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Preparation of decolorizing ceramsites for printing and dyeing wastewater with acid and base treated clay

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Abstract

A new type of decolorizing ceramsites for printing and dyeing wastewater were prepared, by means of acid activation, base neutralization, granulation and heating treatment, by using palygorskite, Hangjin2# clay, bentonite or sepiolite as raw materials. The experimental results show that, the decolorizing ceramsites made of palygorskite have the best performances among different clay minerals in treating printing and dyeing wastewater. Its decolorizing amount is 635 mL g^{-1} and the reduction in COD is 81%, after 5 min static treatment at normal temperature. After calcined at 700 °C for 1 h, the loss ratio of decolorizing ceramsites made of palygorskite is less than 5%. Treated with saturated $(NH_4)_2SO_4$ solution for 10 min, and then calcined at 300 °C for 10 min, the used decolorizing ceramsites can be reused for more than 15 times. The decolorizing effect of the decolorizing ceramsites is mainly attributed to the combined chemical flocculation reaction of various metal ions in the material, with minor physical adsorption involved.

Keywords: Clay minerals; Decolorizing ceramsite; Printing and dyeing wastewater; Decolorization

1. Introduction

Printing and dyeing wastewater is a considerable source of environmental contamination, and its decolorization is the main problem. In recent years, the preparation of decolorizing materials for printing and dyeing wastewater with clay minerals as principal raw materials, such as palygorskite, bentonite, sepiolite and so on, have been widely studied (Murray, 2000; Alkan et al., 2004; Aydin et al., 2004; Bouabdesselam et al., 2005).

The conventional decolorizing materials made of clay minerals are usually modified by the following means: washed thoroughly with distilled water followed by acid activation at high-temperature; added organic coagulant aid as additives after acid activation; soaked in metal-salts solution or added metal-salts as additives directly (Pala and Tokat, 2002; Espantaleóna et al., 2003; Gonzalez-Pradas et al., 2005; Eren and Afsin, 2007).

Table 1
Chemical composition of the clay minerals

Clay minerals	Chemical composition/wt%					
	SiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO
Palygorskite	57.41	9.73	6.20	10.96	0.61	0.73
Hangjin2# clay	56.53	13.10	4.24	3.11	0.12	6.76
Bentonite	57.67	13.22	1.21	3.70	0.05	2.06
Sepiolite	54.74	6.12	2.25	18.15	0.08	0.23

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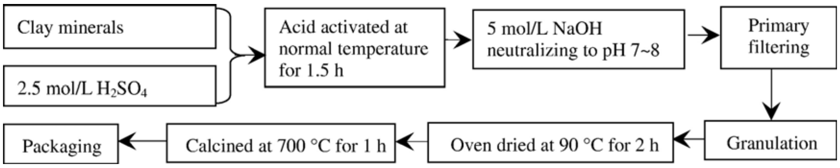

Fig. 1. Technological flow-chart of the decolorizing ceramsites.

Each has its merits, but the problems still exist: such as the large quantities of acid water produced during the process of acid activation, the separation of mushy stage existing in the process when powdered materials were used, the low strength granular material, non- or low-reusability (Brigatti et al., 1996; Özcan and Özcan, 2005; Pushpaletha et al., 2005; Wu et al., 2006).

In this work, the manufacturing technology of the decolorizing ceramsites was optimized; the decolorization mechanism, and the strength, loss ratio as well as reusable method of the decolorizing ceramsites was studied. In addition, the performances of decolorizing ceramsites prepared with different clay minerals (palygorskite, Hangjin2# clay, bentonite and sepiolite) were compared.

2. Experimental

2.1. Materials

Palygorskite concentrate was obtained from Xuyu, Jiangsu province, China. Hangjin2# raw ore was provided by Hangjinqi Hengyi Construction Ltd., Inner Mongolia Autonomous Region, China. Hangjin2# clay was a new clay mineral, containing 24.2% palygorskite, 24.5% illite, 11.0% clinochlore, 12.6% calcite, 11.9% quartz, and 10.7% feldspar, et al. Bentonite concentrate was obtained from Neijiang, Sichuan province, China. Sepiolite concentrate was obtained from Yi city, Hebei province, China. The chemical compositions of these clay minerals were showed in Table 1. All minerals were ground to a particle size of 0.2 mm, respectively. Printing and dyeing wastewater (Sichuan Cotton-Textile Printing and Dyeing Mill) with an absorbance of 0.830 at the maximum absorption wavelength of 532 nm, chemical oxygen demand (COD) of 850–1460, and pH value of 9–10.

2.2. Instrumentation

A DF-101S constant temperature magnetic stirring apparatus, a CS101-2 constant temperature drying oven and a RJM-2.8-10 muffle furnace were used for the preparation of the decolorizing ceramsites. A high speed centrifuge and a 721 spectrophotometer were used for the determination of absorbance. A HY-4 variable frequency oscillator was used for the measurement of loss ratio.

2.3. Preparation of the material

The decolorizing ceramsites (Φ3–5 mm) were prepared according to the technological process in Fig. 1.

2.4. Method

2.4.1. Static decolorizing experiment

The static decolorizing experiment was operated in a Bunsen beaker with 100 mL printing and dyeing wastewater. Certain amount of decolorizing ceramsites were added and treated for 5 min, the absorbance of the supernatant was measured after centrifuging the solution at 4000 rpm for 1 min (using distilled water as blank sample), and COD was measured by means of dichromate titration.

2.4.2. Measurement of the loss ratio and strength of the decolorizing ceramsites

A certain amount of decolorizing ceramsites was oven dried to constant weight at 110 °C, and was weighed accurately (M_1) when cooled to room temperature. And then, transferred it to an Erlenmeyer flask with 50 mL deionized water, and oscillated for 30 min by a variable frequency oscillator at the maximum frequency (200 times/min), flushing away the spattering powder by deionized water. After oven dried to constant weight at 110 °C, the decolorizing ceramsites were weighed accurately

Table 2
Performances of the decolorizing ceramsites made of different clay minerals

Clay minerals	Al_2O_3, Fe_2O_3 and MgO content/wt%	Decolorizing amount/ mL g^{-1}	Removal of COD/%	Strength / day	Loss ratio/ wt%	Ultimate pH value of the decolorization
Palygorskite	26.89	635	82	>20	4.3	7.5
Hangjin2# clay	20.45	565	73	>20	4.5	7.5
Bentonite	18.13	508	62	<0.5	84	7.5
Sepiolite	26.52	606	78	–	–	7.5

mL g^{-1} refers to mL of wastewater that each gram of sample can decolorize.