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Removal of aqueous residues of plant protection compounds by photocatalysis using coating processes

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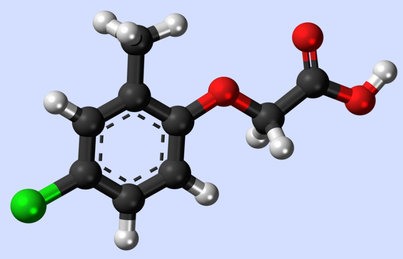
CONTEXT

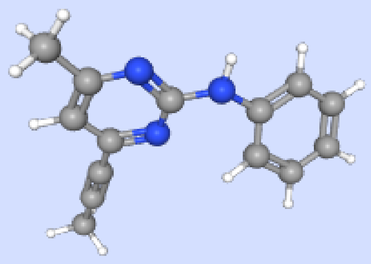
Surface waters are at risk from certain specific chemicals (priority substances) that could cause harm to the aquatic ecosystem (fish, plants, food chain, etc.) or affect human health through exposure to water (e.g. drinking, bathing, seafood, etc.). The Water Framework Directive (WFD) [1] requires the Commission to come forward with a strategy on pollution of surface waters. The European Directive 2000/60/CE stresses the need of adopting measures against water pollution in order to achieve a progressive reduction of contaminants and recuperate water for new uses.

Crossed benefits of wastewater reuse.

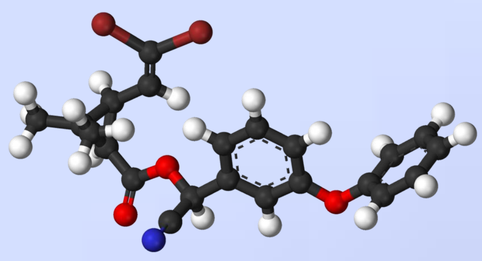
COMPOUNDS STUDIED



2-methyl-4-chlorophenoxyacetic acid (MCPA, herbicide)



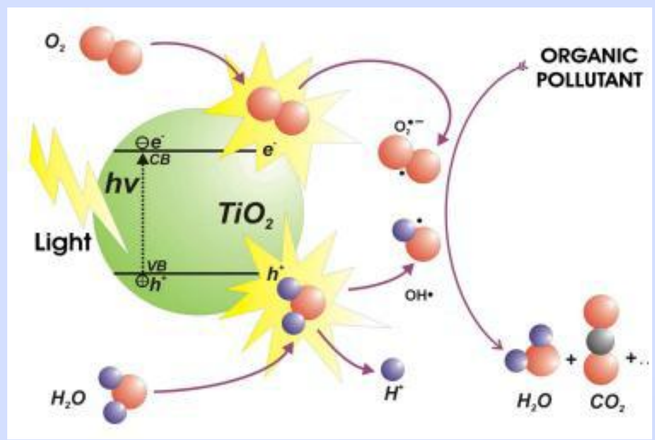
4-methyl-N-phenyl-6-(prop-1-ynyl)pyrimidin-2-amine (Mepanipyrim, fungicide)



(S)-Cyano-(3-phenoxyphenyl)-methyl] (1R,3R)-3-(2,2-dibromoethenyl)-2,2-dimethyl-cyclopropane-1-carboxylate (Deltamethrin, insecticide)

PRINCIPLE

Advanced Oxidation Processess (AOPs) are promising ways to perform the mineralization of pollutants. AOPs are characterized by the in situ production of hydroxyl radicals, which are highly reactive species capable of oxidizing organic materials in a non-selective way.



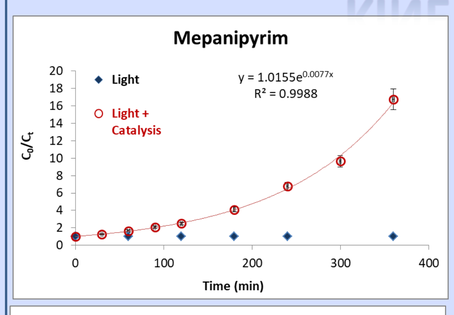
Mechanism of TiO_2 catalytic degradation of organic pollutants

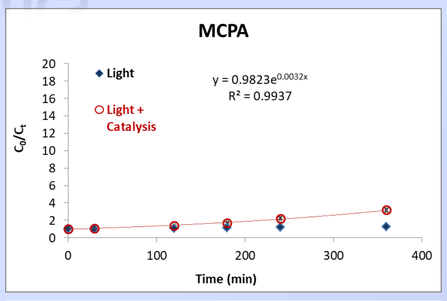
OBJECT- APPROACH

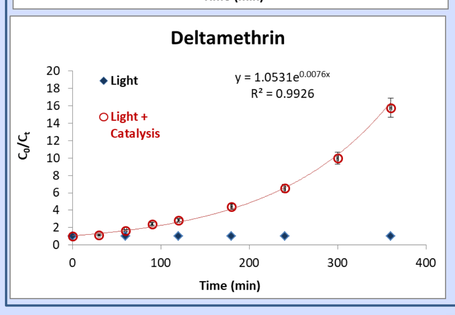
The main objective is to study the photocatalytic degradation of some plant protection compounds (PPCs) in water by heterogeneous photocatalysis using titanium dioxide (TiO_2) supported on borosilicate tubes.

Borosilicate tubes were coated through sol-gel dip-coating process or by hybrid nanoparticle dip-coating with plasma-enhanced chemical vapour deposition (PECVD) process.

KINETICS







	Halflife (min)
MCPA	217
Mepanipyrim	90
Deltamethrin	91

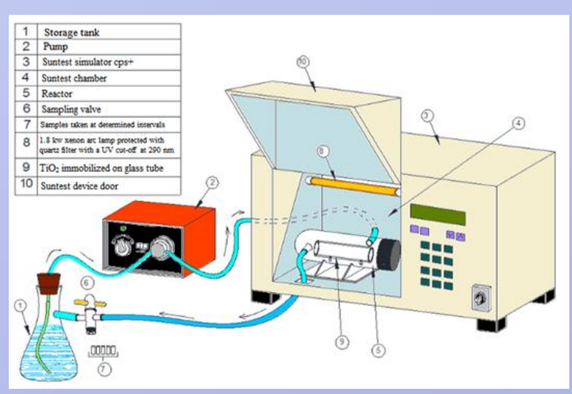
Photocatalytic degradation using sol-gel coated tubes

Results showed poor efficiency and insufficient removal of PPCs through direct photolysis, whereas heterogeneous photacatalysis with TiO_2 coated on borosilicate tubes was found to accelerate their degradation rate with complete decomposition. Kinetics showed a critical difference of performance for the two coating methods used as the degradation rates of pollutants by the sol-gel-coated tubes were much faster than the degradation by the nanoparticle/PECVD-coated tubes.

INSTRUMENTAL

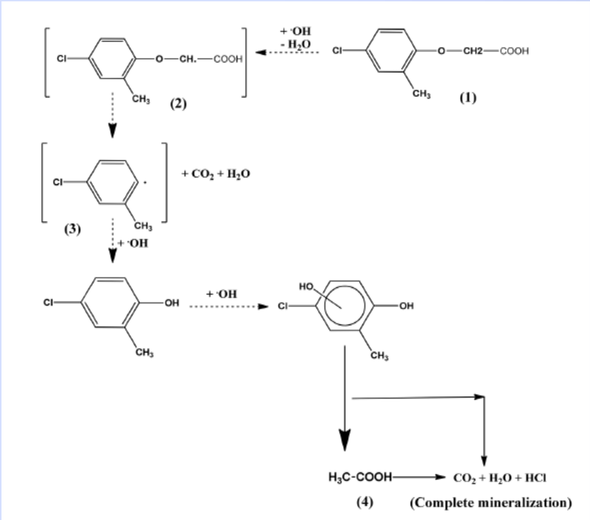
Solar Box Suntest Heraeus

Tandem GC-LC hybrid quadrupole ion trap (LTQ)–Fourier Transform Ion Cyclotron Resonance (FT-ICR) Mass Spectrometer (Thermo Fisher Scientific- Bremen, Germany)

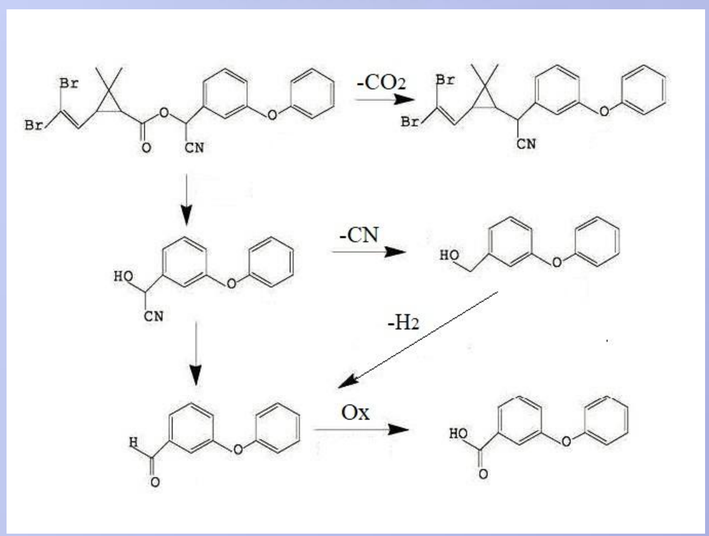


Schematic diagram of the photodegradation system

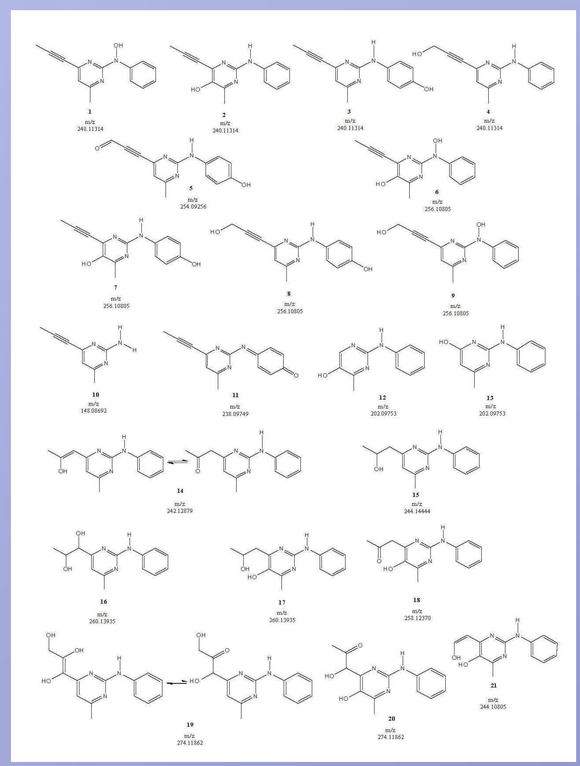
DERIVATIVES



Proposed pathway of MCPA photocatalysis



Proposed pathway of Deltamethrin photocatalysis



Derivatives formed during the Mepanipyrim photocatalysis

[1] 130 Directive 2000/60/EC (OJ L 327, 22.12.2000, p. 1). For more information on the Water Framework Directive, please refer to europa.eu.int/comm/environment/water