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Book Review
Advanced Technologies for Solid, Liquid, and Gas Waste Treatment

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ABSTRACT

There is an urgent need to develop effective ways to efficiently recycle the world's limited resources in the solid, liquid and gaseous phases to achieve sustainability. This could be achieved in accordance with allowable effluent standards, economic considerations and long service life through either single units or hybrid (integrated) units. In this regard, this book is a valuable resource for both academic and industrial researchers, bringing together the latest developments in compost, advanced oxidation, reactive membrane, adsorptive, electrocoagulative, and pyrolytic processes for the treatment of solid wastes, wastewater, and toxic gases. The strengths and weaknesses of the technologies are compared throughout the 15 chapters with extensive tabulated data from the literature and well-illustrated figures. Recommendations for the future and challenges are provided at the end of each section.

BOOK SUMMARY

Chapter 1 describes the entire chain of the composting process, followed by the composting process itself and its subsequent applications (i.e., soil amendment, bioremediation, and landfill cover) on the basis of the contents. Chapter 2 focuses on the integrated management of the electronic and electric waste by means of artificial intelligence. Chapter 3 identifies methods for the thermal conversion of solid waste into energy. The processes and technologies for the recycling of the waste tires including thermochemical conversions into useful energy are presented in Chapter 4. Removal of organic compounds from municipal wastewater by means of electro-fenton, electrocoagulation, anodic oxidation, and combined processes are discussed in Chapter 5.

Chapter 6 focuses on the recent advances in photocatalytic membranes for the treatment of Emerging Pollutants (EPs). The mechanism of photocatalysis is briefly explained. The photocatalyst and the membrane are then combined to form a photocatalytic membrane reactor (PMR) and their synergistic effects are exploited in two birds with one stone approach to the elimination of particle agglomeration and membrane fouling. Two different routes for the preparation of PMRs as shown in Figure 1, are extensively reviewed with their own advantageous/disadvantageous

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properties during fabrication and application. For example, cephalexin is reported to be observed in the order of removal rate from high to low using the spin coating method, interfacial polymerization method, graft polymerization method and blending method, respectively. Readers can find significant inferences within the chapter, such as blending membrane has high flux, the interfacial polymerization membrane has high fouling resistance, the graft polymerization membrane has high photocatalytic degradation and the spin coating membrane has high separation properties. In addition, superior removal efficiencies of the hybrid membranes containing different nanomaterials for pesticides, antibiotics, and dyes are highlighted. The photocatalytic degradation of semi-volatile organic compounds (s-VOCs), including nitrobenzene, in aqueous solution by membrane distillation is also pointed out. At the end of the chapter, the challenges faced by PMRs in the treatment of EPs are highlighted for the importance of the manufacturing process, including the use of natural materials for sustainability, well-dispersed photocatalysts without agglomeration in the membrane matrix, photocatalysts that do not leak from the membrane matrix during application, and membranes that allow high light penetration. PMRs provide active cleaning during filtration that eventually extends the long lasting of the membranes. Comparison of the initial activity with the activity obtained in subsequent uses is important for the stability of the catalyst can be interesting if discussed.

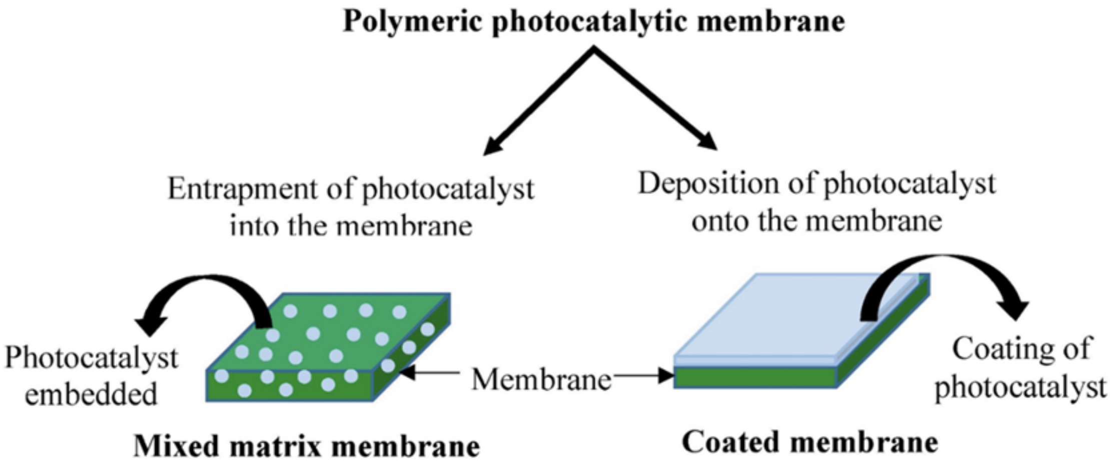

Figure 1 Fabrication methods of PMRs

In Chapter 7, advanced oxidation processes (AOP), alone or in combination with O_3, ultraviolet (UV), H_2O_2, ultrasound and photocatalysts for their degrading efficiencies against persistent pharmaceuticals and personal care products (PPCPs) by comparing their reaction rate constants are discussed. The use of •OH scavengers are also recommended to increase the degradation efficiency of the targeted molecules. Types of the photocatalytic membrane reactors (Figure 2) including photocatalysts in suspension form in the feed reservoir, photocatalysts deposited on a membrane surface, or embedded in membrane pores, with UV irradiation are well summarized. The cost of the UV/TiO_2 suspension system in water and wastewater treatment in terms of electricity consumption is found to be higher than the other systems including UV/H_2O_2 and O_3/H_2O_2, requires further investigation into the selectivity, activity, and durability of the photocatalytic membrane reactors consisting of visible light responsive photocatalysts by combining auxiliary catalysts and transition metals via N-doping or other techniques.

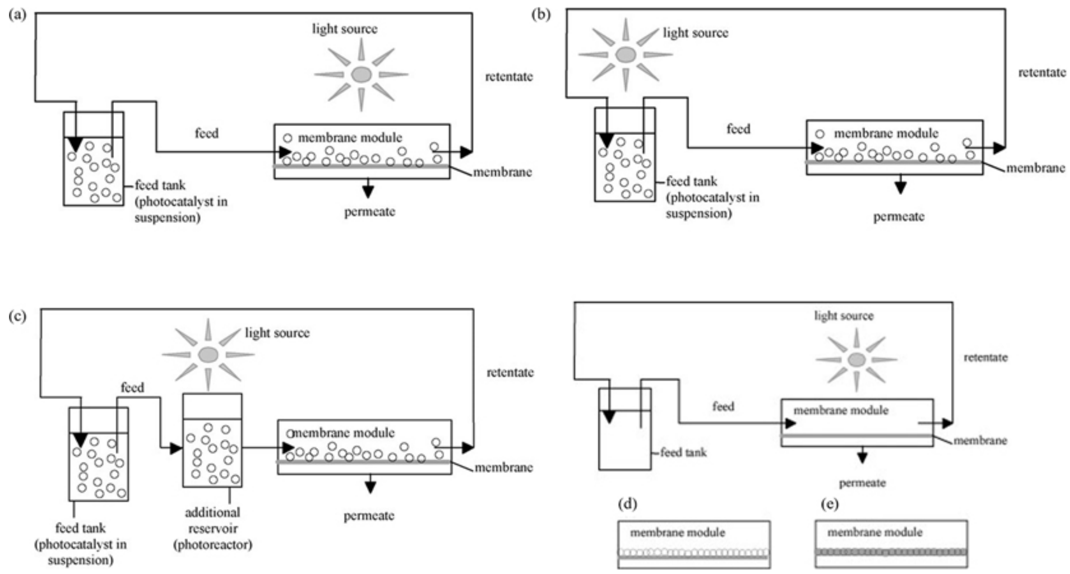

Figure 2 PMR utilizing photocatalyst in suspension: (a) irradiation of the membrane module; (b) irradiation of the feed tank; (c) irradiation of the additional reservoir (photoreactor) located between the feed tank and membrane module. PMR utilizing photocatalyst immobilized (d) on a membrane and (e) within a membrane structure

Chapter 8 focuses on membrane bioreactor (MBR) technologies and discusses their feasibility, configurations, and performance in various types of wastewater treatment. Classifications on the basis of removal mechanisms and membrane materials and modules are extensively described. The advantages and major limitations of conventional and novel MBR configurations shown in Figure 3 are well documented and tabulated in Table 1. The impact of carbon/nitrogen ratio, feed composition and flow rate on operational control, high costs, membrane fouling and the changing nature of wastewater discharges are summarized as challenges to be addressed.

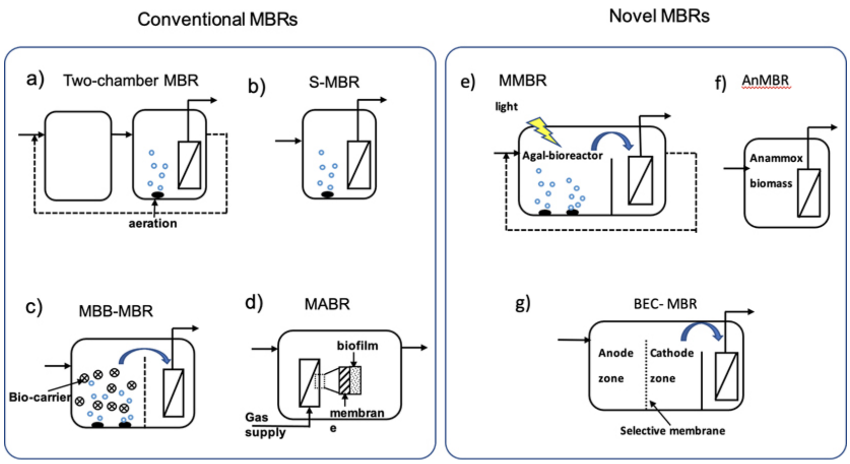

Figure 3 Conventional and novel MBR configurations for wastewater treatment (a) two-chamber MBR; (b) single chamber MBR for nitrogen removal; (c) moving-bed biofilm MBR; (d) membrane aerated biofilm reactor; e) microalgae MBR; (f) anaerobic MBR; and (g) bio-electrochemical MBR.

Table 1 A Summary of MBRs Used in Wastewater Treatment Processes

Type of MBR	Scale	Membrane module	Advantages	Major limitations
Two-chamber MBR	Lab/pilot/full	Flat sheet	Easy to upgrade from conventional activated sludge system	May need external carbon and internal sludge recycle
S-MBR	Lab/pilot/full	Hollow fiber	Small footprint	May need external carbon and intermittent aeration for nutrients removal
MBB-MBR	Lab/pilot	Hollow fiber	Retain high biomass, higher treatment reliability and ease of operation with flexible loading, no requirement for recycling	Membrane fouling may be more severe than conventional MBRs
MABR	Lab/pilot	Hollow fiber	Improved oxygen utilization efficiency, Efficient nitrogen removal at low carbon to nitrogen ratios, potential to be integrated with AnMBRs	Biofilm management is critical to maintain high flux and nutrients removal performance
MMBR	Lab/pilot	Flat sheet Hollow fiber	Decouples HRT and SRT, which enables higher microalgae concentrations for harvesting	Difficult to maintain the system at steady state due to the complexity of the intraspecies relationship among algae and bacteria
BEC-MBR	Lab	Electrically conductive UF/MF membranes	Potential electricity production, potential lower energy cost, potential lower membrane fouling	High cost of the membrane, energy demand for aeration.
AnMBR	Lab	Hollow fiber	Lower energy requirement, less biomass production, potential to decrease membrane fouling, ideal to grow AnAOB, potential to be integrated with MABR	Hard to achieve steady performance when treating real wastewater, most of studies are lab-scale

Advanced oxidation, including ozonation and Fenton processes, prior to the anaerobic digestion of palm oil mill effluent (POME) is discussed in Chapter 9 to improve the biogas yield. Chapter 10 reviews electrocoagulation processes, including Peroxi-electrocoagulation, Photo-electrocoagulation, and Sono-electrocoagulation, with their applications in food wastewater treatment. Opportunities and challenges regarding economic, environmental and technical aspects are emphasized. Chapter 11 provides an insight in the technologies similar to those in Chapter 7 for the degradation of per- and polyfluoroalkyl substances (PFAS) in aqueous environments. Photocatalytic degradation of oily wastewater with metal oxides is presented in Chapter

12. In Chapter 13, the conventional technologies used in air cleaning and recycling are comparatively examined in terms of energy and cleaning efficiencies towards sustainability and climate protection. Recent advances in automotive De-NOx SCR processes are presented in Chapter 14, through catalyst development and process design. The final chapter discusses air pollutants emission, treatments and controls, and describes the latest technologies used to clean syngas.

FINAL REMARKS

The valuable nutrient and energy content of waste streams motivates sectors to pursue research into robust materials and effective processes. The human perspective on the sources of waste has now shifted to that of a recoverable resource rather than a pollutant that needs to be disposed of. In this regard, this book presents various types of processes for the removal of contaminants that are present in solid, liquid, and gaseous environments. It could be the vital references for the academicians, researchers, students, and practitioners. Photocatalytic membranes and membrane bioreactors are the two robust units that are well presented here, with their basic principles and performances collected from recent articles. Membrane processes have potential to provide greater processing efficiencies and improved outcomes. In PMR, the membrane acts as a restraint for the photocatalytic powder in the reacting suspension, a selective barrier for the separation of the photoreaction products and/or a support for the photocatalyst. The focus of recent studies has been on visible light-sensitive photocatalysts, which will increase the selectivity of the catalysts, and the use of sunlight by the catalysts will reduce the cost of the process. On the other hand, advanced membrane bioreactors offer promising solutions for the conversion of wastewater into a resource of water, nutrients and energy, if the operational control obstacles caused by the variation of feed composition and flow rate in real wastewater could be overcome. The high cost of MBR due to installation, maintenance, extensive pre-treatment and increased automation will be the subject of research through the selection of environmentally friendly materials, the development of a model to take into account process variables that affect performance, and new advances in data analytics and artificial intelligence.

REFERENCE

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