CATALYTIC ACTIVITY OF Pt/Pt ELECTROCATALYSTS IN THE HYDROGENATION OF PHENOL IN AQUEOUS ACID MEDIA

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Abstract— The adsorption and hydrogenation of phenol on a platinized-platinum (Pt/Pt) electrocatalyst in 0.5 M H₂SO₄ solutions were studied as a function of time and potential of the electrocatalyst. From the experimental adsorption results a maximum amount of adsorbed phenol of \( \Gamma_m = 2.7 \times 10^{-10} \) mol cm⁻² and an average surface occupied by one adsorbed phenol molecule of \( \sigma = 61 \) Å² were estimated. The \( \sigma \) and \( \Gamma_m \) values support the assumption of a π-d bonded phenol molecule lying flat on the Pt/Pt surface. It was also showed that the hydrogenation of phenol took place only in the potential region corresponding to the weakly adsorbed hydrogen and that the catalytic activity of the Pt/Pt electrocatalyst was dependent on the hydrogenation potential. In addition, it was confirmed that under the experimental conditions used the phenol hydrogenation was 100% selective to the cyclohexanol formation.

Keywords— Phenol Hydrogenation, Adsorption Parameters, Catalytic Activity, Potential Dependence.

I. INTRODUCTION

Recently, hydrogenation processes of aromatic compounds have received a renewed attention due to more strict environmental regulations. Deaeromatization of some crude oil derivatives (e.g., gasoline, diesel, solvents, etc.) is being the main subject of several research groups devoted to study the catalytic hydrogenation in gas-phase (Rahaman and Vannice, 1991; Keane, 1997; Marécot et al., 1991) and, mainly, in liquid-phase (Struijk et al., 1992a,b; Toppinen et al., 1996, 1997).

Electrocatalytic hydrogenation of aromatic compounds is also a liquid-phase process, which provide new and attractive synthesis routes of total or partially hydrogenated products. Besides, this process offers two advantageous operating conditions over the traditional catalytic methods. First, it can be carried out at very mild temperature and pressure conditions. Second, hydrogen is generated in-situ on the electrocatalyst surface. Since the sixties has been shown that metallic electrocatalysts with low hydrogen overpotential, such as Pt or still Raney-Ni, can effectively hydrogenate organic compounds (Beck and Gerischer, 1961; Beck, 1965; Mahdavi et al., 1995; Pintauro et al., 1987).

The hydrogenation of phenol (Ph) to produce cyclohexanol (CyOH), an important industrial product, is particularly important among these processes (Bag et al., 1936; Haggin, 1994). Usually, CyOH is catalytically obtained by Ph hydrogenation at extreme conditions. Electrocatalytically, Ph hydrogenation has been widely studied in order to provide an interesting and promising way to produce CyOH under efficient and competitive operating conditions. Miller and Christensen (1978) obtained CyOH up to a conversion rate of 92% with a current efficiency as high as 79% on Rh/C electrocatalysts. Misra and Sharma (1979) reported that Pt activity towards CyOH production was increased from 16% to 83% by using tetraethylammonium bromide (TEAB) in the reaction medium. However, Sasaki et