Saudi Journal of Biological Sciences (2017) 24, 749–759

King Saud University

Saudi Journal of Biological Sciences

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Comparing the performance of granular coral limestone and Leca in adsorbing Acid Cyanine 5R from aqueous solution

Reza Shokoohi [a], Mohammad Taghi Samadi [a], Mohammad Reza Samarghandi [a], Mohammad Ahmadian [b], Kamal Karimaian [a], Ali Poormohammadi [a,*]

[a] *Department of Environmental Health Engineering, Faculty of Health, Hamadan University of Medical Sciences, Hamadan, Iran*
[b] *Department of Environmental Health Engineering, Faculty of Health, Bam University of Medical Sciences, Bam, Iran*

Received 27 October 2015; revised 3 January 2016; accepted 5 January 2016
Available online 12 January 2016

KEYWORDS

Coral limestone;
Leca;
Adsorption;
Acid Cyanine 5R

Abstract The effect of granular coral limestone and Leca as adsorbents for removing Acid Cyanine 5R (AC5R) from aqueous solution was studied. The optimum pH and adsorbent particles size in both adsorbents were determined to be 3 and 297 μm, respectively. The optimum dosages of coral limestone and granular Leca were 0.150 and 0.145 g/mg of dye, respectively. Also, results have shown that the adsorption efficiency by both coral limestone and Leca increased with the decreasing adsorbent particles size. Moreover, under similar conditions, the maximum removal efficiency by granular coral limestone and Leca was 94% and 88%, respectively. The results revealed that the performance of granular coral limestone was better in AC5R removal than that of Leca granulated under such condition. In total, granular coral limestone and Leca act as suitable adsorbents for removing dye pollutants from an aqueous solution.

1. Introduction

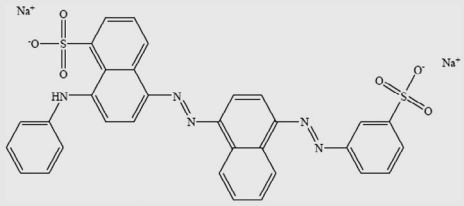
Various industries such as cosmetics manufacturing industries, dyeing industries, paper and paperboard manufacturing industries, and textile industries produce colored effluents (Jayanthy et al., 2014). Dyes have complex molecular structures and are often toxic, carcinogenic (production of amine groups in anaerobic decomposition), non-biodegradable and sustainable (Asgher et al., 2013; Helmes et al., 1984). When dye effluents enter the environment, especially water resources, they disturb the esthetic aspects of the environment, cause eutrophication phenomenon in surface water and disturb the ecology of acceptor water (Ahmadian et al., 2012). The majority of dyes are resistant to heat and light. Moreover, the resistance of dyes to degradation causes them not to be removed by conventional wastewater treatment systems. Different methods have been examined to decolorize color

* Corresponding author. Tel.: +98 831 4216143.
E-mail address: apoormohammadi000@yahoo.com (A. Poormohammadi).
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sjbs.2016.01.012
1319-562X

Table 1 Characteristics of AC5R dye.

Chemical structure	
Symbol	AC5R
Molecular formula	$C_{32}H_{21}N_5Na_2O_6S_2$
Molecular weight (g/mol)	681.6
Maximum absorption wavelength (nm)	494
Type of dye	Azo dye
CAS No.	3351-05-1
CB number	CB3250534

wastewater. Some of these methods include: coagulation, flocculation, chemical oxidation, electrochemical treatment, ion exchange, advanced oxidation, enzyme catalysis, adsorption, and making use of photo-catalysts. Of them, adsorption is one of the highly used processes. In the adsorption process, the main objective is to transfer contaminants from the liquid matrix to the solid matrix and to remove them completely (Magdalena et al., 2011). Activated carbon is one of the most effective adsorbents in removing dyes from aqueous solutions. Since it is expensive and costly to restore, researchers have always tried to find new adsorbents in this field (Ghosh and Bhattacharyya, 2002). In this regard, a lot of research has been carried out to apply and use cheaper adsorbents, which are easier to use. Some of these studies include application of kaolinite ore (Ghosh and Bhattacharyya, 2002), perlite (Arh-Hwang and Shin-Ming, 2009), bentonite (Gulgonu, 2012), rice bran (Guo et al., 2003), porous minerals (Ozdemir et al., 2004), and many other materials to remove various dye contaminants from water and wastewater. Coral has a limestone structure with abundant porosity and is incompressible, non-biodegradable, and resistant to heat. Owing to its abundance in Iran's water, its natural structure and lack of environmental impact in the case of limited use, it can be used as an adsorbent in industrial wastewater treatment (Ohki et al., 1996). Leca (Light Expanded Clay Aggregate) is produced from the expansion of a certain type of clay in rotating kilns in temperature of about 1200 °C. Leca has almost round particles with coarse and rough surfaces (Leca Co., 2006). Since Leca is light, incompressible against constant pressure, non-biodegradable, is a sound and temperature insulator, has a natural pH, is produced in Iran, and is cheaper than other industrial absorbents, it can be used as a convenient, inexpensive, and environmentally friendly adsorbent for removing dyes (Nkansah et al., 2012). According to what was said above, the main objective of this study is to evaluate and compare normal adsorbents of limestone coral and Leca in removing AC5R dye from aqueous solutions. Efficiency of experimental adsorbents was studied after changing pH, contact time, initial dye concentration and the amount of adsorbent; then, Freundlich and Langmuir isotherm models as well as pseudo first and pseudo second order models were examined to evaluate the equilibrium constant of the reaction and removal efficiency.

2. Materials and methods

2.1. The preparation of dye

AC5R dye used in this research was a product of Alvan Sabet Company in Hamadan. Properties of AC5R dye used in this research are presented in Table 1. To prepare a sample, AC5R with a purity degree of 98% was used. This azo dye is widely used in textile companies in Iran. All samples were taken in laboratory temperature using ion free water.

2.2. The preparation of adsorbents

Leca (3–10 mm in size and density of 380 kg/m^3) was bought from Leca Boton Manufacturing Company in Qom. Limestone coral was prepared from limestone substrata of Kish Island. To prepare granules of studied adsorbents, samples were first crushed manually. Then, they were washed with ion free water to remove dust and were placed in the oven for 12 h in 105 °C to remove their extra water and humidity (Ozdemir et al., 2004). After they were dried, they were kept in containers in the laboratory. To assess the chemical structure and to determine type of phases forming adsorbents qualitatively, X-ray fluorescence and X-ray diffraction tests were used.

2.3. The standard curve

To evaluate concentration of the studied dye, VIS–UV Spectrophotometer (model Shimadzu UV-1700), which was made in Japan, was used. Dominant wavelength was studied in the range 400–700 nm and its level was λ_{max} = 494 nm. Standard curve was plotted at this wavelength. That is, 10 certain concentrations of the studied dye were prepared; after absorbance level was read at maximum absorbance wavelength, its standard curve was plotted and dye concentration was determined by this curve.

2.4. Batch experiments

All experiments were carried in batch condition. At the end of each run and before measurement of the residual dye, all samples were centrifuged for 10 min using a centrifuge (Sigma-301, made in Germany) with a speed of 3000 rpm and then were passed through 0.45 μm filter paper. To increase the accuracy, all experiments were done in a triplicate basis. All reported results in this paper are the mean of three measurements. The effect of some parameters such as contact time, pH, adsorbent dosage, initial dye concentration and adsorbents particles size were investigated on the adsorption efficiency by both coral limestone and Leca.

2.5. Effect of contact time

To study the effect of contact time on adsorption process, different contact time in the range 0–180 min were investigated