**VIETNAM NATIONAL UNIVERSITY - HCMC**     **SOCIALIST REPUBLIC OF VIETNAM**
**HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY**   **Independence – Liberty – Happiness**

# DISSERTATION INFORMATION

Title: *Synthesis, characterization and catalytic oxidation of nano-sized gold catalysts supported on granular carbon for volatile organic compounds removal.*

Major:              **Chemical Engineering**              Major code: **62.52.03.01**

PhD candidate:      **Bien Cong Trung**

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*Major Contributions of This Dissertation:*

In recent years, to deal with volatile organic compounds (VOCs) causing environmental pollution, finding new catalysts that are effective at low temperatures and easy-to-use granular catalysts has always been of great interest. Therefore, this study synthesizes precious metal nanocatalysts Au, Pd, and Au(Pd) supported on granular activated carbon with and without $CeO_2$ to catalyze the oxidation of VOCs at low temperatures with the presence of water vapor.

The influence of composition and synthesis conditions on physicochemical properties, morphology, the structural characteristics, and catalytic activity for the oxidation of toluene and formaldehyde (typical VOCs) in low temperatures and humid conditions of the granular catalysts (the particle size of 0.5 – 1 mm) nano-Me/GC and nano-Me/$CeO_2$/GC (Me = Au, Pd, Au(Pd)) have been achieved in this dissertation.

The granular nano-Me/GC and nano-Me/$CeO_2$/GC catalysts were successfully synthesized using the metal-sol method, in which activated carbon is hydrophobic support to create dual-functional materials (adsorption and catalytic oxidation). The physical and chemical properties of the catalysts were studied by X-ray diffraction (XRD), $N_2$ adsorption-desorption isotherms, scanning electron microscopy (SEM), transmission electron microscopy (TEM), High-resolution Transmission Electron Microscopy (HRTEM), inductively coupled plasma mass spectrometry (ICP-MS), energy dispersive spectroscopy (EDS), fourier transform infrared (FTIR) spectroscopy, Point of zero charge (PZC), Hydrogen temperature-programmed reduction ($H_2$-TPR), and Oxygen temperature-programmed desorption ($O_2$-TPD).

Notably, the size of the Au(Pd) nanoparticles was smaller in bimetallic catalyst when Au and Pd were both presents when compared with the individual Au, Pd catalysts. The metal particle size decreases from about 8.4 nm (Au) on a single metal catalyst to less than 5 nm when both Au and Pd are present. Furthermore, the strong interaction of Au(Pd) particles with the ceria surface weaken the Ce–O bond, which improves the surface oxygen mobility, enhancing the catalytic activities of noble metal nanoparticles on nano-Me/$CeO_2$/GC catalysts for oxidation reactions.

At 150 °C, the nano 0.50%Au-0.27%Pd/$CeO_2$/GC sample could make conversion about 81.2% of toluene, which was about 17% higher than that obtained in the case of the 0.50%Au-0.27%Pd/GC sample. In particular, at the reaction temperature of 175 °C, the nano 0.50%Au-0.27%Pd/$CeO_2$/GC could make conversion toluene about 96.5%, which was about 38% higher than the toluene conversion obtained in the case of the 0.50%Au-0.27%Pd/GC. The 0.50%Au-0.27%Pd/$CeO_2$/GC catalyst has good stability after 50 reaction hours. In investigating formaldehyde conversion at room temperature (30 °C), the 0.50%Au-0.27%Pd/$CeO_2$/GC catalyst could make conversion about 84.2% formaldehyde, which was about 22% higher than the formaldehyde conversion obtained in the case of the 0.50%Au-0.27%Pd/GC. Therefore, the toluene/formaldehyde conversion of the 0.50%Au-0.27%Pd/$CeO_2$/GC catalyst is significantly higher than that of the 0.50%Au-0.27%Pd/GC under the same experimental conditions and in the presence of water vapor. In this study, the humidity has an insignificant influence on the catalytic activity due to the hydrophobicity of granular carbon.

The kinetic analysis of 0.50%Au-0.27%Pd/GC catalyst for the catalytic oxidation of toluene showed that the Langmuir–Hinshelwood model with toluene and oxygen adsorbed on two catalyst's active sites provide a good fit towards the experimental data, wherein the reaction between the adsorbed toluene and adsorbed oxygen is the rate-determining step. On the other hand, the kinetic analysis for the catalytic oxidation of toluene showed that the Mars–van Krevelen model provided a good consistency towards the experimental data in which the oxidation of the toluene with 0.50%Au-0.27%Pd/$CeO_2$/GC catalyst took place in two steps. Firstly, the adsorbed toluene reacts with the oxygen in the ceria lattice, resulting in the reduction of the ceria. Next, the reduced ceria is re-oxidized by the oxygen present near the catalyst's surface.

**Advisors**                                     **Ph.D. candidate**




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