Chapter 11
Synthesis of Electrocatalysts for Electrochemistry in Energy

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ABSTRACT

The increasing population demands clean and green energy, encouraging scientists and technologists to make their best effort to develop renewable, available, and low-cost acquisition of non-conventional energy. Researchers in Catalysis and Electrochemistry, working together, have reached good achievements when focused in electrochemistry studies that are under development for alternative, renewable, capture, conversion, storage, supply, uses, and applications of energy. This is called Electrochemistry in energy. The symbiosis Electrochemistry-Catalysis is fundamental in this field for successful results. Important achievements are nowadays found in literature and some of them are reported here with emphasis in the use of electrochemistry for electrosynthesis of the named photoelectrocatalysts. Thus, photoelectrocatalysts, photocatalysts, and catalysts are of importance in many of the aspects involved in the term Electrochemistry in energy. This is such a wide field, with many aspects presented here, that the authors give an appropriate view and pedagogical standpoint for the readers.

INTRODUCTION

Electrochemistry (EC) is concerned with electrodic processes, ionic processes, and interfacial phenomena. An important topic is referred to energy supply, generally associated to electric energy getting from solar panels, wall electricity plugs, batteries, super capacitors, fuel cells and other devices. Indeed, the relation of electrochemistry with sources of energy is not only concerned with energy supply but also with capture, storage, and conversion. All these connections of energy getting (mainly natural, either directly or indirectly) and electrochemistry are involved in the term "Electrochemistry in energy".

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Electrochemistry in energy means the association, interrelation, interaction, complementation of electrochemistry – energy from natural sources and their applications. It includes, as mentioned, the capture, storage, conversion and supply of energy, its uses, and applications within the electrochemical field. In all these branches, catalysis and the use of catalysts are fundamental for successful results; therefore, wide details will be displayed in this chapter.

Electrochemistry is a good tool to prepare semiconductors that could be used in solar cells and many techniques for preparation are available (Márquez, & Márquez, 2012; Kemp, 1990: Velmurugan & Mirkin, 2010; Macdonald, 1977; Bard & Faulkner, 2001; Márquez, & Márquez, 2015). Regarding the capture and conversion of solar energy, it is possible to perform the electrochemical synthesis of catalyst semiconductors, including their modification, the use of photovoltaic, photoelectrolytic, electrolytic, and photolytic (electrochemically assisted) cells and incorporation of new catalysts for improvement of systems. Capture and conversion of solar radiation have mainly to do with the direct production of electricity and the synthesis of fuels.

The direct and indirect storage of natural energy can be performed in electrochemistry by using suitable catalysts as follows: synthesis of fuels, storage in batteries, super capacitors, other chemicals, and devices. The supply is provided from any of these mentioned sources and devices, including also the nowadays fuel cells.

A summary of all these processes is shown in Figure 1, according to the following sequence:

1. Capture and conversion of solar to electrical energy (photovoltaic using EC synthesized catalysts)
2. Storage of energy in batteries and super capacitors, catalysts supported
3. Conversion and storage of solar or electrical energy into chemicals by photo electrolysis (electrolysis into a photovoltaic cell, including photolysis EC assisted), by photovoltaic-electrolysis (electrolysis performed with electrical energy supplied by a photovoltaic cell) or by electrolysis (performed with assistance of any other electric source)
4. Conversion of chemical to electrical energy and supply of electricity (fuel cells) for different applications.

Figure 1 is a good example of the first thermodynamic law and the hydrogen cycle as fuel in electrochemistry in energy. Capture, Conversion, Storage, and Supply are involved in the Cycle. The Electrocatalysis has much to offer in all these processes.

In electrochemistry, great expectation exists for implementation of non-polluting, simple, efficient & economic synthetic methods with the use of solar energy as an energetic source. For that purpose, it is necessary:

- Development of materials for capture of energy and catalysts that are abundant, accessible, stables, durables, economics, recyclables, for redox processes
- Preparation, modification, and optimization of arrays
- Design and optimization of processes
- Design and construction of suitable devices

For oxidation of water, clusters of metals with redox activity have been used (Co_4, Ru_4, Fe_5), as well as mononuclear and tetra nuclear catalysts of cobalt. There are results on metallic oxide electrodes of Co, Ni, Fe, and their modifications, on molecular metallic complexes of Co, Ni, Mo, Cu, for the electrochemi-