

Waste Water Purification from Phenol by Novel Polymer-Containing Nanocatalysts

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Introduction

Nowadays there is a large amount of phenols in the noosphere, hence, novel technologies based on the conversion of phenols to non-hazardous or useful substances should be developed. Catalytic wet air oxidation (CWAO) is one of the most significant methods for wastewater treatment containing high concentration of highly toxic phenol compounds [1]. A great challenge for solving problem of phenol compounds waste water treatment is to design a highly selective catalyst comprising of an active site with the correct ensemble of metal atoms and other active components [1-2]. The advantages of a nanocatalyst prepared in organic functional polymers are not only the "nanoscale" size control of metal crystallites, but also the easy tailoring via variation of the polymer nature [3]. Nanostructures in a polymeric composite are defined as regular nanosized heterogeneous domains (i.e., certain regions of the polymeric material that are separated by some interface). Due to the presence of nanostructures one can control the growth of nanoparticles, the particle size distribution and interfacial interactions and control phenol wastewater treatment rate.

Materials and Methods

The catalysts were synthesized by the impregnation of H_2PtCl_6 into the pores of hypercrosslinked polystyrene (HPS) using complex solvent (tetrahydrofuran + methanol + distilled water in volume ratio of 4:1:1). HPS (MN-270 type) was purchased from Purolite Inc. The samples with 4.95%, 2.91%, 0.95% and 0.11% (wt.) of Pt content (the data of XFA) were synthesized.

The oxidation reaction was conducted batchwise in a PARR 4200 apparatus which provides independent control over parameters such as phenol, catalyst concentration, temperature, (pure) oxygen feed rate, oxygen pressure and stirring rate. A suspension of the catalyst and an aqueous solution of phenol (20 mL) prepared at a predetermined concentration were placed in the reactor. The rate of oxygen feed was controlled by a rotameter. Samples of the reaction mixture were periodically removed for analysis. At the end of each experiment, the catalyst was separated by filtration and the filtrate was analyzed to measure by HPLC the content in phenol and intermediates.

For all the catalysts the physical-chemical investigations of the catalysts, substrate and product were conducted via GC, HPLS, TEM, XFA, XPS and BET. The total organic carbon (TOC) was detected by total organic carbon analyzer. The selectivity of the process was determined due to TOC removal.

Results and Discussion

During the experiments the main intermediates were identified: catechol, o,p-benzoquinones, hydroquinone, formic, acetic, oxalic, maleic, malonic acids. It should be noted that intermediates amount were less than 1.5-2%. The kinetic experiments were conducted at variation of temperature, pressure and substrate-to-catalyst ratio. It was found that conversion increases when temperature increases as well. The decrease of the phenol and the increase of the catalyst concentrations were found to result in the appropriate increase of the reaction rate.

Rigid polymer matrix provides growth control of platinum nanoparticles and prevents platinum nanoparticles from aggregation and leaching. Synthesized nanoparticles have diameter 0.8-3.0 nm and mix valence structure.

The most active catalyst was found to be HPS-Pt-0.95% having most reduced and smallest platinum nanoparticles. CWAO treatment of phenol compounds realized on the base of HPS-Pt-0.95% leads to 97% phenol conversion (see Fig. 1)

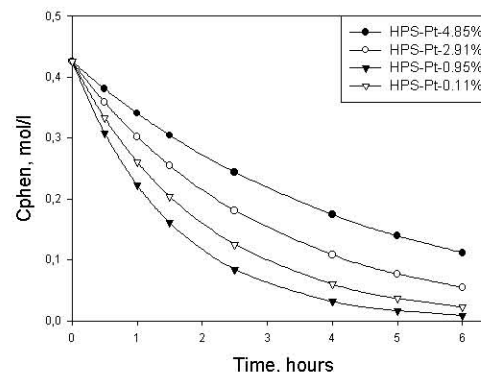


Figure 1. Phenol conversion for HPS-Pt catalysts

Significance

CWAO treatment of phenol compounds realized on the base of HPS-Pt-0.1% leads to full (concentration of left phenol compound is less than 5 ppb) conversion in CO_2 and H_2O . Implementation of the results can present an attractive possibility to decrease the phenol content of industrial wastewaters.

References

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