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Semiconductor Properties of Natural Phosphate Application to Photodegradation of Basic Dyes in Single and Binary Systems

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Abstract : Heterogeneous photocatalysis over semiconductors has proved its effectiveness in the treatment of wastewaters since it works under soft conditions. It has emerged as a promising technique, giving rise to less toxic effluents and offering the opportunity of using sunlight as a sustainable and renewable source of energy. Many compounds have been used as photocatalysts. Though synthesized ones are intensively used, they remain expensive, and their synthesis involves special conditions. We thus thought of implementing a natural material, a phosphate ore, due to its low cost and great availability. Our work is devoted to the removal of hazardous organic pollutants, which cause several environmental problems and health risks. Among them, dye pollutants occupy a large place. This work relates to the study of the photodegradation of methyl violet (MV) and rhodamine B (RhB), in single and binary systems, under UV light and sunlight irradiation. Methyl violet is a triarylmethane dye, while RhB is a heteropolyaromatic dye belonging to the Xanthene family. In the first part of this work, the natural compound was characterized using several physicochemical and photo-electrochemical (PEC) techniques: X-Ray diffraction, chemical, and thermal analyses scanning electron microscopy, UV-Vis diffuse reflectance measurements, and FTIR spectroscopy. The electrochemical and photoelectrochemical studies were performed with a Voltalab PGZ 301 potentiostat/galvanostat at room temperature. The structure of the phosphate material was well characterized. The photo-electrochemical (PEC) properties are crucial for drawing the energy band diagram, in order to suggest the formation of radicals and the reactions involved in the dyes photo-oxidation mechanism. The PEC characterization of the natural phosphate was investigated in neutral solution (Na_2SO_4, 0.5 M). The study revealed the semiconducting behavior of the phosphate rock. Indeed, the thermal evolution of the electrical conductivity was well fitted by an exponential type law, and the electrical conductivity increases with raising the temperature. The Mott–Schottky plot and current-potential J(V) curves recorded in the dark and under illumination clearly indicate n-type behavior. From the results of photocatalysis, in single solutions, the changes in MV and RhB absorbance in the function of time show that practically all of the MV was removed after 240 mn irradiation. For RhB, the complete degradation was achieved after 330 mn. This is due to its complex and resistant structure. In binary systems, it is only after 120 mn that RhB begins to be slowly removed, while about 60% of MV is already degraded. Once nearly all of the content of MV in the solution has disappeared (after about 250 mn), the remaining RhB is degraded rapidly. This behaviour is different from that observed in single solutions where both dyes are degraded since the first minutes of irradiation.

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