

Decolorization of Reactive Red 195 solution by Cassia fistula seed gum

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ABSTRACT

In this paper the ability of Cassia fistula seed gum in color removing reactive red 195 solution has been tested by Jar-test experiment. The influence of several parameters such as pH, agitation speed, reaction time, gum dosage or initial dye concentration (IDC) have been tested. pH results to be an interesting variable and dye removal increases as pH increases to 10. This effect is optimum (57.8 %) at gum

dosage 200 mg/L, agitation speed and reaction time seems not to be so affecting parameter, while IDC appears to be a very important variable in color removal capacity, which is higher as IDC decreases (obtained highest decolorization at IDC 10 mg/L). This result indicates Cassia fistula seed gum can be used as an “green” coagulant for color removal from reactive dyeing solution

Keywords: Decolorization, coagulation, dyeing wastewater, Cassia fistula, Reactive Red 195.

INTRODUCTION

Textile wastewater is characterized by a high color, suspended solids (SS), and salinity. Also, it contains a large amount of bioresistant organic contaminants, which have strong toxic impacts on microbes [1, 2]. Many processes for color removal include ozonation, electrocoagulation, adsorption, membrane, sonolysis, etc.[3-5] are being researched. However, these processes are expensive or difficulties in operation. Hence, they could not be employed to treat real dyeing wastewater.

The use of coagulation for the treatment of textile wastewater is one of the most common processes which is effective, quick and compact but this process generally cost and product large amounts of toxic sludge that may link to Alzheimer's disease in human as metal-based coagulants (aluminum or iron salts) used [6]. This has led to an increasing research interest in

the production of novel low-cost coagulants with higher coagulation capability. Recently, the use of various types of natural coagulants for the treatment of textile wastewater has been reported [7, 8]. Natural coagulants, mainly polysaccharides, are generally nontoxic and biodegradable [7], which is essential from a sustainability point of view. Furthermore, as compared with the metal-based coagulant, natural coagulants could coagulate in around alkaline medium (at effluence pH of reactive dyeing wastewater) and could form effective flocs with relatively less danger in the case of coagulant overdose [9].

Therefore the objective of this research is to study the decolorization efficiency of *Cassia fistula* seed gum to act as coagulants on reactive red 195 aqueous solution by investigating the influence of the following factors: dosage, pH,

dye concentration, agitation speed, and reaction time in Jar-test experiments.

MATERIALS AND METHODS

Materials

Coagulant stock

Cassia fistula seed gum was prepared according to Singh et al. [10] and used without any purification with the characteristic could be found in our previous report [11].

The gum stock solution (5000 mg/L) was achieved by completely dissolving 0.5 g gum

powder into 100 mL distilled water, sonicating for an additional 60 min. Then, the solution was stored in a refrigerator. This stock was diluted to desired mass concentrations (from 100 mg/L to 350 mg/L) before being used.

Reactive dye stock

The commercial reactive red 195 (Sunfix Red S3B 100%) was obtained from Oh-Young (a Korean company). Its molecular structure and absorption spectra are given in *Figure 1*.

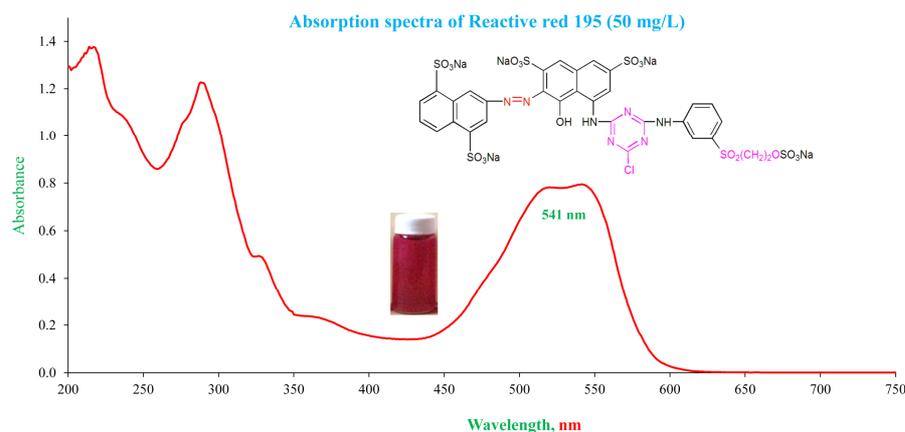


Figure 1. Chemical structure and spectral properties of Reactive red 195

The dye stock solution (1000 mg/L) was achieved by completely dissolving 1 gram of dye powder into 1 liter of distilled hot water at pH 11 for an hour to get the dye stock in the “hydrolyzed” form, and the solution was diluted to appropriate concentrations (10-140 mg/L) before being used.

Procedures

Coagulation studies were conducted in duplicate using Jar-test apparatus (Stuart flocculator sw6) with six beakers of one liter capacity, which is based on the ASTM D2035-13 standard [12]. The effect of pH, reaction time and agitation speed on dye removal were performed by mixing 10 mL solution containing different *Cassia fistula* seed gum dosages with 500 mL of different dye concentration.

The samples were stirred for one minute at 500 rpm followed by regular time mixing of 25 to 120 rpm. The contents are then settled for two hours, filtered and determined the absorbance at maximum absorption (λ_{max}) 541 nm of reactive red 195 using spectrophotometer UV-VIS GENESYS 10, Thermo Fisher Scientific Inc. Other water analysis followed standard methods and the results presented here are the mean values \pm standard deviations (SD).

RESULTS AND DISCUSSION

pH influence

The first run determined the pH required for color removal, by varying the pH (adjusting by 0.5 N NaOH or HCl) and fixing other factors of the sample: gum dosage 100 mg/L, time contact 30 min, agitation speed

60 rpm, initial dye concentration (IDC) 50 mg/L. pH varying from 3-12 mg/L were chosen.

It can be seen on *Figure 2* that the color removal efficiencies of gum rapidly increase when pH increases from 3 to 10, and then decrease when pH increases 12. The highest pH 10 resulted in

about 39.2% color removal of reactive red 195. This result may be explained by the easier formation of intermolecular force between the π electron system of the dyes and the cis-hydroxy groups in the galactomannan of gum at pH 10 compared with other pH values [11].

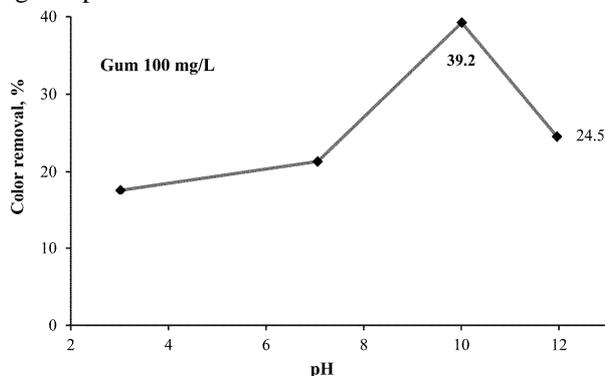


Figure 2. Effect of pH on dyes color removal (Agitation speed 60 rpm, IDC 50 mg/L, and time 30 min)

Effect of agitation speed

The effect of agitation speed on the color removal of the reactive dye was investigated. Agitation speed was increased from 25 to 120

rpm with a fixed amount of gum (100 mg/L) dosage, IDC (50 mg/L) and pH 10 during 30 min. The color removal efficiencies result is shown in *Figure 3*.

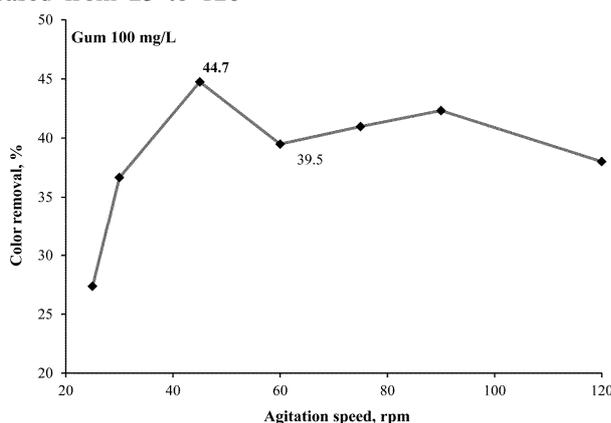


Figure 3. Influence of agitation speed on dye color removal (pH 10, IDC 50 mg/L, and time 30 min)

As can be observed in *Figure 3*, the best color efficiency were obtained at 45 rpm (44.7%). This result is quite similar to the agitation speed recommended by Tatsi et al. [13] with a suitable agitation speed will keep the particles suspended at a sufficient level without shearing them; so that larger and larger aggregates can form, letting the coagulation

reach an optimal efficiency. Hence, this agitation speed was chosen for subsequent experiments.

Effect of slow mixing time

At this stage, the effect of contact time between gum and dye solutions was studied by increasing times (15–90 min) under constant parameters at equilibrium condition.

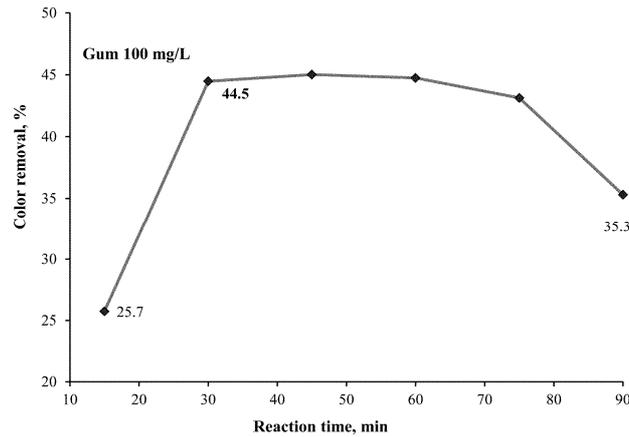


Figure 4. Color removal of the studied dye at various contact time (IDC 50 mg/L, pH 10, and agitation speed 45 rpm)

It can be noted from *Figure 4* that minor changes in color removal were observed for time higher than 30 min (44.5 %), these results may be due to restabilization phenomenon [14]. Therefore, 30 min was selected as the optimum reaction time.

Effect of coagulant dosage

In the Jar-test experiment, coagulant dosage plays a relevant role. To investigate the effect of gum dosages on the decolorization efficiencies of the dye, the experiments were carried out at various reaction dosages (100-350 mg/L).

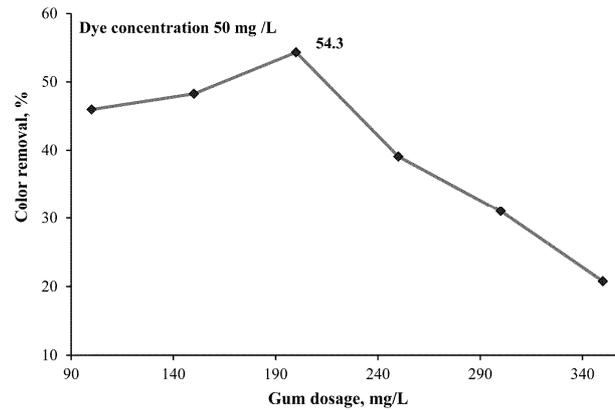


Figure 5. Effect of *cassia fistula* gum concentration on color removal efficiencies of the dye solution (30 min, 45 rpm and pH 10)

According to *Figure 5*, the maximum color removal efficiencies reach 57.8 % at the gum dosage 200 mg/L, and then when dosage increases, they decrease and reach 20.8 % at the highest IDC (350 mg/L). This trend may be due to restabilization phenomenon [15].

Effect of initial dye concentration

Several experiments with different initial dye concentrations (IDC) in the range of 10–140 mg/L were conducted by keeping other parameters constant: optimal pH (10), agitation speed (45 rpm), gum dosage (200 mg/L), and contact time (30 min).

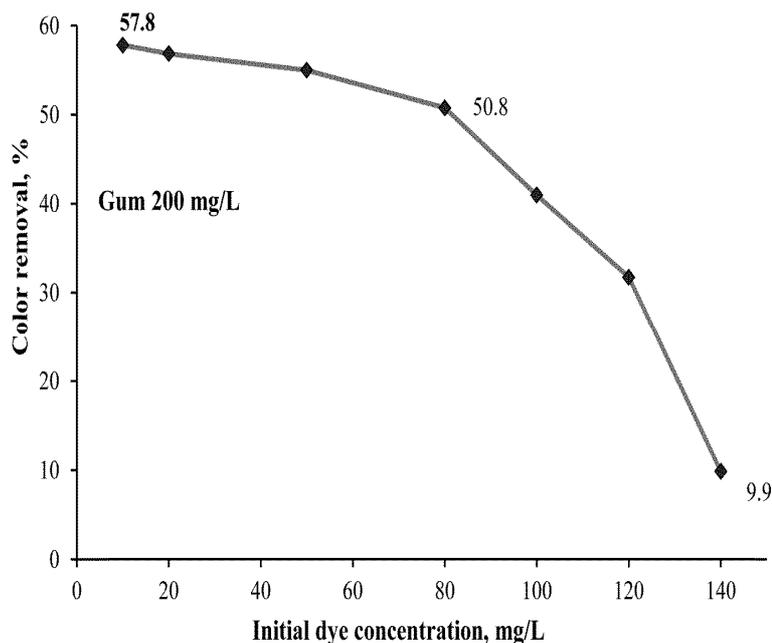


Figure 6. Effect of initial dye concentration on color removal efficiencies for the dye using *Cassia fistula* seed gum (agitation speed 45 rpm, pH 10, and time 30 min)

It is apparent from *Figure 6* that with an increase in IDC, the dye removal efficiency falls down. However, at IDC of the dye ranging from 10 mg/L to 80 mg/L, the decolorization efficient trends are more stable than other ranges. A possible explanation is that the appropriate dosage of gum can cause the dye particles to aggregate (destabilization) and settle out, so that gum-dye bridging occurs [7, 8]. Then, when the IDC in the solution exceeds an optimal threshold, there will be not enough bare gum particles with unoccupied surface available for the attachment of dye [8]. This results in a reduction of gum-dye bridging and the solution restabilizes.

CONCLUSIONS

The use of the low-cost coagulant *cassia fistula* seed gum shows a great potential for decolorization of reactive red 195 dye solution. The best color removal performances were obtained 57.8% with 200 mg/L gum dosage operated at agitation speed of 45 rpm, IDC 10 mg/L and pH 10 through 60 min of treatment. Decolorization of red 195 dye solutions by coagulation with the gum highly depended on the pH and coagulant dosage. Based on these results, *cassia fistula* seed gum can be used as an “green” coagulant for color removal from reactive dye solution.

Nghiên cứu khử màu nhuộm hoạt tính red 195 bằng gum hạt *Cassia fistula*

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TÓM TẮT

Gum hạt cây bò cạp nước (*Cassia fistula*) được sử dụng khử màu của màu nhuộm hoạt tính Red 195. Kết quả cho thấy quá trình keo tụ bị ảnh hưởng nhiều bởi nồng độ chất keo tụ và pH của dung dịch đầu vào. Với nồng độ gum 200 mg/l, pH đầu vào dung dịch khoảng 10 hiệu quả khử màu đạt đến 57.8% hai yếu tố thời gian và tốc độ

khuấy dường như ít ảnh hưởng đến hiệu quả khử màu trong khi hiệu suất khử màu tăng khi nồng độ màu nhuộm giảm (hiệu suất đạt tối đa tại 10 mg/L). Kết quả nghiên cứu cho thấy gum hạt trích ly từ cây bò cạp vàng rất có tiềm năng trở thành một chất keo tụ xanh trong việc giảm màu nước thải nhuộm hoạt tính.

Từ khóa: Khử màu, quá trình keo tụ, nước thải nhuộm, *Cassia fistula*, màu nhuộm red 195.

REFERENCES

- [1]. Gottlieb A., Shaw C., Smith A., Wheatley A., Forsythe S., The toxicity of textile reactive azo dyes after hydrolysis and decolourisation. *J. Biotechnol.* 110 (1), 49 (2003).
- [2]. Sadhasivam S., Saritha E., Savitha S., Swaminathan K., Comparison of the Efficacy of Live and Autoclaved Mycelium of *Trichoderma harzianum* on the Removal of Trypan Blue. *Bull. Environ. Contam. Toxicol.* 75 (5), 1046 (2005).
- [3]. Alinsafi A., Khemis M., Pons M. N., Leclerc J. P., Yaacoubi A., Benhammou A., Nejmeddine A., Electro-coagulation of reactive textile dyes and textile wastewater. *Chem. Eng. Process. Process Intensif.* 44 (4), 461 (2005).
- [4]. Kim T.-H., Park C., Yang J., Kim S., Comparison of disperse and reactive dye removals by chemical coagulation and Fenton oxidation. *J. Hazard. Mater.* 112 (1–2), 95 (2004).
- [5]. Lee J.-W., Choi S.-P., Thiruvengkatachari R., Shim W.-G., Moon H., Submerged microfiltration membrane coupled with alum coagulation/powdered activated carbon adsorption for complete decolorization of reactive dyes. *Water Res.* 40 (3), 435 (2006).
- [6]. Al-Mutairi N. Z., Coagulant toxicity and effectiveness in a slaughterhouse wastewater treatment plant. *Ecotox. Environ. Safe.* 65 (1), 74 (2006).
- [7]. Blackburn R. S., Natural polysaccharides and their interactions with dye molecules: Applications in effluent treatment. *Environ. Sci. Technol.* 38 (18), 4905 (2004).
- [8]. Sanghi R., Bhattacharya B., Dixit A., Singh V., *Ipomoea dasysperma* seed gum: An effective natural coagulant for the decolorization of textile dye solutions. *J. Environ. Manage.* 81 (1), 36 (2006).
- [9]. Sanghi R., Bhattacharya B., Singh V., *Cassia angustifolia* seed gum as an effective

- natural coagulant for decolourisation of dye solutions. *Green Chem.* 4 (3), 252 (2002).
- [10].Singh V., Sethi R., Tiwari A., Structure elucidation and properties of a non-ionic galactomannan derived from the *Cassia pleurocarpa* seeds. *Int. J. Biol. Macromol.* 44 (1), 9 (2009).
- [11].Perng Y. S., Ha B. M., The feasibility of *cassia fistula* gum with polyaluminium chloride for decolorization of reactive dyeing wastewater. *J. Serb. Chem. Soc.* 80 (1), 115 (2015).
- [12].ASTM, 2013. Standard practice for coagulation-flocculation jar test of water. In *annual book of ASTM standards*, Vol. 11.02, United States: ASTM.
- [13].Tatsi A. A., Zouboulis A. I., Matis K. A., Samaras P., Coagulation–flocculation pretreatment of sanitary landfill leachates. *Chemosphere* 53 (7), 737 (2003).
- [14].Klimiuk E., Filipkowska U., Libeck B., Coagulation of Wastewater Containing Reactive Dyes with the Use of Polyaluminium Chloride (PAC). *Pol. J. Environ. Stud* 8 (12), 81 (1999).
- [15].Joo D. J., Shin W. S., Choi J. H., Choi S. J., Kim M. C., Han M. H., Ha T. W., Kim Y. H., Decolorization of reactive dyes using inorganic coagulants and synthetic polymer. *Dyes Pigm.* 73 (1), 59 (2007).