

# Silica-Coated Mesoporous Carbon as Solid Dessiccant in Gas Dehydration Process

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**Abstract** – Dehydration process using solid desiccant is required to reduce water content to meet pipeline gas GPSA specification (4-7 lb/MMscf). Porous silica gel has a high specific surface area (Grade 12 brand Davisil 800 m<sup>2</sup>/g), which is generally obtained via a high-cost supercritical technology. This research aims to substitute that of high-cost super critical technology by developing silica-coated mesoporous carbon. This research uses an impregnating-silica method consisting of pretreatment and hydrophilication processes. Here we found that the pretreatment process can increase the surface area of mesoporous carbon from 504.122 m<sup>2</sup>/g to 823.5 m<sup>2</sup>/g. While for the hydrophilication process, silica-coated mesoporous carbon was obtained via mechanical and chemical force. Silica-coated mesoporous carbon has adsorption capacity 70.59% of commercial silica gel.

**Index Terms** – Gas dehydration, Hydrophilication, Mesoporous carbon, Silica-coated mesoporous carbon.

## INTRODUCTION

The diminished source of world natural gas encourage the application of modern and sophisticated technology in natural gas exploration, such as the use of water injection technology [1], which is designated to trigger the gas out of its well. The use of such technology results more water carried away in the gas from the well, consequently, the moisture content in natural gas is predicted to continue increasing in the future. Significant quantities of water vapor consisted in natural gas can caused many pipeline problems. Dehydration process using solid desiccant (silica gel is the most commonly used) is obviously required to reduce water content to meet pipeline gas specification GPSA, *i.e.* 4-7 lb/MMscf [1].

Porous silica gel has a high specific surface area, *i.e.* Grade 12 brand Davisil 800 m<sup>2</sup>/g [2]. To form the high specific surface area, a high-cost supercritical technology should be used in the drying process of silica gel manufacture. In other hand, activated mesoporous carbon has high surface area to 1050 m<sup>2</sup>/g for Aquasorb 2000 brand [3]. Activated carbon mesoporous has hydrophobic surface so that can't be used for dehydration process effectively. To form hydrophilic mesoporous carbon with high surface area, carbon need to be coated by silica.

In this paper, a detailed study of carbon hydrophilication is reported. These hybrid materials were prepared with activated mesoporous carbon by using sodium silicate solution as precursors. The

impact of mechanical and chemical force were investigated by FTIR analysis and dehydration test.

## MATERIAL AND METHOD

Mesoporous carbon (surface area 504.122 m<sup>2</sup>/g), Sodium Silicat solution (0.1 %wt), sodium lignosulfonate (SLS) solution as water-based surfactant (0.1% wt.), H<sub>2</sub>SO<sub>4</sub> solution (4 N), biogas, and commercial silica gel.

### A. Pretreatment

20 gram of mesoporous carbon put in the pretreatment reactor. Using kinetically control method, compressed air (oxidant) was flowed to the reactor 2 Lpm and heated to 300°C for 60 minutes. Activated carbon was stored in oven with 110°C for 24 hours.

### B. Hydrophilication

20 gram activated carbon from pretreatment was immersed in sodium silicate solution (0.1%.wt) for 19 hours. Then, stirred using magnetic stirrer for mechanical variable (0, 500, and 1000 rpm). The carbon was filtered using filter paper before it stored in oven with 110°C for 24 hours. Carbon immersed in H<sub>2</sub>SO<sub>4</sub> solution (4 N) for 24 hours, and then was filtered using filter paper before it stored in oven with 110°C for 24 hours. Carbon was washed with aquadest and stored in oven with 110°C for 24 hours [3]. The method was repeated for chemical force variabel, carbon immersed in mixed sodium silicate solution (0.1%.wt) and (SLS) solution (0.1%.wt).

### C. Gas Dehydration

17 gram of silica gel was put inside the reactor, and 150 L of biogas was flowed into reactor with rate of 7-8 lpm. Mass of silica gel was weighted before and after dehydration process. These steps were repeated for mesoporous carbon and silica-coated mesoporous carbon.

## RESULT AND DISCUSSION

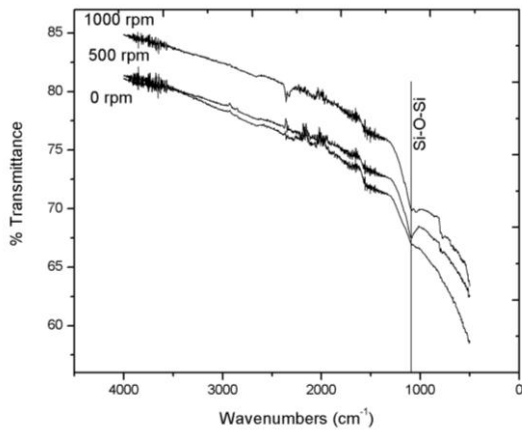
### A. Impact of Pretreatment

Pretreatment process can increase the surface area of mesoporous carbon from 504,122 m<sup>2</sup>/g to 823,5 m<sup>2</sup>/g, make it as a fibrous structure.

### B. Impact of Physical Force

The FTIR analysis result showed that the most increasing of silica content is at the rotation speed of 500 rpm. The introduction of mechanical force by means of stirring significantly helps the deposition of silica on mesoporous carbon surface. However when the rotation speed of stirring process is too high, *i.e.* 1000 rpm, probably will create a thermodynamic controlled condition, where the silica is not deposited as bulk structure instead of one layer.

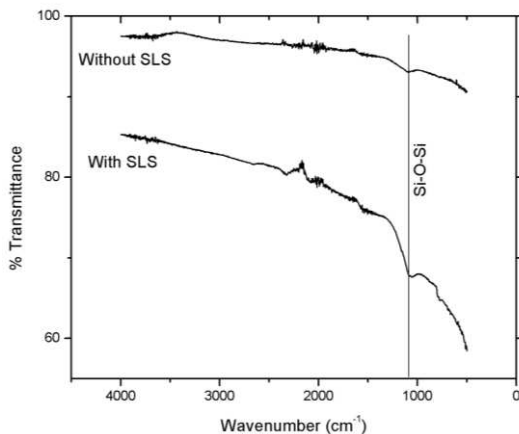
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**Figure 1.** FTIR analysis of the silica-coated mesoporous carbon after different applied rotation speed of hydrophilication process.

### C. Impact of Chemical Force

The FTIR analysis results showed that SLS surfactant can increase the quantity of silica. This can be explained by the fact that the role of surfactant is to reduce the surface tension of mesoporous carbon surface with its solution environment, thus the silica can be easily deposited onto a mesoporous carbon surface.



**Figure 2.** FTIR analysis of the silica-coated mesoporous carbon after different concentration of SLS surfactant.

### D. Gas Dehydration Test

Water adsorption capacity of mesoporous carbon was found to be 1.2 %, while for that of silica-coated mesoporous carbon and respective commercial silica gel was found to be 5.6% and 8%, respectively. This indicates that our proposed silica-coated mesoporous carbon has 70% water adsorption capacity compared with its respective commercial sample, *i.e.* silica gel.

### CONCLUSION

Here we found that the most increasing of silica content on the resulted silica-coated mesoporous carbon at a rotation speed of 500 rpm. Additionally, sodium lignosulfonate as surfactant can increase quantity of deposited silica. Finally, when this silica-coated mesoporous carbon is subjected into a gas dehydration process using a biogas, we found that its adsorption capacity was 70,59 % of that commercial silica gel.

### REFERENCES

- [1] Arthur J. Kidney, Parrish, R. William, 2006. *Fundamentals of Natural Gas Processing*. New York: Taylor & Francis
- [2] Carbon, Jacobi. 2005. *AquaSorb Technical Data Sheet*. United States.
- [3] Yamamoto, Eri., Kobayashi, Jun., Kanamaru, Keiko., Miura, Toshinaki., Watanabe, Fujio., Kobayasi, Noriyuki., Hasatani, Masanobu. 2003. *Hydrophilication of Activated Carbon by Impregnating Silica into Pores*. Department of Energy Engineering and Science Nagoya University, Nagoya 464-8603. Japan