Coupling nanofiltration with Fenton oxidation for pharmaceutical abatement in wastewater treatment

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Fenton oxidation is considered one of the most effective processes to remove micropollutants and pharmaceuticals from waters. However, the presence of organic matter strongly inhibits Fenton's reaction. The aim of this study is to evaluate the combination of membrane technology with the oxidation process to remove the organic substances, thus enhancing the Fenton efficacy.

Carbamazepine (CBZ) was used as representative pharmaceutical, while H_2O_2 and $FeSO_4$ were used as Fenton's reagents. Humic acid, alginate, bovine serum albumin were used in synthetic wastewaters as representative for different types of organic matter. Real secondary wastewater effluents from the Turin municipal treatment plant were also tested. The HYDRACoRe70pHT, characterized by a sulfonated polyethersulfone layer, was used as "loose" nanofiltration (NF) membrane. NF tests were performed in a cross-flow filtration unit, while Fenton oxidation in batch on feed and on permeate solutions from the NF stage.

Near complete rejection of all the three representative organic compounds was observed in NF when synthetic wastewaters were used as feed solution. On the contrary, carbamazepine was transported through the membrane, thus yielding an organic-free permeate solution highly suitable for Fenton oxidation. Filtration experiments performed with secondary wastewater effluents as feed solution confirmed the results obtained with synthetic feed waters, with very low content of organic matter (rejection of organic matter was higher than 90%) in the permeate, and negligible difference in the CBZ concentration between feed and permeate samples. NF pre-treatment had a substantially beneficial effect on the efficacy of Fenton's reaction. The degradation of CBZ required a third of the amount of reagents in the case of treatment of the organic-free NF permeate stream compared to the Fenton applied to the unfiltered feed solution. A systematic study on the use of different amounts and proportions of reagents further corroborated the advantage of a membrane pre-treatment step. Techno-economic and environmental analyses showed also the benefits of this hybrid technology, resulting in overall savings with a payback of approximately 10 years, and also in terms of low environmental impacts.