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Maize straw decorated with sulfide for tylosin removal from the water

Xuetao Guo[a,d,*,1], Yongyuan Yin[a,b,1], Chen Yang[c,**], Zhi Dang[c]

[a] College of Natural Resources and Environment, Northwest A&F University, Yangling, Shaanxi 712100, China
[b] School of Earth and Environment, Anhui University of Science and Technology, Huainan 232001, China
[c] College of Environment and Energy, South China University of Technology, Guangzhou 510006, China
[d] Key Laboratory of Plant Nutrition and the Agri-Environment in Northwest China, Ministry of Agriculture, Yangling, Shaanxi 712100, China

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ABSTRACT

MS-ZnS and MS-ZnS:Mn complexes were synthesized via a simple method. The results showed that sulfide was successfully loaded on the maize straw. The results of fitting the experimental data showed that the sorption conforms to the pseudo-second-order kinetics, and the TYL sorption on MS fit the Henry model well, but the Freundlich model was more suited to MS-ZnS and MS-ZnS:Mn. In addition, the k_f values of MS-ZnS (206.0 (mg/kg)/(mg/L)^n) and MS-ZnS:Mn (382.5 (mg/kg)/(mg/L)^n) were significantly greater than that of MS (72.2 (mg/kg)/(mg/L)^n), indicating that ZnS and ZnS:Mn could improve the sorption capacity of TYL on MS. The pH, ionic strength and temperature influence the sorption process, and the sorption ability of TYL on MS-ZnS and MS-ZnS:Mn showed little change when the solution pH was > 5; the amount of TYL sorption on the adsorbents gradually decreased with the increasing concentration of KNO_3. Electrostatic interactions, H bonding and hydrophobic interactions are involved in the sorption of TYL on MS, MS-ZnS and MS-ZnS:Mn, and compared with MS, the main mechanism is surface complexation. This research can provide technical support for the utilization of biomass and the restoration of water polluted by antibiotics.

1. Introduction

The widespread use of pharmaceuticals and personal care products (PPCPs), such as antibiotics and cosmetics, has led to them being detected in different environmental mediums (Ali, 2009; Ali et al., 2011). PPCPs are recognized as emerging pollutants and can get into the environment in many ways. Sewage effluents and waste water treatment plants are considered the main sources of PPCPs (Yang et al., 2017; Zhang et al., 2017b). Although the impact of PPCPs on the ecological environment and human health is unclear, the removal of PPCPs is worthy of concern (Kyzas et al., 2015; Zhang et al., 2017a). Tylosin (TYL), a macrolide antibiotic, has been widely spread in the environment as an animal growth promoter (Guo et al., 2013; Zhang et al., 2016a).

At present, there are many studies on the removal of antibiotics from the environment, sorption, photodegradation, biodegradation and oxidation are the main methods for the removal of antibiotics. But, sorption has already been used widely because it is simple and efficient (Ali, 2012; Ali et al., 2017). Prior studies of TYL sorption have focused primarily on soils, humic substances and clays (Guo et al., 2016). TYL has one p*K*a (7.1), and can exist as TYL^+ at an acidic pH and as TYL^0 at basic pH, while the solubility in water is 5 g L^{-1} (Pei et al., 2014; Zhang et al., 2016a). Hence, the sorption of TYL is complex. Previous studies have indicated that cation exchange plays a major role for TYL adsorption on soil (Zhang et al., 2016a). Guo et al. (2015) reported that ion exchange, surface complexation and hydrophobic interactions were involved in TYL adsorption on humic acid. Essington et al. (2010) found that pH and ionic strength could significantly affect the adsorption capacity of TYL on clays. These studies are mainly used to evaluate the chemical behavior of TYL in the environment, while there are few reports on the removal of TYL in slightly polluted water.

Maize straw is a renewable resource and ubiquitous in China. However, maize straw cannot be effectively treated, causing serious pollution to air and water (Li et al., 2017). So far, there are many studies on modified biomass, but most studies have focused on the modification of biochar. Li et al. (2017) studied Cd(II) sorption on rape straw biochar and showed that the sorption ability of biochar for Cd(II) was greatly enhanced after a base treatment and $KMnO_4$ impregnation. Yan et al. (2015) studied magnetic biochar coated with ZnS nanoparticles for the removal of Pb(II) in water, and the results indicated that the sorbents can significantly improve the adsorption of biochar for Pb(II). Hajati et al. (2014) studied the sorption of dyes on activated

* Corresponding author at: College of Natural Resources and Environment, Northwest A&F University, Yangling, Shaanxi 712100, China.
** Corresponding author: College of Environment and Energy, South China University of Technology, Guangzhou 510006, China.
E-mail addresses: guoxuetao2005@nwsuaf.edu.cn (X. Guo), cyanggz@scut.edu.cn (C. Yang).
[1] The equal author contribution.

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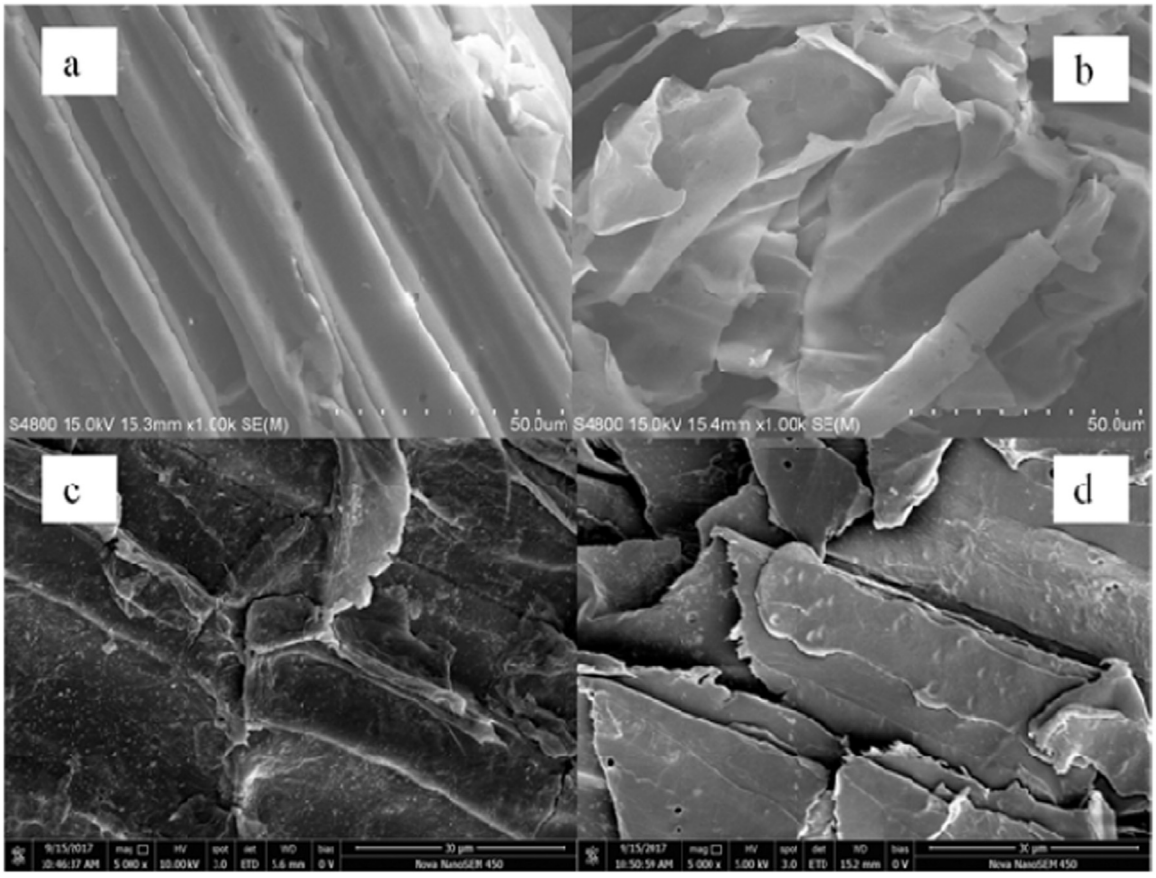

Fig. 1. SEM images of MS, MS-ZnS and MS-ZnS:Mn.

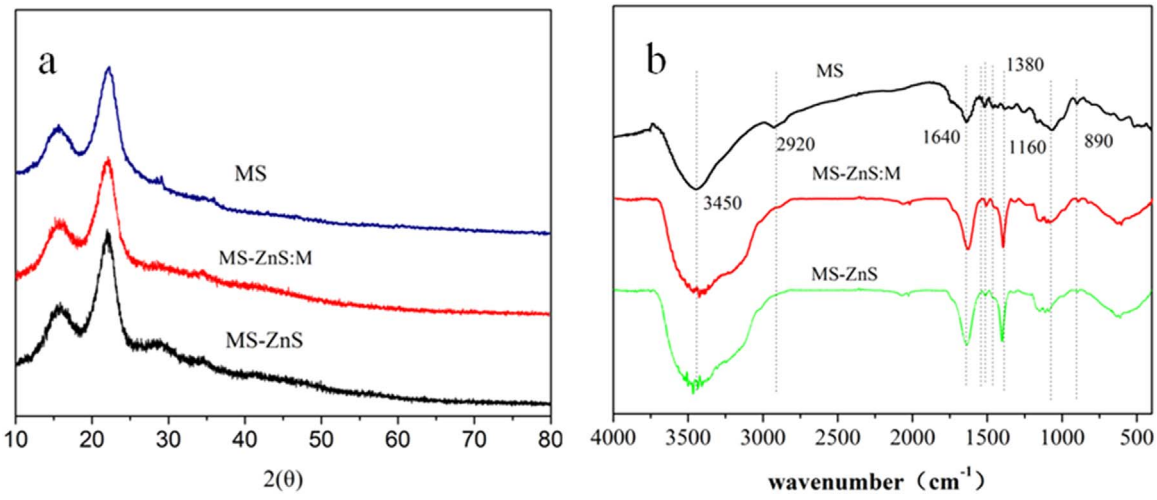

Fig. 2. XRD (a) and FTIR (b) x images of MS, MS-ZnS and MS-ZnS:Mn.

carbon coated with ZnS:Mn nanoparticles, and the results showed that the dyes can be effectively removed. However, there needs to be a carbonization process from biomass to biochar, which will increase costs and produce secondary contaminants. Hence, the biomass was directly modified, which can not only achieve the purpose of utilization of waste but can also reduce costs and secondary pollution.

In this study, to find low-cost and effective adsorbents for tylosin removal from an aqueous solution, and make biomass resources can be fully utilized, maize straw are decorated with ZnS and ZnS:Mn, the TYL sorption on maize straw and complexes were systematically studied by sorption kinetics, isotherms and thermodynamics experiment. In addition, to clarify the best conditions for the adsorption of tylosin on adsorbents, the amount of TYL adsorbed is compared at different temperatures, pH and ionic strength, and the sorption mechanism of TYL onto specified complexes are also analyzed.

2. Materials and methods

2.1. Chemicals

TYL tartrate (MW 916.14 g/mol , purity > 95%) was used as bought from Sigma-Aldrich Corporation. (St. Louis, MO), which was