High-efficiency non-thermal plasma catalytic performance of cobalt incorporated mesoporous MCM-41 for toluene removal

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Introduction

For the abatement of low-concentration VOCs, many researches have proved that combining a non-thermal plasma system with a catalyst could reduce the formation of by-products as well as increased the removal efficiency because of the synergy effect between plasma and catalysis. In order to improve the removal efficiency and carbon balance, it is still necessary to select an appropriate catalyst in a plasma system. Up to now, most of the catalysts were different metal oxides (such as alumina, TiO2) prepared via impregnation method1,2. However, the surface area of alumina or TiO2 is limited, while preparing catalysts using impregnation method is easy to stop up the passageway of the support and even leads to an unequal active constituent distribution. The recent study of MCM-41 and its potential modification has drawn great interest in chemical engineering and environmental science.

The major objectives of this work are: 1, to prepare a series of cobalt incorporated mesoporous MCM-41 catalysts; 2, to degrade toluene by the obtained catalysts using non-thermal plasma catalytic

Materials and Methods

The Co-MCM-41 samples were synthesized by a direct hydrothermal method and the cobalt-loaded MCM-41 catalysts were prepared by impregnation method. The weight ratio of Co to MCM-41 was 2%. For non-thermal plasma catalytic tests: A dielectric barrier discharge reactor was used in the experiment.

Results and Discussion

The main characteristics of as-prepared catalysts are summarized in Table 1.

Table 1. Physicochemical characterization of MCM-41 and Co-MCM-41

<table>
<thead>
<tr>
<th>CATALYSTS</th>
<th>d-spacing* (Å)</th>
<th>Unit cell Parameter* (Å)</th>
<th>Specific surface area (m²/g)</th>
<th>Pure Size (Å)</th>
<th>Pure Volume (cm³/g)</th>
<th>Wall thickness (Å)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCM-41</td>
<td>38.3</td>
<td>44.1</td>
<td>1118</td>
<td>35.0</td>
<td>1.14</td>
<td>9.1</td>
</tr>
<tr>
<td>Co-MCM-41(80)</td>
<td>38.5</td>
<td>44.3</td>
<td>958</td>
<td>36.2</td>
<td>0.89</td>
<td>8.1</td>
</tr>
<tr>
<td>Co-MCM-41(60)</td>
<td>38.9</td>
<td>44.8</td>
<td>843</td>
<td>36.8</td>
<td>0.83</td>
<td>8.0</td>
</tr>
</tbody>
</table>

* Values obtained from XRD studies
1. Calculated using the BJH method
2. Wall thickness = Unit cell parameter - pore size

The catalytic activity of the as-prepared MCM-41 and Co-MCM-41 catalysts (Fig. 2) was evaluated by toluene conversion and total carbon balance. Figure 3 investigate the stability of the Co-MCM-41 catalysts during the DBD plasma catalytic process.