Synthesis, characterization and evaluation of efficiency of new hybrid Pc/Fe-TiO₂ nanocomposite as photocatalyst for decolorization of methyl orange using visible light irradiation

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1. Introduction

Industrial wastewaters containing toxic organic dyes have serious problems to the environment [1]. About 1–20% of the total world production of dyes is lost during the dyeing process and is released into the environment as textile effluents [2,3]. It must be noted that organic dyes can produce toxic substances through oxidation, hydrolysis or other chemical reactions occurring in the wastewater phase [4–6]. The decolorization of dyes in the industrial wastewater has received increasing attention. Therefore, several methods for treating various wastewaters have been developed. One of new technologies for treating wastewaters is advanced oxidation processes (AOPs). AOPs are based on the generation of hydroxyl radicals (•OH) that degrade a broad range of organic pollutants [7]. AOPs such as Fenton and photo-Fenton catalytic reactions, \( \text{H}_2\text{O}_2/\text{UV} \) processes and TiO₂ photocatalysis have been broadly considered [8–10].

Titanium dioxide is widely utilized as a photocatalyst because of its photochemical stability, non-toxic nature and low cost. However, the efficiency of the use of TiO₂ is limited by its relatively large band gap energy (3.2 eV), corresponding to the wavelength of 370 nm where only 3–5% of the solar energy is effective and also by the high recombination rate of electron–hole pairs formed in photocatalytic processes [11–13]. Various methods have been developed for the increment of the photocatalytic activity of TiO₂ particles such as increasing its surface to volume ratio, optimization of particle sizes, coupling of TiO₂ with other semiconductor particles, dispersion of TiO₂ species in zeolite cavities, doping with metal or non-metal ions and dye photosensitization of TiO₂ [14,15].

The introduction of transition metal ions can result in the formation of a doping energy level between conduction and valence bands of TiO₂ and shift the band gap of TiO₂ into the visible region. Also a dopant ion may act as a trap for electrons or holes and increases the catalytic activity of TiO₂ under the visible light irradiation [16,17]. However, the photoactivity of the doped TiO₂