International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.12 pp 604-609, 2015

COD Removal from Landfill Leachate by Electrochemical Method Using Charcoal-PVC Electrode

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Abstract: This study investigated the efficiency of electrochemical oxidation in removing chemical oxygen demand (COD) from leachate. The paper studies the factors affecting the efficiency of removing COD of leachate, such as applied voltage, electrolysis time and Cl^- concentration. Charcoal composite electrode was used as anode, the results show that the electrochemical oxidation can be applied to leachate treatment. The operating conditions were applied voltage of 15 V , the raw pH, Cl^- concentration of 1.5 % (w/v), operating time of 90 min. with charcoal-poly vinyl chloride (C-PVC) electrode, the highest COD removal efficiencies was 82%.
Keywords: electrochemical oxidation; Landfill leachate; C-PVC electrode, treatment.

Introduction

Landfilling is the most widely used method for the waste treatment. Leachate is commonly generated from precipitation, surface run-off, and infiltration or intrusion of groundwater percolating through the landfill[1]. Leachate is difficult to be treated to satisfy the discharge standards for its variable composition and high proportion of refractory materials[2].Many treatment methods have been used to treat the leachate, such as advanced oxidation techniques, membrane processes, biological processes, coagulation–flocculation methods and so on[3].For the characteristics of leachate change with advancing years of the landfill, these methods have some shortages such as decreasing treatment efficiencies and increasing cost[1]. Therefore, some effective and economical treatment methods need to be developed to solve these problems. Electrochemical (EC) is a simple and efficient electrochemical methods for the purification of water and wastewaters[4]. An electrochemical method is characterized by simple equipment, decreased amount of sludge, easy operation[5]. Electrochemical oxidation is an efficient method for the treatment of potable water, textile dyeing wastewaters, tannery wastewater pre-treatment, restaurant wastewater and so on[6] The technology lies at the intersection of three more fundamental technologies: electrochemistry, coagulation and flotation[7].

Materials and Method

Leachate sample

In the experimental study, Leachate samples were collected from Jeram Sanitary Landfill, which is located in an oil palm plantation near Mukim Jeram, Kuala Selangor, Malaysia. The samples were collected in 1L amber glass bottles transported in ice cool container to the laboratory and stored at 4oC in order to keep the leachate characteristics unchanged.

Preparation of C-PVC Electrodes

The composite electrode was prepared accordingly as already discuss by other author elsewhere, by mixing together a weighed portion of charcoal powder with PVC in 4 ml tetrahydrofuran (THF) solvent and swirled flatly to homogeneous followed by drying in an oven at 100˚ C for 3 h. The mixture was then placed in 1 cm diameter stainless steel mould and pressed at 10 ton/cm2[8,9]. A typical pellet contained approximately 70% (w/w) metals powder and 30% (w/w) of PVC polymer. The total weight of pellet obtained is approximately 1 gm. The pellets were connected to silver wire with silver conducting paint prior covered with epoxy gum. The ratio of Charcoal with PVC in the prepared electrode is as summarized in Table 1.

Table 1. Ratio and composition charcoal powder and PVC for electrodes prepared

Electrode	Weight Ratio	C (g)	PVC (g)
C: PVC	70: 30	0.7	0.3

Note: C= charcoal powder

The Experimental cell

The electrochemical cell is consisted of a DC power supply (CP x200 DUAL, 35 V 10A PSU) and a glass beaker (250 ml) completed with C-PVC composite electrode as an anode and stainless steel rod (d = 10 mm) as cathode. The electrodes were placed vertically and parallel to each other in the electrolytic reactor, with the distance between the cathode and anode was approximately 1cm. The stirrer was used in electrochemical cell to maintain an unchanged composition (Figure 1).

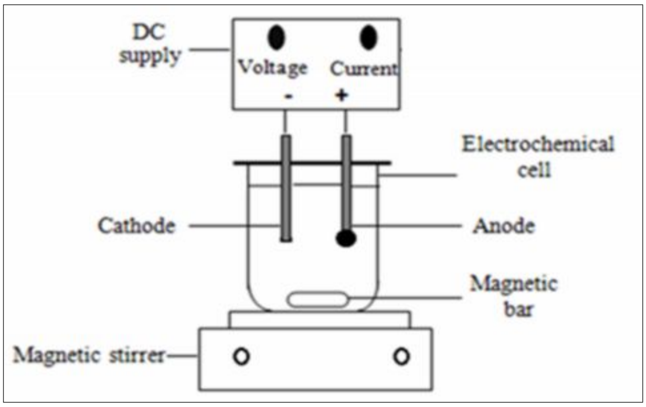

Figure 1.The schematic experimental setup

Analysis

The physicochemical characteristics of landfill leachate were determined on the basis of common physicochemical properties according to the standard methods for analysis of wastewaters and surface water developed by the American Public Health Association[10]. The analysed parameters (COD, color, NH_3-N and total-P) were measured by a spectrophotometer (Hach Odyssey DR/2400). The pH was measured by a pH meter (Metrohm). Total dissolved solids (TDS) and conductivity were measured by using a conductivity meter (Cond 610). The average values of the selected physicochemical parameters of the raw landfill leachate from the Jeram landfill prior to treatment were analysed as listed in Table 2.

Table 2. Characterization of raw leachate samples collected from Jeram Sanitary Landfill

Parameter	**Color Pt-Co**	**COD mg/l**	**BOD5 mg/l**	**NH_3-N mg/l**	**Total-P mg/l**	**pH**	**TDS ppt**	**Conductivity mS/cm**
Value	14960	49000	14790	3800	200	8.65	28.09	29.67

Results and Discussion

Effect of electrolysis time

The effect of electrolysis time was investigated in the range 10 to 120 minutes by the following conditions: raw pH, 10V applied voltage values. As can be seen in Fig. 2, an increase in the time from 10 to 120 minutes yield an increase in the efficiency of COD removal from 17 to 83%, it does not change significantly after 90 min. When the electrolysis time increases, more hypochlorite ion will be produced in solution under fixed current density[11], also the rate of bubble-generation increases. Therefore, COD value in the solution was reduced in higher concentration of hypochlorite, due to ability of hypochlorite ion to oxidize and degrade organic molecules in landfill leachate[12]. The pollutants in leachate were removed by the effect of coagulation and flotation. High electrical energy consumption with the increasing time, the optimum time of electrolysis is 90 min.

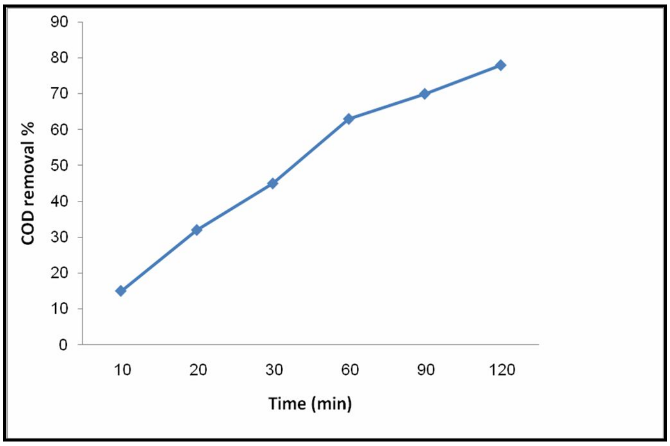

Figure 2.Effect of electrolysis time on COD removal

Effect of applied voltage

The applied voltage had a significant influence on the efficiency of electrochemical process[13]. The investigated applied voltages were5, 10 and 15V. Fig. 4 depicts the effect of applied voltage on the removal efficiencies by the following conditions: raw pH, 90 min electrolysis time. As shows in Fig. 4, the removal efficiency of COD at applied voltage 5 to 20 V increase from 41 to 83%, it does not change significantly at higher applied voltage. By the increasing of applied voltage, the increase in hypochlorite ion approaches equilibrium with degradation of organics present in the effluent[14]. Increasing the applied voltage of the electrochemical cell followed by the production of more electron, which results in increasing the rate of overall reaction[15]. But more energy would be consumed at higher applied voltage, Moreover, the rate of bubble-generation increases and the bubble size decreases with the increasing of applied voltage, resulting in a faster removal of pollutants by H_2 flotation[16]. So 15 V was used for further study.

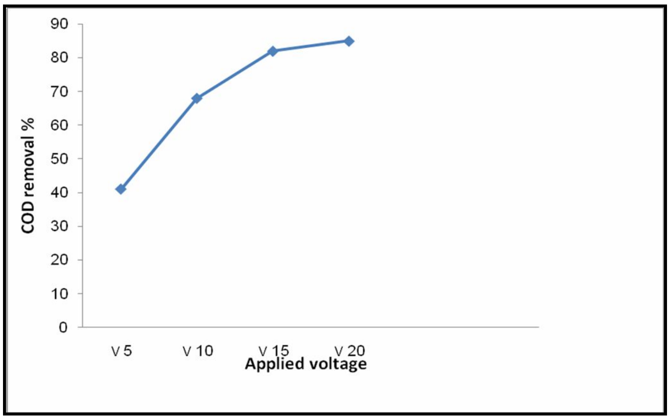

Figure 3. Effect of applied voltage on COD removal

Effect of Cl- addition

The electrical conductivity of the solution is an important parameter for saving electric energy[17].To increases the electric conductivity of the solution, NaCl was used as the supporting electrolyte. The time is 90 min and the applied voltage is 15 V. The effects of Cl^- on the removal efficiency were studied at 0,0.5, 1, 1.5 and 2% (w/v) levels. As is seen in Fig. 6, An increase in the concentration of Cl^- from 0.5 % (w/v) to 2 % (w/v) yield an increase in the efficiency of COD removal from 70 to84%, it does not change significantly after 1.5 % (w/v). With the Cl^- concentration increases, the passivation of the electrode can be relief and the ability of electric conduction can be improve[17,18]. During the electrochemical process, the Cl^- will be discharged at the anode to generate Cl_2, then the Cl_2 can be chemically convert to ClO^-which can oxidize the pollutants effectively[19]. To take into account the cost, the optimum concentration of Cl^- is 1.5% (w/v).

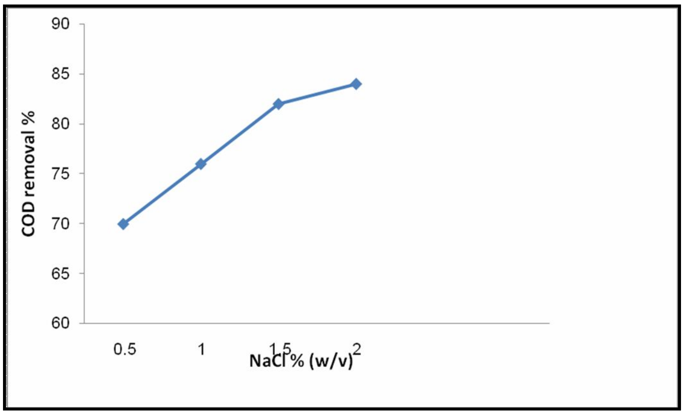

Figure 4.Effect of NaCl concentrations on COD removal

The reduction in COD value was due to the breaking of large molecule to a small molecule which is easier to be oxidized chemically or biologically by electrochemical oxidation technique[21,22]. This breaking process was supported by the existence of self-generated hypochlorite ion which is able to reduce the concentration of organic compound available[23,24].

Conclusions

Based on the experiment of treatment of leachate by electrochemical oxidation, this paper studies the factors affecting the removal efficiencies. The results indicate that e1ectrocoagu1ation can be used to the leachate preprocessing. Under conditions of charcoal-PVC electrode, 15 V applied voltage, 1.5 % (w/v) Cl^- concentration, 90 min electrolysis time and unchanged the raw pH, the removal efficiencies of COD was82%.

Acknowledgment

The authors would like to thank ALIR staff for providing all facilities to do sampling and analysis of landfill leachate samples in the lab. The funding from University Kebangsaan Malaysia and Ministry of Higher Education, Malaysia through grants FRGS/2/2013/SG01/UKM/01/1 are gratefully acknowledged.

References

1. Wu, Jerry J., Chih-Chao Wu, Hong-Wen Ma, and Chia-Chi Chang. "Treatment of landfill leachate by ozone-based advanced oxidation processes." *Chemosphere* 54, no. 7 (2004): 997-1003.
2. Labanowski, Jérome, Virginie Pallier, and Geneviève Feuillade-Cathalifaud. "Study of organic matter during coagulation and electrocoagulation processes: Application to a stabilized landfill leachate." Journal of hazardous materials 179, no. 1 (2010): 166-172.
3. Ilhan, Fatih, Ugur Kurt, Omer Apaydin, and M. TalhaGonullu. "Treatment of leachate by electro coagulation using aluminum and iron electrodes." Journal of hazardous materials 154, no. 1 (2008): 381-389.

4. Kobya, M., C. Ciftci, M. Bayramoglu, and M. T. Sensoy. "Study on the treatment of waste metal cutting fluids using electrocoagulation." Separation and purification technology 60, no. 3 (2008): 285-291.
5. Linares-Hernández, Ivonne, Carlos Barrera-Díaz, Gabriela Roa-Morales, Bryan Bilyeu, and Fernando Ureña-Núñez. "Influence of the anodic material on electrocoagulation performance." Chemical engineering journal 148, no. 1 (2009): 97-105.
6. Chou, Wei-Lung, Chih-Ta Wang, Chia-Wei Hsu, Kai-Yu Huang, and Te-Chao Liu. "Removal of total organic carbon from aqueous solution containing polyvinyl alcohol by electrocoagulation technology." Desalination 259, no. 1 (2010): 103-110.
7. Holt, Peter K., Geoffrey W. Barton, and Cynthia A. Mitchell. "The future for electrocoagulation as a localised water treatment technology." Chemosphere59, no. 3 (2005): 355-367.
8. Othman, Mohamed Rozali, and Amirah Ahmad. "ELECTROCHEMICAL OXIDATION OF GLYCEROL USING GOLD ELECTRODE." Malaysian Journal of Analytical Sciences 19, no. 2 (2015): 291-299.
9. Majdahmed and mohammedrozali "Fabrication Of Pt, Al, Fe, Co, Cu, Ag And Ni Powder Composite Electrode For Landfill Leachate Treatment Using Electrochemical Method. 2014 "skam 27.
10. Federation, Water Environmental, and American Public Health Association. "Standard methods for the examination of water and wastewater." American Public Health Association (APHA): Washington, DC, USA (2005).
11. Nordin, Norazzizi, and SitiFathritaMohd Amir. "Riyanto, and Mohamed Rozali Othman." Textile Industries Wastewater Treatment by Electrochemical Oxidation Technique Using Metal Plate. International Journal of Electrochemical Science 8 (2013): 11403-11415.
12. Panizza, Marco, Cristina Bocca, and Giacomo Cerisola. "Electrochemical treatment of wastewater containing polyaromatic organic pollutants." Water Research 34, no. 9 (2000): 2601-2605.
13. Zhao, Renzun, John T. Novak, and C. Douglas Goldsmith. "Evaluation of on-site biological treatment for landfill leachates and its impact: a size distribution study." water research 46, no. 12 (2012): 3837-3848.
14. Awad, H. S., and N. Abo Galwa. "Electrochemical degradation of Acid Blue and Basic Brown dyes on Pb/PbO 2 electrode in the presence of different conductive electrolyte and effect of various operating factors." Chemosphere61, no. 9 (2005): 1327-1335.
15. Maljaei, Ata, Mokhtar Arami, and Niyaz Mohammad Mahmoodi. "Decolorization and aromatic ring degradation of colored textile wastewater using indirect electrochemical oxidation method." Desalination 249, no. 3 (2009): 1074-1078.
16. Can, O. T., and M. Bayramoglu. "The effect of process conditions on the treatment of benzoquinone solution by electrocoagulation." Journal of hazardous materials 173, no. 1 (2010): 731-736.
17. Chou, Wei-Lung, Chih-Ta Wang, and Shih-Yu Chang. "Study of COD and turbidity removal from real oxide-CMP wastewater by iron electrocoagulation and the evaluation of specific energy consumption." Journal of hazardous materials 168, no. 2 (2009): 1200-1207.
18. Jumaah, Majd Ahmed, Mohamed Rozali Othman, and ZuhailieZakaria. "Fabrication of selected metal powder composite electrode for landfill leachate treatment using electrochemical method." International Journal of Chemical Sciences 13, no. 2 (2015): 943-954.
19. Wang, Chih-Ta, Wei-Lung Chou, and Yi-Ming Kuo. "Removal of COD from laundry wastewater by electrocoagulation/electroflotation." Journal of hazardous materials 164, no. 1 (2009): 81-86.
20. Jumaah, Majd Ahmed, and Mohamed Rozali Othman. "Optimization of operating conditions for landfill leachate treatment using electrochemical oxidation technique." International Journal of ChemTech Research 8, no. 2 (2015): 783-787.
21. Jumaah MA, Othman M. R. optimization of electrochemical parameters for landfill leachate treatment using charcoal base metallic composite electrode. Malaysian Journal of Analytical Sciences.;19(2015):531-40.
22. Zakaria, Z., Nordin, N., Hasan, S. Z., Baharuddin, N. A., Jumaah, M. A., & Othman, M. R. Decolorization of reactive orange 16 dye using fabricated charcoal base metallic composite electrode. Malaysian Journal of Analytical Sciences, 19(2015), 493-502.
23. Jumaah, Majd Ahmed, and Mohamed Rozali Othman. "Decolorization of landfill leachate using electrochemical oxidation technique." In THE 2015 UKM FST postgraduate colloquium: Proceedings

of the UniversitiKebangsaan Malaysia, Faculty of Science and Technology 2015 Postgraduate Colloquium, vol. 1678, p. 050032. AIP Publishing, 2015.

24. Jumaah, Majd Ahmed, and Mohamed Rozali Othman. Study the efficiency of various metal powder composition electrodes based on landfill leachate treatment., International Journal of ChemTech Research 8, no 11.12, (2015), in press.

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