Innovative process combining adsorption, H_2O_2 electro-generation and photocatalysis for the removal of refractory organic compounds in water

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The intense industrialization of the past century has led to the widespread release of Refractory Organic Compounds (ROCs) such as dyes, aromatics, pesticides, solvents, and pharmaceuticals. These contaminants, often toxic and persistent, are poorly removed by conventional wastewater treatment processes, thereby posing significant risks to aquatic ecosystems and human health [1,2]. Advanced treatment methods are therefore needed to limit their dispersion.

Adsorption using porous carbon materials is among the most effective techniques for removing ROCs from water [3]. However, one major drawback is the regeneration step, typically conducted at high temperatures (up to 800 °C), which is energy-intensive and gradually degrades the adsorbent's performance [4].

This study proposes an innovative, sustainable alternative: the *in situ* regeneration of carbon-based adsorbents via electrochemical generation of H_2O_2 [5,6], combined with UV-enhanced oxidation [7,8]. Carbon xerogels were synthesized via a sol–gel method and shaped as cylindrical monoliths with tunable porosity. By adjusting the resorcinol/sodium carbonate (R/C) ratio between 100 and 1500, specific surface areas ranging from 30 to 680 m²/g were obtained.

The xerogel with R/C = 750 exhibited optimal adsorption capacity for three model ROCs: p-nitrophenol, methylene blue, and ibuprofen. Furthermore, electrochemical generation of H_2O_2 within the porous carbon matrix reached concentrations of 5 mg/L. When combined with UV illumination, efficient formation of hydroxyl radicals (•OH) was confirmed, enabling deep oxidation of adsorbed pollutants.

Finally, complete *in situ* regeneration of saturated carbon monoliths was successfully demonstrated for all three model pollutants, without relying on thermal treatment. This approach preserves the structural integrity of the material and offers significant energy savings.

These results open new perspectives for the development of regenerable carbon-based adsorbents integrated into advanced water treatment technologies.

References

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