Journal of Hazardous Materials 244–245 (2013) 10–20

Contents lists available at SciVerse ScienceDirect

Journal of Hazardous Materials

journal homepage: www.elsevier.com/locate/jhazmat

# Hazardous dyes removal from aqueous solution over mesoporous aluminophosphate with textural porosity by adsorption

Chellapandian Kannan*, Kumarasamy Muthuraja, Murugan R. Devi

*Department of Chemistry, Manonmaniam Sundaranar University, Tirunelveli-627 012, Tamilnadu, India*

## HIGHLIGHTS

- In the synthesis of mesoporous aluminophosphate molecular sieve with textural porosity, TMAOH is avoided.
- The synthesized mesoporous $AlPO_4$ has high porosity nature (40 nm) with thermal stability upto 1173 K.
- The mesoporous $AlPO_4$ behave as a good adsorbent for the removal of hazardous Malachite green and Methylene blue dyes.
- The adsorption behavior increased with increasing temperature indicates that the adsorbent activity is induced by temperature.
- The mesoporous $AlPO_4$ is a reusable adsorbent and it can be used for the large molecule transfer reactions.

## ARTICLE INFO

*Article history:*
Received 27 June 2012
Received in revised form 17 October 2012
Accepted 3 November 2012
Available online 19 November 2012

*Keywords:*
Mesoporous aluminophosphate
Textural porosity
High thermal stability
Adsorption
Azo dye removal

## ABSTRACT

Dye pollution in aquatic nature produce serious environmental effects. In this investigation, mesoporous aluminophosphate molecular sieve synthesized and applied for the removal of hazardous dyes Malachite green (MG) and Methylene blue (MB). In the synthesis of mesoporous aluminophosphate ($AlPO_4$) molecular sieve, the structure-directing agent, long-chain alkylbenzene has been used as a template. The template used for the synthesis of mesoporous material is environmentally biodegradable. The mesoporous $AlPO_4$ was synthesized by the absence of an organic base, tetramethyl ammonium hydroxide (TMAOH) which is necessary to maintain the pH for the conventional $AlPO_4$ synthesis methods. The synthesized mesoporous $AlPO_4$ has high thermal stability up to 1173 K and large porosity nature (40 nm). It was confirmed by the characterization techniques such as low-angle XRD, FT-IR, TGA and BET surface area analysis. The morphology of the material was explained by using SEM and TEM. The hazardous dyes MG and MB removal studied under the various conditions like contact time, dye concentration, temperature, pH and adsorbent dosage to examine the adsorption characteristics of the newly synthesized mesoporous $AlPO_4$ molecular sieves.

© 2012 Elsevier B.V. All rights reserved.

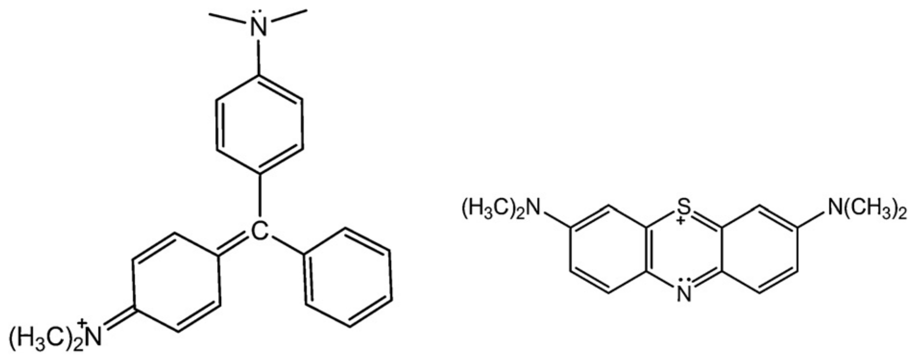
## 1. Introduction

Environmental Pollution (due to hazardous dyes) control is the main concern for dye manufacturing and dyeing industries today. 15% of the total productions of dyes are lost as dye effluent during dye production and dying process [1]. These dye molecules are common water pollutants and a very small amount in water is highly visible and can be toxic to aquatic life [2]. In order to solve this environmental problem, physical and chemical processes have been investigated, such as coagulation, flocculation, biosorption, photodecomposition and ultrafiltration [3–6]. Among these techniques, adsorption process is a procedure of choice for the removal of organic compounds from wastewater [7]. Particularly the cationic dyes Malachite green (MG) and Methylene blue (MB) produce serious environmental problems. Various researchers have utilized adsorption technique for the removal of toxic dyes from wastewater by using various adsorbents like aminofunctionalized acrylamide–maleic acid hydrogels[8], bottom ash, deoiled-soya [9], Fe-zeolitic tuff [10], Brazil nut shells [11], cross-linked chitosan [12], banana pith [13,14] coir pith [15,16], bagasse pith [17], corn cob [18], sawdust [19] and apple pomace [20].

The synthesis of aluminophosphate molecular sieve reported first in 1982 by Wilson et al. [21]. Nowadays mesoporous aluminophosphate based materials have vast applications in catalysis [22,23] and electro chemistry [24]. Synthesis of molecular sieves by structure-directing agents, as a template, opens a path to obtain mesoporous molecular sieves with controlled pore sizes [25,26]. Initial publications on mesoporous $AlPO_4$ synthesis were dominated by reports of utilizing templates like cetyl trimethyl ammonium bromide (CTAB) [27], poly oxo metalate [28], long-chain n-alkylamine [29] and nonionic poly(ethylene oxide) [30],

* Corresponding author. Tel.: +91 9443507036.
*E-mail address:* chellapandiankannan@gmail.com (C. Kannan).

0304-3894/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jhazmat.2012.11.016




MG MB

**Fig. 1.** (a) Structure of Malachite green (b) structure of Methylene blue.

**Table 1**
Dyes properties.

| S.No | Dye name | Molecular formula | Molecular weight (g/mol) | Maximum absorption (nm) |
|---|---|---|---|---|
| 1. | Malachite green | $C_{23}H_{26}N_2Cl$ | 364.92 | 619 |
| 2. | Methylene blue | $C_{16}H_{18}N_3SCI$ | 319.85 | 663 |

etc. In conventional synthesis methods tetramethyl ammonium hydroxide was added [31–33] to maintain pH and the technical synthesis procedures are tedious process and the materials are thermally less stable [34–36]. To overcome the above, the thermally stable mesoporous aluminophosphate molecular sieve was synthesized by using biodegradable template [37]. The mesoporous $AlPO_4$ was used as an adsorbent for the removal of environmentally hazardous cationic dyes MB and MG from aqueous solution through adsorption.

## 2. Experimental

### 2.1. Materials and methods

The chemicals used in the present work were pure analytical grade and used directly without further purification. Aluminium hydroxide (97%; Merck), Phosphoric acid (88%; Nice), the long-chain alkylbenzene (SDBS, 25 wt% in water; Aldrich) were used for the preparation of mesoporous $AlPO_4$. The cationic dyes Malachite green (MG) and Methylene blue (MB) are shown in Fig. 1(a) and (b). These dyes were used to study the hazardous dye removal nature of $AlPO_4$. The properties of dyes are given in Table 1. The synthesized mesoporous $AlPO_4$ sample was characterized by using spectroscopic techniques. Low-angle X-ray diffraction (XRD) patterns were recorded on a Shimadzu 6000 diffractometer using Cu-K$\alpha$ radiation ($\lambda$ = 1.5418 Å) with a voltage and current of 30 kV and 30 mA, respectively at room temperature with the scanning rate of 0.5° per minute. The fourier transform infrared (FT-IR) measurement of sample was recorded by JASCO-410 FT-IR model Spectrophotometer by using KBr pellet technique. Thermal analysis was carried out on SDT Q600 V8.3 Build 101 at a heating rate of 20 °C/min. Nitrogen adsorption–desorption measurement were made using on Micromeritics, ASAP 2020 V3.00 H at 77 K. The surface area of the sample was obtained by the Brunauer–Emmett–Teller (BET) method and the pore size distribution was calculated from the adsorption branch of the isotherm based on BJH method. Transmission electron micrograph (TEM) images were recorded JEOL 2011 microscope operated at

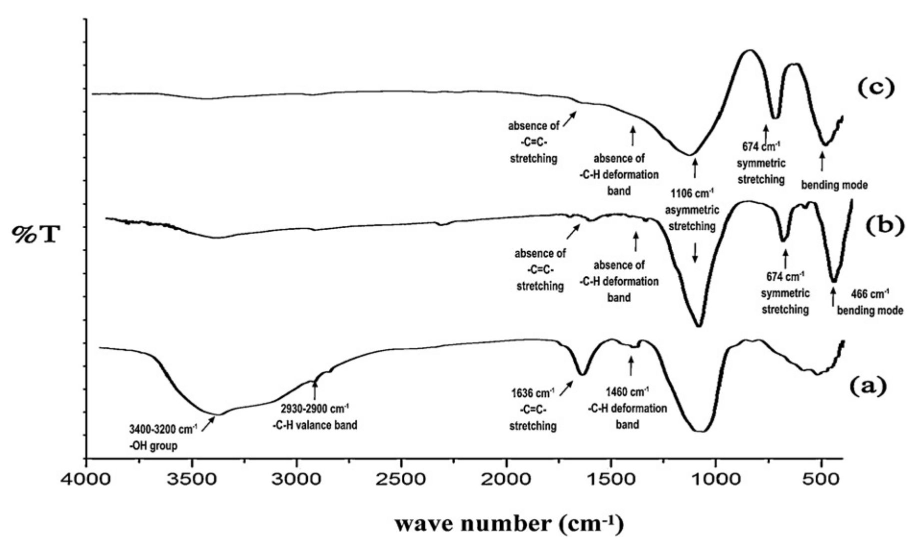



**Fig. 2.** FT-IR spectrum of a) as-synthesized b) calcined c) thermally treated at 1273 K mesoporous $AlPO_4$.

Download English Version:

https://daneshyari.com/en/article/577488

Download Persian Version:

https://daneshyari.com/article/577488

Daneshyari.com