Experimental design and data on the adsorption and photocatalytic properties of boron nitride/cadmium aluminate composite for Cr(VI) and cefoxitin sodium antibiotic

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ABSTRACT

This article reports the experimental data on the adsorption and photocatalytic degradation-reduction properties of pure boron nitride (BN), cadmium aluminate (CdAl₂O₄) and boron nitride/cadmium aluminate (BN/CdAl₂O₄) composite for the hexavalent chromium (Cr(VI)) and cefoxitin sodium (CFT) in aqueous solution under the ultraviolet (UV) and visible light irradiation. This work evaluates the adsorption and photocatalytic efficiency of the 0.2g BN coupled with the CdAl₂O₄ in BN-0.2/CdAl₂O₄ composite for Cr(VI) and CFT. The experiments were performed by mixing the 0.025 material with 50 mL solution of known concentration (15 mg/L) at pH 3 for Cr(VI) and pH 7 for CFT. The obtained data can be valuable to select the proper light source (UV or visible) and pollutant to investigate the application of BN-0.2/CdAl₂O₄ composite. Moreover, presented data can help identify the equilibrium time for the adsorption process and to recognize the best process for the removal of the pollutants from wastewaters. A comparison of the obtained data with previously reported works has been conducted for the understanding of the adsorption and
photocatalysis of Cr(VI) and CFT using various materials under the different experimental conditions.

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1. Data description

The incorporation of the BN with CdAl₂O₄ enhanced the photocatalytic of the synthesized BN-0.2/CdAl₂O₄ composite. However, BN-0.2/CdAl₂O₄ composite is not a very efficient catalyst in visible light. Data reported in this article is related to the article “Photocatalytic degradation of cefoxitin sodium antibiotic using novel BN/CdAl₂O₄ composite” [1]. This article reports why we selected the CFT and UV light source over the Cr(VI) and visible light for the study in Ref. [1]. A schematic diagram
for the synthesis and photocatalytic properties of BN-0.2/CdAl$_2$O$_4$ composite is summarized in Fig. 1. The UV–visible diffuse reflectance spectrum of BN, CdAl$_2$O$_4$, and BN-0.2/CdAl$_2$O$_4$ composite is shown in Fig. 2. Table 1 shows the molecular formula and properties of the CFT. The photocatalytic properties of the BN, CdAl$_2$O$_4$, and BN-0.2/CdAl$_2$O$_4$ composite for CFT degradation under the visible light illumination is illustrated in Fig. 3. The photocatalytic efficiency of the BN, CdAl$_2$O$_4$, and a series of BN/CdAl$_2$O$_4$ composite prepared by varying the amount of BN from 0.1 to 0.4g, for the photocatalytic degradation of the CFT under 108 W UV light irradiating in reported in Ref. [1]. Herein, adsorption and photocatalytic efficiency of the BN-0.2/CdAl$_2$O$_4$ composite for Cr(VI) under UV and visible light irradiation is shown in Fig. 4. Raw data related to this articles mentioned in supplementary file.

A comparison of the experimental conditions, adsorption, and photocatalytic efficiency of the various materials reported previously for the removal of the CFT and Cr(VI) are summarized in Table 2 and Table 3.

Fig. 1. Schematic diagram for the synthesis of BN-0.2/CdAl$_2$O$_4$ composite and its photocatalytic application.

Fig. 2. Diffuse reflectance spectra of BN, CdAl$_2$O$_4$ and BN-0.2/CdAl$_2$O$_4$ composite.
2. Experimental design, materials, and methods

2.1. Materials

The model pollutant cefoxitin sodium (CFT) and potassium dichromate (salt for Cr(VI)) was supplied by Zhzhou Zhijun chemicals and BDH chemical, England. Otto chemical Ltd, India supplied boron nitride sheets. Cadmium nitrate and aluminum nitrate salts were received from BDH chemical Ltd. All the chemicals were used without further purifications. A freshly prepared solution was used for the adsorption and photocatalysis experiments by mixing the fixed amount of the salt in deionized water.

2.2. Synthesis and characterization

The synthesis of the CdAl2O4 and a series of BN/CdAl2O4 composites was performed in a 150 mL Teflon lined hydrothermal reactor at 160 °C. A detailed synthesis procedure and characterization of the BN, CdAl2O4, and BN/CdAl2O4 composites are reported elsewhere [1].

| Molecular Formula | \( \lambda_{\text{max}} \) | Molecular Formula | Molecular weight | Water solubility |
|-------------------|--------------------------|-------------------|-----------------|-----------------|
| \( \text{C}_{10}\text{H}_{10}\text{N}_{3}\text{NaO}_{7}\text{S}_{2} \) | 231 nm | \( \text{C}_{10}\text{H}_{10}\text{N}_{3}\text{NaO}_{7}\text{S}_{2} \) | 449.4 g/mol | soluble |

Fig. 3. Adsorption and photocatalytic degradation of the CFT onto BN, CdAl2O4 and BN-0.2/CdAl2O4 composite under visible light irradiation (solution volume 50 mL, concentration 15 mg/L, pH 7, light intensity 108 W, catalyst mass 0.025 g).
2.3. Adsorption and photocatalysis experiments

All the Cr(VI) and CFT adsorption and photocatalysis experiments were performed in 100 mL pyrex beaker under the dark and UV or visible light irradiation of 108 W intensity, respectively. Initially, 15 mg/L concentration solutions (500 mL) of Cr(VI) and CFT were prepared, and the pH was adjusted to 3 for Cr(VI) and pH 7 for CFT. The pH of the solution was adjusted using the 0.1 M HCl or 0.1 M NaOH solution. Thereafter, 0.025g of the material was added to the 50 mL solution of each pollutant for the adsorption studies in the dark. After 120 min in the dark, the solution was transferred into the LUZE CHEM photo-reactor for the photocatalysis experiment. Samples were collated after a fixed time interval to analyze pollutant concentration in the solution. The concentration of the Cr(VI) was analyzed by the HACH-Dr6000 UV–visible spectrophotometer using HACH ChromaVer® 3 chromium reagent. The concentration of the CFT after the adsorption and photocatalysis was analyzed by UV–visible

Table 2
Comparison of photocatalytic properties of various materials used for the removal of Cr(VI) and CFT.

| Catalyst          | Pollutant | Light Source | Experimental Condition                              | % of removal | Ref.   |
|-------------------|-----------|--------------|-----------------------------------------------------|--------------|--------|
| BN/CdAl₂O₄        | CFT       | UV           | pH-7, conc.-25 mg/L, time –240 min, catalyst mass-0.05g | 84           | [1]    |
| Zn–Al-LDH         | Cr(VI)    | UV           | pH-2, conc.-20 mg/L, time –150 min, catalyst mass-0.1g | 60.49        | [2]    |
| LDH-TiO₂          | Cr(VI)    | UV           | pH-2, conc.-20 mg/L, time –150 min, catalyst mass-0.1g | 95.53        | [2]    |
| rGO@LDO           | Cr(VI)    | Visible      | pH-3, time –210 min, mass-0.1g                       | 69.2         | [3]    |
| TiO₂/AC-AEMP      | Cr(VI)    | UV           | pH-2.5, conc.-40 mg/L, time –180 min, catalyst mass-0.25g | 92.7         | [4]    |
| ZnO/PANI          | Cr(VI)    | UV           | pH-4, conc.-20 mg/L, time-90 min, catalyst mass-0.5g  | 98           | [5]    |
| BN/CdAl₂O₄        | Cr(VI)    | Visible      | pH-3, conc.-15 mg/L, volume-50 mL time-270 min, mass-0.025g | 36.67        | This work |
| BN/CdAl₂O₄        | CFT       | Visible      | pH-7.23, conc.-14.5 mg/L, volume-50 mL, time-180 min, catalyst mass-0.025g | 27.9         | This work |

Fig. 4. Adsorption and photocatalytic reduction of the Cr(VI) onto BN-0.2/CdAl₂O₄ composite under UV and visible light irradiation (solution volume 50 mL, concentration 15 mg/L, pH 3, light intensity 108 W, catalyst mass 0.025 g).
The adsorption and degradation efficiency of Cr(VI) and CFT was calculated by the following equation:

\[
\% \text{ removal} = \frac{(C_i - C_t)}{C_i} \times 100
\]

where, \( C_i \) and \( C_t \) represent the initial and final concentration (mg/L) of the Cr(VI) or CFT at time t.

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**Conflict of Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Appendix A. Supplementary data**

Supplementary data related to this article can be found at [https://doi.org/10.1016/j.dib.2019.105051](https://doi.org/10.1016/j.dib.2019.105051).

**References**

[1] R. Kumar, M.A. Barakat, B.A. Al-Mur, F.A. Alseroury, J.O. Eniola, Photocatalytic degradation of cefoxitin sodium antibiotic using novel BN/CdAl2O4 composite, J. Clean. Prod. (2019), [https://doi.org/10.1016/j.jclepro.2019.119076](https://doi.org/10.1016/j.jclepro.2019.119076).

[2] Y. Yanga, L. Yana, J. Lia, J. Lia, T. Yana, M. Suna, Z. Pei, Synergistic adsorption and photocatalytic reduction of Cr(VI) using Zn-Al layered double hydroxide and TiO2 composites, Appl. Surf. Sci. 492 (2019) 487–496, [https://doi.org/10.1016/j.apsusc.2019.06.229](https://doi.org/10.1016/j.apsusc.2019.06.229).

[3] J. Ye, J. Liu, Z. Huang, S. Wu, X. Dai, L. Zhang, L. Cui, Effect of reduced graphene oxide doping on photocatalytic reduction of Cr(VI) and photocatalytic oxidation of tetracycline by ZnAlTi layered double oxides under visible light, Chemosphere 227 (2019) 505–513, [https://doi.org/10.1016/j.chemosphere.2019.04.086](https://doi.org/10.1016/j.chemosphere.2019.04.086).
[4] Z. Gao, H. Yang, X. Fu, Q. Jin, Q. Wu, L. Kang, J. Wu, Efficient photoreduction of Cr(VI) on TiO2/functionalized activated carbon (TiO2/AC-AEMP): improved adsorption of Cr(VI) and induced transfer of electrons, Environ. Sci. Pollut. Res. Int. (2019), https://doi.org/10.1007/s11356-019-05374-w.

[5] C. Bao, M. Chen, X. Jin, D. Hu, Q. Huang, Efficient and stable photocatalytic reduction of aqueous hexavalent chromium ions by polyaniline surface-hybridized ZnO nanosheets, J. Mol. Liq. 279 (2019) 133–145, https://doi.org/10.1016/j.molliq.2019.01.122.

[6] V. Manirethan, K. Raval, R. Rajan, H. Thaira, R.M. Balakrishnan, Data on the removal of heavy metals from aqueous solution by adsorption using melanin nanopigment obtained from marine source: Pseudomonas stutzeri, Data Brief. 20 (2018) 178–189, https://doi.org/10.1016/j.dib.2018.07.065.

[7] Y.A.B. Neolaka, G. Supriyanto, H. Darmokoesoemo, H.S. Kusuma, Characterization, isotherm, and thermodynamic data for selective adsorption of Cr(VI) from aqueous solution by Indonesia (Ende-Flores) natural zeolite Cr(VI)-imprinted-poly (4-VP-co-EGDMA)-ANZ (IIP-ANZ), Data Brief. 17 (2018) 1020–1029, https://doi.org/10.1016/j.dib.2018.01.081.

[8] R. Kumar, M. Barakat, F. Alseroury, Oxidized g-C3N4/polyaniline nanofiber composite for the selective removal of hexavalent chromium, Sci. Rep. 7 (2017) 12850, https://doi.org/10.1038/s41598-017-12850-1.

[9] P.B. Vilela, A. Dalaliber, E.E. Duminelli, V.A. Becegato, A.T. Paulino, Adsorption and removal of chromium (VI) contained in aqueous solutions using a chitosan-based hydrogel, Environ. Sci. Pollut. Res. Int. 26 (2019) 28481–28489, https://doi.org/10.1007/s11356-018-3208-3.

[10] M.E. Mahmoud, A.M. El-Ghanam, R.H.A. Mohamed, S.R. Saad, Enhanced adsorption of Levofoxacin and Ceftriaxone antibiotics from water by assembled composite of nanotitanium oxide/chitosan/nano-bentonite, Mater. Sci. Eng. C 108 (2020) 110199, https://doi.org/10.1016/j.msec.2019.110199.