Study on the Electro-Coagulation Treatment of a Pulp and Paper Mill Wastewater

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ABSTRACT

Large domestic industrial paper mills wastewater after secondary biological treatments generally attain discharging regulations. However, due to the high residual electrical conductivity (> 2000 μs/cm) and the amber coloration, the effluents are suspected to upset the stability of paper machine wet-end chemistry and are inductive to bacterial slime formation if reused, thus leading to unnecessarily high discharging amounts. If water right and effluent discharging fees are imposed by the Environmental Protection Administration, the large amounts of discharging effluent will cause jump in the operational costs. A pilot pulsed electrocoagulation (EC) unit capable of treating 0.5 to 1.0 m3/h wastewater and having hydraulic retention time (HRT) of 0.2 to 0.25 h comprised of a homogenizing tank, a reaction tank, an aeration tank, a flocculation tank, and a sedimentation tank was use for treatment the wastewaters. The experimental mills selected include a speciality paper mill at Puli (A), with capacity of 5 t/d and effluent discharging amount of 1300 m3/d; a paper core mill at Kuangyin (B) with capacity of 150 t/d and effluent discharging amount of 1800 to 2000 m3/d; and a integrated pulp and paper mill at Hsinyin (C) with capacities for pulp, paper and chemicals at 400, 235, and 110 tons/d, respectively, and an effluent discharging amount of 25000 m3/d. A lab EC unit with a total volume of 3700 mL using either aluminum or iron as electrodes and electrode spacing of 5 mm, comprised of a homogenizing tank, reaction vessel, and sedimentation tank was also constructed and tested. The effluent treated came from mill D at Houli, which produces mainly core tubes, coated whiteboard, corrugating medium, liners, printing and writing paper and art paper with capacities of 110, 115, 650, 540, 300 and 220 t/d and an effluent discharging amount of 20000 m3/d. The study was conducted in 2 parts, the first used the pilot reactor fitted with either iron or aluminum electrodes to treat mill effluents, and in the second, the lab EC unit was used. In the second part, the work entails first design and construct the unit, then use the unit to treat mill D effluent for treatment efficacies. Then ion chromatography (IC), and inductively coupled plasma atomic emission spectroscopy (ICP) was used to analyze the ionic species in the effluent before and after treatment and understand the fundamental properties of the effluent. Finally, the operational parameters of the lab EC unit was compared for the treatment efficacies and establishment of reaction mechanism. The results indicate that the pilot pulsed EC system compared with the traditional effluent treatments could effectively enhance removal of electrical conductivity, SS, COD, and true color. The case of mill A white water during its production of a black-colored specialty paper resulted in electrical conductivity, SS, COD and true color removal of 21.4%, 97.1%, 58.8% and 58.9%, respectively when aluminum electrodes were used. As its white specialty paper production, the aluminum electrode enabled 4.3%, 98.6%, 50.0% and 0% of the above variables. For the mill B effluent, the aluminum electrodes allowed removal of 1.5%, 98.4%, 25.4% and 48.9% of the electrical conductivity, SS, COD and hardness, respectively. The iron electrode, on the other hand, enabled removal of 19.6%, 93.8%, 30.9%, and 47.9% of the same variables, respectively of the same mill effluent.. As for the mill C, the aluminum electrode removed 63.5%, 92.9%, 75.7% and 86.4% of the electrical conductivity, SS, COD and true color for its EO stage wastewater. The corresponding values for iron electrode were 70.1%, 96.4%, 81.1% and 86.6% for the variables, respectively. In order to reduce potential treatment cost, in all cases, no supplemental coagulant polymer was added. Hence, if equipment depreciation rate and personnel costs were discounted, then when the aluminum electrode was used, it required NT$ 2,47/t to treat the mill A ’ s wastewater. The same for mill B would require NT$ 11.6/t for the case of iron electrode and NT$ 12.4/t for the aluminum electrodes. For the mill C, the same costs were NT$ 0.72 and 1.64, respectively for the iron and aluminum electrodes. Lab experiments indicated that the lab reactor could effectively increase the removal rates of electrical conductivity, SS, COD, true color, cations and anions. The results for the mill D under the best treatment conditions achieved removal of the first 4 variables at 21.6%, 91.4%, 48.2%, 53.7% efficacies, respectively. Then 49.4% of the effluent hardness, 12.9% of chloride, 15.5% of sulfate, 9.9% of potassium, 6.9% of sodium, 50.0% of aluminum and 0% of ferric/ferrous ions were removed. The possible reaction mechanism of the treatment entails: 1. Establishment of an electrical field In the lab reactor, the electrical current generated a field among the alternating anodes and cathodes. Which induced charges in the impurity particles in the effluent. Meanwhile, the electrode plates released ferrous/ferric ions. 2. Charge coupling of impurity particles and aggregation Establishment of an electrical field enabled the impurity particles to bear induced charges which attracted oppositely charge ions in the water. The charge coupled particles adsorbed or attached to the floc forming ferrous/ferric ions then allowed removal of the pollutants. 3. Formation of flocs The polarized impurity paticles collided repeatedly in the aeration tank with the activated ions of ferric and aluminum ions to allow flocculation and formed flocs.

Keywords : pulsed electrocoagulation method, electrocoagulation, electrooxidatin, paper mill effluents, lab-scale unit, evaluation of efficiency.

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