

the electrochemical reaction. In the instant reactions of organic substances with bases, for example, the base may function as both a reactant and a conductivity-enhancing agent since many hydroxide bases ionize to a high degree in solution. In the instant reactions of organic substances with water in the absence of a base, it is preferable to include a non-participating conductivity-enhancing agent because water does not appreciably dissociate into ions. Conductivity-enhancing agents are generally ionic substances that readily dissociate into ions in solution. Examples of conductivity-enhancing agents include salts, acids and bases.

[0052] In selecting a conductivity-enhancing agent, it is important that it or the ions formed from it do not interfere with or impede the electrochemical reaction used to produce hydrogen. The conductivity-enhancing agent or ions obtained upon its dissociation may represent species that oxidize at the anode or reduce at the cathode of the electrochemical cell. These reactions may compete with or dominate the anode or cathode reactions needed to produce hydrogen, thereby impeding or preventing hydrogen formation. These competing reactions may also produce unwanted by-products. Unless the conductivity-enhancing agent is a reactant in the hydrogen producing reaction, it is preferable that it does not undergo substantial oxidation or reduction, but rather acts only to facilitate conductivity in the electrochemical cell.

[0053] The instant inventors have completed several experiments that demonstrate the production of hydrogen from organic substances in an electrochemical cell. Representative specific experiments are described hereinbelow.

EXAMPLE 1

[0054] In this example, one embodiment of methanol electrolysis according to the instant invention is described. The reaction was completed at room temperature in a testing electrochemical cell that included an anode, a cathode, and an electrolyte solution assembled within a 250 mL beaker. The anode included 20% Pt supported on high surface area carbon on a Toray paper substrate. The geometric area of the electrode was 4.1 cm². The cathode was identical in design to the anode. The anode and cathode were separated by 5.5 cm in the testing electrochemical cell. The electrolyte solution consisted of 50 mL methanol and 50 mL of a 1M aqueous solution of sulfuric acid. The sulfuric acid is present as a conductivity-enhancing agent and is present at constant concentration during the course of the methanol electrolysis reaction.

[0055] For comparison purposes, an analogous electrochemical cell without methanol was constructed. The electrolyte in the comparison cell consisted of 100 mL of a 1 M aqueous solution of sulfuric acid. Except for the electrolyte, the comparison electrochemical cell was identical to the one used for methanol electrolysis. In the comparison cell, the electrochemical reaction is water electrolysis in the presence of sulfuric acid.

[0056] Once assembled, the testing and comparison electrochemical cells were tested for electrochemical activity at room temperature. The test protocol consisted of applying a voltage from an external source and measuring the current produced by the electrochemical reaction. When no reaction occurs, no current flows through the electrochemical cell. If the voltage is sufficient to initiate a reaction, a current

develops in the cell. The greater the magnitude of the current, the greater the rate of reaction and the greater the rate of hydrogen production.

[0057] The test results are provided in FIG. 1 herein which shows a plot of the current that develops in the electrochemical cell as a function of the voltage applied by an external source. The curve labeled "H₂O(1M H₂SO₄)" is the result obtained for the water electrolysis reaction conducted in the comparison cell and the curve labeled "Methanol/H₂O (1M H₂SO₄)" is the result obtained for the methanol electrolysis reaction conducted in the testing cell. The results for the methanol electrolysis reaction have been corrected for the Ohmic resistance of the testing cell. The results for the water electrolysis reaction have not been corrected for the Ohmic resistance of the comparison cell.

[0058] The results for the water electrolysis reaction show that current is not produced in the comparison cell until the voltage is increased to about 1.9 V. Absence of a current below about 1.9 V indicates that the water electrolysis reaction does not occur at those voltages. Initiation of the reaction occurs at about 1.9 V and acceleration of the reaction occurs upon further increasing the voltage above about 1.9 V. These results indicate that voltage at or above 1.9 V are needed to produce hydrogen from the water electrolysis reaction in the comparison cell.

[0059] The results for the methanol electrolysis reaction show that the methanol electrolysis reaction is initiated at a voltage below 1.0 V and rapidly accelerates at voltages above about 1.1 V. These results indicate that appreciable rates of hydrogen production occur in the methanol electrolysis reaction conducted in the testing cell at voltages near and above 1.0 V.

[0060] This example shows that hydrogen production from methanol electrolysis occurs at lower voltages than hydrogen production from water electrolysis.

EXAMPLE 2

[0061] In this example, production of hydrogen from the electrolysis reaction of methanol in the presence of a base is demonstrated. The reaction was completed in a testing electrochemical cell that included an anode, a cathode, and an electrolyte solution assembled within a 100 mL beaker. The anode included 20% Pt supported on high surface area carbon on a silver plated nickel substrate. The geometric area of the electrode was 2 cm². The cathode was identical in design to the anode. The anode and cathode were separated by 1 cm in the testing electrochemical cell. The electrolyte solution consisted of 40 mL methanol, 20 mL water, and 60 g KOH. The KOH dissolved in the solution to provide hydroxide ion. The KOH was used as received from the vendor and may include adsorbed or hydrated water.

[0062] For comparison purposes, an analogous electrochemical cell without methanol was constructed. The electrolyte in the comparison cell consisted of 40 mL H₂O and 120 g KOH. The KOH dissolved in the water to provide hydroxide ion. Except for the electrolyte, the comparison electrochemical cell was identical to the one used for the reaction of methanol with KOH. In the comparison cell, the electrochemical reaction is the electrolysis of water in the presence of KOH.

[0063] Once assembled, the testing and comparison electrochemical cells were tested for electrochemical activity at

