Preface

The frequent incidence of hazardous chemicals in wastewater produced by anthropogenic and industrial activities is of great concern because these pollutants contaminate lakes, rivers, and underground aquifers; furthermore, currently more pollutants, including traces of contaminants ranging from pharmaceutical drugs, hormones, and sunscreen to pesticides and dyes, are being detected at smaller concentrations in freshwater bodies. In addition, many of these contaminants are recalcitrant compounds, which cannot be degraded by the conventional methods of wastewater treatment; thus, many treated effluents that are considered "safe" for disposal still contain several toxic (bioactive) pollutants. In general, these compounds are undetectable when ingested or absorbed by living organisms and are subsequently accumulated, causing adverse health effects. Therefore, considerable efforts have been devoted to the development of a suitable environmentally friendly, clean purification process that can destroy these recalcitrant organic contaminants from wastewater to reduce the risk of pollution and toxicity.

Advanced oxidation processes (AOPs) have been proposed as alternative methods for the elimination of many toxic organic compounds in wastewater. The principle of AOPs is to produce hydroxyl radicals in water, a very powerful oxidant capable of oxidizing a wide range of organic compounds with no selectivity.

Among these AOPs, heterogeneous photocatalysis employing semiconductor materials has demonstrated its efficiency in degrading a wide range of indistinct refractory organics into readily biodegradable compounds and eventually mineralizing them to innocuous carbon dioxide and water. In this process, a semiconductor is activated with UV-Vis radiation, and a photoexcited electron is promoted from the valence band to the conduction band, forming an electron/hole pair (e^-/h^+). The photogenerated pair is able to reduce and/or oxidize a compound adsorbed on the photocatalyst surface.

Although heterogeneous photocatalysis has been actively investigated as a promising antibacterial, self-cleaning, and deodorization system, the applications of such photocatalytic process are mostly needed for the purification of water to remove pollutants and bacteria, since this will allow for the safe reuse of this scarce liquid.

However, the key point of the heterogeneous photocatalysis is the material to be used as a catalyst which must be a semiconductor with photocatalytic properties. A photocatalyst is defined as a substance that is able to produce, by the absorption of light quanta, chemical transformations of the reaction participants, repeatedly coming with them into intermediate chemical interactions and regenerating its chemical composition after each cycle of such interactions. The physicochemical properties of the material are crucial for a good performance, and these are usually established according to the photocatalyst nature (composition, size, shape, morphology) and the source of the material.

In the first part of this book, the fundamental principles that govern the physicochemical properties of semiconducting photocatalytic materials are presented (Chaps. 1 and 2) with special emphasis on titanium dioxide, since up to now, this material is the most widely used for photocatalytic applications. However, being aware of the numerous photocatalytic materials with activity under visible light that have been proposed lately, in Chap. 2 some general aspects related to these materials are discussed.

Knowledge of the different synthetic methods employed for the preparation of photocatalytic materials is considered essential, since it is well known that depending upon the production procedure, it can be easily controlled for the development of certain properties in the photoactive material, or facilitate the formation of powders or thin layers with the required characteristics that improve the performance of the catalyst in the photocatalytic process. Therefore, Chap. 3 is devoted to describe a variety of techniques which can be used for photocatalytic semiconductor preparation. Also, some recent examples of the material's preparation exploring the different techniques are included.

There are three key steps in the development of photocatalytic materials: material's preparation, property characterization, and material's activity evaluation. Characterization can be divided in two main categories, structure analysis and property measurements. Structure analysis can be conducted by means of microscopy and spectroscopy techniques, while property characterization can be carried out using electrochemical techniques. In Chaps. 4 and 5 the most common characterization techniques are briefly described including the fundamentals and their applications.

Chapters 6–8 are related to articles dealing with the application of photocatalytic semiconductors on water treatment and disinfection. Finally, in the last part of the book (Chap. 9), some perspectives for photocatalytic materials from the economic and toxicological point of view are discussed.

We hope that our book will be useful to students and researchers who are currently working on the development and/or improvement of photocatalytic materials. We also would like that this book would serve as a general introduction for people just entering the field of photocatalytic materials with environmental applications.

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