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An Insight into Electro-dialysis for Water Treatment

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ABSTRACT

Electro-dialysis is used for treatment of industrial wastewater. In this method ion selective membranes separates compartments of the electro-dialysis tank and two ends of the tanks are equipped with positive and negative electrodes. The ions to be separated move towards opposite electrodes. The factors such as initial concentration, applied voltage and temperature affect the performance. Desalination of water for reuse and recycle is purpose of treating water by electro-dialysis. Investigations are reported on electro-dialysis for exploring possibilities of different electrodes, membranes and optimizing operating parameters. Current review summarizes research and studies on electro-dialysis.

Keywords: Voltage, Concentration, Electrodes, Potential, Efficiency.

I. INTRODUCTION

The treatment of wastewater has been important area of research for decades. The removal of organic matter below regulatory limit is normally done with typical wastewater treatment plant. It is equipped with primary, secondary and tertiary treatments. Adsorption, activated sludge process and trickling filters are employed for the water treatment [1-5]. Nowadays recycle and reuse of wastewater is becoming need of the modern day progress. It reduces water consumption and minimizes the problem of waste disposal [6-9]. The advanced treatment methods like membrane separation, dialysis, pervaporation, solar distillation are being explored to make the water usable [10-15]. Electro-dialysis is one of the most effective desalination methods. It is a membrane process, during which ions are transported through semi permeable membrane, under the influence of an electric potential. The membranes are cation- or anion- selective. It means that either positive ions or negative ions will flow through. Desalination of water for reuse and recycle is purpose of treating water by electro-dialysis. Investigations are reported on electro-dialysis for exploring possibilities of different electrodes, membranes and optimizing operating parameters. Current review summarizes research and studies on electro-dialysis.

II. ELECTRO-DIALYSIS FOR WATER TREATMENT

Mohammadi et.al. carried out investigation on electro-dialysis for zinc ion removal from wastewater[16]. They explained a robust design method for separation of zinc ions from a solution. They determined the optimum configuration of factors for the best performance. They determined optimum values of influential parameters such as concentration 1000 ppm, temperature 60°C, flow rate 0.07 mL/s and voltage 30 V. They found that membrane paired with higher ion exchange capacity (IEC) improves the performance. Schoeman et.al. used electro-dialysis for treatment of a hazardous leachate[17].They evaluated electro-dialysis as an alternative method to desalinate/concentrate the leachate for effluent volume reduction and pollution control. Their studies indicated that the leachate could be effectively desalinated/concentrated with ED. They observed that the TDS of the ED feed was reduced from approximately 100g/l to less than 2g/l with 5 stage ED. Dermentzis et.al. carried out an investigation on ammonia removal from fertilizer plant effluents by a coupled electrostatic shielding based electro-dialysis[18]. In this investigation, they interposed electrically and ionically conducting graphite powder beds between the anode and cathode inside an electrolytic setup. These electrodes were used as intermediate bipolar electrodes. Their findings were novel and first of the kind effort.

The applied electric field locally inside the mass was eliminated by graphite powder bed electrodes. According to them, thin electrostatic shielding zones - ionic current sinks can be used to enhance current density. Valero et.al. studied the conditions for the treatment of a wastewater[19]. They treated wastewater from almond industry. In their work they developed a simple and useful method for measuring voltages between different points inside the reactor. An investigation was carried out on removal of cadmium and cyanide from aqueous solutions by using electro-dialysis by Marder et.al.[20]. According to them, one of the largest problems for environmentalists is the discharge of galvanic industry wastewaters containing heavy metals and cyanide. In their investigation they used a five-compartment electro-dialysis cell. They found that the removal of cadmium and cyanide depends on the applied current density. It was limited by the precipitation of cadmium on the cation-exchange membrane in the dilute central cell compartment. Benvenuti et.al. studied electro-dialysis as an alternative for treatment of nickel electroplating effluent[21]. According to them, one of the main contributors of metal discharges into the environment is galvanic process. They evaluated nickel extraction, pH and conductivity for all four compartments. They used flame atomic absorption spectrophotometer for nickel determination. They observed that the ED treatment showed a reasonable extraction for all ions in the solution, making good quality water for reuse. Viader et.al. carried out an investigation on recovery of phosphorus from chemically precipitated sewage sludge ashes by using electrolytic method[22]. According to them, additional steps are required to separate phosphorous (P) from heavy metals. It is also important to ensure its bioavailability in the resulting ashes. They were able to recover P at a rate of 70%. Choi and Jeoung used electro-dialysis for removal of zinc ions in wastewater[23].They obtained useful data for treatment of the wastewater discharged from zinc electroplating processes. They investigated effect of parameters like the initial concentration of dilute solution, the flow velocity and the applied voltage on zinc removal. They observed that, with an increase in the initial concentration of dilute solution, the flow velocity and the applied voltage the removal ratio also increased. Also it was found that the initial concentration of dilute solution and the applied voltage caused increase in The energy consumption.. The effect of flow velocity on energy consumption was negligible. Nowak et.al carried out batch electro-dialysis for removal of fluoride from wastewater[24]. They studied effect of initial fluoride and salt (NaCl) concentration. Also the presence of organic matter on fluoride removal was investigated by them. They observed that the separation efficiency increased upon decrease of initial fluoride content in model solutions. They also observed that humic acids in fluoride solutions subjected to electro-dialysis treatment have no adverse effect on the process. Heidekamp studied desalination of cooling tower blow down (CTBD)[25]. He used electro-dialysis and membrane capacitive deionization (MCDI) for this purpose. In capacitive deionization, ions are collected at carbon electrodes which have ion-selective membranes placed in front. He carried out comparative studies between ED and MCDI for the treatment of cooling tower blowdown water. He observed that energy requirement of MCDI for the treatment of CTBD water was 5 times higher than desalination with ED. He found that the energy requirement for MCDI becomes less with decrease in salt concentrations. Barakat discussed new trends in removing heavy metals from industrial wastewater [26]. In his review, the recent developments and technical applicability of various treatments were discussed. He focused on innovative physico-chemical removal processes such as; adsorption on new adsorbents, membrane filtration, electro-dialysis and photocatalysis. According to his review, important disadvantage of electro-dialysis is high operational cost due to membrane fouling and energy consumption. High separation selectivity drives the researchers to the process. Chemical precipitation and electro-dialysis methods were used for Electroplating wastewater treatment by Peng et.al.[27]. They treated wastewater containing a high chromium concentration through chemical precipitation (CP) and electro-dialysis (ED). They found that that chemical precipitation or electro-dialysis alone could not produce qualified water for recycle. They observed that the combined CP-ED process was able to greatly eliminate about 95% Cr (VI) chromium from the wastewater. A large saving at reagent cost and operation cost, and less environmental concern were salient features of combined process. Allison carried out studies on electro-dialysis for surface water treatment [28]. According to him, membrane separation process is tolerant to turbidity values that can

be routinely achieved using clarification and media filtration processes. The membranes used in the process can bear continuous exposure to effective levels of oxidizing disinfectants. Also according to him, the membranes are extremely resistant to irreversible fouling by dissolved organic material. Oztekin and Altin carried out studies on fouling problems in wastewater treatment by electro-dialysis system[29]. According to them, factors such as the operating conditions and device structures such as ion content of raw water, current density, flow rate, membrane properties, feed concentration, geometry of cell compartments affect the performance of the process. Precipitation of foulants such as organics, colloids and biomass on the membrane surface or inside the membrane is major cause of fouling. These fouling problems results in increase in membrane resistance, loss in selectivity of the membranes and affect negatively to membrane performance. This results in high energy consumption and poor separation efficiency. For reduction of fouling in ED process, they studied the factors such as pre-treatment of the feed solution, turbulence in the compartments, zeta potential control, pH and flow rate optimization, modification of the membrane properties and pulsed voltage. They concluded that decreasing flow velocity, increasing current density and colloid concentration can cause increase in fouling. Electro-dialysis of tannery and metal-finishing effluents was studied by Moura et.al. [30]. These studies were focused on removal of Chromium. They obtained blends of polystyrene and polyaniline to produce membranes for electro-dialysis. They found that synthesized membranes presented similar chromium transport to that observed in the Nafion 450 membrane.

III. CONCLUSION

The factors such as initial concentration, applied voltage and temperature affect the performance of ED process. Desalination of water for reuse and recycle is purpose of treating water by electro-dialysis. Investigations are reported on electro-dialysis for exploring possibilities of different electrodes, membranes and optimizing operating parameters. Current review summarizes research and studies on electro-dialysis. Studies indicated that that the leachate could be effectively desalinated/concentrated with ED. It was reported that, with an increase in the initial concentration of dilute solution, the flow velocity and the applied voltage, the removal ratio also increases. Also decreasing flow velocity, increasing current density and colloid concentration can cause increase in fouling.

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