Grenze International Journal of Engineering and Technology, June Issue

Photocatalytic Degradation of 4-aminophenol using BiOCl Nanoparticles

Nithin kumar S[1], Bharath Kumar S P[2], Kumara Swamy N[3] and Vijayakumar K G[4]
[1-4]Department of Chemistry, JSS Science and Technology University, Mysuru-570006, India
Email: kumaryagati@gmail.com

***Abstract*— The present study is focused on the synthesis of Bismuth oxychloride (BiOCl) nanoparticles by a simple low- low-temperature liquid-phase method. The as-synthesized BiOCl was characterized by X-ray diffraction, Scanning electron microscopy. The visible-light responsive photocatalytic activity of BiOCl nanoparticles was evaluated by the photodegradation of 4-aminophenol (4-AP) under visible light (9W). Under visible light, BiOCl had excellent 4-AP degradation. The optimum degradation of 4-AP was observed to be 68% in 1440 min under LED (9W) irradiation with 5 mg of BiOCl dosage. The results show the obtained BiOCl nanoparticles with excellent photocatalytic and electrocatalytic activities. Based on the preliminary investigation, stated that BiOCl acts as a photocatalyst for the degradation of 4-AP, and it may be used for the treatment of water polluted with 4-AP.**

***Keywords*— Photocatalytic degradation, 4-aminophenol, Mineralisation, Photocatalyst.**

I. INTRODUCTION

Pharmaceutical pollutants like 4-AP have caused a great deal of worry when they are released into the environment because of their toxicity, persistence, and possible health concerns to both humans as well as aquatic life (Sun et al. 2007). The pharmaceutical sector uses (4-AP) extensively, especially in the manufacturing of paracetamol, and its inappropriate disposal may severely impact the environment (Fowler et al. 1991). Such contaminants are frequently not entirely removed by conventional treatment techniques; thus, more effective and sustainable strategies must be developed. In warm climates, photocatalysis has shown promise as a method for breaking down persistent organic contaminants. The (BiOCl) nanoparticles have garnered interest among other photocatalysts because of their exceptional photocatalytic efficacy under visible light, great chemical stability, and distinctive layered structure (Sarwan et al.2012). This study focuses on the degradation of 4-AP using BiOCl nanoparticles as an effective photocatalyst, aiming to evaluate their performance, stability, and potential for practical environmental remediation applications.

II. EXPERIMENTAL SECTION

A. Characterization of BiOCl nano-photocatalyst

The produced BiOCl nanoparticles were characterized using sophisticated equipment. A Bruker D8 Advance X-ray diffractometer with Cu Kα radiation across a 2θ range of 10°–90° was used to identify the crystal phases. while a (SEM, Hitachi H-800, 200 kV) was used to analyze morphology.

Grenze ID: 01.GIJET.11.2.758

Optoelectronic characteristics were examined using UV-visible spectroscopy (Shimadzu UV-1800), These methods guaranteed thorough chemical and physical characterization.

B. Synthesis of BiOCl nano-photocatalyst

A straightforward low-temperature liquid-phase method is employed to produce the BiOCl nanoparticles as per a reported protocol (Cao et al. 2015). The chemicals used were analytical grade and were utilized directly from the container without further purification. In traditional synthesis, the 2D BiOCl nanosheets were prepared in advance. Anhydrous ethanol 10 ml was combined with 1.5 mmol Bi $(NO_3)_3 \cdot 5H_2O$ and was stirred magnetically, to which 3 mol/L nitric acid aqueous solution was added. The solution was added continuously using drops until the solution became transparent. The aforesaid solution was later mixed gently with 40 mL of KCl solution (1.5 mmol). Following that, the resulting mixture was prepared for three hours at 80 °C in a water bath using continuous stirring. To synthesize the BiOCl powders, the white precipitates formed were harvested, washed several times with ethanol and distilled water, and dried at 60°C in a vacuum oven.

C. Photocatalytic experiments.

The 4-AP was photo-catalytically degraded in batch mode using 50 mL of 4-AP solution (10 mg/L) in a 100 mL quartz beaker. To achieve the adsorption-desorption equilibrium, the mixture was magnetically stirred in the dark (the absence of light) for 30 minutes, a suitable quantity of BiOCl catalyst was added, and the suspension was then constantly swirled (350–400 RPM) while subjected to 9W visible LED light. The catalyst was separated by centrifuging, and a 5 mL aliquot was taken at regular intervals. UV-Vis spectrophotometry was used to measure the absorbance of the supernatant. The degradation percentage was calculated by the equation given below

$$\text{Degradation (\%)} = (1 - A_t / A_0) \times 100$$

Where A_t and A_0 are the equivalent values of 4-AP absorbance of 4-AP at irradiation times 0 and t, respectively.

III. RESULTS AND DISCUSSION

A. Characterization of BiOCl nanoparticles by spectroscopic and microscopic techniques

XRD analysis

Powder XRD was conducted to evaluate the crystallinity and purity of the synthesized BiOCl nanoparticles, as indicated in Fig. 1A. The XRD pattern establishes the phase composition and crystalline nature of the material. The diffraction peaks are at 2θ values of 11.980°, 26.820°, 32.340°, 40.800°, 49.310°, 58.720°, and 67.040° for corresponding to (001), (101), (110), (112), (200), (104), and (220) planes and it shows tetragonal phase of BiOCl, (JCPDS card No. 06-02490) (Kumar et al. 2018).

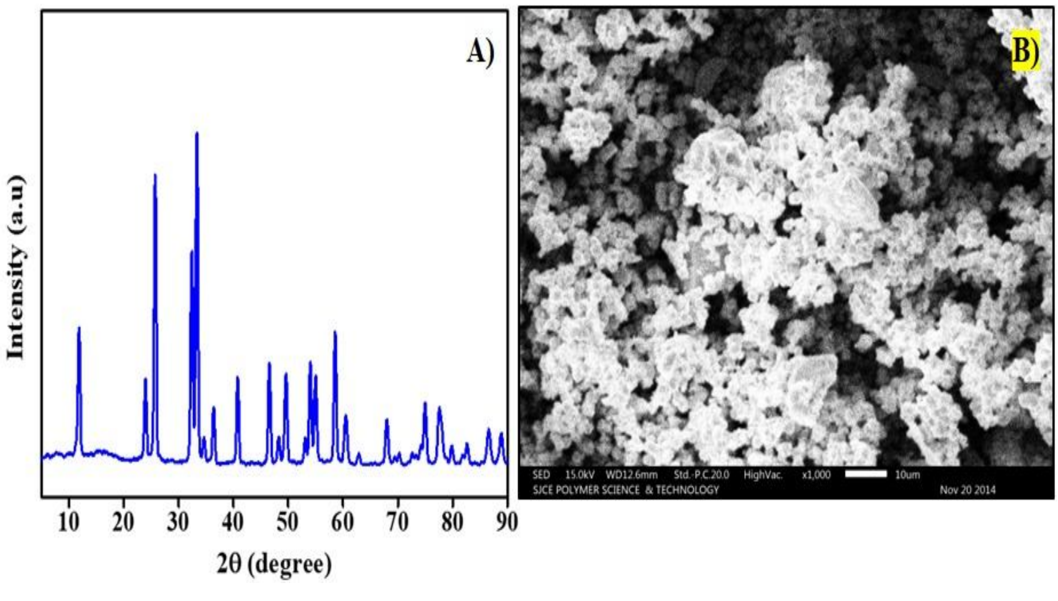

Fig 1. XRD spectra (A) and SEM image (B) of BiOCl nano-photocatalyst

SEM analysis

The scanning electron microscopy (SEM) is used to analyze the sample's surface morphology and shape. Fig. 1B, shows that there are flake- or sheet-like structures dispersed across the surface. The uneven forms and changing diameters of these structures reveal the sample's particles' non-uniform development and random dispersion.

B. Photocatalytic studies

The photocatalytic investigation was to determine the ideal amount of BiOCl for the breakdown of 10 mg/L of 4-AP under LED light exposure, while maintaining a steady magnetic stirring speed for uniform mixing, and the UV-absorbance spectra for 3 and 5mg photocatalyst were shown in Fig. 2A and B. The experimental findings reveal the impact of various catalyst dosages 3 and 5 mg on the degradation efficiency of 4-AP is 64.42% and 68% in 1440 minutes of continuous LED exposure. The findings showed that as the amount of BiOCl increased, the degradation rate also increased, reaching a maximum of 68% when 5mg of the catalyst was used. In contrast, the minimum degradation rate of 64.42% was noted with 3 mg of BiOCl. The photocatalytic efficiency for different concentrations of catalyst is summarized in Table 1.

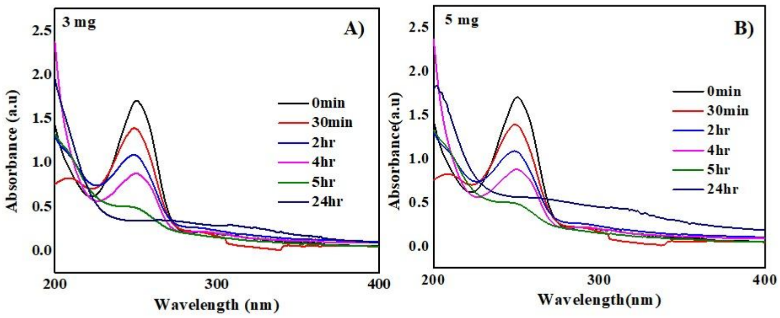

Fig 2. Absorbance plot 3mg (A) and 5mg (B) for photocatalytic breakdown over 4-AP by BiOCl nanoparticle.

TABLE 1. THE PERCENTAGE DEGRADATION OF THE PHOTODEGRADATION OF 4AP OVER BIOCL NANOPARTICLES AS A PHOTOCATALYST

Catalyst	Catalyst Dose (mg)	Degradation (%)	t (min)
BiOCl	3	64.12	1400
	5	68	1400

III. CONCLUSION

This study demonstrated the successful synthesis of BiOCl nanoparticles using a simple low-temperature liquid-phase method and highlighted their excellent photocatalytic potential for the degradation of 4-AP under visible light. The structural, morphological, and compositional characterization confirmed the purity and stability of the prepared nanoparticles. Photocatalytic experiments revealed that an optimal catalyst dosage of 5 mg achieved a maximum degradation efficiency of 68%. Overall, BiOCl photocatalyst shows great promise as a sustainable and efficient material for environmental remediation of pharmaceutical pollutants like 4-AP.

REFERENCES

[1] S M., Yao, R., You, Y., Deng, S., & Gao, W. (2007). Degradation of 4-aminophenol by hydrogen peroxide oxidation using enzyme from Serratia marcescens as catalyst. Frontiers of Environmental Science & Engineering in China, 1, 95-98.

[2] Fowler, Lynn M., et al. "Nephrotoxicity of 4-aminophenol glutathione conjugate." Human & experimental toxicology 10.6 (1991): 451-459.

[3] Sarwan, B., Pare, B., Acharya, A. D., & Jonnalagadda, S. B. (2012). Mineralization and toxicity reduction of textile dye neutral red in aqueous phase using BiOCl photocatalysis. Journal of Photochemistry and Photobiology B: Biology, 116, 48-55.

[4] Cao, C., Xiao, L., Chen, C., & Cao, Q. (2015). Synthesis of novel Cu2O/BiOCl heterojunction nanocomposites and their enhanced photocatalytic activity under visible light. Applied Surface Science, 357, 1171-1179.

[5] Kumar, A., Kumar, A., Sharma, G., Al-Muhtaseb, A. A. H., Naushad, M., Ghfar, A. A., & Stadler, F. J. (2018). Quaternary magnetic BiOCl/g-C3N4/Cu2O/Fe3O4 nano-junction for visible light and solar powered degradation of sulfamethoxazole from aqueous environment. Chemical Engineering Journal, 334, 462-478.