Development of a non-conventional reactor for electrochemical wastewater treatment

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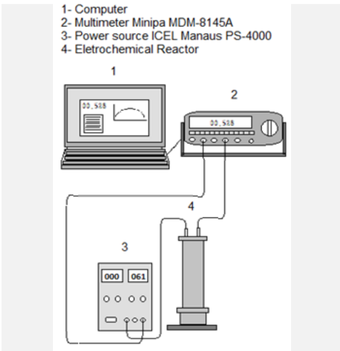


In this work, a tubular-shaped electrochemical reactor was designed with an outer cylindrical shell electrode and an inner cylindrical rod electrode made from aluminum. The experiments were undertaken to investigate the effects of the potential (9, 12, and 15 V) and inner electrode diameter (8, 12, and 20 mm) for the electrocoagulation treatment of aqueous solution containing kaolin (20 g/L) and sodium sulfate (0.1 M). The maximum removal efficiency (91.22%) was achieved at an inner diameter of 20 mm and a potential equal to 15 V. This study showed that the developed tubular-shaped reactor is a promising alternative to electrocoagulation and probably electro-oxidation for wastewater treatment with further studies.

Introduction

Access to safe and potable water is an objective for developed nations, reflecting a basis of public health and socioeconomic development initiatives. Despite advancements in water treatment technologies, the persistence of pathogens in untreated, or inadequately treated, water sources remains a concern, posing significant risks to human health and the economic stability of the affected populations [1].

In response to these challenges, governmental legislation plays an important role in establishing guidelines and standards for wastewater treatment, putting limits on contaminants in the waste [2].

While traditional methods have effectively treated many kinds of wastewater, they may prove inadequate for handling more complex effluents. Exploring alternative treatment methodologies has become imperative, advanced oxidative processes and electrochemical treatments that utilize electricity, such as electrocoagulation and electro-oxidation are some of the possible alternatives for wastewater treatment [3].

Even with extensive research focusing on treatment methodologies, the overall design of electrochemical reactors has often been overlooked, with conventional squared and parallel plate configurations predominating.

This study aims to address this gap by focusing on validating a novel aluminum cylindrical reactor at the bench-scale level. The reactor is designed to facilitate diverse wastewater treatments reliant on electricity-based methodologies. This research aims to contribute to advanced wastewater treatment technologies by evaluating the efficacy of this innovative reactor design, supporting the broader goal of ensuring universal access to safe and potable water for all.

Material and Methods

A bench-scale reactor was made using an aluminum shell with a height of 15 cm and a thickness of 6 mm, housed within a PVC tube with a nominal diameter of 40 mm. The inner electrodes were made with aluminum rods with a height of 15 cm and a diameter of 8, 14, and 20 mm, used one at a time for the electrocoagulation process.

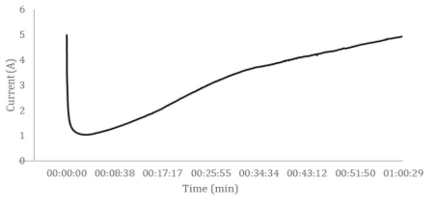
In the study, the efficiency of the bench-scale reactor was evaluated under varying electrical voltages of 9V, 12V, and 15V, with a fixed operating duration of 1 hour for all experiments. Simulated wastewater was prepared by suspending 20 g of kaolin per liter of distilled water with sodium sulfate at a 0.1 M concentration. The mixture was agitated for 15 min, followed by a 10 min settling period. The supernatant was carefully separated and utilized as the effluent for the reactor [4].

Turbidity measurements were conducted using an AKSO turbidimeter (Turbidez Max), before and after treatment, to assess the effectiveness of the reactor to remove the suspended particles in the simulated water. The power supply used in the reactor was an ICEL Manaus, model PS-4000, operating at a fixed voltage. Voltage and current measurements were obtained using a Minipa MDM-8145A multimeter, and data were collected using a computer for further analysis.

Results and Discussion

Figure 1 shows the chronoamperometry for the 20 mm inner electrode with a 12 V voltage, which demonstrates the normal comportment for electrocoagulation, that is the current density falls faster because of electrical double-layer charging, and before increasing due to the presence of aluminum hydroxides at the interface [5,6].

Figure 1. Current x time for 12V and 20mm electrode diameter.



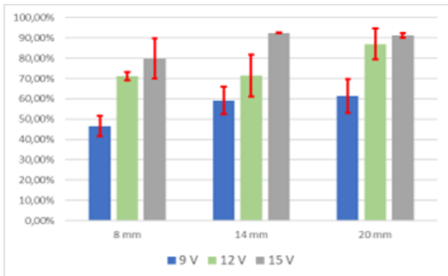
The turbidity reduction efficiency corresponding to each voltage and the diameters of the inner electrodes is illustrated in Figure 2. Upon close study of the results presented in Figure 2, it's noticeable that there exists a relation between the diameter of the inner electrode and the magnitude of the voltage with the efficiency of turbidity reduction. Higher diameters of the inner electrode and the increased voltage tend to yield greater reductions in turbidity. This result suggests that the working area and voltage play important roles in the performance of the reactor in treating the wastewater of study [7].

The results at 15 V reveal a near-maximum efficiency point with an average of 91.22% efficiency. This suggests that optimization of parameters such as voltage and electrocoagulation duration time could enhance the process efficiency, leading to higher treatment outcomes.

The current response observed at 9 V indicates inadequate operational conditions for the electrocoagulation process. This limitation may have a root in the surface area of the reactor, which might necessitate higher voltage levels to achieve optimal performance, particularly when treating the wastewater utilized in this study.

When looking at the diameter of the inner electrode the bigger the merrier, an 8mm diameter could not surpass 80% efficiency at the best voltage, with a floor of 46.62% at 9 V, while with 20 mm both 12 V and 15 V pass the threshold of 80%.

Figure 2. Removal efficiency for different electrode diameters and voltages.



Conclusions

The removal of turbidity using an innovative electrochemical tubular reactor was conducted in the present work. The effects of the potential and diameter were investigated and the results revealed that in the optimal parameters value the removal efficiency of turbidity was 91.22%. These results show that the cylindrical reactor can be used for electrocoagulation processes and probably in electro-oxidation systems in further studies.

Acknowledgments

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References

[1] WHO (World Health Organization). State of the world's drinking water: An urgent call to action to accelerate progress on ensuring safe drinking water for all, 2023.
[2] CONAMA. Resolução nº 430, de 13 de maio de 2011. Diário Oficial da União, Brasília, DF, ano 92, p. 89, 16 maio 2011.
[3] F.Y. ALJABERI, S.M. ALARDHI, S.A. AHMED, A.D. SALMAN, T. JUZSAKOVA, I. CRETESCU, P.-C. LE, W.J. CHUNG, S.W. CHANG, D.D. NGUYEN. Environmental Research, 214 (2022) 113890.
[4] D.D. SALINAS-ECHEVERRÍA, L.C.S. CRUZ. Chemical Engineering Research and Design, 198 (2023) 478.
[5] A.I. VÁZQUEZ, C. GERÓNIMO, I. GONZÁLEZ, R. CRUZ, M.I. LÁZARO, I. RODRIGUÉZ. ECS Transactions, 29 (2010) 81.
[6] A. AHMAD, M. PRIYADARSHINI, I. DAS, M.M. GHANGREKAR, R.Y. SURAMPALLI. Journal of Environmental Chemical Engineering, 11 (2023) 109049.
[7] Ö. GÖKKUŞ, E. BRILLAS, I. SIRÉS. Science of The Total Environment, 912 (2024) 169143.