COMPARISON OF ZEOLITE-BASED HYBRID PROCESSES IN WASTEWATER TREATMENT – PRELIMINARY STUDY

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ABSTRACT

In a preliminary study, three hybrid process for the treatment of compost wastewater were compared, in which electrocoagulation and zeolite were combined with ultrasound or magnets. The results show a certain difference in the change of pH value, electrical conductivity and temperature. However, increased COD and turbidity removal, increased electrode consumption and increased final mass of collected EC sludge and saturated zeolite were not observed when ultrasound and magnet were used. However, further studies need to be conducted to analyse the assistance of magnet and ultrasound at other process conditions to obtain a final conclusion.

Keywords: zeolite-based hybrid process, treatment, electrocoagulation, ultrasound, magnet

INTRODUCTION

The hybrid process that combines the magnetic field and the electrocoagulation (EC) was investigated by Ni'am et al. (2006), finding enhanced removal of suspended solids and turbidity compared to a single EC process [1]. Meanwhile, Emerick et al. (2020) combined EC with ultrasound, finding enhanced colour removal and turbidity [2]. In addition, Zielinski et al. (2015) applied ultrasound on zeolite to increase the zeolite binding capacity [3]. Thus, the aim of this study is to perform preliminary investigations on hybrid approach comprising EC and sorption on zeolite with the assistance of ultrasound or magnet to obtain better effectiveness of wastewater treatment. The comparison was based on the change of pH value, electrical conductivity, turbidity, chemical oxygen demand (COD), electrode mass change, and final mass of collected EC sludge and saturated zeolite.

EXPERIMENTAL

Wastewater – prepared from commercial Agro compost, and characterised by pH value, temperature, electrical conductivity, turbidity and COD.

Electrodes: carbon steel (Fe=98.27%, Cu=1.17%) [4].

Synthetic zeolite (SZ), purchased from Alfa Aesar. The zeolite was crushed and sieved, and granulation < 40 μm was used in this study.

Hybrid processes - electrochemical cell of 500 mL with a pair of carbon steel electrodes, was used to perform all three hybrid processes: EC combined with synthetic zeolite (EC+SZ), EC combined with zeolite and ultrasound (EC+SZ+US), EC combined with zeolite and magnet (EC+SZ+M). Synthetic zeolite was added in the amount of 7.5 g. The ultrasound assistance was done by immersing the electrochemical cell in an ultrasonic bath Asonic Pro, 40 kHz. Magnet assistance was done by placing a NdFeB magnet of 0.55 T under the EC reactor. Each hybrid treatment was performed under the constant conditions of current density i=0.0182 A/cm^2, addition of NaCl electrolyte of 0.5 g/L, at an electrode distance of 3 cm, at a mixing speed of 150 rpm, and at a contact time of 30 min.

During each hybrid process, the pH value, temperature and electrical conductivity were monitored, and after the experiment, the pH value, temperature, electrical conductivity, turbidity, COD, electrode mass change were determined.

RESULTS AND DISCUSSION

Figure 1 compares the pH values, temperature and electrical conductivity during wastewater treatment by different hybrid processes.

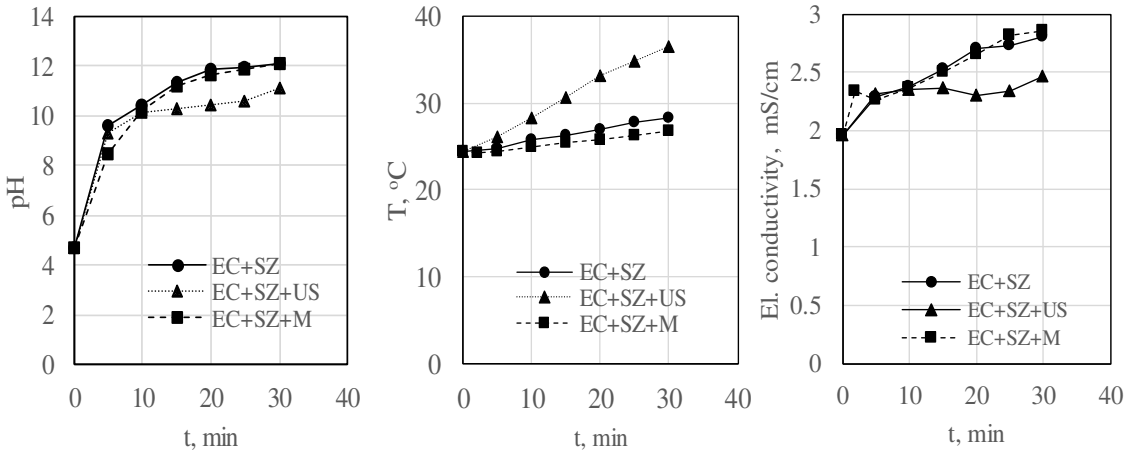

Fig. 1. Comparison of pH values, temperature and electrical conductivity during wastewater treatment by different hybrid processes. (Note: initial pH value, temperature and electrical conductivity are pH_0=4.72, T_0=23.9 °C, σ_0 = 1.958 mS/cm, respectively)

During wastewater treatment by different hybrid processes, pH values, temperature and electrical conductivity show an increasing trend, but with different intensities. A slightly lower increase in pH was observed during the hybrid process with ultrasound assistance (EC+SZ+US), indicating lower production of OH^- ions and hydrogen gas at the cathode. Lower production of OH^- ions is influencing on lower increase in electrical conductivity. In addition, assistance of ultrasound also caused the higher increase in temperature. However, the hybrid process with magnet assistance (EC+SZ+M) behaves rather similar as the hybrid process without additional assistance (EC+SZ).

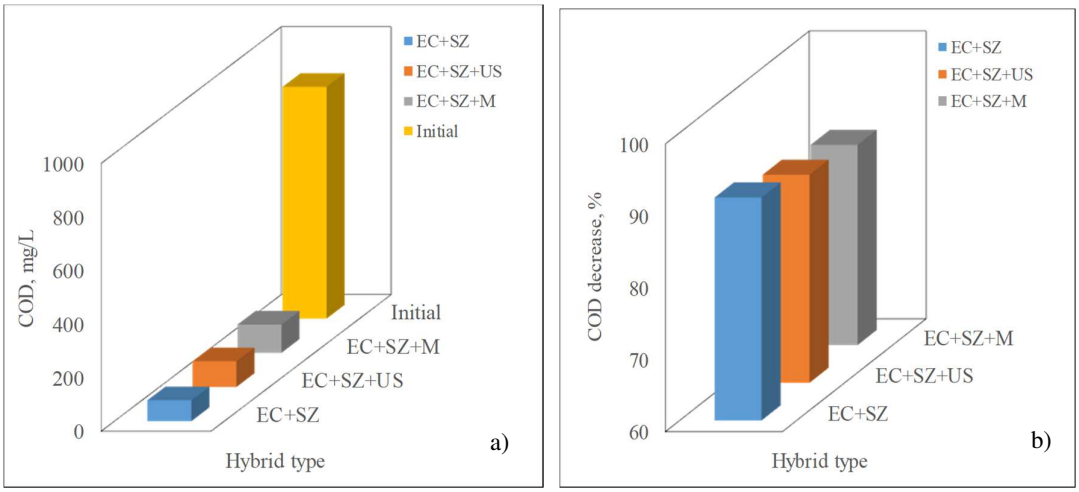

Fig. 2. Comparison of COD values (a) and percentage of COD decrease (b) for different hybrid types. (Note: initial value of COD in compost wastewater equals 864.93 mg O_2/L)

Figure 2 compares the COD values and the percentage of COD decrease for different hybrid types. All hybrid types efficiently decrease the final COD values below the maximum allowable limit for discharge, which equals 125 mg O_2/L [5]. However, although slight differences are evident when comparing the percentage of COD decrease for different hybrid types, the results indicate that the assistance of ultrasound or magnet does not enhance the percentage of COD decrease.

A similar is observed with turbidity removal (Figure 3). The assistance of ultrasound or magnet does not enhance the lowering of the final turbidity values; thus, the percentage of turbidity decrease is the highest in the hybrid process without any assistance (EC+SZ).

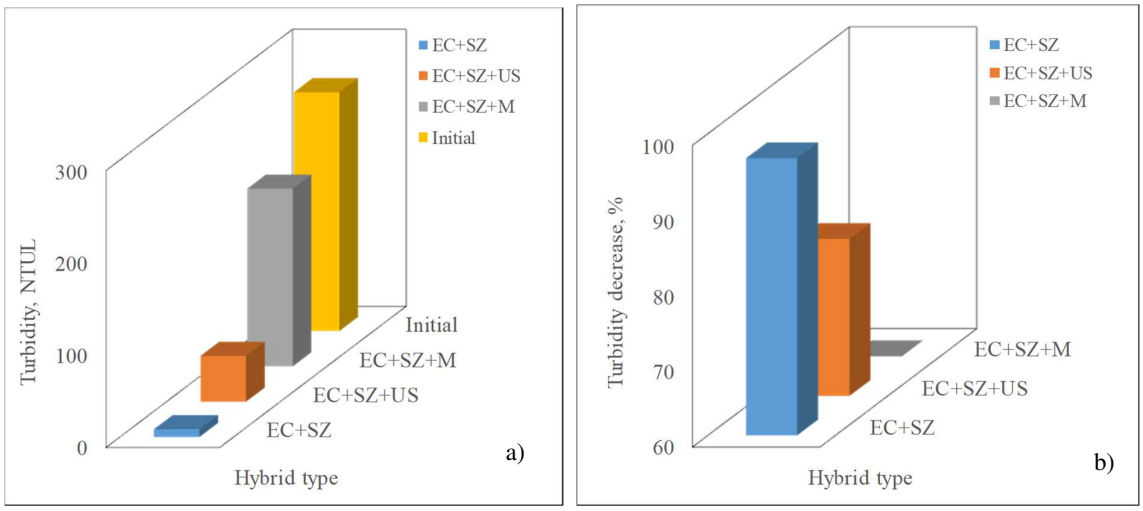

Fig. 3. Comparison of turbidity values (a) and percentage of turbidity decrease (b) for different hybrid types. (Note: initial value of turbidity in compost wastewater equals 258.67 NTU).

The mass of electrodes before and after each hybrid process was measured and values of electrode consumption during each hybrid process are compared in Figure 4a.

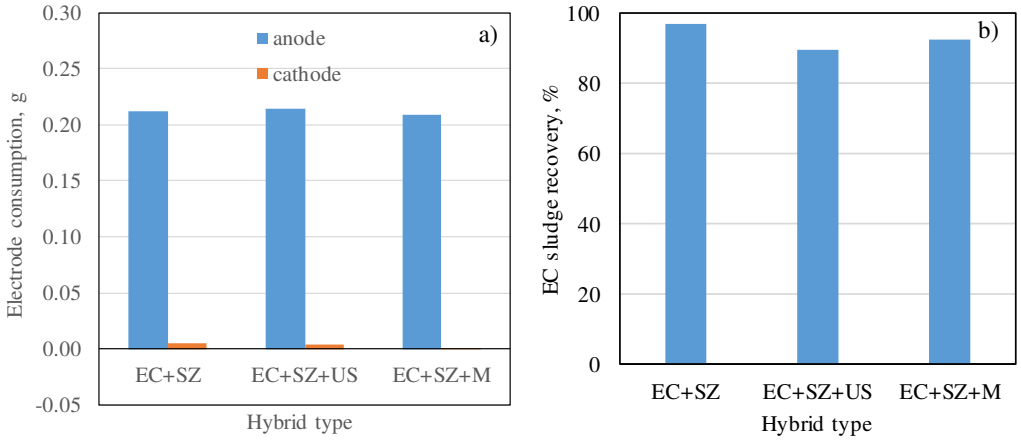

Fig 4. Comparison of: a) electrode consumption; b) EC sludge recovery for different hybrid types.

The results on Figure 4a shows that using magnet assistance slightly reduces electrode consumption compared to the hybrid process without assistance. This effect was not observed with the application of ultrasound. However, collected EC sludge which includes the saturated zeolite as well (Figure 4 b) shows slightly decrease with the assistance of ultrasound or magnet.

CONCLUSION

Three different zeolite-based hybrid processes that combine zeolite, electrocoagulation, and assistance of ultrasound or magnet were compare for treatment of compost wastewater. Results shows that assistance of ultrasound caused lower increase of pH and electrical conductivity compare to hybrid system with magnet assistance or without any assistance. Assistance of ultrasound or magnet does not enhance significantly the COD decrease, while turbidity is even worse. Assistance of magnet slightly reduces electrode consumption, while mass of collected EC sludge slightly decreases with the assistance of ultrasound or magnet.

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