Chapter 29
Electrochemical Technologies for Industrial Effluent Treatment

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ABSTRACT

Electrochemical processes are the most adequate tools in the aqueous effluent treatment. The process will not require chemical addition and indeed electrons are the only reactants added to the process to stimulate the reaction. Anodic oxidation of recalcitrant wastewater in a typical electrochemical set-up is particularly interesting because of its ease of operation and scope for scale-up. Nevertheless, electro oxidation in the three-dimensional carbon bed electrodes is a promising process for electrooxidation of effluents containing non-biodegradable organic compounds. The application of three-dimensional carbon bed electrochemical reactor for the degradation of organic pollutant is demonstrated in this chapter. The role of carbon particles in the three-dimensional electrodes reactor is described in this chapter. It has at least two important functions: 1) adsorption of organic compounds from effluents and 2) act as particle electrode. Various operation and design considerations leading to better understanding of carbon bed electrochemical reactors are discussed.

INTRODUCTION

Water Pollution and Organic Pollutants

Water pollution may be defined as presence of measurable amounts of chemicals, solids, gases other than hydrogen and oxygen in the water. The sources of water pollution are categorized as being a point source or a non- point source. When the polluting substance is emitted directly into the waterway from an identifiable source, it is called as point source. A pipe spewing toxic chemicals directly into a river is an example. A ‘non-point source’ is addressed when there is runoff of pollutants into a waterway, for instance when fertilizer from a field is carried into a stream by surface runoff.

The intensification of industrial activities, since the latter half of the 19th century and throughout

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the 20th century, has inevitably caused severe environmental pollution with drastic consequences in atmosphere, waters, and soils. With a rapidly growing world population and an increasing number of reports on detrimental effects on the environment, its protection has become a major issue and a crucial factor for future technological progress, which will have to meet the requirements for sustainable development. The strategies for environmental protection in industry generally include processes for waste treatment as well as development of new processes or products which have no or less harmful effects on the environment. The consequent restrictions imposed by legislation require effective initiatives for pollution reduction. Typically different classes of pollutants may have accumulated during long periods of uncontrolled waste disposal and reclamation may represent a serious technological problem. Due to the extremely diverse features of pollution phenomena, universal strategies of reclamation have not been developed (Manahan, 1999).

The waste discharge that first comes to mind in any discussion of stream pollution is the discharge of domestic wastewater; a wastewater that contains a large amount of organic wastes. Industry also contributes substantial amounts of organic wastes. Some of these organic industrial wastes come from chemical industry, textile industry, pharmaceutical industry, vegetable and fruit packing, dairy processing, meat processing & packing, tanning and processing of poultry, oil, paper, and fiber (wood) and many more. All organic materials have one thing in common - they all contain carbon. The presence of harmful organic species in water supplies and in the wastewater discharge from chemical industries, power plants and agricultural sources is of global concern (Hoffmann, Martin, Choi, & Bahnemann, 1995; Legrini, Oliveros, & Braun, 1993). According to Metcalf & Eddy (Metcalf, Eddy, & Tchobanoglous, 1979) in wastewater of medium strength, about 75% of the suspended solids and 40% of the filterable solids are organic in nature. Organics often present in wastewater include dyes, organic chemicals, proteins, lipids (oils and grease), carbohydrates, and detergents. More than 30% of this organic matter is non-biodegradable (Drinan & Spellman, 2000).

Organic contaminants have a major impact on effluent quality and treatment process efficiencies by:

- Contributing to high BOD and COD values.
- Influencing the appearance, color and odor of the effluent.
- Acting as a food source for micro-organisms, resulting in bacterial growth in process equipment and depletion of dissolved oxygen in water bodies.
- Interfering with the performance of activated carbon by competing with targeted compounds for active sites.
- Reacting with coagulants causing slower, less effective flocculation and increasing coagulant demand.
- Reacting with disinfectants, thus increasing chemical demand.
- Reducing the capacity of membrane filtration by fouling.

Thus, organic contaminant removal from effluents is necessary prior to discharge or reuse.

Wastewater Treatment Processes

The need for cleaning of water is particularly critical in developing countries. Rivers, canals, estuaries and other water bodies are being constantly polluted due to indiscriminate discharge of industrial effluents as well as other anthropogenic activities and natural processes. In recent years, the control and purification of water pollution has become an increasing concern. Highly developed countries are also experiencing a critical need for wastewater cleaning because of an ever-increasing population, urbanization and climatic changes. Both the treatment of wastewater prior to discharge

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