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# Applications Of Advanced Oxidation For Wastewater Treatment

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2nd Summer School on Environmental Applications of Advanced Oxidation Processes of the European PhD School on AOPs and NEREUS COST Action ES1403 Summer School on Advanced Treatment Technologies and Contaminants of Emerging Concern  
Advanced catalytic oxidation processes : [1st European Conference on Environmental Applications of Advanced Oxidation Processes (EAAOP-1) held in Chania (Crete, Greece) from 7 to 9 September 2006]  
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Applications of Advanced Oxidation Processes (AOPs) in Drinking Water Treatment  
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Photoreactors in Advanced Oxidation Process  
Advanced Oxidation Processes (AOPs) in Water and Wastewater Treatment  
Advanced Oxidation Processes for Water and Wastewater Treatment

*Applications Of Advanced Oxidation For  
Wastewater Treatment*

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## **CANTRELL ELLISON**

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### **2nd Summer School on Environmental Applications of Advanced Oxidation Processes of the European PhD School on AOPs and NEREUS COST Action ES1403 Summer School on Advanced Treatment Technologies and Contaminants of Emerging Concern** John Wiley & Sons

The increasingly stricter standards for effluent discharge and the decreasing availability of freshwater resources worldwide have made the development of advanced wastewater treatment technologies necessary. Advanced oxidation processes (AOPs) are becoming an attractive alternative and a complementary treatment option to conventional methods. AOPs are used to improve the biodegradability of wastewaters containing non-biodegradable organics. Besides, AOPs may inactivate pathogenic microorganisms without adding additional chemicals to the water during disinfection, avoiding the formation of hazardous by-products. This Special Issue of Processes aims to cover recent progress and novel trends in the field of AOPs, including UV/H<sub>2</sub>O<sub>2</sub>, O<sub>3</sub>, sulphate-radical oxidation, nanotechnology in AOPs, heterogeneous photocatalysis, sonolysis, Fenton, photo-Fenton, electrochemical oxidation, and related oxidation processes. The topics to be addressed in this Special Issue of Processes may also include the application of AOPs at various scales (laboratory, pilot, or industrial scale), the degradation of emerging contaminants in water and wastewater and pollutants in the gas phase, the quantification of toxicity in residuals, the development of novel catalytic materials and of hybrid processes, including the combination of AOPs with other technologies, process intensification, and the use of photo-electrochemical processes for energy production.

*Advanced catalytic oxidation processes : [1st European  
Conference on Environmental Applications of Advanced Oxidation  
Processes (EAAOP-1) held in Chania (Crete, Greece) from 7 to 9  
September 2006]* CRC Press

Advanced oxidation processes (AOPs) are considered to be vital methods for treating the contaminations produced mainly by the human activities. In present-day, UV light or solar light, bulk and nano- photocatalysts are often used to enhance this technology by creating the highly reactive species such as the hydroxyl radicals. Extreme hydroxyl radical is considered as a key to start the photoreaction. Photoreaction is widely used in treatment of Lab and industrial contaminations, preparation of compounds and produced the renewable energy, so it, is classified as green technique. In order to improve the efficiency of this reaction with fabrication the surface of the used photocatalyst such as metal doped, sensitized and produced a composite as bulk catalyst or nano catalyst.

*Advanced Oxidation Processes for Effluent Treatment Plants* Royal Society of Chemistry

Advanced oxidation processes (AOPs) are promising techniques that can be used for various environmental applications. Currently, AOPs are receiving extensive interest from many researchers mainly due to their non-selective behaviour, their potential for pollutant oxidation, and the lack of solid waste formation in the majority of them. However, there are some knowledge gaps in the scientific literature, such as the efficiency and applicability of AOPs for real environmental water and/or wastewater matrices, the effectiveness of AOPs for toxicity reduction, the influence of environmental conditions and constituents on AOPs, cost of studied treatment methods, etc. This reprint presents original research papers and reviews focused on various environmental applications of AOPs, including comprehensive reviews on specific AOP technologies, focusing on their applications in specific sectors, such as industrial, agricultural, and municipal wastewater. A dedicated chapter is focused on the application of AOPs for toxicity reduction. The application of AOPs for the removal of organic pollutants such as Contaminants of Emerging Concern, pesticides, or dyes from water matrices of diverse origin is featured in the present reprint as specific chapters. Also, two chapters are dedicated to the innovative application of AOPs in the field of greenhouse gas

reduction.

*Trends in Environmental Applications of Advanced Oxidation  
Processes* John Wiley & Sons

Population growth and industrial development have increased the amount of wastewater generated by urban areas, and one of the major problems facing industrialized nations is the contamination of the environment by hazardous chemicals. Therefore, to meet the standards, suitable treatment alternatives should be established. Advanced Oxidation Processes (AOPs) in Water and Wastewater Treatment is a pivotal reference source that provides vital research on the current, green, and advanced technologies for wastewater treatment. While highlighting topics such as groundwater treatment, environmental legislation, and oxidation processes, this publication explores the contamination of environments by hazardous chemicals as well as the methods of decontamination and the reduction of negative effects on the environment. This book is a vital reference source for environmental engineers, waste authorities, solid waste management companies, landfill operators, legislators, environmentalists, and academicians seeking current research on achieving sustainable management for wastewater treatment.

*Chemical Oxidation Applications for Industrial Wastewaters* Mdpi AG

As society has become increasingly concerned with the protection and preservation of the environment, many industries have been pushed to comply with new policies and social demands for more environmentally-friendly and sustainable practices and products. However, the textile dyeing industry remains a significant source of complex environmental issues with legislative requirements that often vary in detail and severity concerning the exposure and hazards of potentially harmful chemicals and other associated materials. It is vital that the industry sector involved in the application of dyes continues to be sensitive to potential adverse effects on the environment in its widest sense and respond accordingly. Impact of Textile Dyes on Public Health and the Environment is an essential reference source that focuses on the environmental impact and social responsibility of the dyeing

industry. While highlighting topics such as toxicology, bleaching, and greenhouse gases, this publication is ideally designed for chemists, industrialists, non-governmental organization members, environmentalists, fashion designers, clothes manufacturers, scientists, academicians, researchers, students, and practitioners seeking current research on dyeing's potentially adverse effects on the environment and strategic, effective responses.

**Environmental Applications of Advanced Oxidation Processes - EAAOP 3** Elsevier

Provides a comprehensive overview of key methods for treating water tainted by cyanobacteria and cyanotoxins Toxigenic cyanobacteria are one of the main health risks associated with water resources. Consequently, the analysis, control, and removal of cyanobacteria and cyanotoxins from water supplies is a high priority research area. This book presents a comprehensive review of the state-of-the-art research on water treatment methods for the removal of cyanobacteria, taste and odor compounds, and cyanotoxins. Starting with an introduction to the subject, *Water Treatment for Purification from Cyanobacteria and Cyanotoxins* offers chapters on cyanotoxins and human health, conventional physical-chemical treatment for the removal of cyanobacteria/cyanotoxins, removal of cyanobacteria and cyanotoxins by membrane processes, biological treatment for the destruction of cyanotoxins, and conventional disinfection and/or oxidation processes. Other chapters look at advanced oxidation processes, removal/destruction of taste and odour compounds, transformation products of cyanobacterial metabolites during treatment and integrated drinking water processes. Provides a comprehensive overview of key methods for treating water tainted by cyanobacteria and cyanotoxins Bridges the gap between basic knowledge of cyanobacteria/cyanotoxins and practical management guidelines Includes integrated processes case studies and real-life examples Developed within the frame of the European Cooperation in Science and Technology (COST)-funded CYANOCOST A must-have resource for every water treatment plant, *Water Treatment for Purification from Cyanobacteria and Cyanotoxins* is a valuable resource for all researchers in water chemistry and engineering, environmental chemistry as well as water companies and authorities, water resource engineers and managers, environmental and public health protection organizations.

*2nd European Conference on Environmental Applications of Advanced Oxidation Processes : (EAAOP-2)* Mdpi AG

This topic has tried to know the current state-of-the-art advanced oxidation technologies and the green technological solutions that can be offered at the industrial level for today's society. It is a multidisciplinary topic that has collaborated with several journals, including "Catalysts, Processes, Sci, International Journal of Environmental Research and Public Health, and Water," to cover the broad areas of solutions/applications that the current state-of-the-art technology offers.

**Application of Different Advanced Oxidation Processes for the Degradation of Organic Pollutants** CRC Press

This volume reviews the drinking water treatments in which AOPs display a high application potential. Firstly it reveals the typical supply sources and limitations of conventional technologies and critically reviews natural organic matter characterization and removal techniques, focusing mainly on AOP treatments. It then explores using AOPs for simultaneous inactivation/disinfection of several types of microorganisms, including highly resistant *Cryptosporidium* protozoa. Lastly, it discusses relevant miscellaneous topics, like the most promising AOP solid catalysts, the regime change of Fenton-like processes toward continuous reactors, the application of chemometrics for process optimization, the impact on disinfection byproducts and the tracing of toxicity during AOP treatments. This work is a useful reference for researchers and students involved in water technologies, including analytical and environmental chemistry, chemical and environmental engineering, toxicology, biotechnology, and related fields. It is intended to encourage industrial and public-health scientists and decision-makers to accelerate the application of AOPs as technological alternatives for the improvement of drinking water treatment plants.

**Water Treatment for Purification from Cyanobacteria and Cyanotoxins** IGI Global

The use of Advanced Oxidation Technologies (AOTs) for wastewater treatment is an important area of research which has not yet been fully exploited at an industrial level and has significant potential in the disposal of many industrial effluents. In particular, this includes effluents that are difficult to treat by conventional biological treatment processes. This reprint covers the latest advances in the field of wastewater treatment by

Advanced Oxidation Technologies, with a focus on treatments based on photolysis, TiO<sub>2</sub>/solar light, ozone/ultraviolet irradiation, oxidant/ultraviolet irradiation, oxidant/catalyst/ultraviolet irradiation, high-energy electron beam irradiation (E-beam), sonication/photocatalysis, etc.

Advanced Oxidation Technologies CRC Press

*Advanced Oxidation Processes for Waste Water Treatment: Emerging Green Chemical Technology* is a complete resource covering the fundamentals and applications of all Advanced Oxidation Processes (AOPs). This book presents the most up-to-date research on AOPs and makes the argument that AOPs offer an eco-friendly method of wastewater treatment. In addition to an overview of the fundamentals and applications, it details the reactive species involved, along with sections on reactor designs, thus helping readers understand and implement these methods. Presents in-depth coverage of all types of Advanced Oxidation Processes, including Super Critical Water Oxidation, Photo-Fenton and Like Processes Includes a fundamental review, applications, reactive species and reactor designs Reviews applications across waste types, including industrial waste, domestic and municipal sewage, and hospital wastes

Persulfate-based Oxidation Processes in Environmental Remediation Mdpi AG

Municipal wastewater is being increasingly emphasized as a local, reliable source water supply for potable water. Potable reuse facilities frequently employ Full Advanced Treatment (FAT) trains, most often including microfiltration (MF), reverse osmosis (RO) and the UV/hydrogen peroxide (UV/H<sub>2</sub>O<sub>2</sub>) advanced oxidation process (AOP). However, the widespread implementation of FAT treatment is hindered by two major challenges: high cost and the disposal of RO concentrate (ROC). In this dissertation, we evaluated the potential of emerging AOPs, including ozonation followed by biological activated carbon (O<sub>3</sub>/BAC), the UV/chloramines AOP, and the UV/free chlorine AOP to deal with these two major challenges for FAT trains. We evaluated the application of O<sub>3</sub>/BAC to remove nitrate and organic contaminants from ROC to facilitate disposal to marine waters. We characterized the ability of the UV/chloramines and the UV/free chlorine AOPs to serve as more efficient alternatives to the UV/H<sub>2</sub>O<sub>2</sub> AOP for the treatment of RO permeate. Chapter 1 introduces the FAT treatment process train, two of the major

challenges facing these FAT trains, emerging AOPs to address these challenges, existing knowledge gaps and the objectives of this dissertation. Chapter 2 evaluates the feasibility of O3/BAC to treat RO concentrate at pilot-scale. The results suggest the potential for substantial synergy between potable reuse, and the removal of nitrogen and organic contaminants, enabling utilities to meet regulatory limits while partially offsetting the costs of producing a potable water supply. Chapter 3 develops a kinetic model for the UV/chloramines AOP when applied to RO permeate. The model is able to simultaneously predict the loss of chloramines and contaminants, such as 1,4-dioxane by determining quantum yields for chloramines and incorporating the subsequent reactions of NH<sub>2</sub> radical. Initial cost estimates based on bench-scale results indicate UV/chloramines AOP using the residual chloramines in RO permeate could be a cost-effective alternative to the current UV/H<sub>2</sub>O<sub>2</sub>-chloramines AOP in some cases depending on the background chloramines concentrations and other constituents in RO permeate. Chapter 4 evaluates UV/free chlorine and UV/chloramines AOPs as alternatives to the UV/H<sub>2</sub>O<sub>2</sub> AOP for treatment of RO permeate at pilot-scale. First, we characterized the speciation of the oxidants during AOP treatment and validated the ability of our kinetic models to accurately predict oxidant speciation. Second, we evaluated the ability of the different AOPs to degrade important target contaminants, such as 1,4-dioxane. Initial cost estimates indicate the UV/free chlorine AOP treatment to achieve 0.5-log 1,4-dioxane removal would be nearly half the cost for UV/H<sub>2</sub>O<sub>2</sub> AOP. The cost for UV/chloramines AOP treatment could be comparable to UV/H<sub>2</sub>O<sub>2</sub> AOP. Third, we demonstrated that after AOP treatment and chloramination for distribution systems, total halogenated DBP formation was comparable between these three AOPs. Chapter 5 summarizes the findings and contributions of this dissertation and proposes the issues that need to be addressed in future research to better understand the feasibility of these emerging AOPs in practice and to enable scale-up.

Advanced Oxidation Processes for Wastewater Treatment  
Springer

This book covers the most recent scientific and technological developments (state-of-the-art) in the field of chemical oxidation processes applicable for the efficient treatment of biologically-difficult-to-degrade, toxic and/or recalcitrant effluents originating

from different manufacturing processes. It is a comprehensive review of process and pollution profiles as well as conventional, advanced and emerging treatment processes & technologies developed for the most relevant and pollution (wet processing)-intensive industrial sectors. It addresses chemical/photochemical oxidative treatment processes, case-specific treatability problems of major industrial sectors, emerging (novel) as well as pilot/full-scale applications, process integration, treatment system design & sizing criteria (figure-of-merits), cost evaluation and success stories in the application of chemical oxidative treatment processes. *Chemical Oxidation Applications for Industrial Wastewaters* is an essential reference for lecturers, researchers, industrial and environmental engineers and practitioners working in the field of environmental science and engineering. Visit the IWA WaterWiki to read and share material related to this title: <http://www.iwawaterwiki.org/xwiki/bin/view/Articles/CHEMICALOXIDATIONAPPLICATIONSFORINDUSTRIALWASTEWATERS> Authors: Professor Olcay Tünay, Professor Isik Kabdasli, Associate Professor Idil Arslan-Alaton and Assistant Professor Tugba Ölmez-Hanci, Environmental Engineering Department, Istanbul Technical University, Turkey.

Environmental Applications of Advanced Oxidation Technologies  
IWA Publishing

The suitability of Advanced Oxidation Processes (AOPs) for pollutant degradation was recognised in the early 1970s and much research and development work has been undertaken to commercialise some of these processes. AOPs have shown great potential in treating pollutants at both low and high concentrations and have found applications as diverse as ground water treatment, municipal wastewater sludge destruction and VOCs control. *Advanced Oxidation Processes for Water and Wastewater Treatment* is an overview of the advanced oxidation processes currently used or proposed for the remediation of water, wastewater, odours and sludge. The book contains two opening chapters which present introductions to advanced oxidation processes and a background to UV photolysis, seven chapters focusing on individual advanced oxidation processes and, finally, three chapters concentrating on selected applications of advanced oxidation processes. *Advanced Oxidation Processes for Water and Wastewater Treatment* will be invaluable to readers interested in water and wastewater treatment processes,

including professionals and suppliers, as well as students and academics studying in this area. Dr Simon Parsons is a Senior Lecturer in Water Sciences at Cranfield University with ten years' experience of industrial and academic research and development. **Emerging Application of Advanced Oxidation Processes for the Potable Reuse of Municipal Wastewater** IGI Global  
Advanced Oxidation Technologies (AOTs) or Processes (AOPs) are relatively new and innovative technologies to remove harmful and toxic pollutants. The most important processes among them are those using light, such as UVC/H<sub>2</sub>O<sub>2</sub>, photo-Fenton and heterogeneous photocatalysis with TiO<sub>2</sub>. These technologies are also relatively low-cost and therefore useful for countries under development, where the economical resources are scarcer than in developed countries. This book provides a state-of-the-art overview on environmental applications of Advanced Oxidation Technologies (AOTs) as sustainable, low-cost and low-energy consuming treatments for water, air, and soil. It includes information on innovative research and development on TiO<sub>2</sub> photocatalytic redox processes, Fenton, Photo-Fenton processes, zerovalent iron technology, and others, highlighting possible applications of AOTs in both developing and industrialized countries around the world in the framework of "A crosscutting and comprehensive look at environmental problems". The book is aimed at professionals and academics worldwide, working in the areas of water resources, water supply, environmental protection, and will be a useful information source for decision and policy makers and other stakeholders working on solutions for environmental problems.

**Environmental Applications of Advanced Oxidation Processes - EAAOP4** John Wiley & Sons

*PHOTOREACTORS IN ADVANCED OXIDATION PROCESSES* Unique book covering topics related to the evolving photoreactors concepts, design, and application as well as green synthesis of heterogenous photocatalysts which are the key aspects to facilitate the escalation of bench scale works toward industrial/commercial applications. In this book, the editors present the most up-to-date research on Advanced Oxidation Processes (AOPs) to make the argument that AOPs offer an eco-friendly method of wastewater treatment. In addition to an overview of the fundamentals and applications, it provides ample details of the reactive species involved in AOPs as well as reactor

design concepts, thus providing readers with the necessary tools to better understand and implement these methods. Moreover, this book presents some conventional and novel photoreactors equipped with UV/vis lamps for working under solar radiation for wastewater treatment in a laboratory and on an industrial scale, which is an important focus of the book. Readers will find in this book: In-depth coverage of the performance of sustainable eco-friendly and low-cost heterogeneous photocatalysts (biogenic photocatalysts); A state-of-the-art fundamental review of parameters affecting photoreactor designs for the effective performance of reactive species; Identifies, formulates, and analyzes developed processes and technologies to meet desired environmental protection needs of society and formulates solutions that are technically sound, economically feasible, and socially acceptable. Audience This book will be of interest to academic researchers and graduate students from the fields of environment, chemistry, and engineering, and professionals including environmental managers in industry, water treatment plants managers and operators, water authorities, government regulatory bodies, and environmentalists.

*Photochemical Purification of Water and Air* John Wiley & Sons While the treatment of water and exhaust gas using ultraviolet (UV) light offers both ecological and economic advantages, information on photo-initiated advanced oxidation technologies (AOTs) has been dispersed among various journals and proceedings until now. This authoritative and comprehensive handbook is the first to cover both the photochemical fundamentals and practical applications, including a description of advanced oxidation processes (AOPs) and process engineering of suitable photoreactors. The author presents various real-world examples, including economic aspects, while many references to current scientific literature facilitate access to current research topics relevant for water and air industries. Throughout, over 140 detailed figures visualize photochemical and photophysical phenomena, and help in interpreting important research results.

From the foreword by James R. Bolton (President of Bolton Photosciences Inc., Executive Director of the International Ultraviolet Association (IUVA)): "Prof. Oppenländer is well qualified to write about the AOPs/AOTs, since he has contributed to this literature in a very significant manner. This book will be of considerable value to graduate students, science and engineering faculty, scientists, process engineers and sales engineers in industry, government regulators and health professionals."

**Application of Advanced Oxidation Processes for Treatment of Air from Livestock Buildings and Industrial Facilities** Academic Press

Advanced Oxidation Processes for Effluent Treatment Plants provides a complete overview of the recent advances made in oxidation-based water treatment processes, including their limitations, challenges and potential applications in removing environmental pollutants. The book introduces new trends and advances in environmental bioremediation technology with a thorough discussion of recent developments in this field, with multiple biological and chemical wastewater treatment processes presented in detail. Additionally, every chapter explains the wastewater treatment plants that utilize these methods, illustrating them in terms of plant size, layout, design and installation location. New trends and advances in environmental bioremediation technology are also covered. This is the go-to resource for engineers and scientists requiring an introduction to the principles of environmental bioremediation technologies. Illustrates the importance of various advanced oxidation processes in effluent treatment plants Highlights the reuse and recovery of resources from wastewater Examines the occurrence of novel micro-pollutants Emphasizes the role of nanotechnology in the bioremediation of pollutants Introduces new trends in environmental bioremediation

*Application of Advanced Oxidation Processes for Treatment of Air from Livestock and Industrial Facilities* IWA Publishing

Application of Different Advanced Oxidation Processes for the Degradation of Organic Pollutants.

*Advanced Oxidation Processes for Wastewater Treatment* IWA Publishing

Photocatalysts in Advanced Oxidation Processes for Wastewater Treatment comprehensively covers a range of topics aiming to promote the implementation of photocatalysis at large scale through provision of facile and green methods for catalysts synthesis and elucidation of pollutants degradation mechanisms. This book is divided into two main parts namely "Synthesis of effective photocatalysts" (Part I) and "Mechanisms of the photocatalytic degradation of various pollutants" (Part II). The first part focuses on the exploration of various strategies to synthesize sustainable and effective photocatalysts. The second part of the book provides an insights into the photocatalytic degradation mechanisms and pathways under ultraviolet and visible light irradiation, as well as the challenges faced by this technology and its future prospects.

*Industrial Applications of Advanced Oxidation Technologies* BoD - Books on Demand

Wastewater in the food industry contains recalcitrant organic compounds and a certain degree of toxicity. Present wastewater treatment plants are insufficient in dealing with the increasing complexity of effluents from modern food industries. Improperly treated wastewaters can lead to spoil soil and are threats to aquatic life. The reaction of these recalcitrant chemicals with reactive radicals is an efficient treatment strategy. Researchers have proposed advanced oxidation processes (AOPs) that generate reactive radicals including ozonation, UV irradiation, (photo-) Fenton process, etc. This chapter reviews laboratory-scale and pilot-scale AOPs to incorporate with conventional pre-treatment methods and to evaluate their effectiveness and factors including operation condition and catalysts to optimize the process. Further research related to novel catalyst synthesis and cost evaluation of pilot-scale study is suggested.