach would be the combination of UV with a photocatalytic treatment, which has proved to be effective for the elimination of ARGs through treatment!!

4. Ampicillin (β lactams)

High presence of ampC gene after all processes!!
Pilot-scale application targeted

- Solar photocatalysis serving as a tertiary wastewater treatment stage for pathogens elimination
- Post-secondary treatment in conventional wastewater treatment plants (WWTPs)
- Compound parabolic collectors (CPC)
- Successful bacterial elimination (fecal and total coliform populations)

Seeking Partners with relevant expertise!!