

Degradation of Aqueous Bisphenol A by Coupling Zero Valent Iron and Fenton Processes

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Highlights:

- BPA (100 $\mu\text{g L}^{-1}$) removal in a continuous flow system, coupling ZVI and Fenton processes.
- After optimization (experimental design), it was achieved 98% BPA removal at steady state.
- Taking into account the system volume and flow rate, the hydraulic retention time was only 4.0 min.

Keywords: Bisphenol A; Fenton; ZVI

INTRODUCTION

Water quality has been a matter of great concern along the years, mainly due to the fast increase of the world population [1]. Recent investigations about potential aquatic environmental impacts were centered in the search for non-legislated microcontaminants, such as, endocrine-disrupting chemicals.

Bisphenol A is used as an intermediate in the production of polycarbonates, epoxy resins, flame retardants, etc. [2]. Advanced Oxidation Processes (AOPs) have been largely studied as an alternative or additional process to conventional effluents treatments [3]. Among the various AOPs, the Fenton process uses ferrous ions in acidic media (maximum efficiency in a pH range between 2.5 and 3.0) to decompose hydrogen peroxide, leading to hydroxyl radicals formation and oxidation of Fe^{2+} to Fe^{3+} . An alternative for the pH limitation is to use the zero-valent iron (ZVI) process as a Fe^{2+} source of for the Fenton process [4].

The present work aimed at studying the degradation of BPA by coupling the Zero-Valent Iron (ZVI) and Fenton processes, using commercial steel wool as the iron source.

METHODOLOGY

Chemicals and reagents

Bisphenol A (BPA) ($\text{C}_{15}\text{H}_{16}\text{O}_2$) was purchased from Sigma-Aldrich (97% purity; CAS 80-05-7) and used as received. pH values were adjusted with NaOH and H_2SO_4 solutions using a MARCONI 200 PA pHmeter. A commercial steel wool was used (Brombril®). Aiming at removing oxides from the

wool surface, it was first immersed in H₂SO₄ 10% for 1 min and then washed for three times with distilled water, before using in the reactor.

Experimental Procedure

The bench-scale, continuous flow system, was comprised of a 4-L reservoir with BPA (100 µg L⁻¹) in deionized water (Figure 1). The solution was pumped (Cole Parmer Masterflex #7554-90) through a fixed bed reactor filled with commercial steel wool, the ZVI source (approximately 8.5 g). A mixing vessel was connected to the outlet of the fixed bed reactor system. Between the vessels, hydrogen peroxide was continuously pumped (peristaltic pump IPC ISM931 #75M761A-0390). All experiments were performed at 20 ± 0.2°C.

BPA degradation was optimized using the response surface methodology. Factors and levels of the central composite design were: pH (5.1 and 6.1) and C_{H₂O₂} (1.1 and 2.1 mmol L⁻¹).

Degradation Monitoring

The initial and final concentrations of BPA were monitored by HPLC (Shimadzu). Conditions were: column Luna C8 5 µm (150 mm × 4.6 mm) (Phenomenex), 25°C, H₂O:ACN (50:50) in isocratic mode, 1.0 mL min⁻¹, injection volume of 20 µL, detection at 230 ± 4 nm, and running time of 5 min plus 2 min of cleaning.

RESULTS AND CONCLUSIONS

Optimized Degradation

The best operating conditions for BPA degradation were (Figure 2a): pH = 5.8, 1.5 mmol H₂O₂ L⁻¹ (within tested levels), and flow rate 35 mL min⁻¹, yielding 98% BPA removal at steady state.

The results of long-term experiments showed that, after 2 h, the steady state was reached for, at least, 10 h (Figure 2b).

Taking into consideration the system volume (140 mL) and flow rate (35 mL min⁻¹), the hydraulic retention time (HRT) was only 4.0 min.

The proposed system was capable of efficiently operating in near-neutral conditions, with no sludge formation and total iron concentration within discharge limits.

In summary, the coupling of the ZVI (using commercial steel wool as the iron source) and Fenton processes proved to be a fast, efficient, and low-cost system for removing BPA from water.

REFERENCES

- [1] HE et al. Future global urban water scarcity and potential solutions. **Nature Communications**, v. 12, n. 4667, 2021.
- [2] XIE et al. Determination of aqueous bisphenol a and tetrabromobisphenol a using molecular-complex-based liquid-liquid microextraction. **Journal of Molecular Liquids**, v. 303, n. 112501, 2020.
- [3] GARCÍA-ESPINOZA et al. A review of electro-Fenton and ultrasound processes: towards a novel integrated technology for wastewater treatment. **Environmental Science and Pollution Research**, 2023.
- [4] MARTONE et al. Effective degradation of ibuprofen through an electro-Fenton process, in the presence of zero-valent iron (ZVI-EF). **Journal of Cleaner Production**, v. 367, n. 132894, 2022.

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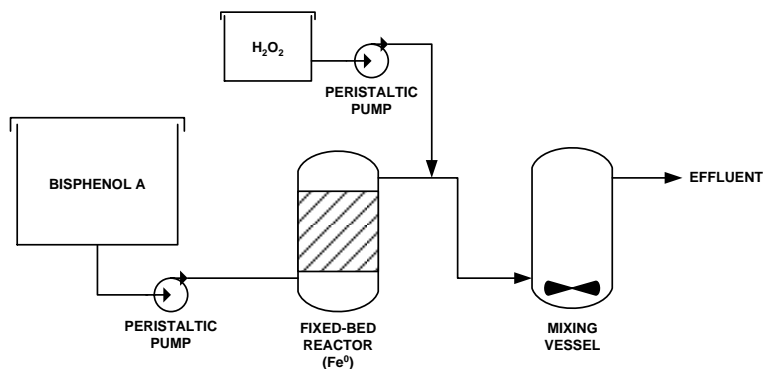


Figure 1. Simplified experimental setup scheme (not in scale).

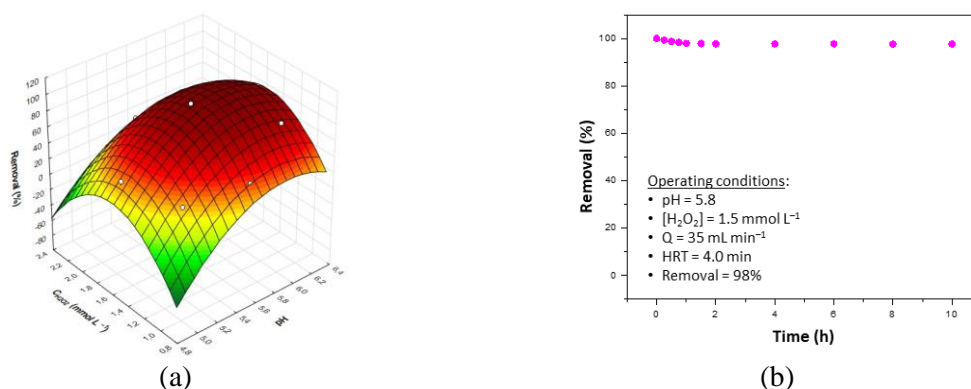


Figure 2. BPA removal: (a) optimized response surface and (b) long-term experiment.