International Journal of Education and Science Research Review
E-ISSN 2348-6457
Volume-5, Issue-6 Nov-Dec- 2018
P-ISSN 2349-1817
www.ijesrr.org
Email- editor@ijesrr.org

ADSORPTION OF CATIONIC DYE BY USING METAL INDUSTRY SOLID WASTE AS AN ADSORBENT

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ABSTRACT

Industrial solid waste coal gangue has tremendous use potential. The cationic dyes red X-5GN and blue X-GRRL were removed from aqueous solutions using a spray drying and sintering process applied to ceramic microsphere adsorbents made from coal gangue. Adsorbents were described for their structural characteristics. Solution pH's influence on adsorption kinetics and isotherms was also investigated. The mechanics of adsorption and the proper way to dispose of used adsorbents were also covered. According to the findings, the adsorption capacities of the cationic red and cationic blue onto the ceramic adsorbents were and. Within 1 minute, the adsorption equilibrium period had been achieved, and more than 90% of both dyes had been eliminated. The adsorbents showed usefulness over a range of ph values for the solutions. It was hypothesized that electrostatic attractions, n- interactions, and hydrogen bonding all played a role in the adsorption process. It may be possible to treat wastes with wastes if colored wastewater is treated using coal gangue ceramic adsorbents.

Keywords: *Congo red dye, Methylene blue dye, Jarosite, Adsorption, Fixed bed column, Breakthrough curve*

INTRODUCTION

Massive amounts of solid waste are produced by industries, which has a direct impact on the natural system. Jarosite and fly ash are two examples of the many forms of solid waste produced by the mining, mineral processing, coal processing, and other related sectors. Some major sectors that continue to generate enormous trash are investigating potential uses for this material from a variety of angles. When zinc is extracted using hydrometallurgy, jarosite is one of the main byproducts. It is estimated that for every ton of zinc produced by the hydrometallurgical process, another ton is created via the pyro-metallurgical process of jarosite, bringing the total amount of zinc produced worldwide to over 80%. Huge quantities of jarosite trash are thrown away and dumped.

Countries like China, India, Australia, Canada, Germany, and Japan are also major producers of jarosite. On average, India produces around of jarosite every year. Because of its huge surface area and adsorption capability, activated carbon is likely the most often used adsorbent in adsorption. In addition, there are a lot of issues with re-activating activated carbon, and it's expensive. Researchers have therefore looked at the viability of using low-cost materials, such as Alunite and agricultural waste, as adsorbents for the treatment of dye effluent. As a result, we need to identify its potential uses in a variety of settings where its toxicity may be mitigated.

India, where millions of people are engaged by small-scale dyeing enterprises that generate enormous volumes of wastewater, has an additional difficulty in handling this effluent. The wastewater from most dye factories is simply dumped.

Plants and animals living in water may be harmed by these wastewaters. Dyestuffs containing azo groups and aromatic structures, including acidic, basic, dispersion, reactive, and direct dyes, are quite common. Methylene blue, the most popular dye, is a heterocyclic molecule with a maximum absorption wavelength of roughly 663 nm (nm), as seen in its chemical formula.

Therefore, wastewater treatment is necessary. Catalytic degradation, coagulation, membrane technology, and adsorption are only few of the methods utilized to clean up dye effluent. In addition to being expensive, time consuming, inefficient, etc., these approaches contribute to secondary pollution. Adsorption stands out among these methods for removing dye because of its great performance, adaptability, simplicity of design, and low operating costs. Dye removal from wastewater by various adsorbents, including clay, has been documented. Adsorption of reactive orange 16 dye was 90.3% utilizing a modified fly ash adsorbent, as reported by Malek et al. Researchers looked at coal gangue's potential as an adsorbent for getting rid of cationic dyes like red and blue with efficiencies of over 90%.

In the current study, cationic dye solution was treated using jarosite as the adsorbent at varying pH, contact times, starting dye concentrations, and dosages.

Chemicals, materials, and characterization of samples

The garbage came from Hindustan Zinc Limited (HZL) in Udaipur, Rajasthan. Hydrochloric acid (HCl), sodium chloride (NaCl), and sodium hydroxide (NaOH) were acquired from Sigma Aldrich, India, while MB was purchased from Loba Chemise Private Limited, India. All solution was made in distilled water. Absorption spectra of the dye solution were recorded using a UV-vis spectrophotometer at nm in a conventional 10 mm path length.

Characterization of prepared adsorbent

The adsorbent's morphological structure (i.e., its shape and size) was studied using FE-SEM. The synthesized adsorbent is lumpy, has an unevenly rough surface, and is of an irregular cubic shape. In the literature, similar findings were observed. As shown, EDS analysis was used to get an elemental assessment of the adsorbent surface.

When untreated or inadequately treated industrial waste, such textile effluents, is discharged into the ecological system, it may have devastating effects on both the environment and human health. In addition, growing urbanization has increased the problem of solid waste from a variety of sectors. For instance, the metal industry has been producing a growing quantity of waste, including Jarosite, which is made up of a number of different metals, metal oxides, and silica. Therefore, adsorption of anionic Congo red (CR) and cationic Methylene blue (MB) dyes from aqueous solutions was achieved by using Jarosite as an adsorbent. The treated adsorbent sample was characterized by BET, XRD, SEM, EDS, FTIR, and XPS methods. Dye adsorption was studied by varying parameters such starting concentration, pH, adsorbent dosage, temperature, and contact duration. At pH 7, contact period 90 min, adsorbent dosage 0.1 g, and beginning dye concentration 50 mg/L, metal industrial waste is employed as a low-cost plentiful adsorbent with excellent potential for adsorption ability to remove the CR (97.5%) and MB (68.5%). Adsorption results for both dyes were in agreement with the adsorption isotherm and the adsorption kinetics. Both dyes were eliminated by an endothermic and spontaneous reaction involving physical adsorption. Adams-Bohart (AB) and Yoon-Nelson (YN) models were used to explain the examination

of adsorption in a column. Since jarosite can be obtained for free from factories, using it to remove dye is a cheap option, at least from a monetary point of view. Since then, hazardous metal industrial waste has been effectively used as an adsorbent in the treatment of wastewater for the first time.

The concerns of water pollution and management have garnered increased attention due to the scarcity of this crucial resource. Better wastewater management is essential to achieving the Sustainable Development Goals set forth in the 2030 Agenda, according to the latest United Nations World Water Development Report. Industrial effluent is still considered a major contributor to water contamination. Thus, substantial work has been done to enhance water quality via source reduction, by-product recovery, and pollutant elimination in wastewater flows.

Dye effluent has been shown to be poisonous, carcinogenic, mutagenic, and teratogenic, and it is released annually into natural water bodies, killing out aquatic life and posing serious health risks to people. Precipitation, flocculation coagulation, photo catalytic degradation, adsorption, and biological oxidation are only some of the technologies that have been developed to remove colors from wastewater in order to lessen effluent damage and conform to discharge regulations. However, many of these procedures have intrinsic restrictions on treating dyes since the aromatic structures of most dyes are stable and non-degradable under heat or light, even with action of common oxidizing agents. sewage Adsorption is a promising and widespread strategy to remove colors from aqueous effluents because it is efficient, cheap, and more practicable than other methods of water treatment. Currently.

Sludge is produced whenever wastewater is treated and disposed of. There are often a lot of organic contaminants, including polymerization products, and a few inorganic pollutants, like silicate, in the effluent from latex facilities. Massive amounts of sludge may be produced by dewatering latex wastewater using coagulation and pressure filtering. Aiming at the features of high organic matter content in latex sludge, recovering and converting latex waste into useable material for resources and environmental sustainability is a crucial problem. The structural formula for the latex sludge utilized in this study may be seen below. It is constituted mostly of styrene-butadiene latex.

OBJECTIVE

1. The Study Adsorption of Cationic Dye by Using Metal Industry Solid Waste.
2. The Study Industrial Solid Waste Coal Gangue Has Huge Utilization Potential.

RESEARCH METHODOLOGY

Guangda Construction Co., Ltd. (Jiangsu, China) provided the latex sludge (LS) utilized in the experiment. The LS was acquired by the treatment of industry effluent by industrial coagulation and pressure filtration. LS was dried at 105 °C to constant weight, and then crushed into powder and stored. The cationic blue X-GRRL was acquired from Runtu Co., Ltd. (Zhejiang, China). In the laboratory, only analytical-grade chemical reagents were employed.

Preparation of Sulfonated Latex Sludge

10 g crushed LS and 30 mL 1,2-dichloroethane were put into the 250 mL three-necked flask and refluxed in an 80 °C water bath for 30 min to make LS completely swollen. Next, 30 mL of 98 wt% sulfuric acid was introduced slowly and kept at that concentration. The product was then washed many times with deionized water and dried at 80 °C until its weight remained consistent. At long last, the sulfonated latex sludge (SLS) was sieved to between 100 and 200 mesh before being put to good use.

Preparation of Latex Sludge Activated Carbon

To begin, 50 g/L of sodium bicarbonate was added to a constant temperature oscillator set to 60 °C, and the crushed LS was heated for 30 minutes. $NaHCO_3$ and LS both weighed the same. Then, the sample was dried in an oven at 105 °C for 24 h to a constant weight, and the dried samples were heated to 700 °C and held for 1 h under N_2. The sample was then washed in a hydrochloric acid solution of 10 weight percent in order to remove any remaining soluble inorganic salts. The pyrolysis product latex sludge activated carbon (LSC) was produced after being rinsed with distilled water and then dried to a constant weight in an oven at 80 °C. The resulting LSC was sieved to 100-200 mesh adsorbent for further usage.

Measurement Techniques

After pressing the sample into a thin slice and treating it with 1% KBr, the Fourier transform infrared (FTIR) spectra were taken using a Nicolet Nexus 470 (Nicolet, Green Bay, WI, USA). Gemini SEM-500 (Zeiss, Oberkochen, Germany) scanning electron microscopy (SEM) was used to assess the morphology of materials. Elementar (Langenselbold, Germany)'s vario elemental analyzer was used to determine the chemical make-up of the organic compounds. HD88 surface area analyzer using N_2 adsorption-desorption to provide Brunauer-Emmett-Teller (BET) analysis. Using a DR5000 UV spectrometer, we determined the X-GRRL concentration to be 608.2 nm.

Batch Adsorption Experiments

To get the desired concentration, X-GRRL (cationic blue) was dissolved in distilled water to make a stock solution (1000 mg/L), and then diluted. Concentrations of HCl and NaOH solution were used to modify the pH of X-GRRL solutions. The X-GRRL solution and the adsorbents were combined and then shaken for a predetermined period of time at a rate of 150 revolutions per minute.

$$q_e = \frac{(C_0 - C_e)V}{m}$$

$$\eta = \frac{C_0 - C_e}{C_0} \times 100\%$$

DATA ANALYSIS

Crushing the LS block produced the LS powder. The LS block was obtained straight from industrial sludge following coagulation and dehydration treatment of production wastewater of latex industry. Tanned and obstructed, the LS. After sulfonate and pyrolysis treatment, the raw material turned into dark brown correspondingly. When compared to LS powder, SLS revealed a grainy structure, but LSC showed a markedly different shape with a greater density of porosity in a honeycomb structure, as shown by scanning electron microscopy (SEM). In comparison to LS's 3.45 m2/g and 0.02 cm3/g, the BET surface area of LSC was measured to be 313.39 m2/g and the total pore volume to be 1.12 cm3/g using a nitrogen adsorption-desorption isotherm. Both the surface area (6.13 m2/g) and total pore volume of SLS were found to be comparable to those of LS. The pyrolysis process, in which organic matter in LS is thermally destroyed to generate a pore structure along with gasses, may account for the observed morphological variation.

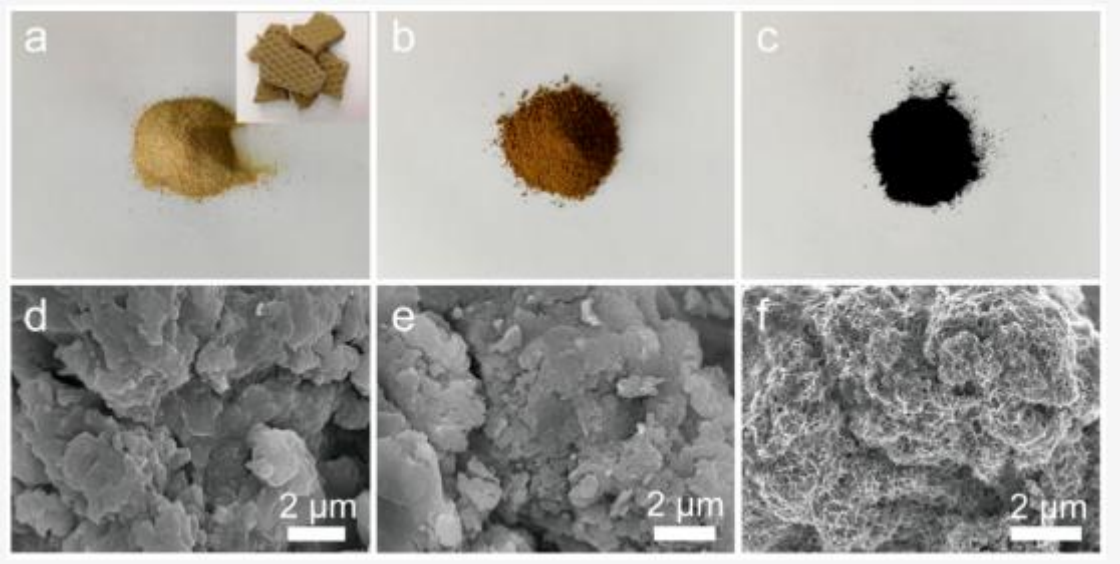

Figure 1. Photograph of (a) crushed latex sludge (LS), (b) sulfonated latex sludge (SLS) and (c) latex sludge active carbon (LSC), the inset in (a) is the uncrushed industrial LS. Scanning electron microscopy (SEM) images of (d) crushed LS, (e) SLS and (f) LSC.

FTIR spectroscopy was used to examine how LS, SLS, and LSC's surface functional groups changed over time. The -OH stretching vibration was shown to be responsible for the peaks at 3437 cm1 in all samples. =C-H stretching vibrations were identified as the source of peaks in the LS and SLS spectra about 3028 cm1. Peaks at 2950 and 2874 cm1 were identified as C-H stretching vibrations in all samples. C=O stretching vibrations were determined to be the cause of the peaks around 1734 cm1. The peaks at 1601 and 1453 cm1 were attributed to aromatic ring C=C skeletal vibrations. The FTIR spectrum of SLS is quite comparable to that of LS, suggesting that there was little to no fundamental change in the framework structure of SLS throughout the modification

process. A stretching vibration of O=S=O was used to explain the appearance of two additional peaks in the SLS spectra at 1184 and 1039 cm1, suggesting that -SO3H had been grafted onto SLS. Weakened =C-H and C-H peaks in the LSC spectra revealed that the cracking process took place at high temperatures.

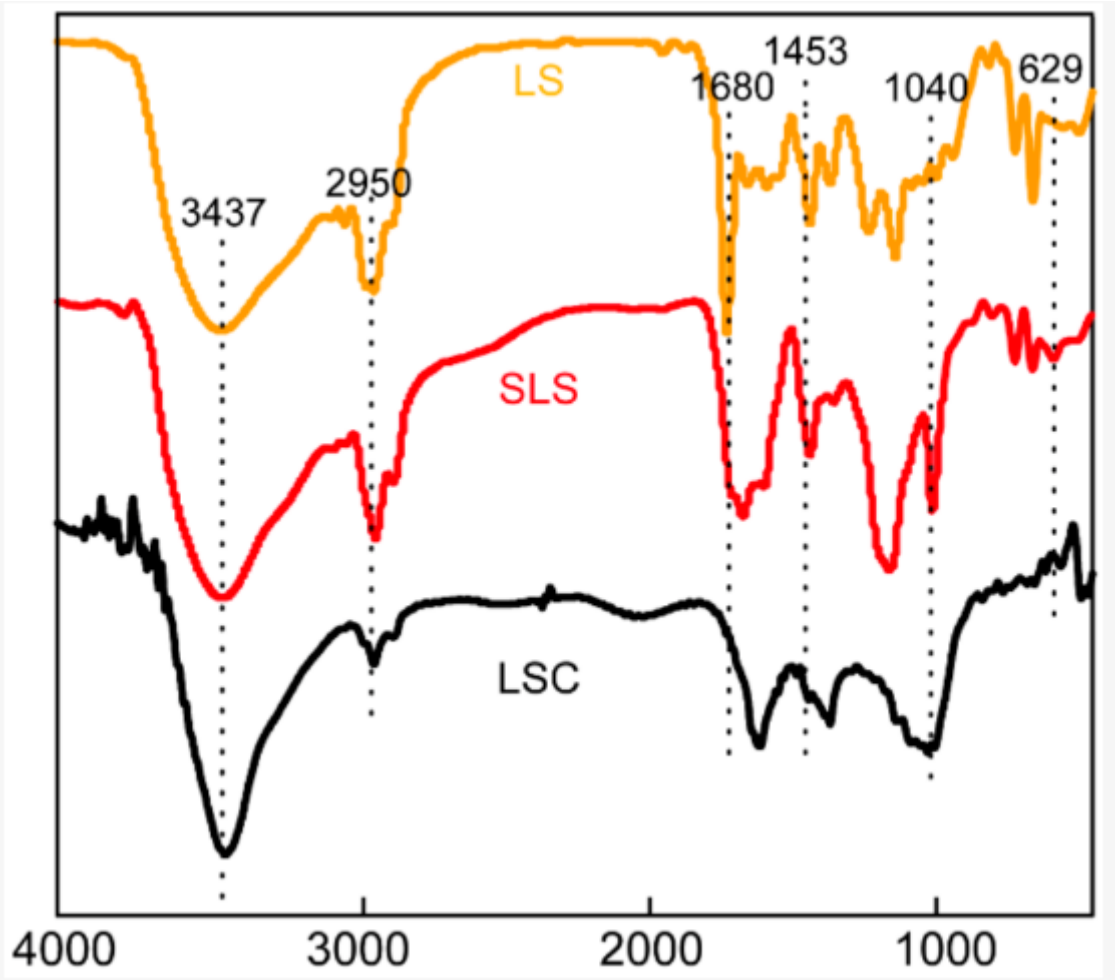

Figure 2. Fourier transform infrared (FTIR) spectrum of LS, SLS and LSC.

CONCLUSION

Dye removal from effluents has to be effective and long-lasting because of the damage it causes to ecosystems. Among these methods, adsorption continues to be the most accessible and widely utilized for cleaning up dye effluent. In order to get rid of MB dye in water, this research employed industrial solid waste as an adsorbent. The adsorbent surface was characterized by FE-SEM, EDS, XRD, and FTIR. Industrial latex sludge was converted into SLS and LSC absorbents by sulfonate and pyrolysis treatment, with the results depending on a number of variables such as contact duration, pH, and adsorbent dosage. The X-GRRL textile dye was removed using SLS and LSC absorbents. Absorbents made from SLS and LSC have their adsorption capabilities and mechanisms compared. As expected, increasing the adsorption period, pH, and starting concentration of X-GRRL revealed a dramatic increase in the effectiveness of adsorption onto both SLS and LSC. Both processes were endothermic and conformed to the pseudo-second-order rate equation. Adsorption of X-GRRL on SLS was a chemical adsorption by electrostatic interactions at a homogenous surface via monolayer adsorption, whereas adsorption on LSC was a hybrid process driven by a physisorption mechanism.

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