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Photodegradation of methylene blue catalyzed by titaniumniobates

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Due to the increasing ambiental pollution, a demand on sustainable development has been rising. One of such demands is the efficient treatment of industrial waste for the betterment of the quality and supply of water. Among such wastes, textile dyes have a particular problem due to their inefficient removal during water treatment, which causes a decrease in the available supply of oxygen in the water, affecting the organoleptics properties. A solution for this problem is the use of advanced oxidative processes such as photodegradation for the proper removal of such dyes. This work has as an objective the evaluation of titaniumniobates [$Co(TiNbO_5)_2$, $Ru(TiNbO_5)_2$, $KTiNbO_5$, $HTiNbO_5$, $Mn(TiNbO_5)_2$, and $Cu(TiNbO_5)_2$] as photocatalysts for the removal of dyes, using methylene blue as a model molecule. The catalysts were synthesized starting from the $KTiNbO_5$ and substituting the potassium with different metals. The evaluation of the photocatalytic process was done with the use of a chamber with 4 UV lamps (λ = 100–280 nm) (LUCMAT LAMPS, germicidal fluorescent lamp 15 W GL) eradiating the reaction, a magnetic stirrer and a thermostatic bath. The removal percentage was done by getting aliquots at pre-determined times and analyzed in a UV-Vis spectrophotometer UV-Vis Micronal da AJX – 6100PC. The measurements were done in the scan mode, using the max absorbance in 664 nm and the quantification done with an analytical curve in the studied range. Different reaction parameters were evaluated, such as the pH of the solution, using different buffers (pH 3, 5, 7, and 9). The best catalyst in the photodegradation was the $Co(TiNbO_5)_2$, achieving a almost complete removal of the methylene blue dye in the spam of 2 hours, using the citrate buffer pH 3 (0.1 mol L^{-1}). Effects such as methylene blue concentration (0.4, 1, 10, 25 mg L^{-1}) and catalyst load (1, 2, 10 mg) were studied, were the dye concentration of 10 mg L^{-1} and catalyst load of 10 mg had the highest removal percentage. A possible mechanism was also studied, using tert-butyl alcohol as a hydroxyl radical (·OH), inhibitor, which reduced significantly the dye removal, confirming the hydroxyl radical as the main responsible for the removal. Finally, the degradation products were analyzed by gas chromatography with a mass spectrometer GCMS QP2010, by doing a microextraction of the final reaction product with chloroform. The only identified product was dimethylsulfoxide (DMSO), which supports the importance of the hydroxyl radical in the reaction, in which the oxidation of the sulfur is the first step of the proposed mechanism[1]. The study is still evaluating means to identify different reaction products which may be volatile, such as the use of a headspace during the reaction. Through this study it was possible to verify the photocatalytic proprieties of the titaniumniobates, which will be tested for different dyes in the future.

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References

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