

Catalytic wet oxidation treatment process for reduction of COD, phenol, and cyanide in coking wastewater

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Highlights

- The CWW contain highly toxic chemicals like phenol, cyanide, and other substances
- The wet oxidation was performed for reduction of pollutants
- Homogenous and heterogenous catalysts were used for wet oxidation
- Kinetics parameters were evaluated for the wet oxidation process

Introduction

Carbonisation of coal in coke oven is carried out to produce coke. This process is performed in most of metal industries where coke is used in blast furnace. After the carbonisation (heating of coke at 900-1300 °C) the hot coke is quenched using water, produces wastewater called coking wastewater (CWW), which is highly polluting effluent. The CWW contain highly toxic chemicals like phenol, cyanide, ammonia, oil and grease, polycyclic nitrogen etc[1]. These substances causes high chemical oxygen demand (COD) and biochemical oxygen demand (BOD) of wastewater. During the process coke formed is used in blast furnace. Due to the presence of harmful components in CWW, its treatment is necessary before its discharge into the water bodies [2,3]

Many processes have been reported for the treatment of CWW which include chemical and biological process. One of the advanced treatment technology used for the treatment of non-biodegradable pollutants is wet air oxidation (WAO). It permits the treatment of many refractory organic compounds and high detoxification hazardous substances at moderate temperature and pressure. In present work, various homogeneous and heterogeneous catalysts were used for the oxidation of CWW. The parameters like temperature, oxygen partial pressure, catalyst mass loading, pH and treatment time were studied for degradation of pollutants. The kinetic parameters were also determined from experimental data .

2 Method

Batch mode oxidation of CWW was conducted in a 700 ml high pressure reactor which contain variable speed stirrer and PID controller to maintain the temperature. In the reactor CWW (250 ml) , catalyst and oxidant (air) were taken. When the desired temperature was reached, the air as oxidant was supplied for

oxidation of pollutant, it was the zero time for reaction. The treated CWW samples were withdrawn at different time intervals, and analysed for COD and Phenol, and others parameters using standard method [4].

3. Results and discussion

The degradation of pollutants was carried out using catalytic wet air oxidation (CWAO) process at operating parameters of initial pH (pH_i) 3 - 11, temperature (T) 100 - 160 °C, air partial pressure (p_{air}) 2 - 6 MPa, catalyst mass loading (C_w) 2 - 5 g/L and treatment time (t_R) of 0 – 6 h. Copper chloride was found best among the various homogenous and heterogenous catalysts used. Results showed that T, p_{air} , C_w and t_R play an important role in the process. The optimum conditions for the WAO was evaluated to T 130 °C, p_{air} 8.8 MPa, C_w 3 g/L and t_R = 6 h at which percentage reduction of COD, phenol, and cyanide were 86.41%, 93.63% and 87.65%. The kinetics studies shows activation energy $E = 1410.88$ kJ/ mol, order of reaction (n) = 1.10, order of catalyst mass loading (m)= 0.55, order of partial pressure of oxygen (l) = 0.93 for COD removal; $E = 1104.56$ kJ/ mol, $n = 1.15$, $m = 0.63$, $l = 1.0$ for phenol removal; and $E = 771.7$ kJ/ mol, $n = 1.2$, $m = 0.71$, $l = 1.05$ for cyanide removal.

4. Conclusions

The degradation of the hazardous chemicals such as COD, phenol and cyanide of CWW was performed using CWAO using air as oxidant. Results showed that T, p_{air} , C_w and t_R play an important role in the process. Temperature increases the collision between oxidant, catalyst and pollutant. Oxidant generates free radicals and catalyst decreases the activation energy, so degradation rate increases. The treated CWW was having COD= 43.42 mg/L, Phenol = 5.01 mg/L, and CN= 0.03 mg/L from $COD_i = 1620$ mg/L, $Phenol_i = 243$ mg/L, $Cyanide_i = 18.88$ mg/L. Results show that CWAO could be one of best method to treat CWW for the removal of hazardous substances, and treated effluent can be recycled in the same industry.

Keywords: Catalytic wet air oxidation; coking wastewater; COD; cyanide; phenol; kinetics

References

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