International Journal of Engineering Research & Management Technology
ISSN: 2348-4039
IJERMT
Sep-Oct-2017 Volume 4, Issue-5
Email: editor@ijermt.org www.ijermt.org

Adsorption of Cationic dye and Anionic dye- A Comparison

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ABSTRACT

Any solid materials that are rendered worthless during the production process are considered industrial solid waste (ISW). The ISW recognizes a worldwide environmental crisis, demanding urgent action to address it and lessen its effect on the planet. As an alternate strategy for ISW management, adsorption of heavy metals from industrial effluents using ISW is seen as promising, prospective, and economical. The ISW has potential benefits since it is a renewable, cost-free, highly efficient, and environmentally friendly energy source. The initial concentration of metal ions, contact duration, pH of the solution, temperature, and adsorbent dosage are only a few of the variables that impact the efficiency of heavy metals adsorption onto ISW. In this study, we discuss how contact duration, temperature, pH, and adsorbent dosage all play a role in heavy metal adsorption onto ISW.

Keywords: *Heavy Metals, Adsorption*

INTRODUCTION

The environmental society has felt the effects of modern industrial advances. When using dyes to color their goods, industries like the textile industry generate organic waste water. In the dying process, for example, half of the dye is lost in the waste water due to insufficient dye fiber attachment. Those who may utilize effluents for drinking, cooking, and cleaning may be adversely affected by the discharge of these colors. Since even a concentration of 1.0mg/L of dye in drinking water may cause a noticeable change in color, rendering the water unsafe for human consumption, it is crucial to check the water's quality. Because they block some of the light that would normally reach aquatic plants, dyes may have a negative impact on them. Dyes have the potential to be mutagenic, carcinogenic, and poisonous to aquatic life, as well as to cause serious harm to humans, including kidney, liver, brain, and central nervous system problems.

More than 7 x 105 tons of dye are manufactured every year, and there are more than 100,000 different dyes on the market. Dye wastewater is notoriously difficult to treat due to the colors' properties as refractory organic compounds that are persistent against light and resistant to aerobic digestion. Synthetic dyes in wastewater are resistant to common decolorization processes. This is due to the textile and paper industries' inability to affordably handle their massive amounts of dye effluent and the associated disposal issues. Because even trace amounts of dye in water may be harmful and highly visible, it is crucial that they be removed from waste effluents. There is a continuing need for a technology that can efficiently remove these colors from textile waste water since doing so is an environmental problem and is mandated by law. In spite of the availability of several methods, such as coagulation, chemical oxidation, membrane separation, electrochemical, and aerobic and anaerobic microbial degradation, for removing these contaminants from waste water in compliance with legal standards, they continue to be a problem.

Many limitations make these approaches ineffective. Due to its low cost and excellent quality treated effluents, adsorption has been favored over other available procedures. This is particularly true for sorption systems that have been carefully developed. Adsorption by activated carbon is a crucial method for cleaning up effluents and waste water, where it is used to polish the influent before it is discharged into the environment. Despite its importance, adsorption by activated carbon is limited by factors like the price of the activated carbon, the need for regeneration after exhaustion, and the loss of adsorption efficiency after regeneration.

In order to improve the adsorption capacity of the adsorbent, researchers have followed numerous activation strategies and they mainly employed the Langmuir isotherm to show the efficiency of the activation process. Carbonization is an example of a physical activation approach, whereas chemical activation involves the use of chemical activating substances. Some research examined agricultural wastes as adsorbents for the contaminants found in real textile waste water, which includes a wide variety of colors, organic compounds, heavy metals, total dissolved solids, surfactants, salts, and chlorinated compounds. In their research, Ahmad and colleagues revealed that bamboo activated carbon may reduce color and chemical oxygen demand by up to 91.84% and 75.21 %, respectively. Dye adsorption may be affected by anionic and cationic surfactants. An anionic surfactant may improve the adsorption of basic dyes. However, the addition of a cationic surfactant may improve the adsorption of anionic dyes. The anionic dye may be adsorbed after the negative ion of the surfactant has been adsorbed on the adsorbent via van der Waals contact. Although dye adsorption is reduced by surfactants, using too much of them might lead to aggregation or solubilization of the dye.

Dyeing using cationic compounds:

Cationic dyes have widespread use in the processing of acrylic, wool, nylon, and silk. The atomic groups of these dyes are replaced in various ways, resulting in a wide variety of chemical structures. Harmful consequences include allergic dermatitis, skin irritation, mutations, and birth defects have been linked to these poisonous colorants. Dye molecules with a positive charge, like hydrochloride or zinc chloride, are referred to as "basic dyes." Cationic dyes are water-soluble and produce colorful cations in solution; they also have a positive charge. The most fundamental colors are the most eye-catching because of their extreme luminosity, Anthraquinon, di- and tri-arylcarbenium, phthalocyanine, and a wide variety of polycarbocyclic and solvent-based dyes all include cationic activity. Crystal methylene methylene blue, an essential basic dye, is extensively used in the textile industry and has been the subject of much study in the field of dye adsorption. Increased heart rate, shock, vomiting, cyanosis, jaundice, quadriplegia, Heinz body formation, and tissue necrosis may result after an acute exposure to methylene blue. Adsorption of methylene blue dye by various agricultural wastes, including peanut shells, coconut husks, guava pits, neem leaves, and gulmohar plant, has been the subject of extensive study. Good adsorption capabilities for the color methylene blue were shown by all of these wastes.

Objectives

1. The Study Absorb Cationic Dye, Solid Waste from The Metal Sector.
2. The Study Adsorption of Heavy Metal from Industrial Effluents Using Isw Is Considered as A Promising.

Anionic dyes:

It is the negatively charged ions on which anionic dyes rely. Water-soluble, ionic substituents are a defining property of anionic dyes, which include a wide range of compounds from a wide variety of dye families. Chemically speaking, a high fraction of reactive dyes may be found within the class of anionic azo dyes. Most reactive colors develop covalent bonds with natural fibers like cotton, wool, etc. Hydrolysis of reactive groups in the water phase leads to a low degree of fixation for the reactive dyes, making their escape into the environment undesirable. Typically employed with hydrophobic fibers like silk, wool, polyamide, modified acrylic, and polypropylene, acid dyes are also effective with olefins. Because they are organic sulfonic acids, acid dyes are toxic to humans.

Dye removal adsorbents:

There have been several attempts to filter the colors out of the wastewater by using different adsorbents. The dye's characteristics and the chemistry of the adsorbent's surface both have a role in the adsorption process. Adsorption is a useful technique for cleaning colors out of wastewater. Adsorption offers advantages over other procedures since it is sludge-free, clean, and can remove colors from diluted solutions entirely. For organic compounds, activated carbon (in powdered or granular form) is the most popular adsorbent due to its high adsorption effectiveness. However, activated carbon that may be purchased is somewhat expensive. Regeneration with a solution yielded little extra effluent, but regeneration using a refractory approach depleted the adsorbents and their ability to absorb by 10-15%.

The sorption data have been connected with adsorption isotherm to assess the effectiveness of adsorption process. Many scientists have done preliminary work on a number of different adsorbents, some of which are listed here. Wool yarn and tamarind Nut hulls, sugar beet pulp, rice husk ash, coir pith, tea scraps, almond hulls, lemon rind, bagasse fly ash, neem sawdust, guava seed carbon, etc. are all examples of adsorbents. Activated carbon is the most common kind of adsorbent used for this purpose. Coal, charcoal and sawdust may be the raw material for the manufacturing of the commercial activated carbon where the activation involves partial oxidation and pore structure develops.

Activated carbon may be made in two different varieties: H-type and L-type. H-type molecules are hydrophobic and have a positive charge in water, whereas L-type molecules are charged negatively and are hydrophilic. Activated carbon may be provided in granular form (granular activated carbon (GAC)). Because of its adaptability for continuous contacting and because there is no need to separate the intraarticular diffusion in GAC, an issue faced in the application of adsorption techniques to water treatment, GAC may be made from hard materials that are utilized to remove water contaminants. Powdered activated carbon (PAC) is another kind of activated carbon that may be purchased. It is necessary to separate carbon from fluid after using PAC since it is produced when tiny particles constitute the raw materials and are generally combined with the liquid to be treated and disposed of. Yet the PAC employed for waste water treatment due of inexpensive cost and minimal contact time, where it provides a broad exterior surface and a limited diffusion distance.

Agricultural Solid Wastes:

Agricultural solid wastes, which, due to their physicochemical features and low cost, may be suitable prospective adsorbents, have been the subject of several efforts to identify cheap and conveniently accessible adsorbents for the removal of pollutants. Agricultural outputs are accessible in enormous amounts over the globe; hence, significant quantity of waste structural components which include lignin, cellulose and hemicelluloses. These substances have a significant molecular weight and provide mass. Many investigations on dye adsorption by agricultural solid wastes have been published, and a variety of adsorbents produced from these wastes have been employed for dye removal from waste water. Dye removal from wastewater sometimes employs adsorbents made from agricultural solid wastes such as sugarcane bagasse activated carbon manufactured from mosambi.

Adsorbents made from agricultural wastes are cheap, abundant, and sustainable alternatives to those made from other sources. When compared to other adsorbents, agricultural wastes are superior because they may be utilized with little to no processing (washing, drying, grinding), lowering manufacturing costs by making use of a cheap raw material and avoiding the energy expenditures involved with thermal processing. There is a lot of trash from the various companies that have begun using oil palm, thus several research are using the waste products, including palm kernel fiber, as dye adsorbents. More than 80 nations cultivate coconuts for use in the food industry, and the byproducts of these businesses create a great deal of trash that is put to good use in dye adsorption research, including empty coconut shells, coconut coir, and coconut tree sawdust.

Effect of initial dye concentration:

Prepare adsorbent-adsorbate solution with a constant adsorbent dosage and varying starting dye concentration over varying time intervals, then shake until equilibrium to observe the influence of initial dye concentration. The starting concentration of dye has a significant impact on the final percentage of elimination. It is the direct relationship between dye concentration and accessible binding sites on an adsorbent surface that determines the onset of dye concentration factor's impact. As the initial dye concentration rises, less of it is removed, perhaps because more of the adsorption sites on the adsorbent are already occupied. As the initial dye concentration rises, less available active sites on the adsorbent surface will be available for adsorption of the dye molecules.

However, they also found that as the Methylene blue concentration was increased from 50 mg/L to 250 mg/L, the unit adsorption for SDC increased from 12.49 mg/g to 51.4 mg/g, while the percentage of dye removal decreased from 99.9% to 82.2%. This discrepancy may be due to the high driving force for mass transfer at a high initial dye concentration. As can be seen from Table 6, which summarizes past research on the topic, the percentage of removal of both cationic and anionic dyes decreases with increasing starting dye concentration. Researchers employed empirical design approaches based on adsorption equilibrium conditions to forecast the adsorber size and performance since real textile wastewaters include color concentrations higher than those used in literatures.

The needs of a steadily expanding population have led to widespread contamination of water supplies with chemicals like artificial colors. Chromophores and auxochromes make up the bulk of synthetic colors derived from organic or inorganic substances. The chromophore is responsible for the dye's hue, whereas the auxochrome determines its saturation. Natural dyes from plants such roots, berries, bark, leaves, wood, fungus, and lichens were the standard prior to the development of synthetic alternatives in 1956. Many goods on store shelves now employ artificial dyes made from petrochemicals to get their colors after 1956.

Industries as diverse as those working with textiles, paper, animal skin tanning, food processing, plastic, cosmetics, and dyes have all benefited from the introduction of new, more visually appealing hues in recent years. Most synthetic dyes are known carcinogens, may be very detrimental to water supplies, and add to global pollution. Because of the negative effects that wastewater effluents may have on the environment and human health, researchers have been looking for quick and cheap remedies. Physical, biological, and chemical processes are the three options for the putrefaction of colors in wastewater. Membrane separation, adsorption, coagulation, oxidation, and precipitation are all examples of such processes. Adsorption is a straightforward, low-cost, and practical process for removing organic dyes from wastewater. Adsorbents made from a wide variety of synthetic substances have been utilized successfully in purifying water.

Activated carbon (AC) is the most popular adsorbent utilized to get rid of pollutants in the business world. With a large surface area and effective adsorption capacity, the AC has a highly developed pore structure. AC is employed in a wide variety of applications for the removal of organic and inorganic impurities from polluted water due to its exterior chemical functional groups and structural features. However, commercial AC production is expensive, prompting efforts to build a low-cost but nonetheless effective AC from a variety of different sources. Because of their excellent qualities and the fact that they are renewable, the generation of AC from natural sources or agroindustrial wastelands was studied. Destroying them is necessary for a healthier planet.

Physical activation and chemical activation are the two main routes to making AC. In physical activation, raw material is carbonized and subsequently activated using steam and carbon dioxide. In chemical activation, a chemical-activating agent is impregnated into the precursor material, and then the substance is activated at temperatures between 400 and 700 °C in an environment of nitrogen. Here are some benefits of chemical activation: Because (a) it happens faster than physical activation, (b) the AC produced has a large surface area and (c) the activating chemical agent influences the breakdown of carbon and prevents the development of tar and volatile substance, the yield of AC is increased.

When it comes to activating lignocellulosic materials that haven't been carbonized, the chemical activation approach relies heavily on ZnCl2, KOH, and H3PO4 as chemical-activating agents. In addition, chars, which are the precursors of coal, may be activated with KOH. Therefore, as H3PO4 has been described as an effective and inexpensive activating agent for of AC, it was attempted to employ it instead. The activation agent concentration, temperature, and activation time are only few of the variables that have been examined in the scientific literature.

CONCLUSION

Adsorption of cationic dyes is favored at high pH values, whereas that of anionic dyes is favored at low pH values. The pH factor is the most influential component affecting dye classification. Past research has shown that pHNpHpzc is optimal for the adsorption of cationic dyes, whereas pHbpHpzc is optimal for the adsorption of anionic dyes. Both cationic and anionic dyes may be effectively removed by adjusting the adsorbent dosage in relation to the dye concentration. Most investigations of dye adsorption by agricultural solid wastes indicated a larger adsorption capacity for cationic dyes than an adsorption capacity for anionic dyes, and this was determined using the Langmuirmodel. The Pseudo-second-order model is often used to describe the kinetic data of the adsorption of cationic and anionic dyes onto agricultural solid wastes. Cost comparison between the cationic and anionic dye adsorptionby agricultural solidwastes is animportant necessity in order to assess the dye-classified adsorption method from the economic point of view. The literature study highlights the need of more systematic research into the dye removal process and the technological enhancement of adsorbent preparation and application. The following are some suggestions for potential follow-up efforts.

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