Basic surface sites of various Ni-supported catalysts for methanation of CO$_2$

M.A.A. Aziz$^1$, A.A. Jalil$^{1,2}$, S. Triwahyono$^{3,4,*}$

$^1$ Institute of Hydrogen Economy, Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

$^2$ Department of Chemical Engineering, Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

$^3$ Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.

$^4$ Ibnu Sina Institute for Fundamental Science Studies, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

*Corresponding author: sugeng@utm.my

Carbon dioxide (CO$_2$) is considered to be a major factor in the greenhouse effect and its concentration in the atmosphere is increasing. Thus, decrease of CO$_2$ in the atmosphere is very important. Many techniques for CO$_2$ reduction and fixation have been developed and studied over the last decade. In these techniques, the process of CO$_2$ methanation is a practical approach to effectively decrease CO$_2$, because CO$_2$ is converted into reusable chemicals and an appropriate catalyst can promote the reaction under relatively moderate conditions at ambient pressure. Extensive studies have been carried out on the methanation reaction under various catalytic systems$^{1-3}$.

In this study, the catalysts containing 0.5 wt% Ni supported on Mesostructured silica nanoparticles (MSN), Silica, MCM-41 (Mobile Crystalline Material), HY (protonated Y zeolite) and $\gamma$-Al$_2$O$_3$ were prepared by impregnation method for the methanation of CO$_2$. Catalytic testing was conducted in the temperature range of 423-723 K under atmospheric pressure in the presence of H$_2$. The activity of CO$_2$ methanation followed the order: Ni/MSN > Ni/MCM-41 > Ni/HY > Ni/SiO$_2$ > Ni/$\gamma$-Al$_2$O$_3$. The high activity of Ni/MSN is due to the presence of both intra- and interparticle porosity which led to the high concentration of basic sites evidenced by N$_2$ isotherm and pyrrole adsorbed IR spectroscopy results. The methanation activities were found to be correlated to the concentration of basic sites as the basic sites were determined from the IR peak intensity of FTIR pyrrole adsorption (Figure 1).

Therefore, high basic sites is essential for high carbon dioxide adsorption on the catalyst to form carbon species, while Ni sites dissociated hydrogen to form atomic hydrogen. The surface carbon species then interacted with atomic hydrogen to form methane.


Mr. Muhammad Arif Ab Aziz
Universiti Teknologi Malaysia, Malaysia
Phone: +60197421753
E-mail: ibnabaziz@gmail.com
Research interests: Heterogeneous catalysis, microporous/mesoporous materials

2005-2009 B.Eng (Chemical) Universiti Teknologi Malaysia
2009-2011 M.Eng (Chemical) Universiti Teknologi Malaysia
2011-present PhD (Chemical engineering) Universiti Teknologi Malaysia