ABSTRACT
Large domestic industrial paper mills generally already comply with the environmental regulations after secondary biological waste-water treatments. However, due to the high electrical conductivity (> 2000 μs/cm) and amber-colored appearance of the effluents, reusing of the water often impact seriously on the wet-end chemical stability and cleanliness of the production system, which also foster slime growth as well. Thus the post-treatment effluents must be discharged. Beginning in July 2006, the EPA intends to surcharge water pollution and right of usage taxes, therefore causing hefty increases to the operational costs of the major water users.
In this study, we designed and built a laboratory electro-oxidation treatment unit capable of high currents under low voltages that can be used to treat paper mill effluents to remove target effluent pollutants such as COD, electrical conductivity and color in a bid to supplement existing mill wastewater treatment facilities and reduce overall treatment cost. The phase I reactor was a designed to combine electro-dialysis and electro-oxidation. The reactor, however, encountered excessive electrical resistance that hinder the flow of necessary current. Thus, modification was necessary. In the phase II, we based design on the original reactor and filled the 2 cells with iron pellets to lower resistance. The same problem beset the phase I reactor recurred, however, after a few minutes of reaction time. A fixed-bed reactor design was then adopted for the phase III electrochemical unit, which had a reduced volume and forwent the dialysis membrane. We then tested paper mill effluents in the unit to examine the treatment suitability and feasibility. The reactor had a total volume of 400 mL, using 2 -vistainless steel (SS304) electrode rods which were wrapped with synthetic fiber mesh and the cell filled with 3 mm iron pellet to 80~95% of the reactor volume. The iron pellets were washed with dilute acid, and the electrodes sanded with emery paper before each treatment. The effluent treated in the study was from an industrial corrugating medium mill which produces 400 t/d of paper and discharges 3500~4000 m3/d of effluent. The post-DAF stage effluent was studied. The study was based on a 2³ factorial experimental design with operational variables of electrode spacing 5 and 15 mm; current density 287, 3454 A/m²; hydraulic retention time (HRT) 57 and 180 s. In the semibatch experiment, the total reaction time was 2 hr. The inflow effluent had pH of 6.8. The results indicate that the long HRT of 180 s had the greatest influences on pollutant removals, while the efficacy was unstable. With regard to the factorial design, the ANOVA also suggested that the 180 s HRT was detrimental to all effluent parameters. Hence, we deleted the condition and adding an aeration and filtration unit to the reactor, and changed the design to a 2² factorial. The results indicate that the optimal conditions entail an electrode spacing of 15 mm, current density of 3454 A/m², and an HRT of 57 s. Removal efficiencies under this condition were 23% for COD, 18% for electrical conductivity, and 27% for color. The overall reaction seemed to have reached end-point within 5 min in a recirculation mode. In addition, when we adjusted effluent pH using mineral acid or alkali to pH 3 and 9, respectively, before conducting the treatments, the results indicate that at pH 9, the above optimal conditions led to COD removal of 28%, conductivity of 15% and color of 93%.
Our reactor system used cast iron as material for the fixed-bed. Under an alkaline condition, COD removal (28%) was superior to the neutral and acidic conditions. Conductivity removal was better under neutral and alkaline conditions than the acidic condition. Neutral condition gave somewhat better result (18%) than the alkaline one. Alkaline condition was needed for true color removal and removal rate of 90% or better could be achieved. The overall results suggest that electrocoagulation was the main mechanism of pollutant removal, while electrooxidation played an insignificant role.

Keywords : electrochemistry, electrooxidation, fixed-bed, current density, COD, conductivity, true color, paper mill effluents