XIV ENCAT
Encontro de Catálise do Norte, Nordeste e Centro-Oeste
Catálise: Impulsionando a transição energética para um futuro mais sustentável
17-19 novembro 2024 • Fortaleza
SBCAT SOCIEDADE BRASILEIRA DE CATÁLISE

ÁREA: Catálise ambiental, fotocatálise e eletrocatálise

Evaluation of $Bi_{25}FeO_{40}$ obtained from mining waste as a photocatalyst in norfloxacin degradation

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Abstract

Norfloxacin (NOR) is a second-generation fluoroquinolone antibiotic widely used in the treatment of bacterial infections of the urinary, biliary and respiratory tracts. It is frequently detected in water bodies, which raises significant environmental concerns, mainly due to its persistence and resistance to conventional effluent treatment methods. This scenario highlights the need to develop and implement new approaches, such as Advanced Oxidative Processes (AOPs), which have the ability to effectively degrade these organic pollutants. Among the AOPs, heterogeneous photocatalysis stands out, a process that involves the use of a solid catalyst, which, when irradiated, promotes chemical reactions capable of decomposing contaminants [1]. Recently, research focusing on catalysts obtained from mineral waste has gained interest, with bismuth ferrite ($Bi_{25}FeO_{40}$) being one of these materials, presenting high photocatalytic activity due to its optical properties [2]. In this work, the efficiency of $Bi_{25}FeO_{40}0$ as a photocatalyst in the degradation of NOR under UV-visible irradiation was investigated. $Bi_{25}FeO_{40}$ was synthesized via solid-state reaction using bismuth III subcarbonate (Bi_2CO_5) and iron III oxide (Fe_2O_3), obtained from mineral waste. $Bi_{25}FeO_{40}$ was characterized by energy-dispersive X-ray fluorescence spectroscopy (EFRXF), diffuse reflectance spectroscopy (DRS) and X-ray diffraction (XRD). Photolysis and photocatalysis tests were performed in NOR solution (20 ppm), using a concentration of 500 ppm of $Bi_{25}FeO_{40}$, neutral pH and analyzed by UV-Vis absorption spectroscopy and ion chromatography. XRD analysis of $Bi_{25}FeO_{40}$ identified the formation of the silenite phase (COD ID 4030661), with cubic symmetry and space group 123, having a body-centered cubic crystal structure, in addition to the presence of a spurious $BiClO_2Pb$ phase, with phase fractions of 95.05% and 4.95%, respectively. The band gap of $Bi_{25}FeO_{40}$ was 3.01 eV. The results of the photolysis and photocatalysis tests indicated NOR degradation rates of 21.8% and 42.2%, respectively. The photolysis and photocatalysis processes followed pseudo-first-order kinetics, with rate constants of 1.2 x 10^{-3} min^{-1} and 2.5 x 10^{-3} min^{-1}, respectively. In the photocatalysis test, ion chromatography studies revealed the formation of short-chain organic acids, such as acetate and formate, confirming the degradation of NOR. Thus, the results show that $Bi_{25}FeO_{40}$ obtained from mining waste has potential for drug degradation, and degradation tests with variation of physicochemical parameters, such as pH and photocatalyst concentration, should be performed to improve degradation rates.

Keywords: Minerals, Bismuth ferrite, Heterogeneous photocatalysis.

References

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Acknowledgements

To the Capes, Laboratório de Eletroquímica e Química Analítica of UERN and to the Laboratório de Análises Magnética e Óptica of UERN.