Wastewater Treatment by Catalytic Wet Peroxidation

Subjects: Others

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Nowadays, there is an increasing interest in the development of promising, efficient, and environmentally friendly wastewater treatment technologies. Among them are the advanced oxidation processes (AOPs), in particular, catalytic wet peroxidation (CWPO), assisted or not by radiation. One of the challenges for the industrial application of this process is the development of stable and efficient catalysts, without leaching of the metal to the aqueous phase during the treatment. Gold catalysts, in particular, have attracted much attention from researchers because they show these characteristics. Recently, numerous studies have been reported in the literature regarding the preparation of gold catalysts supported on various supports and testing their catalytic performance in the treatment of real wastewaters or model pollutants by CWPO. This review summarizes this research; the properties of such catalysts and their expected effects on the overall efficiency of the CWPO process, together with a description of the effect of operational variables (such as pH, temperature, oxidant concentration, catalyst, and gold content). In addition, an overview is given of the main technical issues of this process aiming at its industrial application, namely the possibility of using the catalyst in continuous flow reactors. Such considerations will provide useful information for a faster and more effective analysis and optimization of the CWPO process.

Catalytic Wet Peroxidation Gold-Based Catalysts Wastewater Treatment

The world's population growth and increasing industrial development led to the intense usage of natural resources with the water bodies being used as a final destination for wastewater containing pollutants [1][2][3]. The discharge of untreated wastewater introduces persistent contaminants into the environment, some examples being metals, organic, and inorganic compounds [4][5][6], which have harmful effects on ecology and public health [7].

In an attempt to minimize the impacts of effluent discharges, the European Union Water Framework Directive (EU-WFD), in 2000, imposed maximum permissible values for ecotoxic or possibly ecotoxic substances [8]. Thus, it is mandatory to adopt practical, efficient, and low-cost effluent purification technologies [9][10], which will allow the complete elimination or, at least, reduction of the contaminants concentration up to the limit values imposed by legislation [10][11], before wastewaters are discharged into water bodies.

The wastewaters can be treated by physical-chemical processes, such as sedimentation, coagulation/flocculation, filtration, adsorption, ultrafiltration, reverse osmosis, ion exchange, or chemical precipitation [12][13], by biological degradation [13][14][15], and/or by conventional oxidative processes, which degrade the pollutant by the action of oxygen or other oxidants, such as hydrogen peroxide, ozone, and permanganate [16][17][18]. Physical-chemical processes are not very appealing because the pollutants are concentrated at another phase, which requires a subsequent treatment [10]. Biological degradation, although economically advantageous, is inefficient since the compounds present in effluents are very often toxic and/or non-biodegradable [19][20]. Moreover, conventional oxidative processes might not have enough capacity to completely oxidize refractory compounds with high chemical stability and, therefore, there is a high risk of intermediate products being formed during oxidation, which can be even more toxic than the initial ones [21][22][23].

Advanced oxidation processes (AOPs) are emergent and attractive treatment technologies to degrade compounds with high chemical stability, toxicity, and non-biodegradability [10][24]. AOPs generate the hydroxyl radical ($HO^{\bullet}$), responsible for oxidizing refractory organic compounds into non-toxic products, such as CO_2 and H_2O [10][25][26][27]. Given the high efficiency of the hydroxyl radical, the AOPs have been widely used, not only in wastewater treatment [9][19][28][29][30], but also in soil and sediment remediation [31][32], decontamination of gaseous effluents containing volatile organic compounds and elimination of odors [33][34][35][36], water and groundwater treatment [37][38][39], and conditioning of municipal sludge [40][41].

Several AOPs are available, as will be detailed in the next section, that use different oxidants, with or without catalysts, in the presence of absence of radiation. Herein, we will focus on the catalytic wet peroxidation (CWPO) process using nano gold-based catalysts for wastewater treatment. This process presents several advantages compared to other AOPs, namely: it uses environmentally friendly reagents, does not require sophisticated equipment, and is operated under mild conditions of pressure and temperature. Moreover, catalysis by gold presents additional advantages, such as non-leaching of the metal to the treated effluent and efficient and stable performance, which are important for industrial applications.

A survey of the catalyst properties, operating conditions, and their effect on the efficiency of the process will be discussed. To the best of the authors knowledge, such review has not yet been reported in the literature.

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