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Study the Efficiency of Various Metal Powder Composition Electrodes Based on Landfill Leachate Treatment

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Abstract: In this research, new composite electrodes of platinum (Pt), silver (Ag), aluminium (Al), cobalt (Co), copper (Cu), nickel (Ni) and iron (Fe) with PVC were prepared. The ready composite electrodes were then used as a working electrode to treat a leachate samples using electrochemical method with stainless steel as the counter electrode. Electrochemical oxidation processes, is one of the environmental friendly technologies in landfill leachate treatment processes**.** The results showed a composition of Co_{85}-$PVC_{15}$was the best electrode whichgave the removal percentage of color, COD and NH_3-N are 82, 80 and 76% respectively.
Keywords: metals powder, landfill leachate, electrode, electrochemical.

Introduction

Landfill leachate is a complicated wastewater and it always contains high strength of pollutants which has adverse effect to the environment[1]. In an effort to control the pollution caused by landfill leachate, many treatment processes have been studied, including biological treatment[2], photocatalysis[3], adsorption[4], chemical precipitation[5], Fenton's oxidative treatment[6], coagulation/flocculation[7], advanced oxidation processes[8] and membrane processes[9]. These test methods have troubles such as decreasing treatment efficiencies and increasing cost. Upto now, electrochemical oxidation process has been proved to be promising for wastewater treatment mainly due to its high effectiveness, easy to operate and more economic. Especially in the case of landfill leachate, have rich chloride ions and good conductivity. Electrochemical oxidation technique is an effective method not only for color removal but also for COD removal. The pollutants are destroyed by either direct or indirect oxidation process. The main aim of this study is to fabricate metal powder electrodes to treat landfill leachate and Study the efficiency of these electrodes in the landfill leachate treatment.

Method and Materlials

Preparation of electrodes

The composite electrodes at the composition of M_{85}-PVC_{15} were prepared accordingly, as already discussed by other author elsewhere[10,11], by mixing together a weighed portion of metals 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 at10 ton/cm^2. A typicalpellet contained approximately 85% (w/w) metals powder and 15% (w/w) of PVC polymer. The total weight of pellet obtained is approximately 1 g. The pellets were connected to silver wire with silver conducting paint prior covered with epoxy gum. The ratio of Pt, Al, Fe, Co, Cu, Ag and Ni powder with PVC in the prepared electrode are as summarized in Table 1.

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

Electrode	Weight Ratio M: PVC	M (g)	PVC (g)
M: PVC	85:15	0.85	0.15

Sampling

Leachate samples were collected from Jeram Sanitary Landfill, which is located in an oil palm plantation near MukimJeram, Kuala Selangor. Observed in the landfill site that there are several ponds containing leachate, raw untreated leachate and treated leachate. Leachate samples were collected from raw leachate pond and stored at temperature $4^{o}C$ to keep the wastewater characteristic unchanged.

The Experimental setup

The electrochemical cell is consisted of a DC power supply (CP x200 DUAL, 35 V 10A PSU) and a glass beaker (100 ml) completed with M_{85}-PVC_{15} composite electrode as an anode and stainless steel rod (d = 10 mm) as cathode. The experiment equipment was consisted of a DC power supply, glass reactor and magnetic stirrer than added a known amount of supporting electrolyte to 50 ml of leachate. All experiments were carried out at lab scale. Color, COD and NH_3N of the leachate were measured by using standard method for the examination of water and wastewater[12].

Results and Discussion

Metal-PVC Composite Electrode

In new combination electrode prepared from several metals powder (Pt, Ag, Cu, Ni, Al, Fe and Co) are studied with PVC as shown the results in Table 2.

Table 2. Electrochemical oxidation of landfill leachate in 1.2% w/v NaCl using selected metals powder with PVC as an anode and Stainless steel rod as cathode, voltage of 10V was applied with 90 min. electrolysis time

Electrode	Decoloring percentage (%)	Observation		Cost USD	OCl^- Production
		Electrolysis product	Anode		
Pt_{85}-PVC_{15}	99	Clear solution	Unchaged	176.4	20.5*
Ag_{85}-PVC_{15}	68	Yellowish solution	Slightly corroded	4.34	4.5*
Cu_{85}-PVC_{15}	71	Yellowish solution	Slightly corroded	3.91	1.65
Ni_{85}-PVC_{15}	47	Yellowish solution	Completely corroded	3.73	1.5
Al_{85}-PVC_{15}	66	Yellowish solution	Slightly corroded	0.24	2.9
Fe_{85}-PVC_{15}	72	Yellowish solution	Slightly corroded	0.44	1.8
$Co_{85}PVC_{15}$	82	Clear solution	Unchanged	0.86	1.9

Note: OCl-= the formation of OCl- in 50 ml deionized water, 1.2 % (w/v) NaCl and 30 min. electrolysis time, *the sample with dilution.

Effect of the Electrode Material on Color Removal

Different electrode materials affect on the performance of the electrochemical oxidation process. In this study, several electrodes of metals powder consisting of platinum (Pt), aluminum (Al), iron (Fe), cobalt (Co), copper (Cu), silver (Ag) and nickel (Ni) with PVC as anode were fabricated. The best electrode base on color removal under the operating condition of applied voltage 10V, electrolysis time 90 min, NaCl concentration 1.2 % (w/v) was chosen compared with the other properties[13]. The results obtained are summarized in Figure 1.

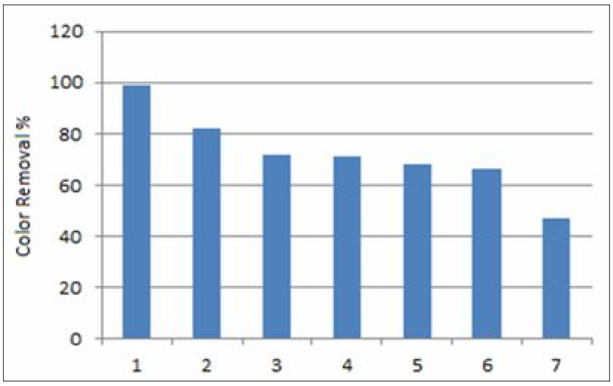

Figure 1.Effect of the Electrode Material on Color Removal

Note: 1: Pt_{85}-PVC_{15}, 2: Co_{85}-PVC_{15}, 3: Fe_{85}-PVC_{15}, 4: Cu_{85}-PVC_{15}, 5: Ag_{85}-PVC_{15}, 6: Al_{85}-PVC_{15}, 7: Ni_{85}-PVC_{15}.

The best color removal (99% and 82%) was observed during 90 min. using Pt_{85}-PVC_{15} and Co $_{85}$-PVC_{15}electrode, respectively compared with others. Meantime, the result of color removal using Al_{85}-PVC_{15}, Fe_{85}-PVC_{15}, Cu_{85}-PVC_{15}, Ag_{85}-PVC_{15} and Ni_{85}-PVC_{15} electrodeswere 66, 72, 71, 68 and 47%, respectively. The selection of the best electrode is notonly to remove the color, but also on the basis of chemical stability. Because electrode usedin any electrochemical process must be stable chemical and physical[14], as shown in Table 2.

The Electrode stability

The electrode material must have the following properties: high physical and chemical stability, high electrical conductivity, rapid electron transfer kinetics in a wide range of redox, easy to set up as well as inexpensive and durable must be favored[15,19]. Different types of anode materials were used and selected the best electrode stability after electrolysis as show in Figure 2. It's clear from the results Pt-PVC, Co-PVC and Al-PVC unchanged and others between slightly corroded and completely corroded.

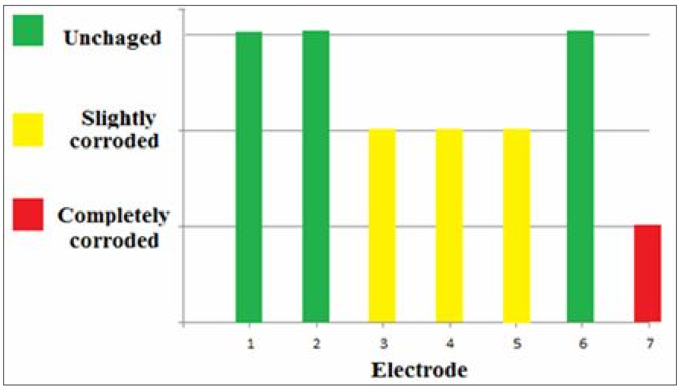

Figure 2.The Electrode stability

Note: 1: Pt_{85}-PVC_{15}, 2: Co_{85}-PVC_{15}, 3: Fe_{85}-PVC_{15}, 4: Cu_{85}-PVC_{15}, 5: Ag_{85}-PVC_{15}, 6: Al_{85}-PVC_{15}, 7: Ni_{85}-PVC_{15}.

Cost Estimation for Different Types of Electrode

The costs of each electrode were calculated through sigma Aldrich. As summarized in Figure 3. The results show Pt-PVC very high cost, Ag-PVC, Cu-PVC, Ni-PVC middle cost and Co-PVC, Al-PVC and Fe-PVC low cost.

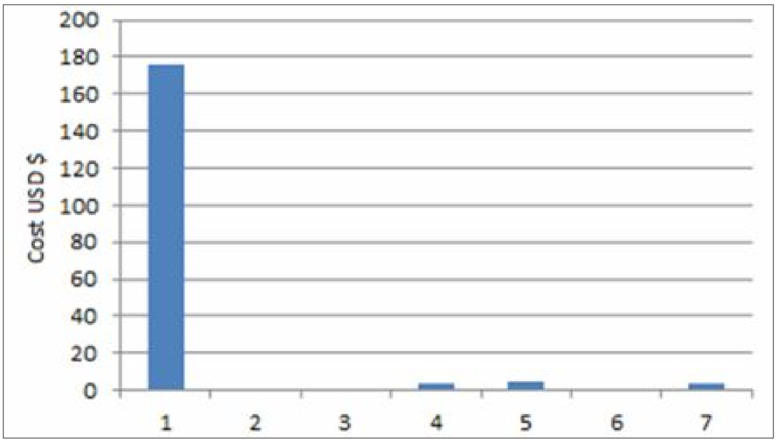

Figure 3.Cost Estimation for Different Types of Electrode

Note: 1: Pt_{85}-PVC_{15}, 2: Co_{85}-PVC_{15}, 3: Fe_{85}-PVC_{15}, 4: Cu_{85}-PVC_{15}, 5: Ag_{85}-PVC_{15}, 6: Al_{85}-PVC_{15}, 7: Ni_{85}-PVC_{15}.

The Formationof OCl^-

In a separate experiment, formation of OCl^- has been investigated by adding 1.2% (w/v) NaCl to 50 mL of deionized water. During electrolysis, OCl^- has been produced due to the presence of chloride ions that is responsible to make hypochlorite ions in order to degrade the pollutants in leachate[16]. The formation of OCl^- in aqueous solution has been monitored using UV-visible spectrophotometer. FromFigure4the formation of OCl^- for Pt and Co were 20.5 and 2 respectively, but Pt electrode is so expensive 176.4 $, when compression with Co electrode is just 0.86 $.However, cobalt-PVC was found to be the best electrode based on the color removal efficiency, chemically and physically stable, low cost and formation of OCl^- is good. However, the electrochemically stability of electrode is necessary during electrooxidation process[17,18].

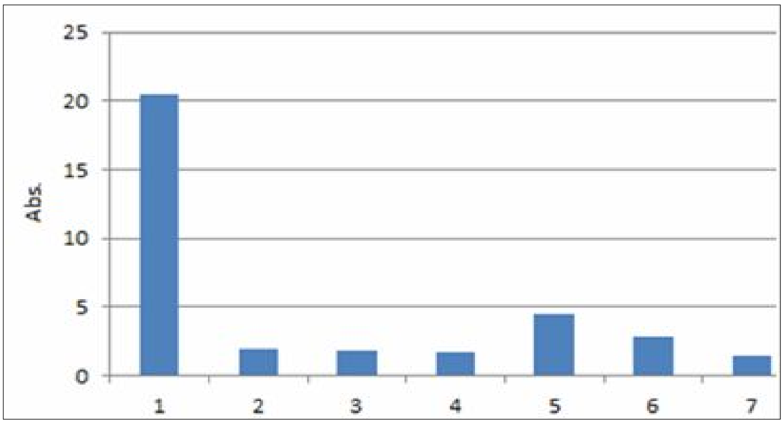

Figure 4.Effect the electrodes on OCl- Formation

Note: 1: Pt_{85}-PVC_{15}, 2: Co_{85}-PVC_{15}, 3: Fe_{85}-PVC_{15}, 4: Cu_{85}-PVC_{15}, 5: Ag_{85}-PVC_{15}, 6: Al_{85}-PVC_{15}, 7: Ni_{85}-PVC_{15}.

The results obtained show that the electrochemical oxidation process using Co-PVC electrode is able to reduce the color, COD and NH_3N values in landfill leachate. From those three parameters (color, COD and NH_3N)theremoval percentages were not less than 82, 80 and 76% respectively Table 3.

Table 3.Removal percentage of pollution

Electrode	Removal percentage %		
	Color	**COD**	**NH_3N**
Co: PVC	82	80	76

Conclusion

Based on the experiment of landfill leachate treatment by electrochemical oxidation, the results indicate electrochemical oxidation technique can be used for the leachate treatment by Co-PVC composite electrode, the removal of color, COD and NH_3N were 82, 80 and 76 % respectively.

Acknowledgment

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