**Catalytic Wet Air Oxidation of Effluent Containing 2, 4, 6-Trichlorophenol Using Bimetallic Feru/Carbon Xerogel Catalyst.**

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**Highlights**

* A low-cost carbon xerogel was prepared using resorcinol, tannic acid and formaldehyde.
* Iron-ruthenium/carbon xerogel catalyst was used in CWAO of TCP solution.
* A TCP and COD removal efficiency of 95.82 % and 93.14 % respectively were obtained.

**1. Introduction**

Chlorophenols are a group of toxic and recalcitrant compounds commonly found in the effluent of industries such as pesticides, petrochemical, pulp and paper, dye, olive oil, pharmaceuticals, etc. (Olaniran & Igbinosa, 2011). The permissible limit of chlorophenols in drinking water is 10 µg/L (Pera-Titus et al., 2004). Therefore, it is mandatory to treat industrial effluent containing chlorophenol before its discharge in the environment. Advanced oxidation processes have proved to be a successful method for the treatment of high strength and toxic effluents. Wet air oxidation involves oxidation of pollutant at elevated temperature and pressure conditions but oxidation in presence of suitable catalyst, catalytic wet air oxidation (CWAO), can be performed at mild conditions of temperature and pressure leading to a substantial reduction in capital and operating costs. The use of carbon materials (activated carbon, carbon nanotubes, carbon gels, etc.) as catalyst support is advantageous as they are prepared from natural materials, possess high specific surface area and the precious active metals impregnated on the carbon support can be recovered from the spent catalyst (left over ash) by its oxidation in presence of oxygen (air). Carbon gels, commonly prepared from natural materials, are advantageous as they possess high surface area & pore specific volume, mechanical strength and are stable at high temperatures. The bimetallic catalysts, often referred to as ‘alloy catalysts’, show synergistic effect. The addition of a small amount of the second metal to a monometallic catalyst causes better dispersion of the metal particles and reduces the size of metal particles on the support surface resulting in an increase in active specific surface area of the catalyst which leads to better activity (Garrido-Ramirez et al., 2016). Thus, in the present study, the carbon xerogel (MCXO) based bimetallic (FeRu/MCXO) catalyst was prepared and used in the CWAO of an aqueous solution containing 100 ppm 2, 4, 6-trichlorophenol (TCP).

**2. Methods**

Xerogel was prepared by a sol-gel reaction of a natural precursor tannic acid (67 %), resorcinol (33 %) and formaldehyde. The water content of the wet organic gel was exchanged using a solvent (such as t-butanol, acetone, toluene and ethanol) of lower surface tension. Later, the carbon xerogel was modified using an acid (such as o-phosphoric acid, nitric acid and sulphuric acid) in order to enhance its surface properties. The active metals Fe and Ru were impregnated on the surface of the xerogel support material by co-impregnation method. The catalyst was characterized using various techniques such as BET, XRD, SEM & TEM analysis, FTIR, TGA, etc. The CWAO of TCP was carried out and the results were interpreted in terms of TCP and COD removal efficiencies. The effect of various operating parameters such as metal loading, initial pH of TCP solution, air flow rate, catalyst dose, reaction temperature and operating pressure on TCP and COD removal efficiencies was studied. The kinetics of the degradation of TCP was studied. The reusability and stability of the bimetallic catalyst was also studied.

**3. Results and discussion**

A low-cost carbon xerogel was prepared by partially replacing the costly resorcinol with a low-cost precursor tannic acid. The solvent exchange with t-butanol conserved the porosity of the xerogel and modification with o-phosphoric acid induced oxygenated functional groups on the surface of the carbon xerogel. The bimetallic catalyst (FeRu/MCXO) having a high specific surface area (562 m2/g) and pore specific volume (1.51 cm3/g) showed the maximum TCP and COD removal efficiency of 95.82 % and 93.14 % respectively at the optimum value of operating parameters. The optimum value of metal loading, initial pH of TCP solution, air flow rate, catalyst dose and operating pressure for FeRu/MCXO catalyst were found to be 4 wt. % iron and 0.3 wt. % ruthenium, 4, 3 L/min, 0.8 g/L and 1 bar respectively at 75 °C. The kinetics of the degradation of TCP by CWAO was studied and it was found that the reaction followed pseudo-first order kinetics with respect to the concentration of TCP in the aqueous solution. The FeRu/MCXO catalyst was found to be stable with a marginal decrease (3.11 %) in its activity after third reuse of the spent catalyst.

**4. Conclusions**

A novel bimetallic FeRu/MCXO catalyst was prepared having high specific surface area (562 m2/g) & poro specific volume (1.51 cm3/g). The CWAO of aqueous solution containing TCP resulted in good removal of TCP (TCP-95.82 % & COD-93.14 %) at the optimized value of operating parameters. The catalyst was found to be stable and suitable for use in continuous processes.

**References**

1. A.O. Olaniran, E.O. Igbinosa, Chemosphere 83 (2011) 1297-1306.
2. E.G. Garrido-Ramirez, J.F. Marco, N. Escalona, M.S. Ureta-Zanartu, Microporous Mesoporous Mater. 225 (2016) 303-311.
3. M. Pera-Titus, V. Garcia-Molina, M.A. Banos, J. Gimenez, S. Esplugas, Appl. Catal., B47 (2004) 219-256.