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Nanotechnology advances in photocatalytic reactors for water treatment and wastewater reuse

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Abstract Innovative and scalable photocatalytic reactors have been developed for the degradation of pesticides in agro-industry and the disinfection of effluents from municipal waste water treatment plants. The reactors (slurry batch reactor, or membrane reactor) are working under continuous flow conditions, can incorporate novel, environmentally friendly photocatalytic materials and be powered by solar light, a key factor for the reduction of energy requirements for water treatment. They represent a cost-effective cutting-edge application of nanotechnology for enhancing water quality.

Keywords: photocatalysis, water treatment, reactor engineering

1. Photocatalytic Nanofiltration Reactor

The Photocatalytic Nanofiltration Reactor (PNFR) technology, refers to a continuous flow system than have been manufactured at lab-scale, prototype module and demonstration field, applying ceramic membranes transformed into photocatalytic ones following immobilization of titania-based photocatalysts. The lab scale reactor working under UV or/and visible light was manufactured within the Clean Water (Water detoxification using innovative vis-nanocatalysts) FP7 EU project and patented (Photocatalytic purification device EP2409954A1 European Patent Office). It can treat some lit of polluted water and has successfully been used for detoxification of artificial wastewater form organic pollutants. The prototype module and the demonstration (at Zagorin cooperative, Zagora, Pelion, Greece) PNFR reactor units have been manufactured within the recently ended LIFE PureAgroH2O (Pollutant Photo-NF remediation of Agro-Water) project. The optimization of the PNFR reactor to a fully solar driven system using newly developed VLA photocatalysts and PV panels (to power the system and cover the entire energy needs) is currently under implementation after LIFE activities and especially in the frame of the S.W.I.F.T. project. This project is funded by EDA and aims at exploring the potential of emerging water reuse concepts and technologies, including photocatalysis, to provide clean and safe water in harsh environments.

The slurry Municipal Wastewater Treatment Reactor (MWTR) is a LED driven system that has recently been implemented at the Greek island of Antiparos (Cyclades, Greece) for the treatment of tertiary effluents. The, easily scalable to a pilot unit, custom-designed photocatalytic reactor system consists of two in-line, open-to-air tanks. The photocatalytic one, is the main vessel where the photocatalyst is mixed with the wastewater body using air blowers to provide continuous mixing and aeration. The following precipitation tank is designed for the VLA photocatalyst separation and collection after the detoxification and disinfection step. Currently, the research efforts are focusing on design optimization using newly developed magnetic-VLA photocatalysts, ensuring the reactor operation under solar light and easy final photocatalyst separation.

2. Municipal Wastewater Treatment Reactor

The slurry Municipal Wastewater Treatment Reactor (MWTR) is a LED driven system that has recently been implemented at the Greek island of Antiparos (Cyclades, Greece) for the treatment of tertiary effluents. The, easily scalable to a pilot unit, custom-designed photocatalytic reactor system consists of two in-line, open-to-air tanks. The photocatalytic one, is the main vessel where the photocatalyst is mixed with the wastewater body using air blowers to provide continuous mixing and aeration. The following precipitation tank is designed for the VLA photocatalyst separation and collection after the detoxification and disinfection step. Currently, the research efforts are focusing on design optimization using newly developed magnetic-VLA photocatalysts, ensuring the reactor operation under solar light and easy final photocatalyst separation.

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