Integrated System for Pharmaceutical Waste Treatment: Fighting Antimicrobial resistance

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Abstract

The concentration of active pharmaceutical ingredients and antibiotic on the environment have been the focus of increased concern from the pharmaceutical industry, prompting industry leaders to search for new approaches to better manage pharmaceutical wastewaters.

This paper presents the holistic approach undertaken by Hovione, a Contract Development and Manufacturing Organization (CDMO), to manage its pharmaceutical wastes, adopting a concerted strategy that simultaneously acts at the point of generation and, at the end-pipe, increases treatment capabilities, by integrating the electroperoxicoagulation (EPC), an emergent innovative electrochemical technology for complex wastewater treatment.

Keywords: pharmaceutical, API, wastewater, electroperoxicoagulation, EPC.

Pharmaceutical wastewater – towards a safe discharge

Pharmaceutical products play a vital role in modern medicine; however, the potential adverse effects of pharmaceutical compounds in the environment have been the focus of increased concern from regulators and the pharmaceutical industry itself [1].

Active pharmaceutical ingredients (APIs) are developed to treat and prevent human and animal diseases in a way to be highly active, toxic for many infectious organisms and biologically stable, to activate under specific conditions [2]. The characteristics of API poses severe issues to human and environmental health when they occur in the environment: bioaccumulation, persistence, antimicrobial resistance, endocrine disruptive and reproductive effects in live organisms [3].

There are several routes for pharmaceutical compounds to reach the environment, being one of them through pharmaceutical industry wastewater [2].

Hovione has produced, for decades many APIs and has enabled that innovative molecules are brought to the patient quickly or that generic medicines finds a reliable and accessible supply of high quality API. Hovione is involved in the development efforts to fight antimicrobial resistance by supporting the clinical development of new antibiotics and is committed to making sure the quality of its waste streams is such that they cannot contribute to antimicrobial resistance and degradation of the ecosystems.

This paper presents the holistic approach undertaken by Hovione to manage its pharmaceutical wastes, adopting a concerted strategy that simultaneously acts at the point of generation and, at the end-pipe, increases treatment capabilities, by integrating an emergent innovative technology for wastewater treatment, the electroperoxicoagulation (EPC).

Challenges into Opportunities

Hovione's business is growing in volume and complexity and therefore increased volume and complexity of the waste streams are expected for the next years.

The requirements to re-evaluate and design a new concept for managing Hovione's wastewaters emerged on an environmental integrated framework, with opportunity to include waste segregation at source, best available techniques and anticipating API safe discharge regulations.

Application of Electroperoxicoagulation to Pharmaceutical Wastewaters

The electroperoxicoagulation (EPC), patent by Aquatec [4], is an innovative technology that combines the electrochemical technology with hydrogen peroxide (H2O2) dosing, causing a Fenton-type reaction, with very high oxidation potential.

It is based on electrocoagulation. The coagulant is generated in situ by means of the electrolytic oxidation of the iron anode, which is sacrificed so it is not necessary to add other salts to promote coagulation. Simultaneously the iron radicals Fe2+ generated in the sacrificial anode reacts with contaminants and hydrogen peroxide, dosed and regenerated at the cathode [4]. Fenton reactions [5] take place, creating a highly oxidizing environment.

Under this highly oxidizing environ¬ment, organic pollutants are removed by oxidation with the hydroxyl radical and by coagulation with iron hydroxide Fe(OH)3 [5].

Hovione initiated EPC pilot testings with their own pharmaceutical wastewaters from Loures manufacturing site. These tests were conducted with the following sequence: EPC reaction, followed by sludge separation with ultrafiltration (UF) and final step of activated carbon filter (AC) to remove the non-reacted hydrogen peroxide. The EPC unit was submitted to utmost stress conditions, to in order to validate the higher capacity of EPC to degrade APIs and high concern compounds such as halogenated substances, solvents and metals (see Table 1 for more details).

Table 1 – Results for removal efficiency and API degradation with EPC.

Critical compound removal [%]		Selected generic API degradation [%]	
AOX (organo-halogenated)	99	Minocycline	99
Dichloromethane	> 99	Lisacline	99
Zinc	99	Fluticasone	≥ 89 (*)
Iron	84	Iohexol	≥ 96 (*)
COD (chemical oxygen demand)	83	(*) Reached analytical method limit detection	

The key results and conclusions of the EPC trials were:

- 80% pollution removal (chemical oxygen demand) in the first 30 minutes of reaction, Fig. 1;
- 67% increase of biodegradability, from slowly biodegradable to easily biodegradable;
- 88% toxicity removal, by destabilization of the pollutant molecules and API, causing their precipitation and oxidation to more biodegradable compounds.

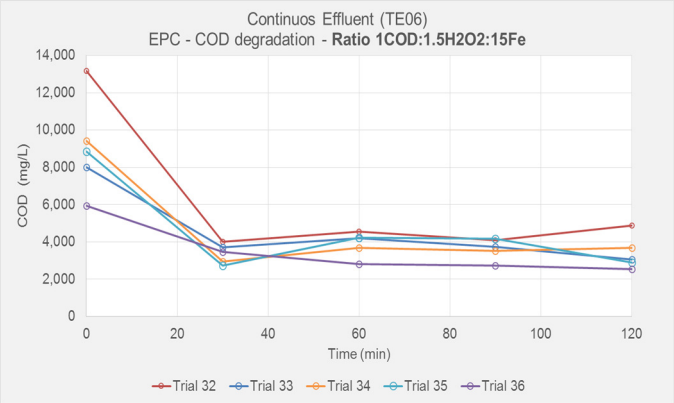


Fig. 1 – Curve of chemical oxygen demand (COD) degradation in EPC.

Breaking Paradigms – Segregation at Source and Selective Treatment

The optimized solution for Hovione pharmaceutical wastewater is based on the segregation at source: eco-toxicity characterization of individual streams, downstream segregation and routing to the most suitable treatment, adequate to each stream pollutant for higher efficiency removal rates whilst having economic benefits.

Fig.2 represents the actual setup where the waste streams are treated according to its calorific value for energy recovery by thermal oxidation or solvent stripping being sent to downstream Municipal wastewater treatment plant. It also represents the future setup that considers a hybrid treatment system combining four complementary technologies: energy recovery for energetic streams, stripping separation of solvents, EPC to degrade API and recalcitrant pollutants and biological treatment to degrade remaining biodegradable pollutants.

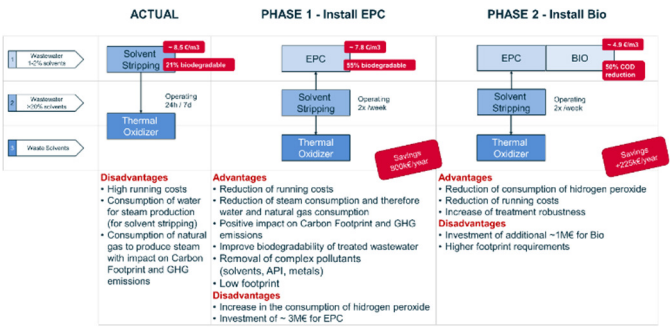


Fig. 2 – Current and future pharmaceutical waste treatment at Hovione.

Environmental Benefits

With this strategy, Hovione sets the commitment to API safe discharge and combating antibiotic resistance. Furthermore, a significant reduction in the Carbon Footprint is expected due to the reduction of Natural Gas consumption for the production of steam necessary for the solvent stripping and, in a second phase, due to the reduction of consumption of hydrogen peroxide. The increase in the biodegradability and lower toxicity of Hovione treated wastewater will also benefit positively the biological treatment at the downstream Municipal wastewater treatment plant.

References

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Biography

Environmental Project Manager, responsible for Hovione environmental strategy, responsible for defining and implementing Hovione environmental strategy, regarding liquid emissions, gaseous emissions and environment protection, ensuring compliance with legal regulations in line with future growth of the company, by applying the best available technologies. Ana Rafael is an Environmental Specialist with 16 years of experience in the design of water and wastewater treatment systems, reuse and optimization of production processes environmental performance.

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