Decomposition of Gaseous Isopropanol by UV/TiO₂ Process with Applying Bias Potential in a Polymer Electrolyte Cell

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Extended Abstract

Photocatalytic (PC) oxidation processes using semiconductor particles have attracted numerous researches as a promising and effective technology to degrade refractory pollutants in the field of water and air treatment. However, the effectiveness of PC processes is critically restricted by the rapid recombination of photogenerated electron-hole pairs [Ku et al., 2010]. The photoelectrocatalytic (PEC) process is considered as a promising modified PC process by applying bias potential in the photoanode [Ku et al., 2006]. The potential electric field drives the photogenerated electrons and holes in opposing directions and then prevents the recombination of electron and hole.

The PEC process is wide utilized in the environmental treatment; however, the application of PEC decomposition of organics is extremely restricted in gas phase due to limitation of aqueous electrolyte [Georgieva et al., 2010]. A proton exchange membrane (PEM) fuel cell using Nafion as the solid electrolyte is commonly applied to generate electricity by oxidizing hydrogen and reducing oxygen, respectively.

Photoelectrocatalytic decomposition of gaseous isopropanol (IPA) was investigated by applying bias potential in a polymer electrolyte cell. The Nafion membrane, a proton exchange medium, served as the solid electrolyte in the polymer electrolyte cell. The TiO₂ particles were well dispersed on the surface of stainless steel electrode through the dip-coating process as the photoanode and attached one face of the membrane. The cathode made by a plain stainless steel was attached to the opposite face of photoanode. The effect of applied bias and the role of water molecules on the PEC reaction were discussed in electrocatalytic (EC), PC and PEC reaction.

Table 1: The effect of applied bias on the removal ratio of PC, EC and PEC processes.

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<tr>
<th>Applied bias (V)</th>
<th>Removal ratio (%)</th>
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<tr>
<td></td>
<td>PC</td>
</tr>
<tr>
<td>Without bias</td>
<td>39.6</td>
</tr>
<tr>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
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<td>3</td>
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The removal ratios of IPA by PC, EC and PEC process for experiments conducted with various applied biases in the presence of 10 % relative humidity were summarized in Table 1, respectively. Only 40 % IPA was degraded by PC process without any applied bias. The decomposition of IPA was not enhanced by PEC process as the applied bias higher lower than 3 V; however, the IPA decomposition was remarkably increased with increasing applied bias from 3 to 5 V. The significant
enhancement of PEC decomposition of IPA was ascribed that the photogenerated electrons could be efficiently driven out of photoanode due to the introduction bias potential [Ku et al., 2010].

![Graph showing the effect of humidity on the removal ratio of IPA by various treatment processes.](image)

**Figure 1. The effect of humidity on the removal ratio of IPA by various treatment processes.**

The humidity revealed a significant impact on the photocatalytic decomposition of gaseous organics due to the formation of hydroxyl radical enhancing the oxidation process or competition adsorption between water molecules and pollutants on the active sites [Wang and Ku, 2003; Pichat, 2010]. Figure 1 demonstrates the effect of humidity on the PEC decomposition of gaseous IPA for experiments conducted with relative humidity in the range from 0 to 40 %. The inhibition of IPA decomposition in the presence of humidity was reported due to the extremely hydrophilic TiO₂ surface favoring the competitive adsorption of water molecules [Vildozo et al., 2010]. The humidity presented a complex influence between a promoter and retardant in the PEC reaction of this study; therefore, the more details of mechanism for the effect of humidity in anode or cathode side need further exploration to extend the application.

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**References**