DISADVANTAGES OF ELECTROCOAGULATION-FLOTATION TREATMENT OF OFFSET PRINTING EFFLUENTS

Savka Adamović[1], Vladimir Rajs[1], Dragan Adamović[1], Ivana Tomić[1], Ivan Pinćjer[1], Miroslav Dramićanin[1]

[1]*Faculty of Technical Sciences, University of Novi Sad, 21000 Novi Sad, Trg Dositeja Obradovića 6, Serbia*
e-mail: adamovicsavka@uns.ac.rs

Abstract
The efficiency of electrocoagulation-flotation (ECF) treatment was estimated based on the quantity of pollutants (cooper, turbidity, and organic substances) in printing effluents (waste offset printing developer and waste offset fountain solution) at selected process parameters. Four sets of aluminum or/and iron electrode combinations were applied, each with a current density of 2, 4, and 8 mA cm^{-2} and interelectrode distances of 0.5, 1.0, and 1.5 cm. In the progress of the ECF treatment, samples were taken at certain process times (1, 5, 10, 20, 40, and 60 min). Based on the obtained results, the disadvantages of ECF treatment of offset printing effluents are defined.

Introduction
The ECF treatment is an electrochemical process that includes in-situ generation of coagulants (metal hydroxides and/or polyhydroxides) by electrodissolution of a soluble sacrificial metal anode immersed in the treated wastewater, such as printing effluents [1].
ECF technique has many advantages regarding the conventional methods: easier operation, simpler equipment, a short process time, better safety, selectivity, flexibility, cost-effectiveness, lower amount of sludge [1, 2], environmental compatibility, operational and investment costs [2], and a practical method of treating various effluents and pollutants [3].

Experimental
The electrode combinations set: four iron electrodes (1), four aluminum electrodes (2), two aluminum (one was anode) and two iron electrodes (3), and two iron (one was anode) and two aluminum electrodes (4) were used. All four electrodes are the same size (10 cm x 5 cm x 0.1 cm). Each set of electrode combinations was immersed in borosilicate glass (ECF cell) with 220 mL of the printing effluent and 0.50 g of sodium chloride. The outer electrodes were connected in a bipolar mode to a digital DC power supply (DF 1730LCD). The ECF cell is set to a magnetic stirrer (IKA color squid, Germany). When the appropriate set of electrodes was selected (1, 2, 3, or 4) and adjusted the interelectrode distances (0.5, 1.0, or 1.5 cm), the suitable current density (2, 4, or 8 mA cm^{-2}) was applied. Then, ECF samples (15 cm^3) were taken at certain process times (1, 5, 10, 20, 40, and 60 min) and centrifuged for 10 min at 2000 rpm [3]. Turbidity was determined in triplicate by HI 93703 microprocessor turbiditymeter (HANNA Instruments, Portugal). The concentration levels of copper were determined in triplicate by atomic absorption spectroscopy with PerkinElmer Aanalyst 700 spectrophotometer. The UV absorbance of organic substances was detected by UV-1800 SHIMADZU spectrophotometer (at a wavelength of 326 nm and with a 1 cm quartz cell). Selected pollutants turbidity, copper, and organic substances were analysed according to the standard EPA 180.1, EPA 7000B, and AWWA–APHA–WEF method, respectively [1, 2].
The percentage of ECF removal efficiency of pollutants (cooper, turbidity, and organic substances) from investigated printing effluents was calculated as a function of process time by

the universal equation [3]: Removal efficiency = ((X_o – X_t) 100) / X_t. Where X_o – the initial values of content of copper or turbidity or organic substances in printing effluents and X_t – values of the mentioned pollutants in effluents after a particular process time (t).

Results and discussion

The results of ECF treatment show that the removal efficiencies of pollutants from the waste developer decrease in turbidity (99%) >| cooper (93%) > organic substances (53%) [3]. In the case of waste offset fountain solution, the order is cooper > turbidity > organic substances. So the removal efficiency of turbidity, copper, and organic substances from waste offset fountain solution was 90, 65, and 44%, respectively.

The electrode combinations sets with aluminum (as an anode) provide better removal efficiency of cooper and turbidity in both offset effluents. In addition, combining an iron electrode as an anode with aluminum improves the removal of organic substances.

The best current density for all pollutants in both effluents was 8 mA cm^{-2}. Interelectrode distances of cooper and turbidity in investigating printing effluents were 1 cm, while for the organic substances, it was 0.5 cm. The best process times for cooper and turbidity in waste developer was 5 minutes, while in the second effluent, the values were 20 and 60 minutes, respectively. For organic substances, the best process time was 60 minutes in both effluents.

Conclusion

The type of pollutants and offset printing effluents affect the removal order. Also, the combinations of electrodes, the current density, the interelectrode distance, and the process time determine the highest removal efficiency.

Removal efficiency increases with current densities and process time for all electrode combination sets: the higher the current density and time, the more efficient the ECF treatment for all pollutants.

Of course, ECF treatment of offset printing effluents has disadvantages. Optimization is necessary (for example, with Response Surfaces Analysis) to show the relationship between operational variables and to determine the optimum process conditions. A passivation layer on aluminum or iron electrodes was formed during the treatment, which reduces its effectiveness. Although a small amount of sludge is generated during ECF treatment, the characterization of the sludge and its safe disposal in the environment is needed. The efficiency of pollutant removal, which is lower than 90%, needs to be increased by combining the ECF treatment with other processes (for example, adsorption).

Acknowledgements

The authors acknowledge the financial support of the Ministry of Education, Science and Technological Development, Republic of Serbia through the project no. 451-03-68/2020-14/200156: “Innovative scientific and artistic research from the FTS (activity) domain”.

References

[1] M. Prica, S. Adamovic, B. Dalmacija, Lj. Rajic, J. Trickovic, S. Rapajic, M. Becelic-Tomin, Process Saf. Environ. Prot. 94 (2015) 262.
[2] S. Adamović, M. Prica, B. Dalmacija, M. Kragulj Isakovski, Đ. Kerkez, S. Rapajić, D. Adamovic, Measurement 131 (2019) 288.
[3] S. Adamović, M. Prica, B. Dalmacija, S. Rapajic, D. Novakovic, Z. Pavlovic, S. Maletic, Arab. J. Chem. 9 (2016) 152.