

EFFECT OF G-C₃N₄ NANOSTRUCTURE ON ADSORPTION OF METHYLENE BLUE

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ABSTRACT

The synthesis of nanostructured adsorbents for the removal of pollutants plays an important role in improving the environment. In the present study, bulk graphitic carbon nitride (b g-C₃N₄) was synthesized by simple thermal polymerization using urea in a muffle furnace at 550 °C for 4h with a heating rate of 2.3 °C/min. Also, the nanosheet (ex g-C₃N₄) were prepared by exfoliation of bulk sample with thermal oxidation of the bulk g-C₃N₄ was placed in the open alumina crucible unlike bulk sample and was heated at 520 °C for 2h with a ramp rate of 5 °C/min.

In the X-ray diffraction patterns of b g-C₃N₄ and ex g-C₃N₄, both of them showed two distinct diffraction peak at 13.1° and 27.4° are indexed to the (100) and (002) peaks for graphitic materials. Although, the intensity of peak at 13.1° for exfoliated sample was decreased. The peak at 13.1° was related to the carbonate nitride layer structure. This means that graphitic carbon nitride was properly peeled off during the peeling process and a layer structure was gone. Furthermore, the peak at 27.4° was indicated the presence of aromatic structures in the system.

The crystal structure of two synthesized samples can be further confirmed by FTIR.

Both samples (0.3 g/lit) have been investigated for adsorption of methylene blue (5 ppm). After 20 minutes, efficiency of adsorption of methylene blue by ex g-C₃N₄ was 2.7 times higher than b g-C₃N₄.

The superior efficiency of ex g-C₃N₄ proves that nanostructure could effectively address the limitation of bulk g-C₃N₄ suffering from its low specific surface area.

Objectives

The purpose of synthesizing graphitic carbon nitride nanosheets was to increase the surface area. Increasing the surface area causes more contaminants to be adsorbed on the adsorbent.

Materials & methods

Bulk graphitic carbon nitride was synthesized by heat treatment of urea. Normally, 16 g of urea was placed inside the alumina crucible. It was heated in furnace at 550 °C for 4 h at a rate of 2.3 °C/min. The product was obtained as a yellow powder. Synthesis of graphitic carbon nitride nanosheets was performed by an easy thermal peeling method of bulk g-C₃N₄. For the synthesis, bulk material was placed in an alumina crucible without a door at 520 °C for 2 h at 5 °C/min. The product was obtained as a pale yellow.

Results

The X-ray diffraction pattern (XRD) shows a sharp peak at 2θ 27.4° and a peak at 2θ 13.1° for bulk graphitic carbon nitride (JCPDS No. 87-1526). The peak in 2θ is 27.4° corresponding to the plate (002) in the graphitic material and is a characteristic for aromatic structures. The peak in 13.1° was corresponded to the page (100) and shows the layered structure. This peak is not observed in nanostructures. This means that carbon nitride is properly peeled off during the peeling process and the layered structure was gone. The peak was seen in 2θ 27.4° for nanostructures, with the difference that the peak intensity was reduced for nanostructures.

The adsorption spectrum of peeling nitride carbon was similar to that of bulk graphitic carbon nitride. Adsorption spectra in 3000-3300 cm⁻¹ represent primary and secondary amines. The observed peaks from 900 to 11800 cm⁻¹ were related to N- (C) 3 or C-NH-C units. The peak was shown at 806 cm⁻¹, which corresponds to the 3-5 triazine units and indicated that the layered graphitic carbon nitride has the same chemical structure as g-C₃N₄ bulk and the original structure was preserved after peeling.

shows the N₂ adsorption and desorption isotherms of graphitic carbon nitride (bulk and exfoliated). It can be seen that the shape of the diagram has not changed after making changes on the bulk material. It was indicated that the structure of the material has not changed during the process and the path has been correct. Exfoliated graphitic carbon nitride showed type IV isotherms with a residual ring in the higher relative pressure range. The Hysteresis ring indicated the presence of mesoporous material. Also, the specific surface area of exfoliated and bulk carbon nitride was 336.39 and 170.07 m²/g, respectively.

efficiency of adsorption of methylene blue by ex g-C₃N₄ was 2.7 times higher than b g-C₃N₄. The superior efficiency of ex g-C₃N₄ proves that nanostructure could effectively address the limitation of bulk g-C₃N₄ suffering from its low specific surface area.

The color of bulk g-C₃N₄ powder was yellow. After exfoliation, it was changed from yellow to pale yellow-white. FESEM was conducted to examine the morphology of the samples. The g-C₃N₄ powder consists of particles with lateral dimensions of several micrometers and layered morphology. Upon exfoliation, the lamellar shape is retained, but the lateral dimension of the particles decreases and g-C₃N₄ has a soft, loose and layered morphology after thermal peeling.

A solution of methylene blue was prepared at a concentration of 5 ppm. Then 0.03 g of adsorbent was mixed with the contaminant (methylene blue) at room temperature and under constant conditions. Then 5 ml of the solution was analyzed for 180 minutes by UV-VIS spectroscopy using peak absorption at 664 nm. Exfoliated graphitic carbon nitride adsorbent was used in the same way. The degradation efficiency was 16.3% for bulk g-C₃N₄ and 72.1% for Ex. g-C₃N₄.

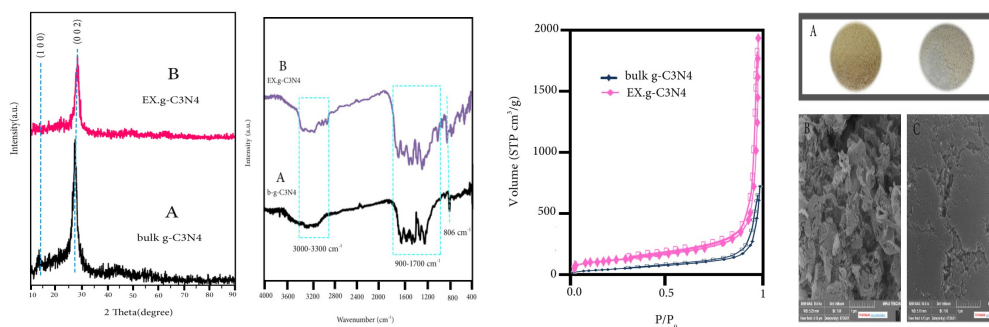


Fig.1. XRD pattern FTIR Spectra N₂ adsorption and desorption isotherms FE-SEM images

CONCLUSIONS

Exfoliated graphitic carbon nitride adsorbent was synthesized from bulk graphitic carbon nitride carbon in an easy and cost-effective peeling method. According to the adsorption results, peeled graphitic carbon nitride has more adsorption than bulk. The adsorption capacity of peeled graphitic carbon nitride was higher than bulk due to its higher surface area. FT-IR and XRD results showed that the synthesis of graphitic carbon nitride was successfully performed. The present work can help develop a new high-capacity graphitic nitride carbon layer structure to adsorb methylene blue and provide valuable resources for g-C₃N₄ applications as dye adsorbents.

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