Technical Note

CWAO of phenol using CeO$_2$/γ-Al$_2$O$_3$ with promoter—Effectiveness of promoter addition and catalyst regeneration

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Abstract

The effect of promoter addition on activity of CeO$_2$/γ-Al$_2$O$_3$ was assessed via the CWAO of phenol. Adding Cu as the promoter rendered the most effective performance, followed by Mn, although the performance of Mn-promoted catalyst was inferior to CeO$_2$/γ-Al$_2$O$_3$. Mineralization of phenol was effectively implemented at 180 °C using Cu-promoted catalyst (Ce15Cu5). Furthermore, at 180 °C this catalyst produced about 100% conversion of phenol (1 h) and 95% removal of chemical oxygen demand (4 h), higher than that of CeO$_2$/γ-Al$_2$O$_3$. In contrast, Mn-promoted catalyst (Ce15Mn5) required a temperature above 220 °C for acceptable performance. Activity of re-used catalyst declined noticeably, due to deposits of carbonaceous compounds and leaching of metal ions. Regeneration with acetone rinsing after the first run was effective in regenerating activity of Ce15Cu5, although after a second run further regeneration with acetone rinsing had only a moderate effect, due to residual carbonaceous deposits and the additive effect of leached metal species in each run. As an alternative to acetone, HCl or HNO$_3$ solution (0.01 M) was less effective at regenerating activity. In promoted catalysts, leached metal ions accounted for the majority of mineralization of phenol, while the solid catalyst played a dual role of initiator and terminator of free radicals. Despite a superior catalytic performance, leaching of Cu$^{2+}$ from the promoted catalyst caused a severe decline in activity and poses the problem of secondary pollution of treated wastewater. Therefore, addition of Cu, as well as other metal species, is unfavorable in promoting the CeO$_2$/γ-Al$_2$O$_3$ catalyst.

Keywords: Catalytic wet air oxidation; Phenol; Promoter; CeO$_2$/γ-Al$_2$O$_3$; Regeneration; Leached metal ions