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Removal of COD by Electrocoagulation at Optimized Conditions

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ABSTRACT

Coal gasification is considered as one of the prominent technologies which helps to reduce energy problems caused by decrease in supplies of natural gas and petroleum. But, waste water that is generated coal gasification contains huge amounts of phenols, cresols, ammonia and other organic compounds. Electrocoagulation technology was used successfully to pre-treat the effluent coal gasifier as an electrolyte for the removal of polluting factors as a result of coagulation and precipitation of suspended solids followed by sedimentation under gravity. COD determines the amount of organic pollutants found in the water making it a useful measure of water quality. The environmental significance of COD is very high. Coagulation process is one of the best ways to treat wastewater and industrial effluents like coal gasifier and can be considered as an efficient treatment method to reduce COD of the effluent. The study and experiments of the project mainly involves treatment of the coal gasifier effluent. The parameters such as pH, Electrolysis time (ET), Voltage are used in order to explore the changes it can account for the removal of COD. The optimum values of pH, Electrolysis time (ET), Voltage are determined as 7.0, 90 min., 10V respectively. These optimum values are finally used to treat the coal gasifier effluent. Analysis of COD is done to find the amount of COD present in the final sample using a standard method.

Keywords : Coal gasifier Effluent, COD, Electrocoagulation, Copper electrode, Optimization.

I. INTRODUCTION

Industrial wastewater consists of impurities including colloidal particles and dissolved organic substances. The finely dispersed colloids or suspended solids are usually repelled by their outer layer of negative electrical charges and will maintain the colloidal nature until treated by flocculants/coagulants for their removal. The process of flocculation and coagulation can be defined as "the ionic bridging between the finely divided particles to make flocs followed by their grouping into larger aggregates to be settled under gravity".The terms flocculation and coagulation can separately be restricted to the preparation of flocs and grouping of flocs into aggregates respectively. The mechanism involved is the neutralization of the charges on the suspended solids or compression of the double layer of charges on the suspended solids. Overdose of coagulants may reverse the charge at the outer layer of the colloidal particles to re-stabilize them in a reverse mode. The waste water treatment and down streaming of industrial fluids can be performed by using a number of flocculating/coagulating agents based on chemical salts and organic polymers.

A wide variety of chemical and organic compounds have been recognized as good agents to remove the suspended solids from the wastewater.. A range of industrial processes are involved to exhaust a variety of effluents with different nature of pollutants. The treatment by the chemicals as well as organic molecules depends on the nature of pollutants and pH conditions.

Organic polymers are considerably preferred as coagulating/flocculating agents because of their biodegradable nature as compared to the chemicals causing to produce activated sludge.

COD (Chemical oxygen demand) is the measurement of the amount of oxygen required to oxidize the organic matter in water or waste water sample, under specific conditions of oxidizing agent, temperature, and time. COD is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. The chemical oxygen demand (COD)test is commonly used to indirectly measure the amount of organic compounds in water. This method covers the determination of COD in ground and surface waters, domestic and industrial wastewaters. The applicable range is 3-900mg/L [1]. The removal of COD and color from waste water using Fenton's oxidation process was studied by Meic et al [8].

Coagulation is in routine practice for the treatment of drinking water, waste water and industrial effluents [2]. Treatment of water using electricity was first proposed in UK in 1889. The application of electrolysis in mineral beneficiation was patented by Elmore in 1904 [3]. Electrocoagulation, precipitation of ions (heavy metals) and colloids (organic and inorganic) using electricity has been known as an ideal technology to upgrade water quality for a longtime. It is being successfully applied to a wide range of pollutants in even wider range of reactor designs. Electrocoagulation is the technique to create conglomerates of the suspended, dissolved or emulsified particles in aqueous medium using electrical current causing production of metal ions at the expense of sacrificing electrodes and hydroxyl ions as a result of water splitting. Metal hydroxides are produced as a result of EC and acts as coagulant/flocculent for the suspended solids to convert them into flocs of enough density to be sediment under gravity. The electrical current provides the electromotive force to drive the chemical reactions to produce metal hydroxides [4,5].

Copper electrodes were used as electrodes in different batch experiments. This study was also partially focused to compare the effectiveness of Copper as electrodes to reduce the polluting nature of coal gasifier effluent andsimultaneous hydrogen production during Electrocoagulation (EC). The metal (anode) based coagulants were found enough efficient to reduce the chemical oxygen demand (COD) and turbidity of coal gasifier effluent. The remarkable pollutants removal was also associated with the hydrogen production as revenue to contribute the operational cost of wastewater treatment. Hydrogen production was also found helpful to remove the lighter suspended solids towards surface.

This study deals with the %removal of COD from coal gasifier effluent using electrocoagulation at optimized conditions of pH, Electrolysis time (ET),Voltage.

II. METHODS AND MATERIAL

A. Description of Experimental Setup:

Experiments were carried out in a batch electrochemical reactor of 1000ml. Copper electrodes of dimensions 7.5x2.3x0.1 cm were used as anode and cathode. The electrodes were washed with dilute acid to remove surface grease/other impurities on the metal surface. The experiments were carried out under potentially static conditions covering wide range in operating conditions and samples were collected periodically for analyzed. The anode was weighed before and after the experiment for each experiment run to estimate the electrode consumption. At the end of the each run the solution was centrifuged at 500 rpm, filtered and the filtrate was analyzed. The pollutant degradations were estimated by Colorimeter by standard estimation procedure for COD estimation. Fig.1 is the pictorial representation of the experimental setup [6,7].

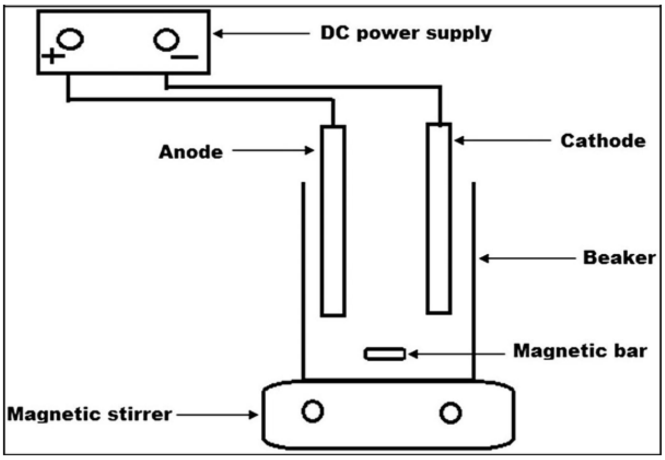

Figure 1. Batch Mode Electrocoagulation Experimental Setup

B. Principle of Electrocoagulation

Electrocoagulation involves dissolution of metal from the anode with simultaneous formation of hydroxyl ions and hydrogen gas occurring at the cathode.

C. COD Analysis

The organic matter present in sample gets oxidized completely by potassium dichromate ($K_2Cr_2O_7$) in the presence of sulfuric acid (H_2SO_4), silver sulfate($AgSO_4$) and mercury sulfate ($HgSO_4$) to produce CO_2 and H_2O. The sample is refluxed with a known amount of potassium dichromate ($K_2Cr_2O_7$) in the sulfuric acid medium and the excess potassium dichromate ($K_2Cr_2O_7$) is determined by titration against ferrous ammonium sulfate, using ferroin as an indicator. The dichromate consumed by the sample is equivalent to the amount of O2 required to oxidize the organic matter.

III. RESULT AND DISCUSSION

A. Effect of pH

pH is varied in electro coagulation process to obtain the optimum value so that further experimentation is based on the obtained optimum pH value. The experiments were conducted at different pH's 4 to 9 by copper electrodes to study the effect of pH on the electrocoagulation process. The electrolysis was performed for 120 minutes with a constant current density of 16mA/cm2 (0.32A), agitation speed was kept constant at 500 rpm and the spacing between the electrodes was nearly 2cm. The maximum % COD removal is 58.5% which was achieved at the pH of 7 and the results are shown in Fig.2 respectively. Table 1 shows the effect of COD concentration on % COD removal.

Table 1: Influence of pH on %COD removal

pH	COD conc. (ppm)	% COD removal
4	33268	40.9
5	32417	44.6
6	30798	52.2
7	29574	58.5
8	31779	47.5
9	36450	28.6

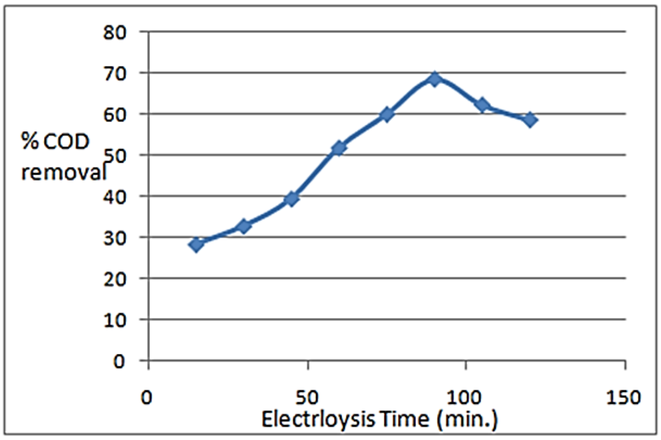

Figure 2: Effect of pH on % COD removal

B. Effect of Electrolysis Time

The electrolysis time has a significant effect on the pollutant removal. Initial experiments were conducted at 120 minutes. Optimization of electrolysis time is done to find the maximum % COD removal. The effect of time was studied at a constant current density of 16mA/cm2 (0.32A), agitation speed was kept constant at 500 rpm and spacing between the electrodes was nearly 2cm and a pH of 7. The maximum % COD removal is 68.3% which was achieved at the electrolysis time (ET) of 90 min. and the results are shown in Fig.3 respectively. Table 2 shows the COD concentration and % COD removal.

Table 2: Influence of electrolysis time on %COD removal

Electrolysis Time (min.)	COD conc. (ppm)	% COD removal
15	36507	28.4
30	35297	32.8
45	33626.2	39.4
60	30899.8	51.7
75	29333.5	59.8
90	27852.1	68.3
105	28917.3	62.1
120	29574.1	58.5

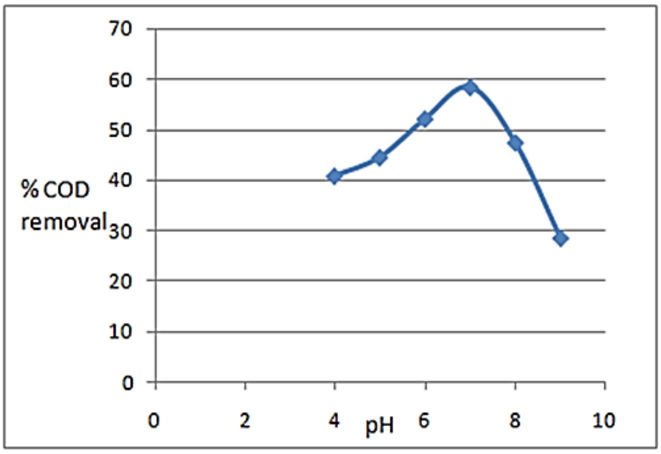

Figure 3. Effect of electrolysis time on % COD removal

C. Effect of Voltage

Voltage is an important parameter for the electro coagulation process. Initial experiments were conducted at an original solution Voltage 6. Further experiments were conducted at different Voltages (4, 6, 8, 10 and 12) by copper electrodes to study the effect of Voltage on the EC process. The electrolysis was performed for 90 minutes with a constant current density of 16mA/cm2(0.32A), agitation speed was kept constant at 500 rpm, pH at 7 and the spacing between the electrodes was 2 cm. The maximum % COD removal is 66% which was achieved at the voltage of 10V and the results are shown in Fig.4 respectively. Table 3 shows the COD concentration and % COD removal at different voltages. The characteristics of coal gasifier effluent before and after electrocoagulation are tabulated in table 4.

Table 3: Influence of voltage on %COD removal

Voltage (V)	COD conc. (ppm)	% COD removal
4	33869	38.4
6	31544.4	48.6
8	29388	59.5
10	28237	66
12	29630	58.2

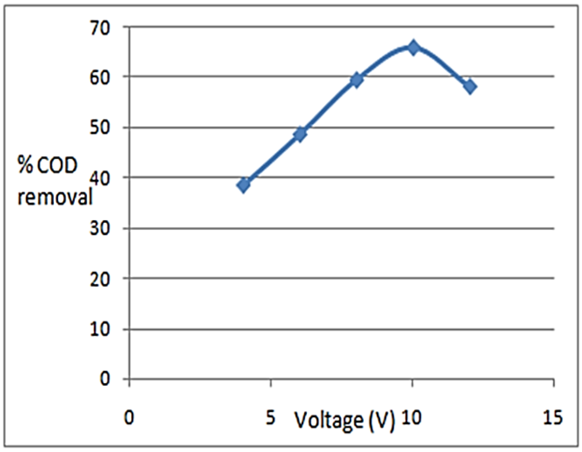

Figure 4. Effect of voltage on % COD removal

Table 4: Characteristics of effluent before and after treatment (All units mg/L, except pH)

S.NO	Parameter	Effluent before treatment	Effluent after treatment
1	pH	8	7.5
2	TSS	1,160	650
3	TDS	6000	2560
4	BOD	80	67
5	COD	46875	28237
6	Sulfates	3,292	3,199
7	Chlorides	480	463

IV. CONCLUSION

The following conclusions were drawn from the present studies of coal gasifier effluent treatment by electrocoagulation showed good reduction in COD compared to other methods. It was also noted that selection of appropriate pH, Electrolysis time (ET), Voltage were necessary as they play a major role in reduction of COD. The optimum conditions of pH, Electrolysis time (ET), Voltage were 7, 90 min., 10V for maximum % COD removal on using a copper electrode in electrocoagulation for maximum removal of COD plays a more dominant role as compared to other electrodes.

V. REFERENCES

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