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Illustrator: **Polona Kolar**

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CARBON-BASED MATERIALS FOR CATALYTIC WET PEROXIDE OXIDATION

R.S. Ribeiro[a], A.M.T. Silva[a], J.L. Faria[a], H.T. Gomes[a,b]

[a]Laboratory of Separation and Reaction Engineering - Laboratory of Catalysis and Materials (LSRE-LCM), Faculdade de Engenharia, Universidade do Porto, 4200-465 Porto, Portugal

[b]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, 5300-253 Bragança, Portugal

Introduction

Advanced oxidation processes (AOP) are regarded as a suitable technological alternative to meet the increasingly demanding quality criteria for sustainable and safe urban water cycles and complying with the use of treated wastewater as a reliable alternative of water source. Catalytic wet peroxide oxidation (CWPO) is an AOP employing hydrogen peroxide (H_2O_2) as oxidation source and a suitable catalyst to promote its partial decomposition to hydroxyl radicals ($HO^•$) – highly oxidizing species able to efficiently degrade most of the organic pollutants present in aqueous phase (Gogate and Pandit, 2004).

Carbon-based materials are the cornerstone of our research group in the quest towards optimization of catalysts for CWPO (Ribeiro et al., 2016a). This is a primary requirement to enable effective real-scale applications. Accordingly, carbon-based materials with increasingly improved activity and stability for CWPO have been developed in the last decade by our research group. The main findings obtained in the last years are reported in this communication.

Results and discussion

Metal-free glycerol-based carbon materials were considered upon production by partial carbonization of glycerol, followed by activation in air atmosphere (the material obtained at 300 °C was denoted as $GBCM_{300}$). The importance of the interplay between chemical and textural properties when developing efficient catalysts for CWPO was highlighted in that study (Ribeiro et al., 2015a). The unique structural and electronic transfer properties of graphene-based materials were also explored, namely by using the material named rGOV (reduced graphene oxide prepared using vitamin C as reducing agent). The results obtained emphasize the relevance of adsorptive interactions between the pollutant molecules and the surface of the catalysts (Ribeiro et al., 2015b).

Carbon structures decorated with magnetic particles were studied afterwards. For that purpose, magnetic carbon xerogels with iron and/or cobalt microparticles embedded in their structure were developed and applied in CWPO. A clear synergy arising from the simultaneous inclusion of iron and cobalt species within carbon frameworks (CX/CoFe) was revealed (Ribeiro et al., 2016b; Ribeiro et al., 2017a).

Magnetic carbon nanocomposites in which the magnetic phase is protected against the external environment by a carbonaceous shell were also considered. The application of a hybrid magnetic graphitic nanocomposite catalyst (MGNC) – composed by a magnetite core and a graphitic shell (Fe_3O_4/MGNC), revealed in CWPO a clear synergy arising from the carbon encapsulation of magnetic nanoparticles (Ribeiro et al., 2017a).

The findings reported (summarized in Figure 1) enabled the design of a high-performance nanostructured catalyst, composed by a cobalt ferrite core and a graphitic shell ($CoFe_2O_4$/MGNC). This new catalytic system enabled the treatment of the liquid effluent from a mechanical biological treatment plant (MBT) for municipal solid waste by CWPO at pH 6 (as depicted in Figure 2), in spite of its very high pollutant load (COD: 9.2 g L^{-1}; TOC: 2.0 g L^{-1}; HCO_3^-: 14.4 g L^{-1}; Cl^-: 2.8 g L^{-1}). This achievement opens future prospects for the applicability of CWPO in wastewater treatment (Ribeiro et al., 2017c).

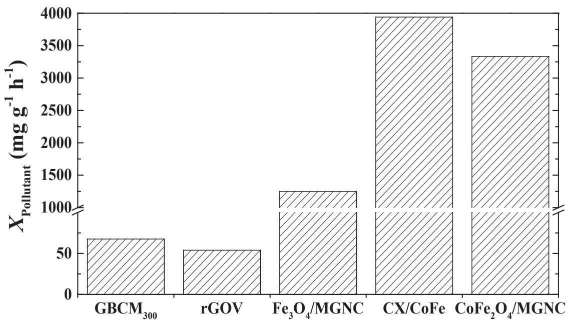

Figure 1. Pollutant mass removal rate ($X_{Pollutant}$) obtained in CWPO runs performed with different carbon-based materials. Experiments performed with 4-nitrophenol (5 g L^{-1}) as model pollutant, T = 50 °C, pH = 3 and stoichiometric amounts of H_2O_2. In the case of $GBCM_{300}$, a 2-nitrophenol (0.5 g L^{-1}) model system was considered.

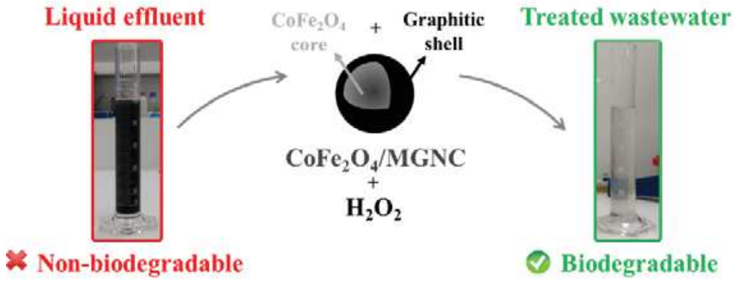

Figure 2. CWPO treatment of the liquid effluent from a MBT plant.

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