



Adsorption of norfloxacin in aqueous solution by Mg–Al layered double hydroxides with variable metal composition and interlayer anions

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HIGHLIGHTS

- ▶ Norfloxacin (NOR) in water was adsorbed by MgAl-LDHs.
- ▶ LDHs with different metal cations and interlayer anions were synthesized.
- ▶ Incorporation of Sn^{4+} weakened the adsorption ability of MgAl-LDHs.
- ▶ Electrostatic attraction was suggested to control NOR adsorption on Mg–Al– CO_3 -LDHs.
- ▶ Anion exchange and electrostatic attraction contributed to Mg–Al–Cl-LDHs adsorption.

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ABSTRACT

Mg–Al layered double hydroxides (Mg–Al-LDHs) were synthesized and used for adsorption on norfloxacin (NOR) in aqueous solution. Batch adsorption experiment was conducted to study the adsorption kinetics and isotherms of norfloxacin on Mg–Al-LDHs. Adsorption of NOR by Mg–Al-LDHs with variable $\text{Mg}^{2+}/\text{Al}^{3+}$ molar ratios (2:1, 3:1 and 4:1), with Sn^{4+} incorporation and different interlayer anions (CO_3^{2-} and Cl^-) were investigated to explore the effect of metal composition and interlayer anions on the adsorbing performance of LDHs. LDHs with higher Al^{3+} content and Cl^- as interlayer anion exhibited better performance for NOR adsorption both in adsorption rate and adsorption capacity. The incorporation of Sn^{4+} resulted in the deterioration on the adsorption ability of Mg–Al-LDHs. The pseudo-second rate model correlated the adsorption kinetics data well. Freundlich model fitted well with the adsorption equilibrium data. The negative value of ΔG° and ΔH° observed for Mg–Al– CO_3 -LDHs and Mg–Al–Cl-LDHs proved the spontaneity and exothermic nature of the adsorption process, while ΔS° value was negative for Mg–Al–Cl-LDHs and positive for Mg–Al– CO_3 -LDHs, which indicated an opposite trend in the entropy of the solid/liquid system. pH-dependent experiments showed both Mg–Al– CO_3 -LDHs and Mg–Al–Cl-LDHs had high pH buffering ability and the adsorption amount of NOR insignificantly changed within a wide initial pH range (pH 3.0–11.0). The electrostatic attraction was suggested to control NOR adsorption on Mg–Al– CO_3 -LDHs, while the dominating anion exchange process along with electrostatic attraction contributed to the adsorption by Mg–Al–Cl-LDHs.

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1. Introduction

Norfloxacin (NOR), a fluoroquinolone antibiotic, has now been widely used as human and veterinary medicine for its broad spec-

trum activity against both Gram-negative and Gram-positive bacteria by inhibiting DNA gyrase [1]. Also, a large quantity of NOR was used in aquaculture application as food additive to improve growth and feed efficiency. Relevant reports showed that, in China, fluoroquinolones were administered widely for treatment of animal disease, among which norfloxacin (NOR), ciprofloxacin, and ofloxacin accounted for about 98%, and the annual yield of NOR was about 3500 tons [2]. However, extensive use of NOR and other fluoroquinolone antibiotics has brought concerns on environmental pollution. The synthetic antibacterial compounds were hard to be metabolized in humans and animal bodies, and often discharged into aquatic environment through disposal of pharmaceuticals, wastewater effluents and excretion both in original and

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