WASTEWATER TECHNOLOGY FACT SHEET

Electro-oxidation + biodegradation of microplastics

University of Girona (UdG) technology
developed under the EU-funded NYMPHE project

PROBLEM

CONVENTIONAL WASTEWATER TREATMENT PLANTS (WWTPS) MAINLY SEPARATE MICROPLASTICS RATHER THAN DEGRADE THEM, LEADING TO SLUDGE CONTAMINATION AND RISKS OF SECONDARY POLLUTION DUE TO LOW BIODEGRADABILITY.

Target pollutants:

Persistent microplastics, especially polyethylene (PE).

TECHNOLOGY

System setup:

- Two-step process: Electro-Fenton oxidation + biological degradation.
- Electro-Fenton under mild conditions: 5 h, 10 ppm Fe, 5 A/m².
- Aerated bioreactor with specific microbial consortia.

Operation:

Electro-Fenton step:

- In-situ generation of hydroxyl radicals (·OH) through reaction of hydrogen peroxide with Fe(II).
- Radicals attack microplastic surfaces, introducing oxygen-containing groups.
- Surface functionalization increases hydrophilicity and creates reactive binding sites.
- Partial solubilization of plastic fractions and additives improves bioavailability.
- Coupled electrochemical reactions enable continuous H_2O_2 production and recycling of Fe(III) → Fe(II), reducing chemical input.

Biological step:

- Functionalized microplastics transferred into an aerated bioreactor.
- Tailored microbial consortia colonize modified surfaces and utilize polymers as carbon sources.
- Accelerated breakdown of polymers into simpler compounds, progressing towards complete mineralization.

Function:

- Significantly enhances biodegradability of microplastics.
- Allows microbes to achieve efficient degradation beyond conventional tertiary treatments.
- Prevents secondary pollution by reducing microplastic persistence in effluents.

NYMPHE

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INNOVATION

The technology goes beyond physical separation by degrading microplastics through combined Electro-Fenton oxidation and microbial degradation, representing a breakthrough in quaternary wastewater treatment. The system enables true elimination of persistent microplastics (e.g., PE), preventing long-term environmental accumulation.

TRL:
3, the process has been validated with real microplastics and WWTP effluents.

RESULTS

- Electro-Fenton pre-treatment increased PE **biodegradability 2–3×.**
- Surface functionalization confirmed by analytical methods.
- Over 80% of PE particles were removed after 21 days of biological treatment. Adding a microfiltration step at the bioreactor outlet could boost efficiency to nearly 100% while shortening treatment time.

ELECTRO-FENTON OXIDATION:

80%*

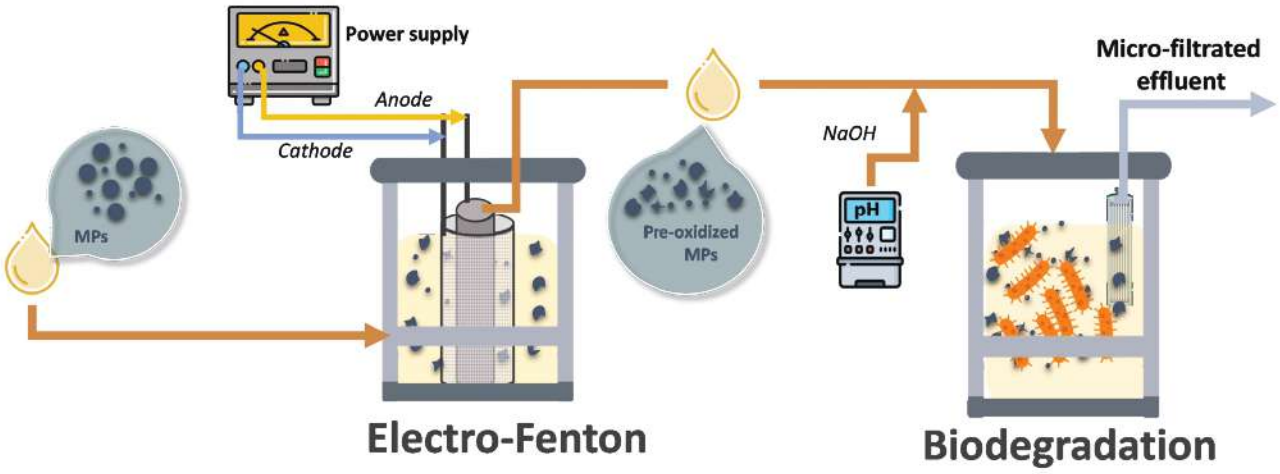
PE REMOVAL *21 days

ELECTRO-FENTON OXIDATION + MICROFILTRATION:

NEARLY 100%

PE REMOVAL

Figure 1: Scheme of the combined electro-oxidation-assisted biodegradation treatment of microplastics.



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