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Decolorization of Distillery Effluent Using Poly(Vinyl Chloride) and Cellulose Acetate Phthalate as Adsorbents

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Decolorization of distillery effluents, using low cost polymer adsorbents, is one of the challenging areas for environmental technologists. Untreated distillery effluents are harmful to the environment, causing foul smell, spoiling fresh water sources and killing aquatic life. The color of distillery effluents have been decolorized by using polymer based adsorbents, such as poly(vinyl chloride) (PVC) and cellulose acetate phthalate (CAP), which are water insoluble, easily available, and cheap. In the present article, special emphasis is given to studies such as the effect of contact time, dosage amount, dilution, and the variation in the amount of sample on the degree of decolorization of the effluent. The decolorization of a distillery effluent was monitored by using UV/Visible spectroscopy and Fourier transform infrared spectroscopy (FTIR). From these studies, it was noticed that moderate to fair results were obtained and it was also found that CAP was a better adsorbent, compared to PVC, for decolorization of distillery effluents.

Keywords distillery effluent, decolorization, poly(vinyl chloride), cellulose acetate phthalate, UV/Visible spectroscopy and FTIR

Introduction

The demand of water requirements for basic needs increases with an increase in population and industrialization. Major consumers of water are the tannery, pulp and paper, distillery and electroplating industries. These industries generate large volumes of colored wastewater along with colloidal or suspended material, which is unfit for recycling without proper treatment. Thus, color is removed to make water suitable for general or industrial applications (1).

Treating of industrial effluents is one of the challenging areas for environmental technologists. A variety of methods, such as coagulation, sedimentation, electrolysis, colloids, adsorption, decolorization, etc., are available to treat and reprocess industrial effluents (2, 3). The distillery unit is one of the largest polluting industries that discharges

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polluted water daily in gallons. Distillery effluent contains many organic or colloidal ingredients and pollutants, which are difficult to dispose without further purification (4). These toxic ingredients or compounds must be neutralized or removed before the effluent is let out into drains or rivers as they emit foul smell after exposed to radiation/light for a longer time. This may cause respiratory problems to humans, affect the quality of both river and ground water and is harmful to the plant and aquatic world (5–7). The effect of reduced light transmittance on organic productivity and mutagenicity is due to the absorbance of UV light by the pollutants present in effluents.

The treated effluent can be used for production of biogas when used in combination with cattle waste (8). Recently polymer based decolorization, which is economically viable and feasible, has been vastly studied for the treatment of pulp and paper mill industrial waste water (1). However, less emphasis or study has been given in the case of distillery effluents (9–16). The widely used technique for treatment of distillery effluents is the Upflow Anaerobic Sludge Blanket (USAB) process (10). However, no reports have been found for the use of poly(vinyl chloride) (PVC) and cellulose acetate phthalate (CAP) as polymer based adsorbents for distillery effluent treatment. In this article, the authors made an attempt to decolorize the effluent obtained from a distillery unit, using the two polymer based adsorbents such as cellulose acetate phthalate and poly(vinyl chloride). Both CAP and PVC are water insoluble, low cost, easily available, eco-friendly (degraded products are environment friendly) polymers, which are extensively used in pharmaceutical industries. In the present work, special emphasis is given to factors such as the effect of contact time, dosage amount, dilution and variation in amount of sample on the degree of decolorization of a distillery effluent. All the tests were carried out in duplicate and the average values are reported.

Experimental

Materials and Method

The studied effluent was obtained from a local distillery industry situated in Nanjangud, India and was dark brown in color. The raw effluent was stored in dark bottles at room temperature. The undissolved components present in the effluent were separated by centrifugation at 500 rpm and filtering through Whatmann no. 42 filter paper. CAP and PVC used were of analytical grade and procured from Loba Chemie, Mumbai. All the experiments were carried out in the dark by covering the flasks with carbon paper. This was done to minimize light sensitive degradation of organic pollutants into more harmful compounds. The percent of absorption of light by the effluent sample was measured at a λ_{max} of 465 nm on a Shimadzu 1601 UV/Visible spectrophotometer. The average characteristic properties of distillery effluent are given in Table 1.

Effect of Contact Time

In this study, 300 mg of CAP and PVC were weighed separately in 100 ml volumetric flasks to which 20 ml of diluted effluent was added. The samples were kept in duplicate for different time intervals viz., 0.5, 1, 2, 3, 4, 6, 12, and 24 h with intermittent manual stirring. The samples were centrifuged at 500 rpm for 15 min, filtered using Whatmann no. 42 filter paper and the percent of transmittance was measured by UV/Visible spectroscopy.

Table 1
Average characteristics of distillery effluent

Parameter	Magnitude
Color	Dark brown
pH	4–7
Total solids (g/lit)	23–30
Dissolved solids (g/lit)	5–9
BOD (mg/lit)	22,000–65,000
COD (mg/lit)	50,000–2,00,000

Effect of Adsorbent Dosage

In this study, different weights of polymer adsorbents viz., 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000 mg each of CAP and PVC were weighed in 100 ml volumetric flasks to which 20 ml of diluted effluent was added and kept for 24 h at room temperature with occasional stirring. After 24 h, the samples were centrifuged, filtered and analyzed by UV/Visible spectroscopy.

Effect of Dilution

The distillery effluent was diluted to different concentrations such as 0.5, 1, 1.5, 2, 2.5, and 3 ml per 100 ml of distilled water. To 20 ml of the different diluted effluents, 300 mg of CAP and PVC were added and kept for 24 h with intermittent stirring. The samples were centrifuged, filtered, and analyzed by UV/Visible spectroscopy.

Variation in Initial Amount of Sample

CAP and PVC (300 mg each) were taken separately, to which 20, 40, 60, 80, and 100 ml of diluted effluent (1 ml to 100 ml) were added. These were kept for a constant period of 24 h with occasional stirring. The rest of the procedure to analyze the samples was described above.

FTIR Study

A Perkin-Elmer 1000 spectrophotometer was used to record FTIR spectra of polymer adsorbents before and after exposure to the distillery effluent. The polymer powders were well grounded and dispersed in KBr to form pellets and the spectra were recorded in the wave number range of 4000–400 cm^{-1}.

Results and Discussion

Effect of Contact Time

The effect of contact time of polymer adsorbents on the reduction in color intensity of the distillery effluent has been studied with 300 mg of adsorbent. The plot of absorbance as a function of contact time of adsorbent is shown in Figure 1. This figure clearly indicates

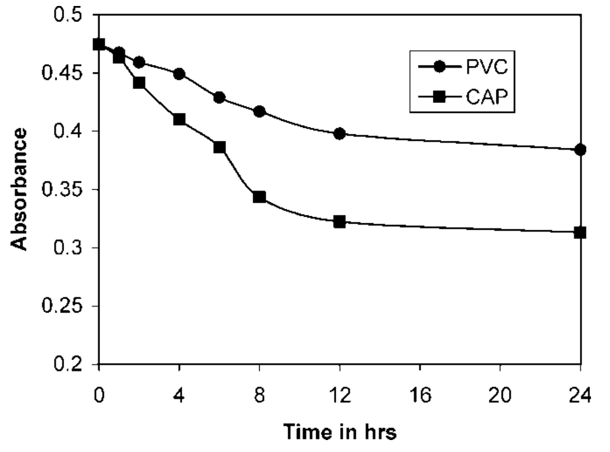

Figure 1. Effect of contact time.

reduction in color intensity of effluent up to 24 h of contact time. From the figure, it was also noticed that two types of transitions occurred. In the beginning, a drastic reduction in percent absorbance was noticed up to 8 h, followed by marginal changes with further increase in contact time. At the end of 8 h, a 12% reduction in absorbance was observed in the case of PVC and 27.3% for the CAP. This clearly shows that the adsorption process occurring between the polymer adsorbents and distillery effluent is a slow process and occurs over a period of time.

Effect of Adsorbent Dosage

The influence of different weight fractions of polymer adsorbents on the decolorization process of the distillery effluent was studied for 24 h. The absorbance as a function of dosage amount of polymer adsorbents is shown in Figure 2. From the figure, it was noticed that a drastic change in absorbance occurred up to 200 mg of adsorbent and marginal changes with a further increase in the dosage amount of adsorbents. This result clearly

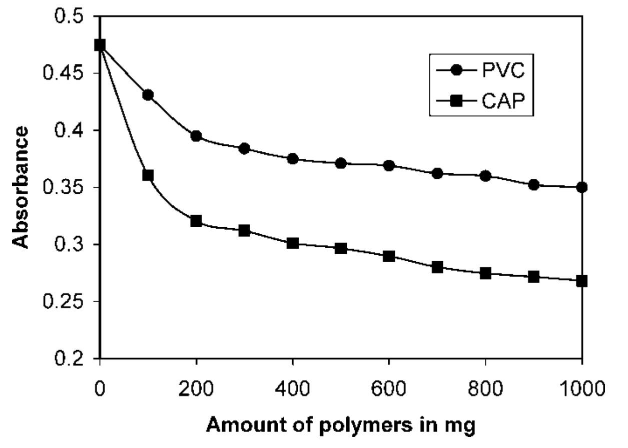

Figure 2. Effect of polymer adsorbents dosage amount.

revealed that the optimized dosage level of the adsorbent lies between 200–400 mg. Figure 2 also revealed that, the CAP is a more efficient adsorbent than PVC as it showed 32.5% reduction in absorbance value, whereas PVC reduced only a 16.8% reduction with respect to 200 mg of adsorbents. The increase in PVC and CAP (polymer adsorbents) dosage increases the number of –Cl and –OH groups respectively, which enhances the interaction between polymer adsorbent and color pigment present in the effluent. This interaction plays a vital role in decolorization process of the distillery effluent. From the study, it was concluded that the –OH group of CAP shows a greater tendency of interaction with color pigment present in the effluent than the –Cl group of PVC.

Effect of Dilution

The effect of dilution of effluent on the extent of color removal was studied with 300 mg of polymer adsorbents for 24 h of contact time. The measured plot of percentage reduction in absorbance versus amount of dilution is shown in Figure 3. From Figure 3, it was found that as the extent of dilution was increased, the extent of color adsorption by the polymer adsorbents also increased. CAP and PVC treated 0.5 ml diluted effluent showed a decrease in absorbance of about 31.5 and 51.4%, respectively. On the other hand, 3 ml diluted effluent showed only a slight reduction in absorbance of about 4.1 and 9.8%, respectively. This is because as the distillery effluent is diluted, the coloring matter in the effluent gets diluted and the efficiency of color adsorption by the polymer adsorbents enhanced.

Variation in Initial Amount of Sample

The influence of the initial amount of distillery effluent on the adsorption behavior was reported for 300 mg of polymer adsorbents. The plot of percentage reduction in absorbance as a function of the amount of initial concentration of distillery effluent is shown in Figure 4. From the figure, it was found that the extent of color adsorption was inversely proportional to the amount of effluent. This is because as the amount of effluent decreases, the coloring matter present in the effluent decreases and as a result, efficiency of color adsorption by the polymers increases. From the investigation, it was revealed that the CAP acts as a better color remover than PVC. The mechanism of

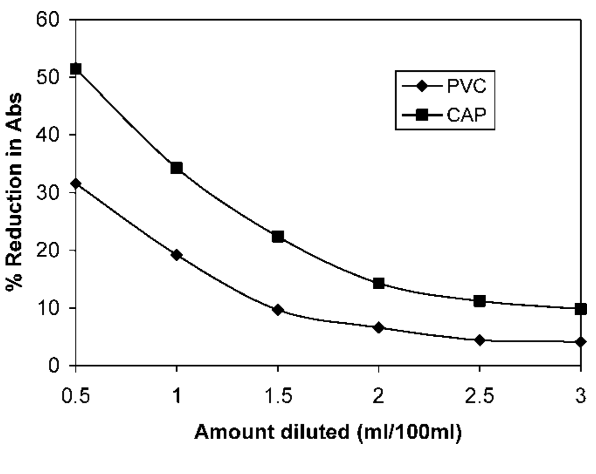

Figure 3. Effect of dilution on decolorization.

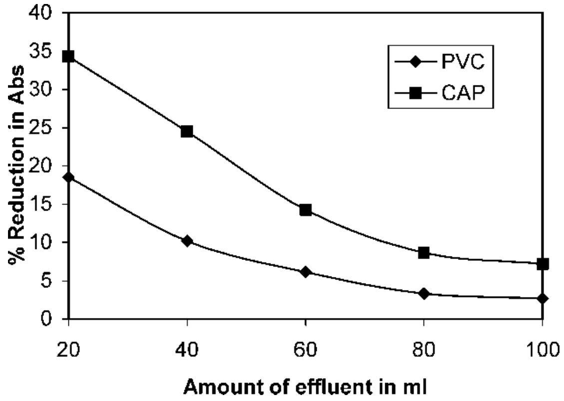

Figure 4. Influence of initial amount of sample on decolorization.

decolorization is due to interaction of PVC and CAP with the polar groups of color pigments present in the effluent.

FTIR Study

The FTIR spectrograms have given less information regarding the mechanism of color adsorption by the polymer adsorbents. The effluent treated and untreated powder spectra of CAP and PVC are shown in Figures 5 and 6, respectively. The characteristic

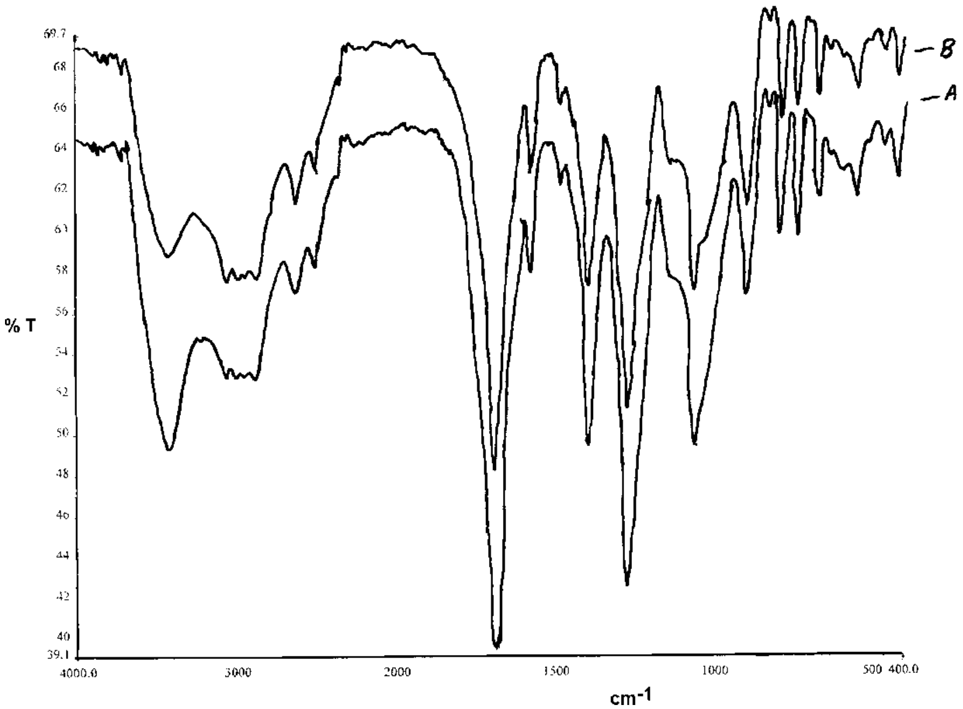

Figure 5. FTIR spectra of CAP: (A) before and (B) after treatment with distillery effluent.

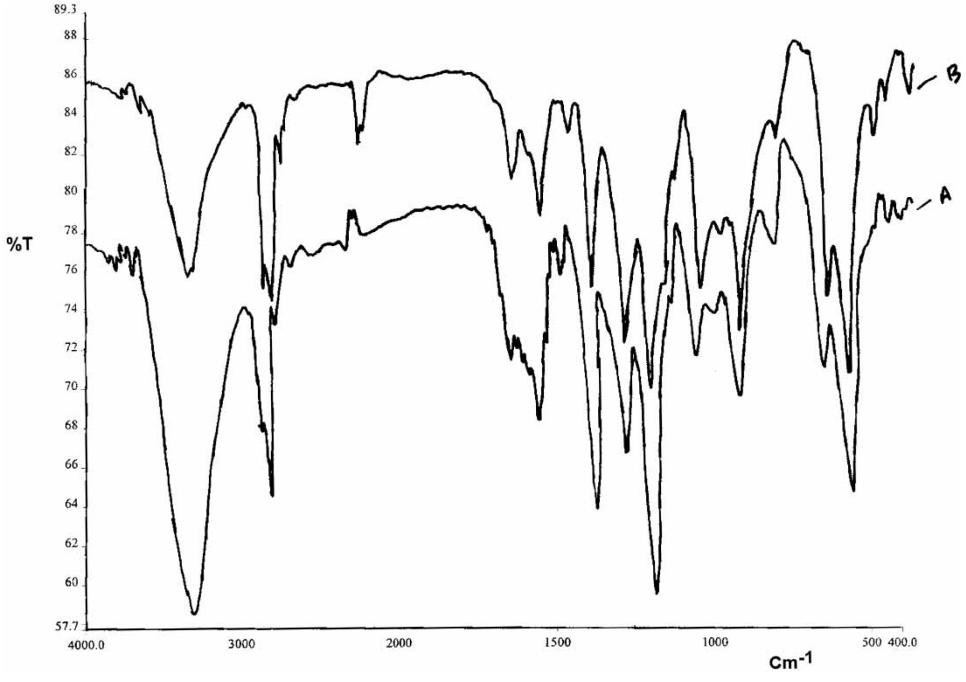

Figure 6. FTIR spectra of PVC: (A) before and (B) after treatment with distillery effluent.

absorption peaks for CAP was noticed at 3500, 2800, 1700, 1300, 1000, and 800 cm^{-1} and for PVC at, 3400, 1800, 1600, 1400, 1200, and 800 cm^{-1}. Some of the absorption peaks size, shape and position are changed after treatment with the effluent. This result clearly indicates some kind of interaction between hydroxyl groups of CAP and chlorine groups of PVC with the polar groups (color pigments) present in the effluent.

From this results, one can interpret that PVC and CAP have been found to be color removing adsorbents for distillery effluents. Being hydrophobic in nature, CAP and PVC do not coagulate or flocculate the coloring bodies, but there is a possibility of interaction between the charged moieties of the polymer adsorbents and free colloid ions present in the distillery effluent.

Conclusions

From the present study, it is clear that polymer adsorbents can be used as decolorizing agents for effective treatment of distillery effluents. PVC and CAP have been found to be a good option for effective decolorization of distillery effluents. The mechanism of color adsorption may be due to the interaction between chlorine groups of PVC and phthalate or acetate and free hydroxyl groups of CAP with polar groups of color ingredients present in the effluent. The residual polymers obtained could be further investigated for utilization as modified polymers. From the above study, it was concluded that CAP is a better color adsorbent than PVC.

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