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Acid modified carbon coated monolith for methyl orange adsorption

Willie Cheah [a], Soraya Hosseini [a], Moonis Ali Khan [b], T.G. Chuah [a,c], Thomas S.Y. Choong [a,c,*]

[a] Department Chemical and Environmental Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[b] Advance Material Research Chair, Chemistry Department, College of Science, King Saud University, Riyadh 11451, Saudi Arabia
[c] INTROP, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

HIGHLIGHTS

- Carbon coated monolith (CCM) was modified by nitric acid.
- Twofolds escalation in acidic sites was observed on modified compared with unmodified CCM.
- Comparatively 53% higher MO adsorption was observed on modified CCM than CCM.
- Optimum MO uptake was 132.7 mg/g at equilibration time 4560 min, agitation 200 rpm and temperature 30 °C.
- Optimum MO elution (73%) was achieved with 1 N NaOH solution.

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ABSTRACT

Carbon coated monolith (CCM) was chemically modified by treating with nitric acid. The acid modified carbon coated monolith (ACCM) was then characterized by using various techniques. Two folds increase in acidic sites was observed on ACCM compared to CCM. Surface studies showed mesoporous nature of ACCM. A decrease in ACCM surface area and an increase in pore volume observed after the modification. The ATR-FT-IR studies showed increase in carboxylic groups on ACCM confirming CCM oxidation by nitric acid. The pH studies showed optimum adsorption (88 mg/g) at pH 6 which is very near to pH_{PZC} of ACCM. Contact time studies showed equilibration time in between 4320 and 4560 min for initial MO concentration range 0.05–0.6 g/L. Comparatively 53% higher MO adsorption was observed on ACCM than CCM under similar experimental conditions. Freundlich model applicability confirms multilayer MO adsorption on ACCM surface. Pseudo-second-order kinetics model was fitted best to the experimental data revealing chemical nature of adsorption process. The adsorption process is endothermic and spontaneous in nature. Desorption studies showed optimum MO recovery (73%) when 1 N NaOH was used as an eluent.

1. Introduction

As the world population increases, the demands on textile industry are augmented due to the improving sense of lifestyles and fashion by human beings. Dyes are the coloring agents visible with human naked eyes. The presence of dyes not only hampers the aesthetic quality of water but also affects and alters the aquatic ecosystem by reducing the penetration of sunlight and oxygen [1]. Methyl orange (MO), a water-soluble azo dye, commonly present in effluent discharges form textile, food, pharmaceutical, printing and paper manufacturing industries [2]. Due to the toxicity and persistence these discharges can cause serious threat to physico-chemical properties of fresh water and to aquatic life.

Various chemical, biological and physical treatments have been utilized to treat the azo dyes [3–7]. Since dyes are resistant to aerobic biodegradation, recalcitrant organic molecules, and stable to oxidizing solutions, adsorption process is proven as a reliable and effective act for this treatment [8]. Simplicity in process design, ease in operational conditions and economical aspects are some of the major advantages of adsorption process [9,10].

Activated carbon (AC), an adsorbent, widely used for dyes removal from wastewater [11,12]. The well developed pore structure and high internal surface area results in AC's excellent adsorption properties. Furthermore, AC can remove highly odorous dissolved organic compounds from industrial effluents. Several studies have reported the utilization ACs for dyes removal form wastewater

* Corresponding author at: Department Chemical and Environmental Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia. Tel.: +60 389466293; fax: +60 386567120.
E-mail address: tsyc2@eng.upm.edu (T.S.Y. Choong).

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