Parametric Studies on Electrochemical Treatment of Synthetic Wastewater

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***Abstract*—The present study focuses on effects of operational parameters on electrochemical wastewater treatment for synthetic wastewater. Electro-oxidation has emerged as one of the advanced oxidation processes gaining more attention because it offers many distinctive advantages over other conventional methods such as versatility, high treatment efficiency, safety, amenability of automation and cost effectiveness. In the present work, Reactive Red2 dye was used as model pollutant to prepare synthetic wastewater. Cerium (Ce) based mixed metal oxide electrode prepared by thermal decomposition method was usedas anode andthe effectiveness of the treatment was analyzed on the basis of total organic carbon(TOC)removal and decolorization.**

***Keywords*—Electrochemical,mixed metal oxide,TOC, color removal.**

I. INTRODUCTION

Dyes are important class of pollutants, and can be identified by the human eye. Dyes are classified on the basis of their chromophore group, among various classes of dye; reactive dyes are extensively used due to their vast shade range, excellent fastness property and cost effectiveness. Reactive dyes are mainly constituted of azo azo(-N=N-) group with different reactive group such as vinyl sulfone, chlorotriazine and also a metal nucleus. It is estimated that about 70% of the dye production is consumed by textile industry [1]. Effluents containing reactive dyes are very tricky to treat as they are covalently bound to textile fibers and conventional treatments are not effective for their mineralization [1], [2], [3]. Increased environmental concern and stringent government rule has encouraged researchers for developing new technologies to deal with environmental problem. Among various methods electrochemical method is gaining more attention, as it offers many distinctive advantages such as versatility, high energy efficiency, amenability of automation, cost effectiveness andsafety [4], [5].

Electrochemical oxidation is an effective wastewater treatment method [6]. Metal oxide-coated substrates are commonly used as anode in this process. Dyes, toxic organic molecules, inorganic salts, aromatic pesticide residues, drugs and surfactants are the major components of wastewater released from textile, leather, pulp and paper, printing, photograph, cosmetic and food industries [7]. In recent years Mixed Metal Oxides (MMO's) have drawn tremendous attention for treatment of recalcitrant organic compounds present in wastewater [8]. A combination of different valve metal based oxides has been tested to fabricate catalytic coating on metal substrate. Metal oxide represents one of the important categories of solid catalysts which are widely used either as active phase or support [9]. By mixing different metal oxides, new stable compounds can be formed, which exhibit significantly improved catalytic activity than their respective metal oxide. This is attributed to the fact that it increases surface area, increases active acidic or basic sites, or it might possibly change the chemical states of the metal ions [10].

Electrochemical oxidation can be carried out by either of the two ways – by direct oxidation (direct electron exchange with the anode) or by indirect oxidation (by the active species or mediators generated during electrolysis). In case of direct oxidation, exchange of electron takes place between the anode material and organic molecule at the electrode solution interface. On other hand indirect electrochemical oxidation is carried out via mediation of some electro active species regenerated there, which act/acts as an intermediary for shuttling electrons between electrode and organics.

Reactive Red 2 dye is extensively used in textile industry because of its bright color shade availability, excellent fastness property and cost effectiveness. Reactive dyes have a synthetic origin and complex aromatic structure which is responsible for its resistance towards biodegradability.

II. MATERIALS AND METHOD

A. Chemicals

All chemicals used for carrying out this study wereof analytical grade. Fig 1 shows the structure of Reactive Red2 dye which was used as model pollutant. Isopropanol (99.8% CDH) and hydrochloric acid (37% CDH) were used as

solvents to prepare the precursor solution. Salts of Cerium ($CeCl_3.7H_2O$) and Ruthenium ($RuCl_3.H_2O$)were used to prepared precursor coating solution. Sodium Chloride salt was used as electrolyte.

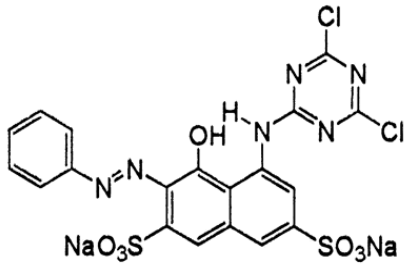

Fig.1Structure of Reactive Red 2 dye

B. Experimental setup

All the experiments were carried out in laboratory unit of 1L capacity.Titanium substrate coated with mixed metal oxide was used as anode and stainless steel (SS 304) was used as cathode.The electrode spacing between anode and cathode was kept as 8 mm. A constant potential was applied by means of a D.C. power supply (Aplab India, LD-3205). Sodium

C. Preparation of electrode

Working electrode was prepared in laboratory using thermal decomposition method. Titanium metal piece (75mm x 50mm x 3mm)was used as substrate and it was polished using sand paper. The polished substrate was then etched in 10% oxalic acid solution at 80°C for 60 min.The known quantity of Ce and Ru salts were added in solvent mixture containing 10 mL Isopropanol and 0.5 mL hydrochloric acid. A thin layer of precursor solution was coated on the substrate using brush and then it was kept in hot air oven at 110°C for 5min. It was then kept in muffle furnace at 550°C for 5 min. The above procedure was repeated for 8 to 10 times. Finally the electrode was kept in muffle furnace at 550°C for 1 hour for final calcination to obtain a catalytic loading of about 3 mg/cm^2.

III. RESULTS AND DISCUSSION

A. Effect of pH on TOC removal

Synthetic wastewater containing 200 ppm of Reactive Red 2 dyewas prepared for all the experiments. Experiments were conducted at three different pH of 3, 7 and 11 to analyze the effect of pH on TOC removal. It was found that for mineralization of Reactive Red 2 (RR2)dye, neutral condition gave better results compared to acidic or alkaline conditions. Fig 2 shows that at pH 7,TOC removal efficiency was 40.33% while it was 37.89% and 34.8% at pH 11 and 3 respectively.

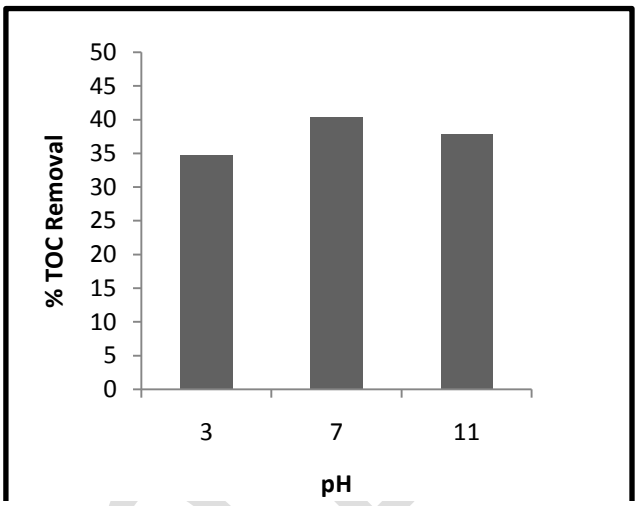

Fig.1 Effect of pH on %TOC removal

B. Effect of pH on decolorization efficiency

Effect of pH on decolorization efficiency was also investigated in present study. It was found that neutral pH gave better results for color removal of RR2 dye wastewatercompared to acidic or alkaline conditions.Fig.3 reveals that 99.96 % color reduction was observed at pH of 7 as compared to 96.63% and 98.69 % color reduction at pH of 11 and 3 respectively.

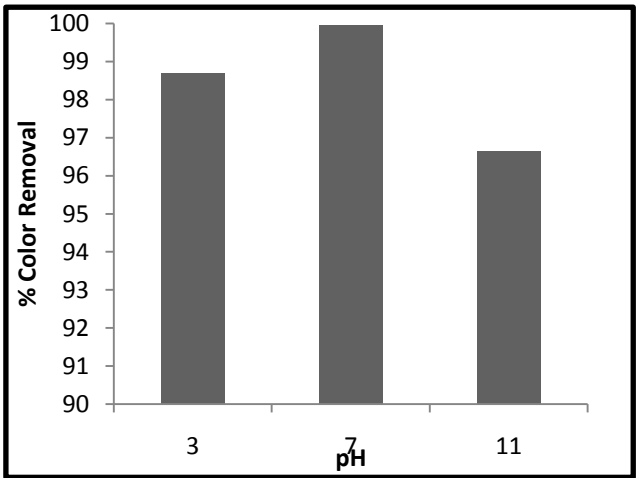

Fig.2 Effect of pH on %Color Removal.

A. Effect of salt concentration on TOC removal

The effect of varying salt (NaCl) concentration on %TOC removal was also investigated. It was found that highest TOC removal of 44.15% was found at salt concentration of 4g/l. At salt concentration of 2g/l and 6g/l, TOC removal was 32.1% and 22.78% respectively as shown in fig. 4.There was no significant difference observed in color removal for all the three salt concentrations with almost 99% decolorization in all the three cases

as shown in fig. 5.

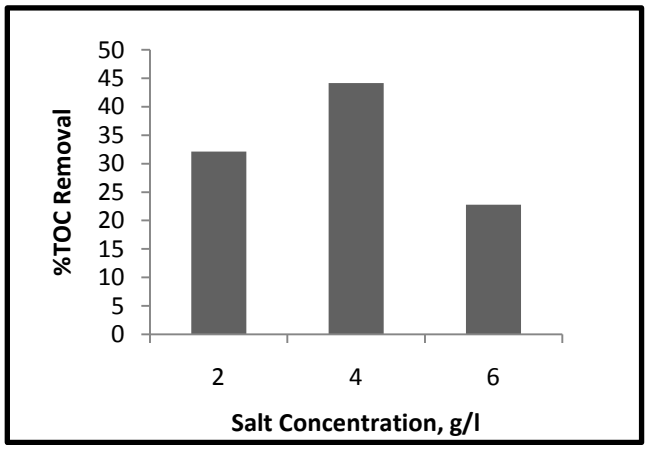

Fig.4 Effect of salt concentration on %TOC removal

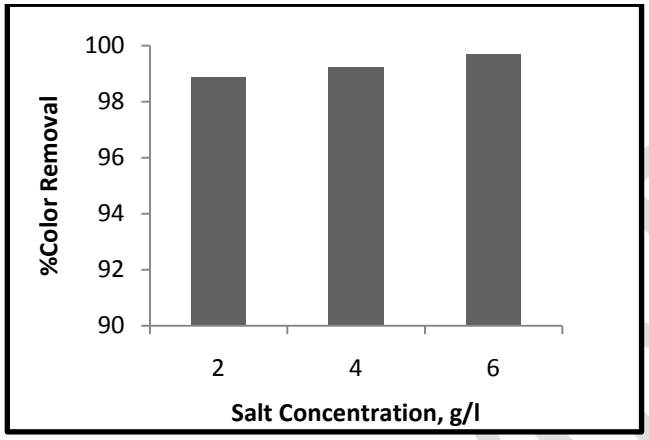

Fig. 5 Effect of salt concentration on % color removal

IV. CONCLUSION

It can be concluded from the present work that for degradation of Reactive Red 2synthetic dye wastewater using Ce based mixed metal oxide electrode, neutral (pH=7)conditiongave better results with 40.33% TOC removal and 99.6% color removal as compared to acidic or alkaline conditions.Further study also revealed that salt dosage of 4g/lgave better TOC removal as compared to 2 g/l and 6 g/l, whereas varying salt concentration showed almost 99% color removal at all the three salt concentrations.

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