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RESEARCH ARTICLE

STUDY OF NORFLOXACIN ADSORPTION ISOTHERMS ON SPENT COFFEE GROUNDS

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ABSTRACT

The adsorption isotherms of norfloxacin (NOR) by the spent coffee grounds (SCGs) was investigated. The adsorption isotherms were well described by the Langmuir model. This suggested that the strong interaction of NOR with the SCGs. Therefore, SCGs, as a green, environmental-friendly adsorbent, can be applied to the adsorption of contaminants in environment.

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INTRODUCTION

Fluoroquinolones, which act as inhibitors of DNA topoisomerase II, exhibit both strong bactericidal and sterilizing activities; as one of the fluoroquinolones, norfloxacin (NOR) is one of the drugs which was widely used (Zhang *et al.,* 2019). However, NOR is considered highly harmful to plants, algae, and bacteria, as well as hazardous to animals and human (Sija Arun *et al.*, 2020). Therefore, the monitoring of NOR in various environmental samples became crucial. In recent years, biomass is used as sorbents to adsorb drugs due to their big surface area, low-cost usage, feasible generation and excellent adsorption properties. Spent coffee grounds (SCGs) can also been used as an inexpensive adsorbent for removal of pollutants. In this study, spend coffee grounds was applied to adsorb NOR. The adsorptive kinetics and adsorptive isotherm of SCGs for NOR were investigated. The results were analyzed by high performance liquid chromatography (HPLC).

EXPERIMENTAL

Chemicals and Materials: NOR was purchased from Sigma-Aldrich (Steinheim, Germany), high performance liquid chromatography-grade methanol (MeOH) and acetonitrile (ACN) were provided by J&K Chemical (Beijing, China). NaH_2PO_4, H_3PO_4, NaOH, and other affiliated chemicals were all obtained from Sinopharm Chemical Reagent Co. Ltd. (Shanghai, China). All solvents and chemicals were of analytical grade and used without further purification unless otherwise specified. HPLC-grade water was obtained by purifying demineralized water in a Milli-Q system (Millipore, Bedford, MA, USA), and was used throughout the work.

Apparatus and software: For chromatographic separation, an Agilent 1260 HPLC system (Agilent Technologies, CA, USA), equipped with a quaternary pump, a degasser, a column compartment, and a UV detector were used. Separation was performed on a Pursuit 5 C18, 5 μm, 4.6 mm ×150 mm column. The injection volume was 20 μL and the ultraviolet (UV) detector was set at 278 nm.

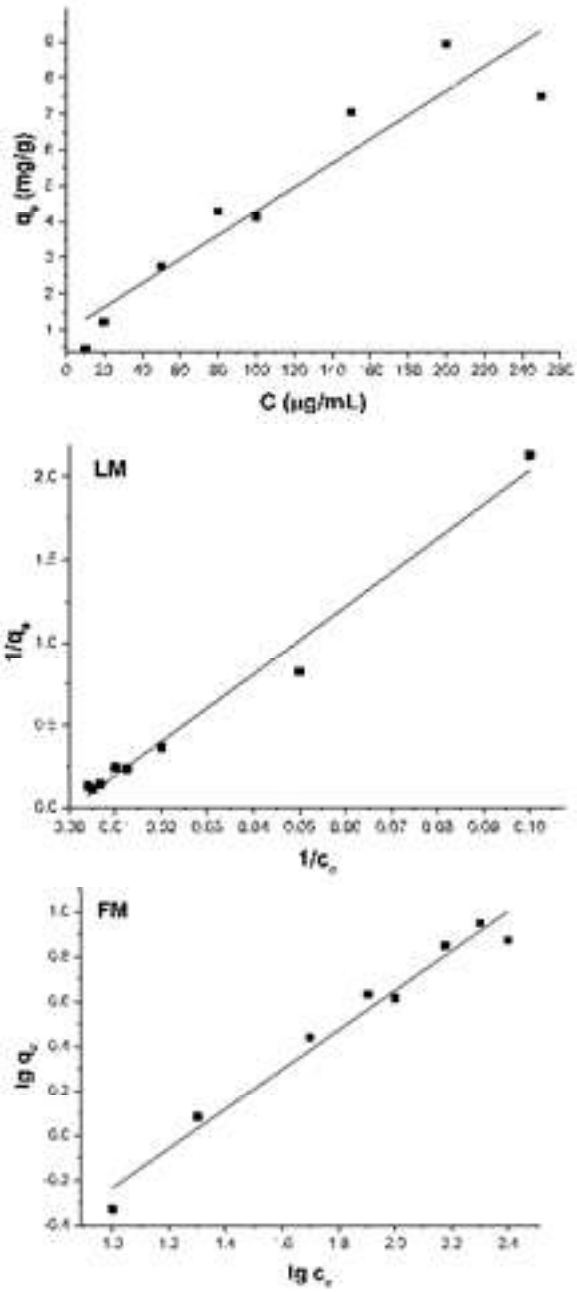

Figure 1. Fitted curve of HM, LM and FM

Table 1 Adsorption parameters of HM, FM and LM for NOR onto SCGs

HM			FM			LM	
R^2	K_D	intercept	R^2	K_F (L/kg)	1/n	R^2	K_L
0.8656	0.03339	0.9542	0.9658	0.07570	0.8855	0.9816	-0.01

The mobile phase consisted of 0.2% acetic acid and ACN with a ratio of 85:15 (v: v) at a flow rate of 1.0 mL/min. All the samples were passed through microporous nylon filters of 0.45 μm pore sizes in diameter (Pall Corporation, USA). An Ion 510 pH meter (Ayer Rajah Crescent, Singapore) was used to monitor pH adjustment. A centrifuge (Xiangyi, Hunan, China) was used for sample preparation.

Preparation of standard: Standard stock solution containing 1000 μg/mL of NOR was prepared by dissolving the required amounts of the standard in MeOH. It was stored in a refrigerator at 4 °C.

Working solutions were prepared from the stock solutions by dilution with appropriate amounts of Milli-Q water.

Adsorptive performance experiment and isotherm modeling: Each desired NOR concentration used in batch experiments was prepared by appropriately diluting the stock solutions with 10 mmol/L NaH_2PO_4 and successive dilutions. SCGs were added into 5 mL NOR solution with a fixed concentration. All the adsorption experiments were performed in conical flasks under ultrasonic bath for 0.5 h to achieve an adsorption equilibrium. After adsorption, all solutions were filtered through 0.45 μm membrane filters and analyzed by HPLC. The adsorption capacity (q_e, mg/g) of SCGs for NOR, and three common isotherm models, such as Henry model (HM), Freundlich model (FM) and Langmuir model (LM) were referenced by our previous work (Yang *et al.* 2021).

RESULTS AND DISCUSSION

Adsorption isotherms: The adsorption isotherm is crucial in understanding the adsorption capacity of SCGs and very useful to describe how the NOR distribute on the SCGs when the adsorption process reaches an equilibrium state. In order to study the mechanism of the adsorption, equilibrium adsorption data of the NOR were described using well-known HM, FM and LM. The correlation coefficients (R^2) obtained in fitting adsorption data in three models, the adsorption parameters (K_D, K_F, K_L and 1/n) for the three NOR onto the SCGs are referred in Table 1. Moreover, the fitted curve of the three models were shown in Figure 1. The data in Table 1 and Figure 1 showed that the LM model is the best one to interpret the absorption of NOR onto SCGs. A non-linear LM can be used to describe homogeneous adsorption systems in which adsorption takes place on a homogeneous surface by a monolayer without any interaction between the adsorbed molecules. A Langmuir-type isotherm indicates that the compound has a moderately high affinity for the adsorbents at the initial stage of adsorption, whereas successively, it has increasing difficulty in finding vacant sites, finally reaching a maximum of adsorption. (Sheshmani *et al.*, 2014).

CONCLUSION

In conclusion, a green, environmental-friendly adsorbent was supplied to the NOR adsorption. The adsorption isotherm indicated that the LM fitted better than HM and FM. As a highly efficient adsorbent for NOR, SCGs could be a candidate to adsorb contaminants in environment in the future.

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