Platinum Catalysed Wet Oxidation of Phenol in a Stirred Slurry Reactor: A Practical Operation Window

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Abstract

The catalytic performance of graphite supported platinum (5 wt.%) catalyst in liquid phase oxidation has been studied using a continuous flow stirred tank slurry reactor (CSTR) in order to determine the proper operation window. The study was carried out in a temperature range of 120–180 °C and in a total pressure range of 1.5–2.0 MPa. Other operational variables employed were oxygen partial pressure (0.01–0.8 MPa), initial phenol feed concentration (0.005–0.07 M), and catalyst concentration from 1 to 10 kg m^{-3}. It was found that the extent of oxygen coverage on the platinum surface determines the reaction pathway and selectivity to CO_2 and H_2O. Complete oxidation of phenol to CO_2 and H_2O could be achieved at 150 °C when the reaction proceeds within the range of weight specific oxygen loads of 0.15–0.35 mol s^{-1} kg_{Pt}^{-1} and at stoichiometric oxygen excess in the range of 0–80%. The activity of the platinum catalyst remained high when the residual partial pressure of oxygen in the reactor was kept below 150 kPa. Higher residual oxygen partial pressure resulted into deactivation of the platinum catalyst (over-oxidation), which was temporary and could be reversed at reducing conditions. The formation of *p*-benzoquinone, followed by the formation of polymeric products was also favoured at higher oxygen load, which resulted into permanent deactivation of the platinum catalyst (poisoning). While the platinum surface was vulnerable to poisoning by carbonaceous compounds when insufficient oxygen was used, a fully reduced platinum surface favoured the formation of acetic and succinic acids which are difficult to oxidize. Higher temperatures can enhance the activity of the platinum catalyst, while at lower temperatures catalyst deactivation occurs with increased formation of polymeric products and lower selectivity to CO_2 and H_2O. In order to maintain the catalyst within the proper operation window, a CSTR is the preferred reactor.

Keywords

Catalytic wet oxidation;
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Platinum catalyst;
Operation window;
Catalyst deactivatio