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Journal of Applied Research and Technology

CCADET
CENTRO DE CIENCIAS APLICADAS Y DESARROLLO TECNOLÓGICO

Journal of Applied Research and Technology xxx (2017) xxx–xxx

www.jart.ccadet.unam.mx

Original

Dye decomposition by combined ozonation and anaerobic treatment: Cost effective technology

Smita Venkatesh [a,*], Kumar Venkatesh [b], Abdur Rahman Quaff [c]

[a] *Department of Chemistry, Motilal Nehru National Institute of Technology, Allahabad, India*
[b] *Department of Civil Engineering, Motilal Nehru National Institute of Technology, Allahabad, India*
[c] *Department of Civil Engineering, National Institute of Technology, Patna, India*

Received 12 August 2016; accepted 23 February 2017

Abstract

To control the total treatment cost of textile dye effluent a new advanced combined treatment technology has been investigated. Advanced oxidation processes like ozonation have much potential to degrade dye but its main drawback is high cost. To reduce the cost of ozonation for dye degradation and decolourization, ozonation followed by anaerobic biodegradation using upflow anaerobic sludge blanket (UASB) reactor was carried out. The synthetic textile wastewater containing Reactive Black 5 has been used in this study by this combined treatment process. The system of ozonation and anaerobic treatment by UASB reactor showed that the chemical oxygen demand (COD) reduction has reached to about 90% and dye removal 94% respectively. Combined treatment enhanced the overall color removal up to 10 on platinum cobalt (Pt–Co) scale. Thus the combined treatment process results in high color, COD and total organic carbon (TOC) removal efficiency which would minimize the overall treatment cost. Dye degradation products were analyzed by ion chromatography (IC) and UV–vis spectroscopy.

Keywords: Reactive Black 5; Decolourization; Degradation; Ozonation; Anaerobic biodegradation; UASB reactor

1. Introduction

Ozonation as pre-treatment of textile dye wastewater is an efficient step for improving wastewater biodegradability, as well as reducing acute ecotoxicity, which can be removed completely through sequential biological treatment (Somensi, Simionatto, Bertoli, Wisniewski, & Radetski, 2010). Abidin, Fahmi, Soon-An, Makhtar, and Rahmat (2015) reported that the application of ozonation as pre-treatment for biological treatment may further mineralize the dye-containing wastewater. COD was reduced simultaneously by ozonation and biological treatment mechanism at lower ozone doses (Abidin & Ridwan, 2011). Punzi et al. (2015) used anaerobic biofilm reactor followed by ozonation for treatment of textile wastewater containing azo dyes. In combined treatment, ozonation and biological method in wastewater, ozone removed COD, color and pathogens and increased the biodegradability of the wastewater (De Souza, Bonilla, & De Souza, 2010).

A new combined treatment process, ozonation and anaerobic biodegradation by UASB reactor has been proposed to see the degradation effect of dye wastewater, so that an efficient and economical, wastewater treatment system could be generated.

2. Materials and methods

Reactive Black 5 as di-azo dye synthetic solution was used for making synthetic wastewater. The concentration and pH of dye wastewater were very high i.e. 1500 mg/L and 10.13. Figure 1 shows the chemical structure of Reactive Black 5. Ozone was generated by corona discharge type ozone generator model Eltech el-5g/h.-A with flow rate of 5 g/h. Ozonation of dye solution was carried out in a batch mode. Detail ozonation procedure including decomposition mechanism and experimental analyses have been described in earlier work (Venkatesh, Quaff, Venkatesh, & Pandey, 2014).

* Corresponding author.
E-mail address: smita.venkatesh@gmail.com (S. Venkatesh).
Peer Review under the responsibility of Universidad Nacional Autónoma de México.

http://dx.doi.org/10.1016/j.jart.2017.02.006

Please cite this article in press as: Venkatesh, S., et al. Dye decomposition by combined ozonation and anaerobic treatment: Cost effective technology. *Journal of Applied Research and Technology* (2017), http://dx.doi.org/10.1016/j.jart.2017.02.006

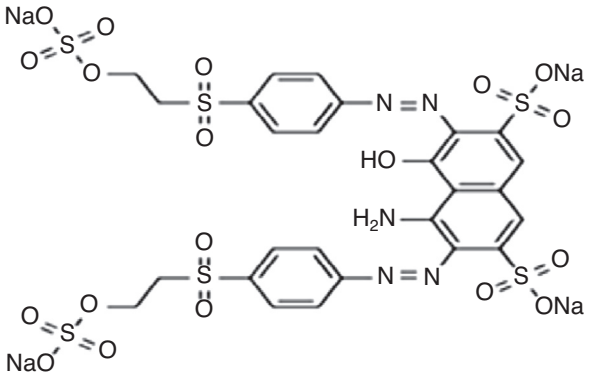

Fig. 1. Chemical structure of Reactive Black 5.

The biological analysis was performed in a lab scale upflow anaerobic sludge blanket (UASB) reactor shown in Figure 2. The biomass in the UASB reactor was conditioned sludge. This conditioned sludge was prepared using fresh sludge fed with synthetic media containing 500 mg/L sucrose for 30 days in a laboratory. The fresh sludge was obtained from the anaerobic digester tank of full-scale activated sludge process based sewage treatment plant at Bakshibandh, Allahabad, India. Reactor was fed by synthetic wastewater containing sucrose as carbon source whose COD was 534 mg/L up to steady state condition achieved. The flow rate was 25 mL/h, which translated to up flow velocity 0.16 m/h and hydraulic retention time (HRT) of 40 h. Yasar and Tabinda (2010) reported UASB reactor performs better removal efficiency at lower hydraulic retention time. After achieving a steady state condition, the reactor was continuously running on synthetic medium strength domestic wastewater. After that, the reactor was subjected to ozonated synthetic dyes solutions. The ozonated azo dye solutions were mixed with synthetic wastewater in a 1:1 ratio. For determination of the extent of anaerobic biodegradation, mixed ozonated azo dye solutions were used as feed for anaerobic bacteria and assessed for the extent of biodegradability in UASB reactor.

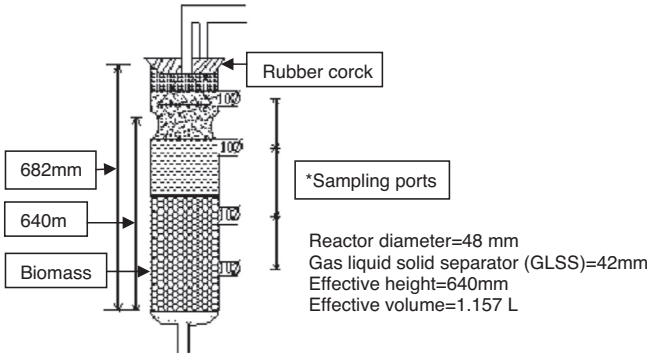

Fig. 2. Schematic diagram of UASB reactor.

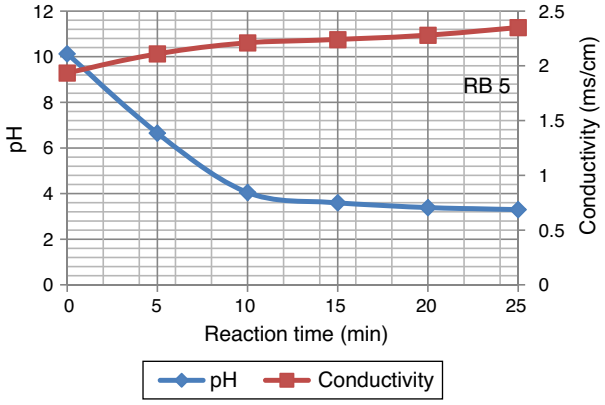

Fig. 3. Variation in pH and conductivity at 25 °C with ozonation time for initial dye concentration of 1500 mg/L of Reactive Black 5.

3. Results and discussion

3.1. Effect of ozonation on dye wastewater

Decline in pH value of Reactive Black 5 dye samples were observed during ozonation. This decreases rapidly from 10.13 to 3.30 in 25 min whereas conductivity of dyes solution increased during ozonation. Increase in conductivity after ozonation may partly be attributed to an indirect confirmation of ion accumulation. Figure 3 displays the variation in pH and conductivity at 25 °C.

After 25 min of ozonation the initial concentration of dye wastewater reduced from 1500 mg/L to 97.4 mg/L. The degradation of high concentration Reactive Black 5 dye molecules required longer ozonation time. Ozonation of dye solution reduced the COD concentration. 50% COD reduction occurred in 10 min of ozonation time, although in some cases the values of COD increase with ozonation time. An increase in COD value was mainly because of an organic species produced due to destruction of the molecular structure of azo dye by ozone (Constapel, Schellentriager, Marzinkowski, & Gab, 2009; Venkatesh, Quaff, Venkatesh, & Pandey, 2015). Figure 4 presents the dye concentration and COD decline during ozonation of Reactive Black 5 dye solution. Fahmi, Abidin, and

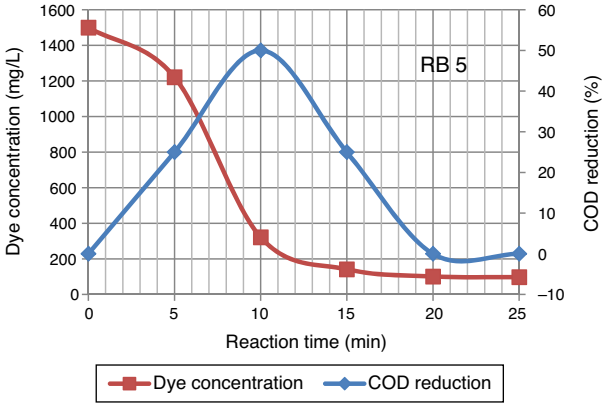

Fig. 4. Reduction in the dye concentration and COD during ozonation of Reactive Black 5 dye solution.

Please cite this article in press as: Venkatesh, S., et al. Dye decomposition by combined ozonation and anaerobic treatment: Cost effective technology. *Journal of Applied Research and Technology* (2017), http://dx.doi.org/10.1016/j.jart.2017.02.006