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PII: S1002-0721(18)30363-6

DOI: 10.1016/j.jre.2018.03.013

Reference: JRE 186

To appear in: *Journal of Rare Earths*

Received Date: 19 October 2017

Revised Date: 19 March 2018

Accepted Date: 20 March 2018

Please cite this article as: You J, Wang R, Liu C, Shi X, Han F, Guo R, Liu X, Facile synthesis and highly efficient selective adsorption properties of $Y_2Mo_4O_{15}$ for methylene blue: Kinetics, thermodynamics and mechanical analyses, *Journal of Rare Earths* (2018), doi: 10.1016/j.jre.2018.03.013.

# Facile synthesis and highly efficient selective adsorption properties of $Y_2Mo_4O_{15}$ for methylene blue: Kinetics, thermodynamics and mechanical analyses☆

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**Abstract:** $Y_2Mo_4O_{15}$ particles were prepared using a simple solution method (SSM) and used as a highly efficient selective adsorbent for methylene blue (MB) in aqueous solutions. The maximum adsorption capacity of the samples was determined based on the adsorption isotherms with different adsorbent doses at 298, 318 and 338 K. The fittings of the temperature-dependent isotherms yield $\Delta_r G_m^\theta$ = –34.1 kJ/mol, $\Delta_r H_m^\theta$ = –36.9 kJ/mol and $\Delta_r S_m^\theta$ = –9.67 J/mol·K. The as-prepared $Y_2Mo_4O_{15}$ has a very large maximum adsorption capacity (i.e., 198 mg/g) for MB at room temperature, and this value is only less than that of amorphous hardwood powder. Notably, 80 mg of adsorbent is able to completely decolorize 250 mL of 30 mg/L MB aqueous solution. The kinetic parameters of the adsorption process were obtained from the temperature-dependent adsorption isotherm (i.e., $E_1$ = 26.9 kJ/mol and $E_{-1}$ = 63.8 kJ/mol). The results of adsorption kinetics show that it is a pseudo-second-order reaction. The mechanism of the high selectivity and the large adsorption capacity is discussed based on competitive ion (CI) experiments and coordination theory.

**Keywords:** $Y_2Mo_4O_{15}$; Adsorption; Methylene blue (MB); Simple solution method (SSM); Rare earths

## 1. Introduction

Over the past few decades, the detrimental effects of printing, dyeing, pharmaceutical, chemical and other industrial wastewater on human health and the environment have been increasing quickly.[1-3] In particular, dye-containing wastewater is a problematic pollutant that is discharged by these industries because dyes are not easily degraded due to their complex structures.[4] Therefore, many physical, chemical and biological methods have been developed for wastewater treatment.[5-12] However, many methods have application limitations, such as secondary pollution, higher costs, and non-reusability. Encouragingly, the dye adsorption method is economical, effective and easily operated.[1, 2, 13]

In the past few years, the preparation of nano-/micro-materials with novel and controllable morphologies became an important research topic due to fundamental and application of adsorption materials. In this aspect, organic functional group-modified metal oxides have shown great potential for removal of MB, owing to insufficient functional groups on the surface.[14] Another kind of strong adsorbents was mesoporous materials (i.e., ordered mesoporous carbons and mesoporous polymer). Among them, polypyrrole/$TiO_2$ was reported with a large $Q_m$ of 273.22 mg/g.[15] In addition, natural materials such as kaolin are also strong adsorbents.[16] But few adsorbents were reported with selective adsorption properties for MB. Therefore, the studies of the mechanism of the selective adsorption properties of $Y_2Mo_4O_{15}$ for MB are interesting. Y-Mo-O ternary compounds are commonly used as

☆Foundation item: This work was supported by the Fundamental Research Funds for the Central Universities (N162302001), the Basic Key Program of Applied Basic Research of Science and Technology Commission Foundation of Hebei Province in China (15961005D), the Natural Science Foundation of Liaoning Province (2015020665), the Hebei Province Higher Education Research Project (ZD2017309) and Northeastern University at Qinhuangdao Campus Research Fund (XNK201602)

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