Int. J. Chem. Sci.: 11(2), 2013, 728-734
ISSN 0972-768X
www.sadgurupublications.com

COD REDUCTION FROM INDUSTRIAL WASTEWATER USING THERMAL LIQUID – PHASE OXIDATION TECHNIQUE

RAJ KUMAR SHARMA*, JYOTI SHARMA, D. V. RAI and MOHAMMAD ZAFAR

Agri Informatics Engineering, Shobhit University, MEERUT (U.P.) INDIA

ABSTRACT

The feasibility of a thermal liquid-phase oxidation process has been tested to treat the organic content of industrial waste water derived from chemical industries. The effect of the operating parameters on COD removal including temperature, pressure, pH, and residence time was studied. The experiments were conducted in a stainless steel autoclave reactor and the maximum of 49.77% of COD removal was achieved after 120 min of reaction time at 230^0C temperature and pH 7.9, indicating a significant improvement in degradability of organic effluent. An ideal pressure of 28 Kg/cm^2 was observed for maximum COD removal of 43.18%. This liquid-phase oxidation technique shows the significant potential for the treatment of organic load of industrial wastewater.

Key words: Thermal liquid-phase oxidation, COD reduction, Industrial waste water, Organic content, Chemical industry.

INTRODUCTION

In recent years, increasing awareness of the environmental impact of wastewater pollutants has prompted a demand for the removal of organic load, i.e. chemical oxidation demand (COD) from industrial wastewater streams prior to discharge into natural water system[1]. The environmental Protection Agency of the USA has recommended discharge limits of 0.1 mg/L in waste water. These chemicals are present in the wastewater of different industries (e.g, petroleum refineries, resin manufacturers, organic industries etc.)[2].

There are many aspects and methodologies for assessing the problem of pollution of water, so that all environmental burdens are taken into account, when framing the real

*Author for correspondence; E-mail: rks_sum@yahoo.com

solutions that meet the needs of potable water supply. Thermal liquid-phase oxidation is an attractive treatment for waste and wastewatser streams, which are too dilute to incinerate, and also too concentrated for biological treatment. It can be defined as the oxidation of organic substances in an aqueous solution in the presence of oxygen or air at elevated temperature and pressure. This process is considered as 'Clean-Technology', as it does not involve the use of any harmful chemicals regents and the final product (if complete oxidation occurred) are carbon dioxide and water[3].

Industrial wastewaters, containing organic compounds, are toxic and not amenable to direct biological treatment. These industrial wastewaters must be treated in order to meet the specifications for discharge or for recycling in the process. The incapability of conventional methods to effectively remove many organic pollutants has made it evident that new, compact and more efficient systems are needed. Therefore, liquid-phase oxidation is a eco-friendly process for organic contaminants. It is dissolved in water either partially degradation by means of an oxidizing agent into biodegradable intermediates or mineralized into innocuous inorganic compounds such as CO_2, H_2O, which remain in the aqueous phase.

The purpose of this study to investigate the performance of the thermal liquid-phase oxidation of organic wastewater collected from organic industries. The effects of operating conditions on COD remoal of the wastewate, including temperature, pressure, pH, and reaction residence time was studied.

EXPERIMENTAL

Material and methods

The thermal liquid-phase oxidation of organic content was carried out in a 1.0 L stainless steel batch autoclave (Fig. 1) equipped with automatic temperature control, an adjustable speed stirrer, a valve for sampling and a pressure gauge. The reactor was equipped with a mechanically/magnetically driven stirrer ensuring good mass transfer from gas to the liquid phase. Experiments were carried out by addition of 500 mL of wastewater to the reactor. The reactor was heated with an electrical heating jacket under pressure, while agitator continuously stirred the solution. After reaching the desired reaction temperature, oxygen was forced into autoclave. At appropriate time intervals, an aliquot of the solution was drawn and sample was analyzed[4].

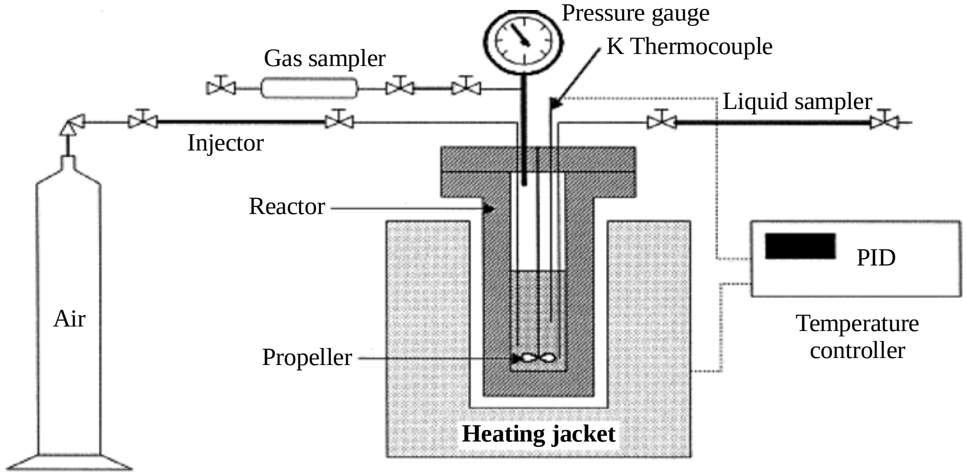

Fig. 1: Thermal liquid-phase oxidation process unit (Basic flow diagram)

RESULTS AND DISCUSSION

Effect of the temperature on COD removal

In the thermal oxidation of organic pollutants, the temperature is an important parameters affecting the significant removal of organic load. The treatment of organic wastewater by thermal oxidation process was carried out at different temperatures of 200°C, 210°C, 220°C and 230°C, and oxygen partial pressures were kept at 9.0 Kg/cm^2 at a reference temperature of 25°C. The results of COD reduction at different temperature is shown in Fig. 2. It has been found that when the temperature was raised from 200°C to 230°C, COD removal significantly increases from 33.28% to 49.77% after 120 min of residence time[5].

The maximum of 49.77% of COD removal was achieved at 230°C under thermal liquid-phase oxidation process. Significant improvement in COD removal efficiency was noticeable at 220°C and 230°C temperatures, however, the reaction temperature of 200°C and 210°C are refractory to total oxidation, but are compatable for biodegradable. Hence, the temperature of 230°C is an economically optimal reaction temperature for COD removal of industrial wastewater.

It is noteworthy that the oxidation of organic matter present in wastewater is an irreversible process, the reaction rate constant increases with increase in reaction temperature[8]. With the increase in temperature, the oxidation rates of organic matter degradation increases gradually. It is also reported that the density of water becomes smaller with the increase in temperature at constant pressure resulting in the slow reaction rate by decrease in reactant concentrations. However, the increasing temperature leads to an increase in reaction rate constant as well as increase in COD removal[8].

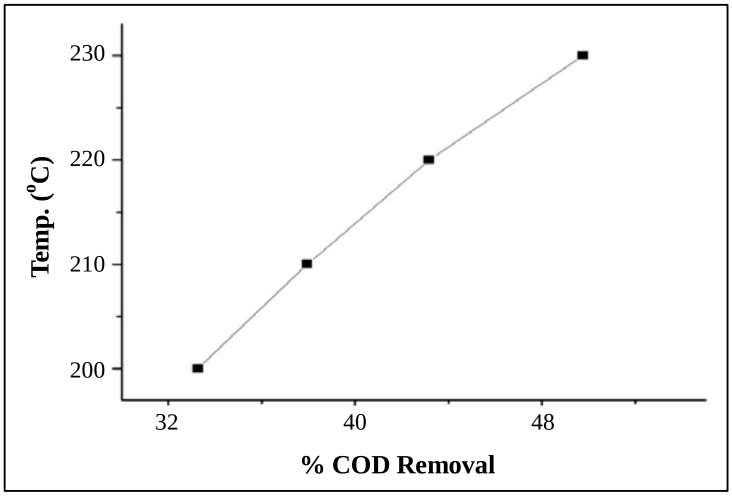

Fig. 2: Effect of temperature on COD removal

Effect of the pressure on COD removal

The treatment of industrial wastewater was carried out at four levels of pressure, i.e. 22 Kg/cm^2, 25 Kg/cm^2, 28 Kg/cm^2, and 31 Kg/cm^2 with supply of partial oxygen fixed at 9 Kg/cm^2 (Fig. 3).

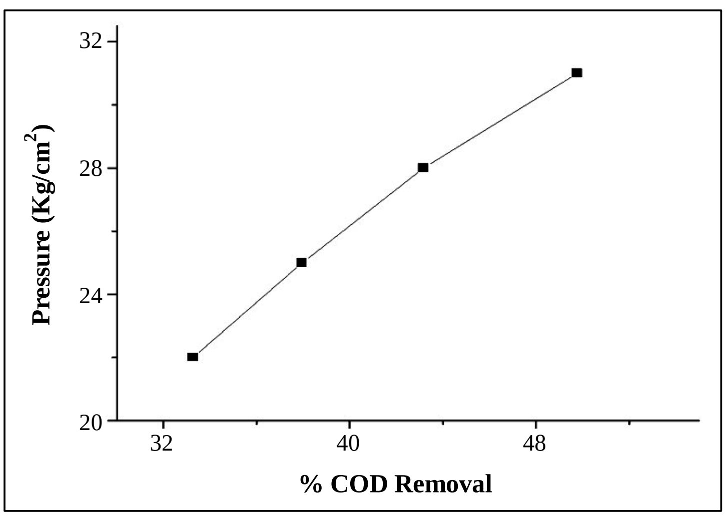

Fig. 3: Effect of temperature on COD removal

It is observed that the increase in pressure resulted in an increase in COD removal from wastewater. At different total pressue of 22 Kg/cm^2, 25 Kg/cm^2 and 28 Kg/cm^2, the COD removal rate of 33.28%, 37.95% and 43.18% was achieved, respectively[6].

The operating pressure is an important parameter affecting the organic matter removal from wastewater. The fugacity, i.e. partial pressure of gases, increases with increase in total pressure. At fixed partial flow of dry gases, the partial flow of water vapour decreases with increase in total pressure, resulting in higher adiabatic temperature and better environment for COD removal.

Effect of the reaction residence time on COD removal

The wastewater COD conversion experiments were conducted at different temperature in the range (200-230^{0}C) and at varying pressure ranging from 22-28 Kg/cm^3. It is observed that COD removal from wastewater significantly affected by reaction residence time in reactor. The COD removal increased rapidly during initial hours of reaction time; maximum of 49.77% was observed after 120 min, and further dercesed to 43.18%, 37.95%, and 33.28% with increase in residence time of 150, 180, and 210 min, respectively[7].

The reaction rate depends on both; temperature and reactant concentrations. As the reaction proceeds, the concentration of organic matter of wastewater decreases and resulting in decrease the reaction rate. In addition, the generation of intermediate compounds during reaction also interfere with the reaction rate.

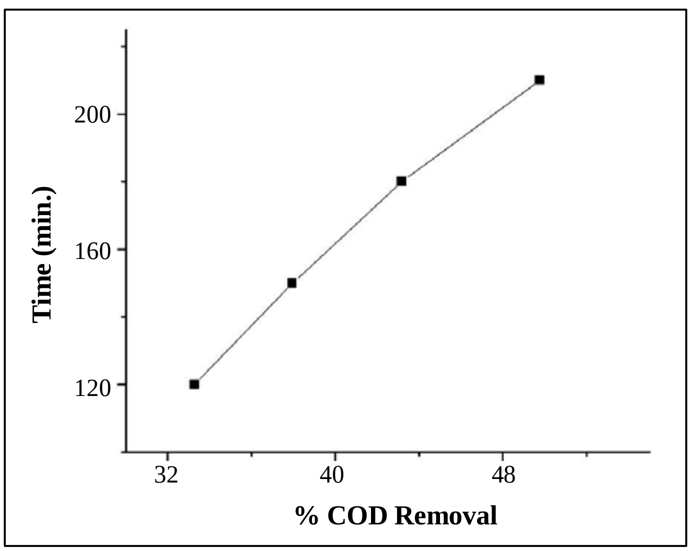

Fig. 4: Effect of reaction time on COD removal

Effect of pH on COD removal

The influence of pH on COD removal from wastewater is illustrated in Fig. 5. It was found that the COD removal is more sensitive to pH of wastewater. It was observed that the increase in the pH decreases the COD removal rate and maximum COD removal of 49.77% was observed at pH 7.9 followed by decrease as 43.18% and 37.95% at pH 8.6 and 9.7, respectively. At high pH value, probably the reaction mechanism changes and the formation of $OH^{\bullet}$ radicals may interfere with the oxidation of organic matter of wastewater.

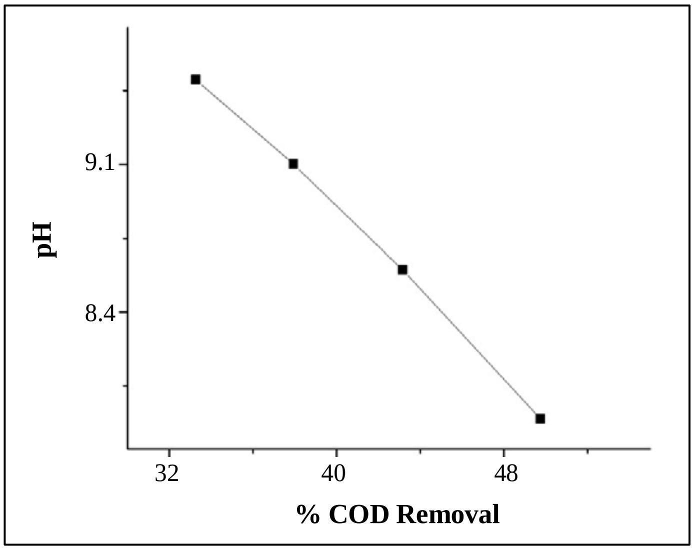

Fig. 5: Effect of pH on COD removal

CONCLUSIONS

In this study, the impact of various operating parameters such as temperature, pH, pressure, and reaction residence time on the feasibility of wastewater treatment in a thermal liquid oxidation process was evaluated. The process was successfully demonstrated as an efficient treatment method for organic content in industrial wastewater. The reaction kinetics of this work showed that thermal liquid-phase oxidation of organic substances of industrial wastewater follows a fast reaction stage. This process can be operated under medium pressure and temperature. Therefore, it will reduce the operation risk resulting from high pressure and high temperature within conventional oxidation process.

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Revised : 27.04.2013 *Accepted : 30.04.2013*