234g Indirect Electrochemical Treatment of Textile Wastewater: Influence of Design and Operational Parameters on Color Removal

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Effluents from textile industry pose threats to the ecosystem due to the presence of elevated levels of toxic colorants and inorganic salts. Electrochemical methods have recently gained attention as promising alternatives to traditional chemical treatments for textile wastewaters. Indirect electrochemical treatment makes use of sodium chloride (NaCl) present in textile wastewater to produce active chlorine based oxidants at the anode that decolorize highly-colored azo compounds forming colorless end-products. Field scale application of electrochemical treatment systems are limited by power requirements. The major goals of this study were to: 1) develop design strategies providing maximum color removal utilizing minimum power, and 2) investigate the effect of design and operational parameters on decolorization rate and power consumption.

Electrochemical cell configuration, surface area-to-volume (S-V) ratio and applied current were the critical factors chosen for the investigation. S-V ratio plays a vital role in reactor scale-up and most investigators have combined this parameter with applied current, expressing the combination as current density. In this study, individual effects of electrode surface area and applied current on decolorization rate were quantified. Fixed variables included: 1) solution pH (pH = 7), 2) cell re-circulation flow rate (1650 ml/min), 3) bulk solution ionic strength (1 M), 4) contaminant: Acid Alizarin Violet N (AAVN) concentration (14.65 ppm), 5) NaCl concentration (20.48 g/L). Graphite and stainless steel rods were employed as anodes and cathodes, respectively. Two electrochemical cell designs, split and undivided cell were tested in this study. In the split cell configuration, the anode and cathode compartment are separated using a cation exchange Nafion membrane. In the undivided cell configuration, both electrodes are installed in the same compartment. Applied current levels were 72 mA and 144 mA. The S-V ratio levels were 0.0185 m^2/m^3 and 0.037 m^2/m^3. The treatment runs were terminated after reaction completion, overcoming the limitations of conventional time-based studies. The re-circulation loop was placed in the path of UV-Vis diode array detector, which recorded the *in situ* solution absorbance every 3 minutes for real-time dye concentration monitoring.

The initial pseudo-first order rate constant, *k*, was calculated as the slope of the line fitted to a ln(C/Co) versus time curve up to a cut off point of ln(C/Co) = 0.5. The computed reaction rate constant and power consumption values for the treatment runs are summarized in Table 1. Decolorization rates for comparative runs with different cell designs revealed that the split cell design showed higher removal rates than the undivided cell except for the 72 mA and 0.037 m^2/m^3 run. Higher decolorization rates observed in the split cell were due to the conservation of oxidants produced at the vicinity within the anode compartment by the Nafion membrane. In the undivided cell, oxidants produced at the anode were reduced to other compounds at the cathode, resulting in lower decolorization rates. Increasing the S-V ratio increased the decolorization rate at all tested conditions. This result might be due to the occurrence of unwanted side reactions competing for electrode surface along with the preferred oxidation reaction. A linear relationship between applied current and decolorization was observed. Influence of design and operational parameters were also verified using Analysis of Variance. Cell type, S-V ratio and applied current had a significant effect on decolorization rate at 95 % confidence limit.

When the applied current was doubled, power consumed was increased in the undivided cell as opposed to a decrease recorded in the split cell. This conflicting trend in power consumption confirms that adding more electrons to the undivided cell may increase rates initially, but excess electrons are lost to unwanted side reactions resulting in a loss of efficiency. Electrochemical reactor design strategies to attain maximum color removal and minimum power consumption developed from this study will be presented. Significance of considering surface area-to-volume ratio in electrochemical investigations will also be discussed.

Table 1. Experimental conditions and results

Cell Type	**S-V Ratio**	**Current**	**Average Voltage**	**Time**	**Initial Rate Constant**	**Power Consumption**[*]
	m2/m3	*mA*	*V*	*min*	*min-1*	*KJ*
Undivided Cell	0.0185	72	1.79	363	0.002	2.81
	0.037	72	1.72	216	0.0034	1.6
	0.0185	144	1.88	231	0.0033	3.76
	0.037	144	1.72	123	0.0064	1.83
Split Cell	0.0185	72	1.75	216	0.0032	1.63
	0.037	72	1.67	225	0.0031	1.62
	0.0185	144	1.75	99	0.0077	1.5
	0.037	144	1.62	75	0.009	1.05

[*] Power consumption: P = Current (amp) * Voltage (V) * Time (sec), computed at 50 % color removal