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Adsorption of Reactive Blue 114 dye by using a new adsorbent: Pomelo peel

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ABSTRACT

This paper describes the removal of Reactive Blue 114 dye from aqueous solutions by using pomelo (*Citrus grandis*) peel. Pomelo peel can be described as a new, low cost, abundantly available adsorbent. The optimum adsorbent mass, dye concentration, contact time and pH were determined in this study. The parameters of Langmuir, Freundlich and Temkin adsorption isotherms were also obtained using concentrations of the dyes ranging from 1.0 to 200 mg/L. Maximum adsorption capacity was obtained as 16 mg/g at pH 2 and 303 K solution temperature. The adsorption process was observed to be reaching equilibrium after about 90 min.

1. Introduction

A significant amount of dye production world-wide consist of azo dyes (10–15%) [1–3]. After dying process, residue azo dyes are released into the environment via wastewater. It is well known that some of the azo dyes or their breakdown products have hazardous effects on living organisms [4]. RB 114 dye contains anthraquinone chromophore group, which is known as toxic for microorganisms and inhibits biological treatment. Therefore, RB 114 removal has crucial importance in order to protect environmental health and to improve biological treatment.

The removal methods of dyes from industrial effluents has been widely studied in recent years such as advanced oxidation processes [5–8], chemical or electrochemical precipitation [9], biological treatment processes [10,11] and adsorption [12]. However, most of the dyes are found to be resistant to conventional treatment processes [13] and the dewatering problem of precipitated sludge is the main disadvantage of precipitation methods. The adsorption is a promising process among these methods to remove a wide range of azo dyes [14].

Pomelo (*Citrus grandis*) peel (PP) can be described as a new, low cost, abundantly available adsorbent. However, the usage of pomelo peel as an adsorbent is rather rare [15]. Therefore, adsorption of Reactive Blue 114 (Levafix Brilliant Blue E-BRA; RB114) dye from aqueous solutions by means of pomelo (*C. grandis*) peel was experimented in this study. This study also aimed to identify the isotherm parameters of the decolorization process.

2. Materials and methods

2.1. Adsorbents and reagents

Pomelo (*C. grandis*) peels (PP) used throughout the experiments were collected as solid waste. The collected materials were washed with distilled water several times to eliminate the interference effect of other dirty particles. The washed materials were cut into small pieces (0.5–1 cm) and dried in the sunlight for 4–5 days followed by in a hot air oven at 60 °C for 48 h. The resulting material was crushed using a crushing mill and sieved to obtain particle size under 500 μm, separately. Finally, the powdered materials were preserved in an airtight container and used for adsorption experiments without further chemical or physical treatments.

The azo dye RB 114 was obtained from Kucuker Textile industry, Denizli, Turkey. All the chemical compounds used to prepare the reagent solutions were of analytic grade (Merck, Whitehouse Station, NJ). Concentrations of the RB 114 solutions ranged from 1 to 200 mg/L. Before mixing the RB 114 solution with the adsorbent, we created test solutions with pH values ranging from 2 to 6 (to permit a determination of the optimal pH for adsorption) by adding 0.1 M NaOH or 0.1 M HCl. Some photos and images of pomelo peel were given in Fig. 1(a–d).

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2.2. Instruments

A thermal stirrer was used for the batch adsorption experiments. The adsorption medium was placed in a mechanical platform shaker (ZHWY-200B, ZHICHENG Analytical Co., Ltd) and stirred for different time intervals and at a fixed agitation speed of 250 rpm. The RB 114 concentrations in solution were analyzed using a UV Visible spectrophotometer (Dr Lange Cadas 200, Germany). Firstly, the calibration curve formed by preparing different RB 114 concentration ranged from 1 to 200 mg/L. Thereafter, the absorbance of the dye solution before and after adsorption was analyzed and converted to mg/L using the calibration curve. Pomelo peel was observed itself giving some color to solution and this lead to interference at the absorbance reading. Therefore, the residual color by PP was determined for each experiment and the obtained value was extracted from color measurement of the adsorbate solution. Infrared spectra of the PP in solid phase were performed using a Fourier Transform Infrared Spectrometer (Spectrum 100, Perkin-Elmer, USA). Scanning Electron Microscopy (FESEM, ZEISS SUPRATM 50 VP, Germany) was used to study surface topography of the PP powder. Zeta potential measurements were conducted using a zetameter (Nano ZS, Malvern Inst., UK) equipped with a microprocessor unit. The unit automatically calculates the electrophoretic mobility of the particles and converts it to the zeta potential using the Smoluchowski equation [16]. The surface area of the clinoptilolite was measured by "three point" N_2 gas adsorption method using Quantachrome surface analyzer (Model Autosorb-1, Boynton. Beach, FL). The pH measurements were performed using a digital ion analyzer with a combination electrode (Multi 340i, WTW, Weilheim, Germany).

2.3. General procedures

The effects of adsorbent mass, pH, contact time, temperature and initial dye concentration on adsorption of RB 114 were studied. The sorption experiments were performed in a batch reactor using stoppered Pyrex glass flasks. The dye concentrations in the solutions were determined at the beginning (C_o) and end (C_e) of the shaking period. Eqs. (1) and (2) were used to compute the adsorption capacity (q) and sorption percentage of the dye:

$$q(\text{mg/g}) = \frac{(C_o - C_e) \times V}{M} \quad (1)$$

$$\text{Sorption}\,(\%) = \frac{(C_o - C_e) \times 100}{C_o} \quad (2)$$

where $V(L)$ is volume of the solution and $M(g)$ is mass of the adsorbent.

The deviation of the experimental and calculated values for the dye uptake per unit weight of adsorbent (Δq_m) was calculated as

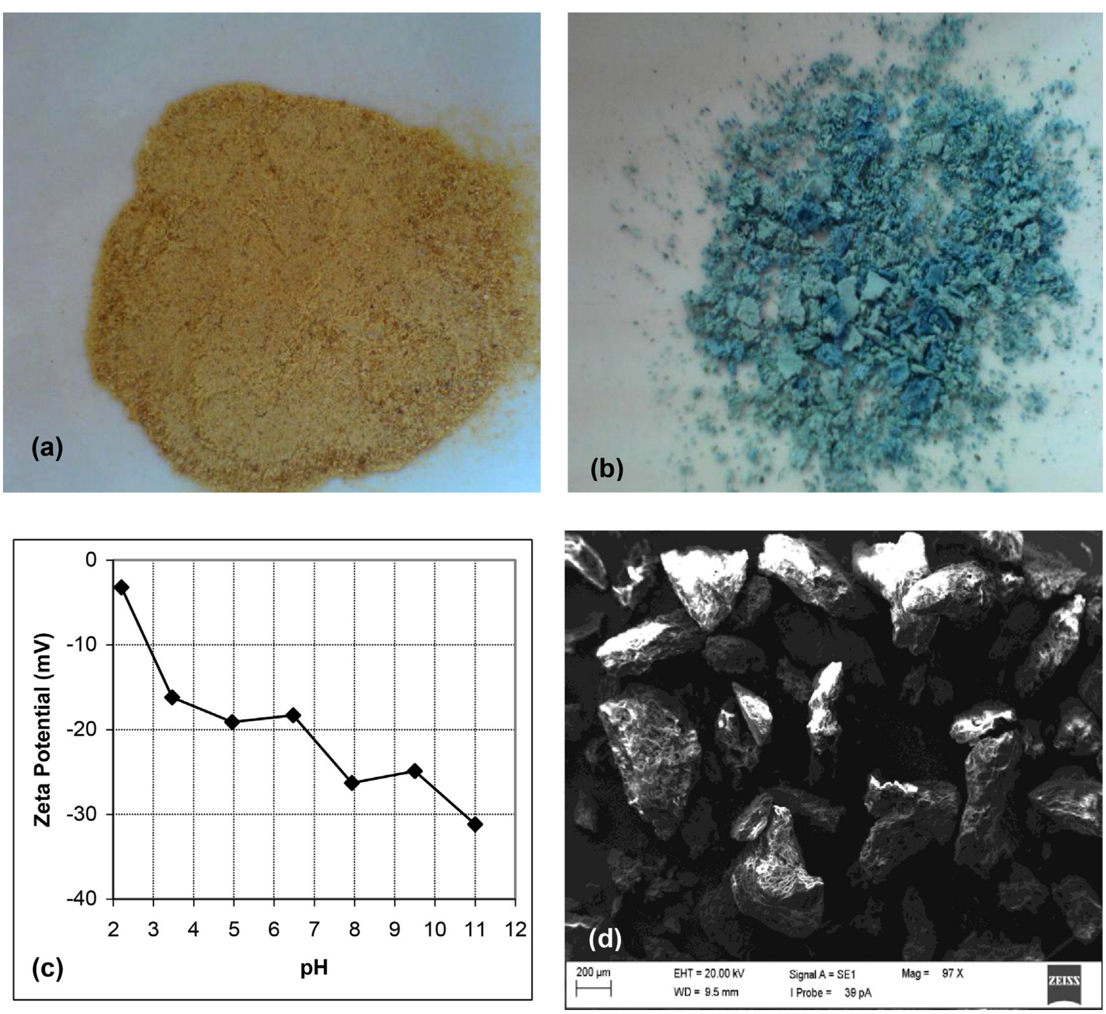

Fig. 1. (a) Raw PP, (b) RB114 adsorbed PP, (c) Zeta potential of PP, (d) SEM image of PP.