Chemical Engineering Journal 313 (2017) 336–344

Contents lists available at ScienceDirect

Chemical Engineering Journal

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

# Modification of clays and zeolites by ionic liquids for the uptake of chloramphenicol from water

Ken Sun [a,*], Yan Shi [a], Wei Xu [b], Nicholas Potter [c], Zhaohui Li [b,c,*], Jianxi Zhu [d]

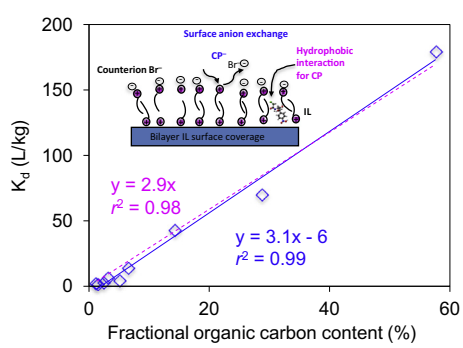
[a] School of Environmental and Municipal Engineering, North China University of Water Resources and Electric Power, Zhengzhou 450045,China
[b] School of Materials Science and Technology, China University of Geosciences, Beijing 100083, China
[c] Geosciences Department, University of Wisconsin–Parkside, Kenosha, WI 53144, USA
[d] CAS Key Laboratory of Mineralogy and Metallogeny/Guangdong Provincial Key Laboratory of Mineral Physics and Materials, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

## HIGHLIGHTS

- Ionic liquids (ILs) were used to modify selected Earth materials of high cation exchange capacities.
- Modified materials resulted in significant uptake of chloramphenicol (CP), an antibiotic.
- CP uptake was affected by the surface configuration of ILs and the fractional organic carbon content.
- Partitioning mechanism contributed significantly to CP uptake.
- This research extended new application of ILs for wastewater treatment.

## GRAPHICAL ABSTRACT

Uptake of CP on Earth materials modified by IL was attributed to surface anion exchange and hydrophobic interaction. However, the CP distribution coefficient was highly correlated to the factional organic carbon content, suggesting that partitioning played a major role for CP removal from water.




## ARTICLE INFO

*Article history:*
Received 1 November 2016
Received in revised form 18 December 2016
Accepted 19 December 2016
Available online 21 December 2016

*Keywords:*
Chloramphenicol
Clays
Ionic liquid
Modification
Sorption
Zeolite

## ABSTRACT

Chloramphenicol (CP) is frequently detected in wastewaters even after treatment. In this study, the interactions between CP and selected Earth materials modified by an ionic liquid (IL) were investigated. Changes in surface hydrophobicity of the materials after modification were demonstrated in contact angle measurements and zeta potential determination. The sorption sites of IL on zeolite and illite were limited to the external surfaces, while interlayer sorption sites of IL in montmorillonite (MMT) played a major role in addition to surface sorption. The different sites for IL modification resulted in different sites for CP sorption. CP uptake was limited to the external sites for IL-modified zeolite and illite, while both external and interlayer sites were available for CP uptake on modified MMT. The dual sorption sites for CP by modified MMT resulted in a much larger CP distribution coefficient ($K_d$). The adsorption of CP on the modified materials followed a linear sorption isotherm and the $K_d$ increased as the IL loading on the Earth materials increased. In addition, good correlation was found between the fractional organic carbon content ($f_{oc}$) of the modified materials and the $K_d$ values. These results all pointed to a partitioning mechanism for the uptake of CP on IL-modified Earth materials.

© 2016 Elsevier B.V. All rights reserved.

* Corresponding authors at: Geosciences Department, University of Wisconsin–Parkside, Kenosha, WI 53144, USA (Z. Li).
*E-mail address:* li@uwp.edu (Z. Li).

http://dx.doi.org/10.1016/j.cej.2016.12.083
1385-8947/© 2016 Elsevier B.V. All rights reserved.

## 1. Introduction

Great concerns have been raised over the last couple of decades due to extensive use and misuse of pharmaceuticals, and thus their frequent detection in the natural environment. Among them, antibiotics were the mostly reported, as their presence would result in an increased antibacterial resistance of microorganism in nature. Chloramphenicol (CP) is a synthetic antibiotic of a broad spectrum against both gram positive and gram negative germs [1] and the drug of choice for the treatment of Salmonella infections [2]. It was commonly used in all major food-producing animals [3], before being banned in use of food-producing species in EU, Australia, and Canada [4]. It is a highly polar and yet stable compound [5], particularly in neutral and moderately acidic solutions [2].

Despite its infrequent use in human medicine, concentrations of 112.3 ng/L and 0.1957 mg/kg were found in the water and sediments collected from Southern China, respectively [6]. Due to its low distribution value between soil organic carbon content and water, it is highly leachable in soil [7]. In addition, high concentrations of CP were found in wastewaters in Guangzhou, China [8].

Earth materials, particular phyllosilicates were tested for their uptake of pharmaceuticals as early as 40 years ago. However, there have been only limited studies on CP-clay interactions. Due to its highly polar feature, CP does not have much affinity for solid surfaces. No adsorption of CP was found on kaolinite under pH < 5 under which CP is a neutral substance [2]. CP showed much less sorption on montmorillonite (MMT) and rectorite, and little removal under direct photolysis was observed, confirming the persistence of CP in aquatic environments [9].

Zeolites are tectosilicates with three-dimensional framework containing water molecules, alkali and alkaline earth metals in their structure [10]. The unique microporous structure and large isometric substitution induce several excellent properties, such as ion exchange and selective adsorption, which make them potentially useful as sorbents in the treatment of polluted waters.

Ionic liquids (ILs) are a group of organic salts composed of organic macromolecular and inorganic anions. Their unique properties include non-volatility, low vapor pressure, and remarkable stability in a large temperature range, making them an ecological friendly solvent for organic synthesis in recent years [11]. Due to their cationic nature, ILs may be a promising alternative to cationic surfactants for the modification of Earth materials to enhance their removal of organic contaminants from water. Silica modified by ILs resulted in an enhanced uptake of Pb from solution with a capacity as high as 1.3 mmol/g [12]. Modification of layered double hydroxides by ILs resulted in spontaneous sorption of reactive orange 5 [13]. Coating of hyperbranched polymers with ILs increased the sorption of Congo red up to almost 2 g/g [14].

However, the uptake of pharmaceuticals by IL-modified Earth materials was rarely reported. In this study, illite, MMT, and zeolite were modified by an IL to different levels of surface coverage. The modified materials were then tested for their enhanced uptake of CP from solution. The possible mechanism dominating the CP adsorption on the modified Earth materials was discussed.

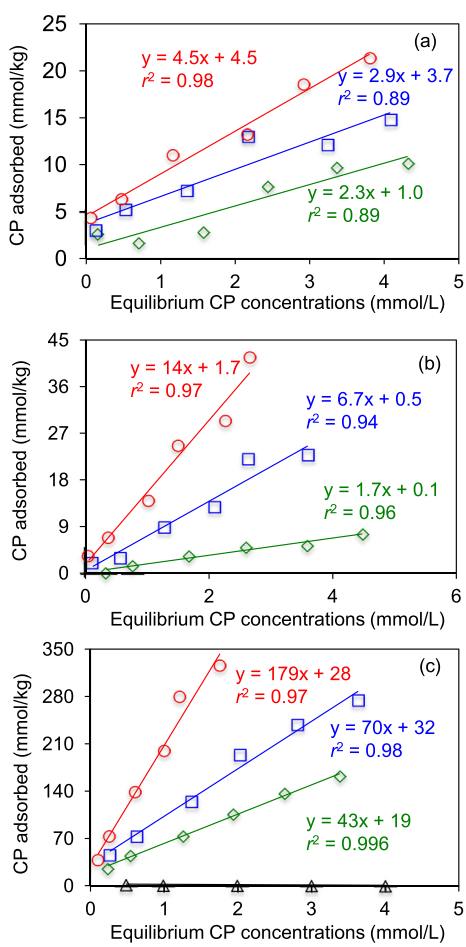



**Fig. 1.** CP adsorption on zeolite (a), illite (b), and MMT (c) modified to 50 (green), 100 (Blue), and 200% (red) CEC. Triangles in (c) are CP adsorption on raw MMT. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

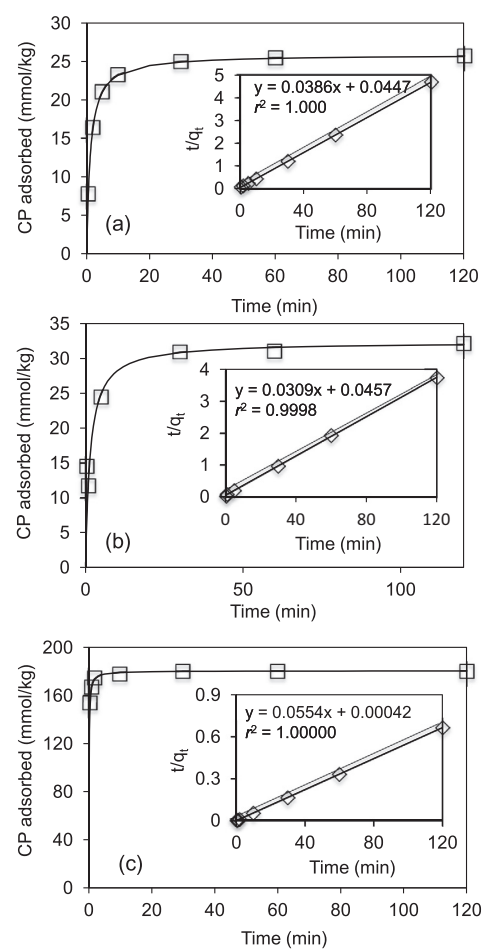



**Fig. 2.** Kinetics of CP adsorption on IL-modified zeolite (a), illite (b), and MMT (c).

Download English Version:

https://daneshyari.com/en/article/6466554

Download Persian Version:

https://daneshyari.com/article/6466554

Daneshyari.com