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APPENDICES

Appendix A Adsorbent Physical Characterization

The technical specification of the adsorbents that was certified by Carbokarn Co., Ltd. is summarized in Table A1.

Table A1 Physical characteristic properties of investigated adsorbents

Physical Characterization	Adsorbent Specification	
	Coconut Shell Activated Carbon (CSAC)	Palm Shell Activated Carbon (PSAC)
Apparent Density (g/cm^3)	> 0.48	> 0.48
Moisture Content (%w/w)	< 8.0	< 8.0
Ash Content (%w/w)	< 3.5	< 5.0
pH	9-11	9-11
Iodine Number (mg/g)	> 1,100	> 1,100
Hardness Number (%)	> 98.0	> 98.0

Appendix B   Adsorption and Desorption Curves in Different Scale

Some of the adsorption and desorption curves from the breakthrough experiments are rewritten in a different scale. The breakthrough curves in Figure 4.11 are shown here in Figure B1.
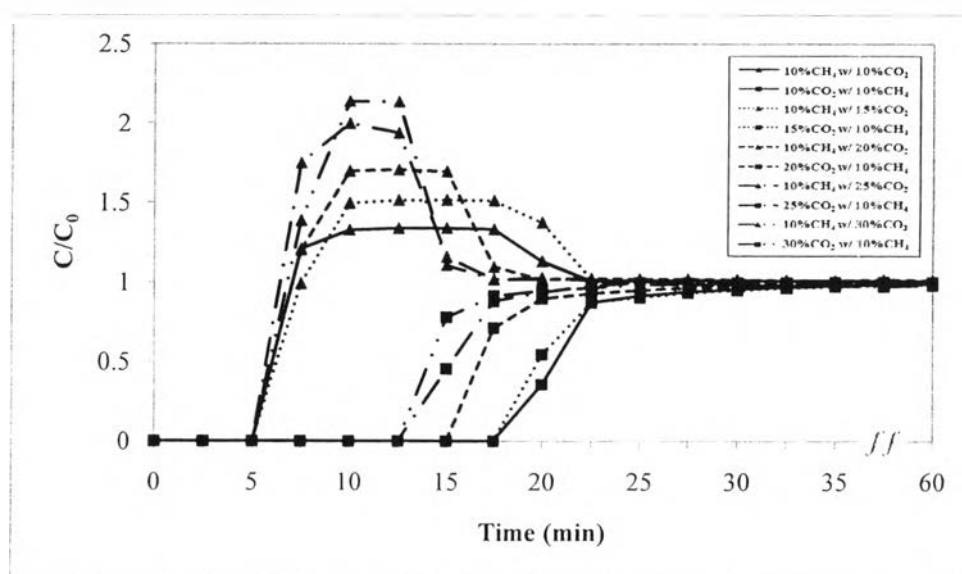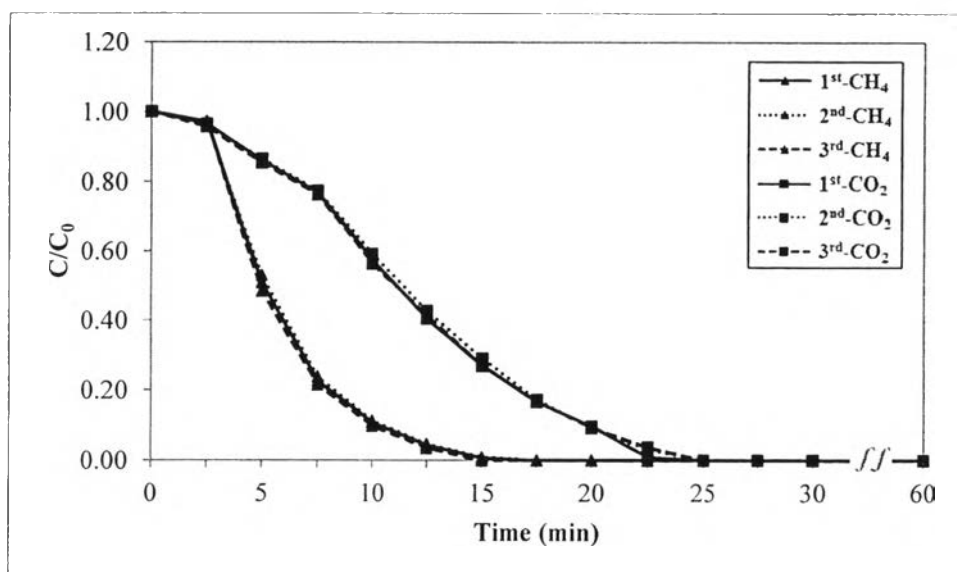

Figure B1   Breakthrough curves of methane and carbon dioxide from the competitive adsorption on the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10, 15, 20, 25, and 30 vol% at room temperature.

The 3-cycle adsorption-desorption profiles in Figures 4.12 to 4.21 are shown in Figures B2 to B11.
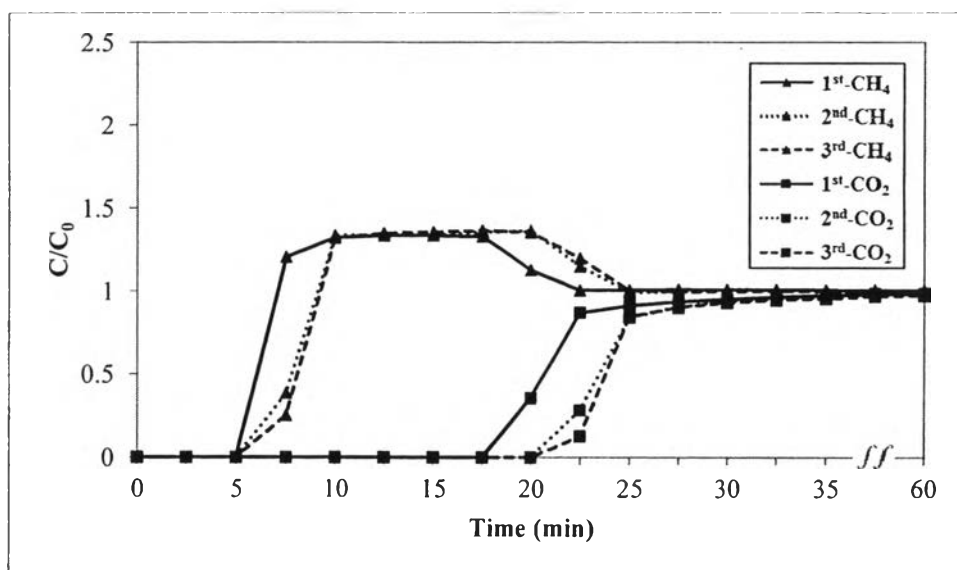
Figure B2 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
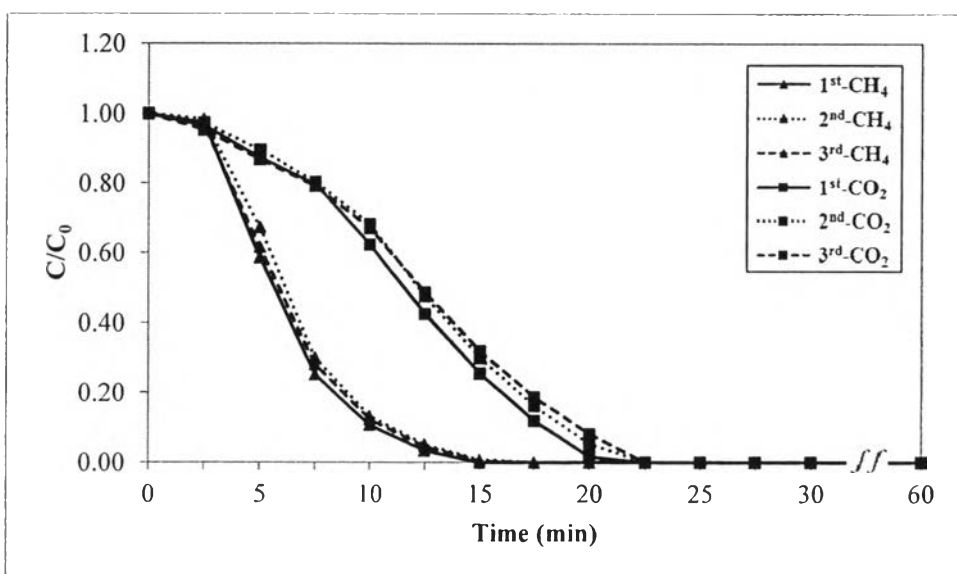
Figure B3 Three desorption cycles of methane and carbon dioxide from the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
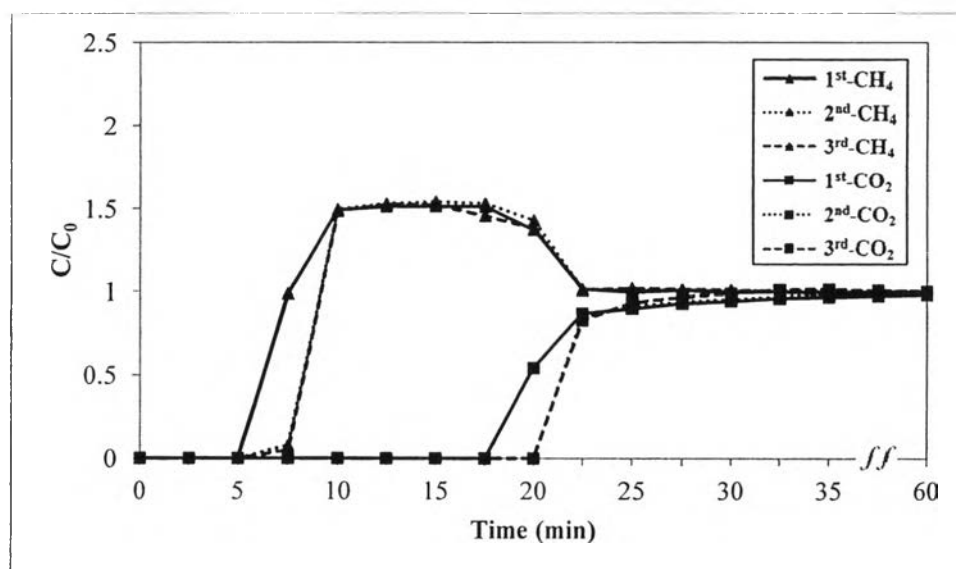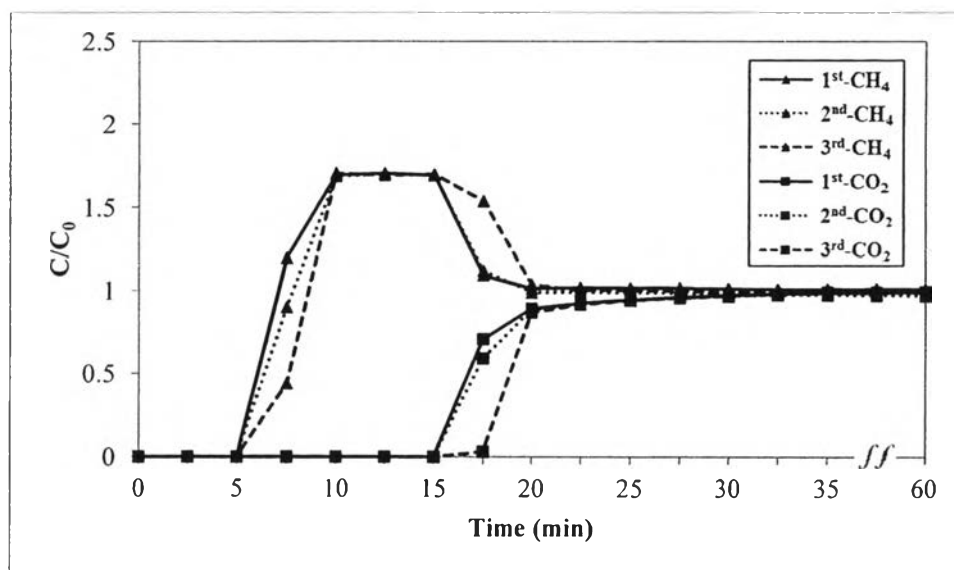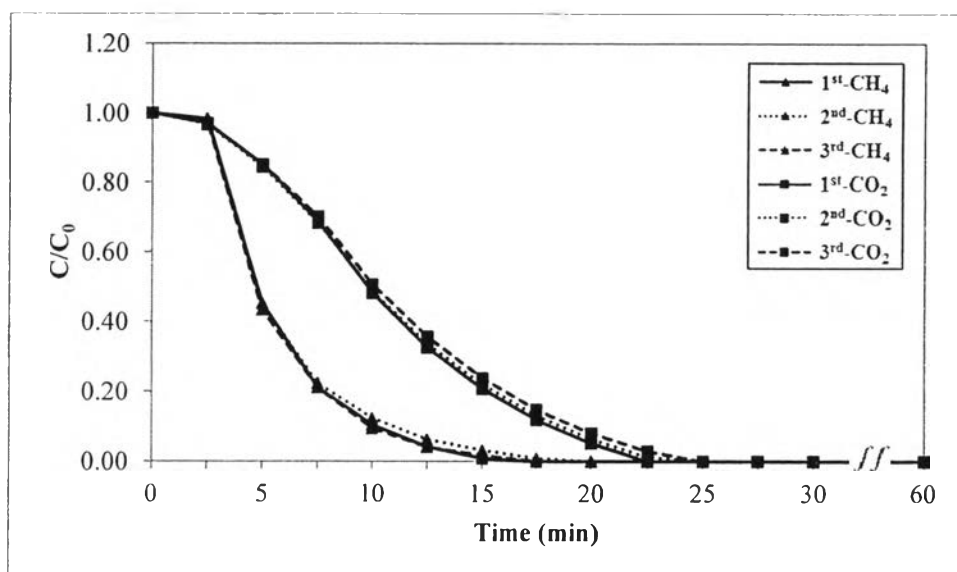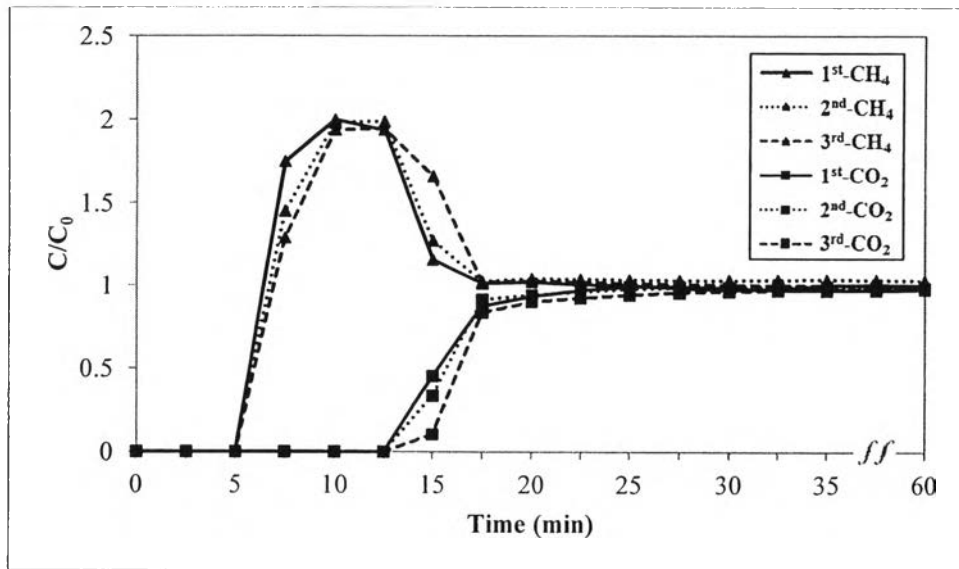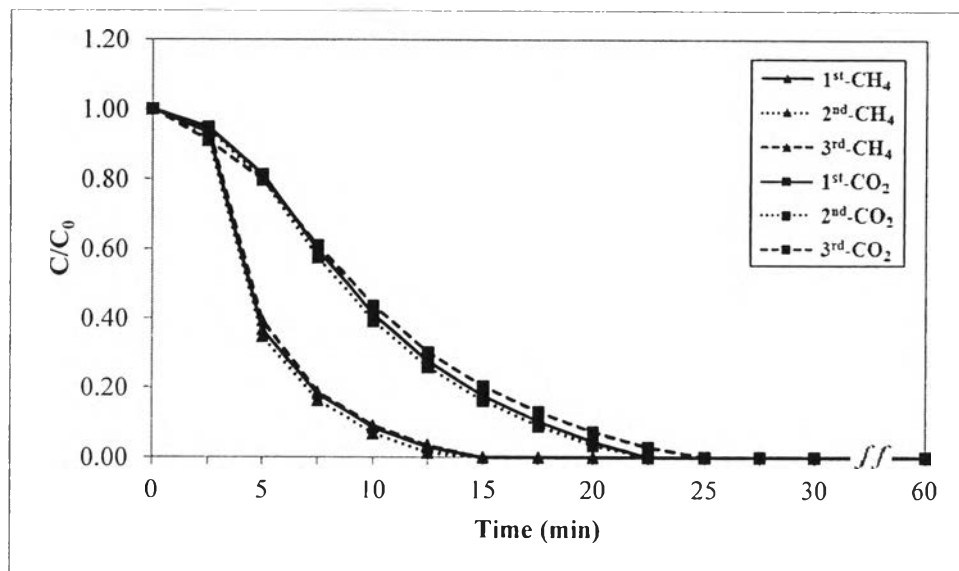
Figure B4 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 15 vol% at room temperature.
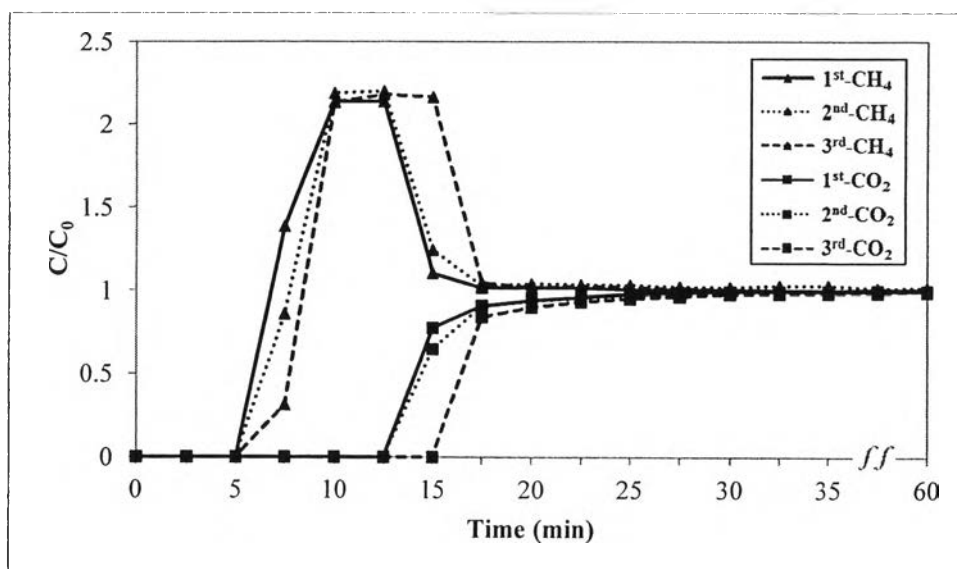

Figure B5 Three desorption cycles of methane and carbon dioxide from the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 15 vol% at room temperature.
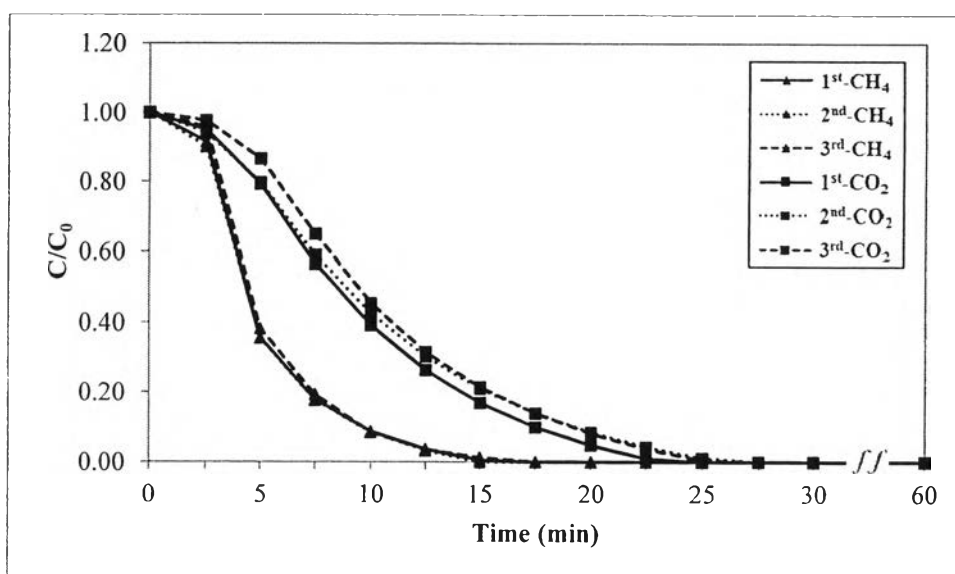
Figure B6 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 20 vol% at room temperature.

Figure B7 Three desorption cycles of methane and carbon dioxide from the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 20 vol% at room temperature.
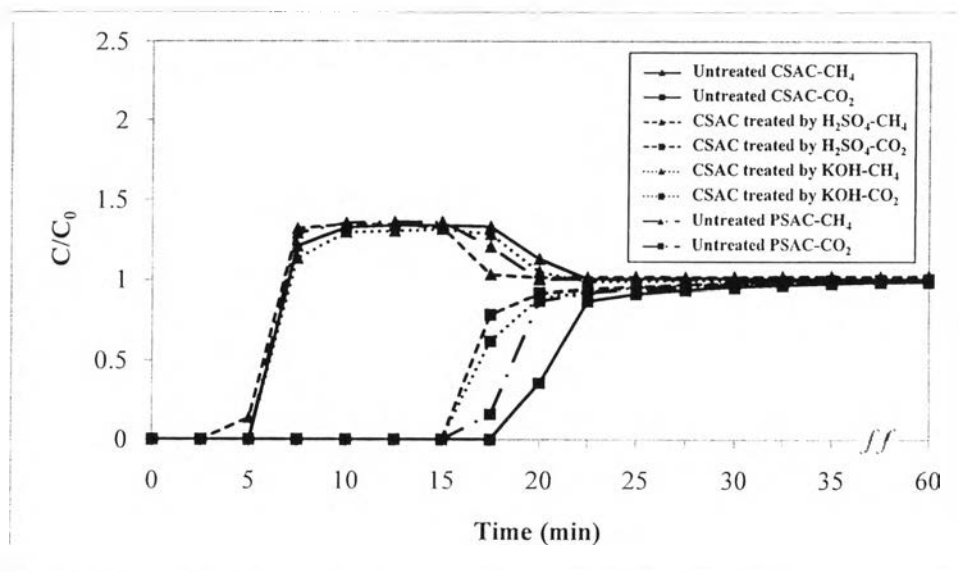
Figure B8 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 25 vol% at room temperature.

Figure B9 Three desorption cycles of methane and carbon dioxide from the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 25 vol% at room temperature.

Figure B10 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 30 vol% at room temperature.
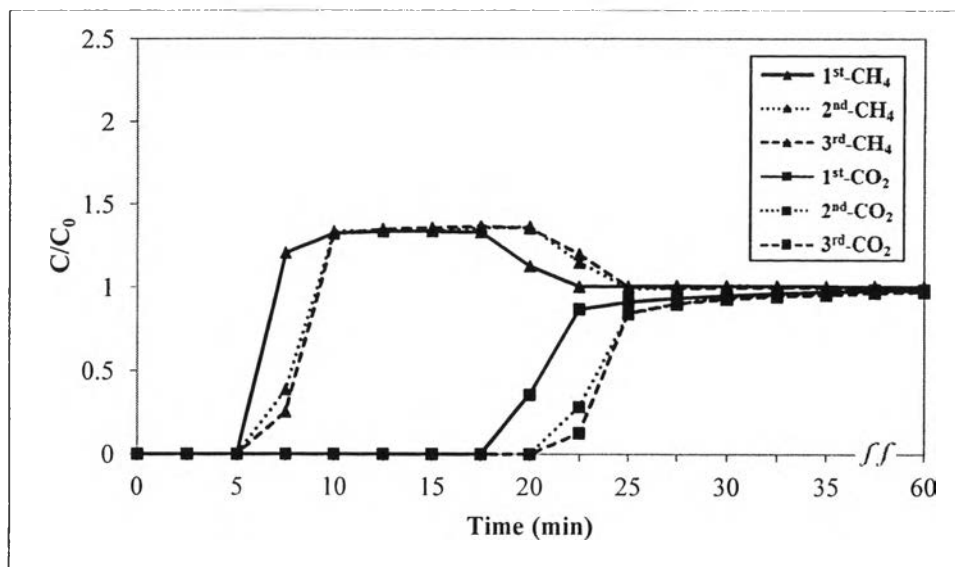

Figure B11 Three desorption cycles of methane and carbon dioxide from the CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 30 vol% at room temperature.

The breakthrough curves in Figure 4.26 are shown in Figure B12.
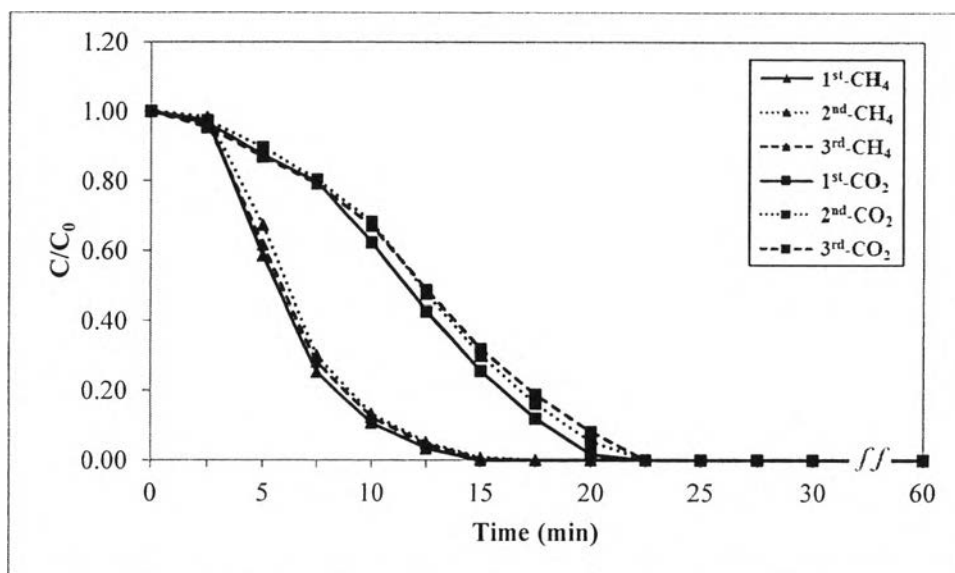

Figure B12   Breakthrough curves of methane and carbon dioxide from the competitive adsorption on the untreated CSAC, CSAC treated by sulfuric acid, CSAC treated by potassium hydroxide, and untreated PSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
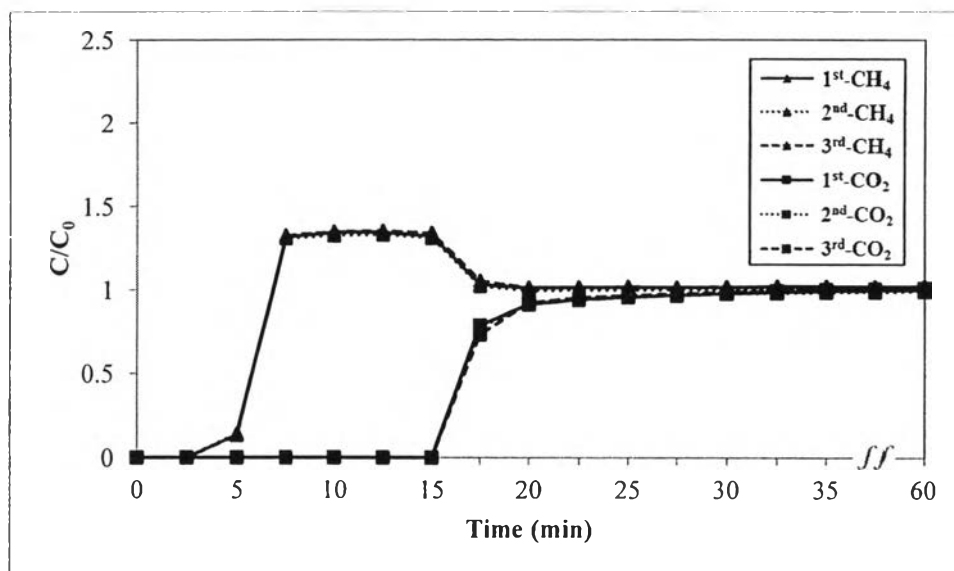
The breakthrough curves and the desorption cycles in Figures 4.27 to 4.34 are shown in Figures B13 to B20.
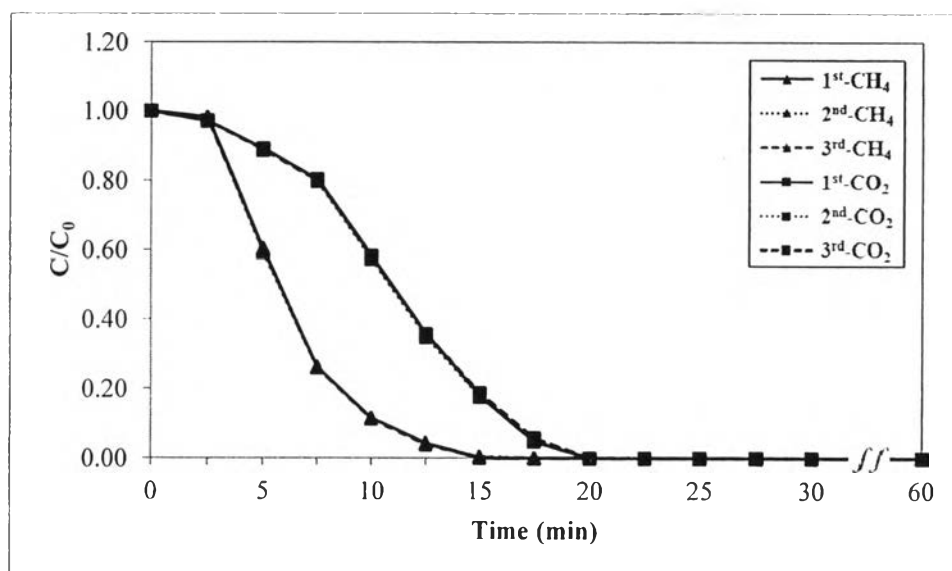
Figure B13 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the untreated CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
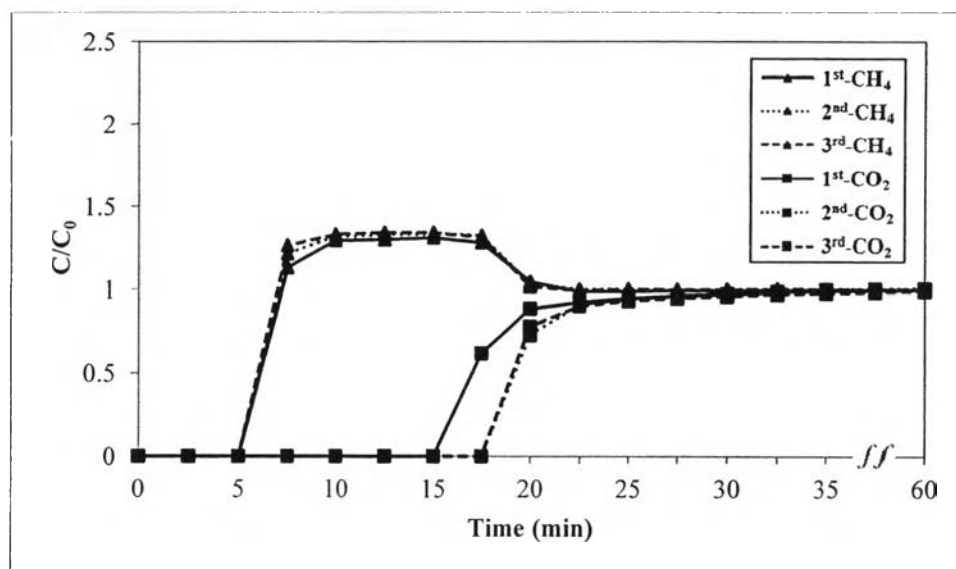

Figure B14 Three desorption cycles of methane and carbon dioxide from the untreated CSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
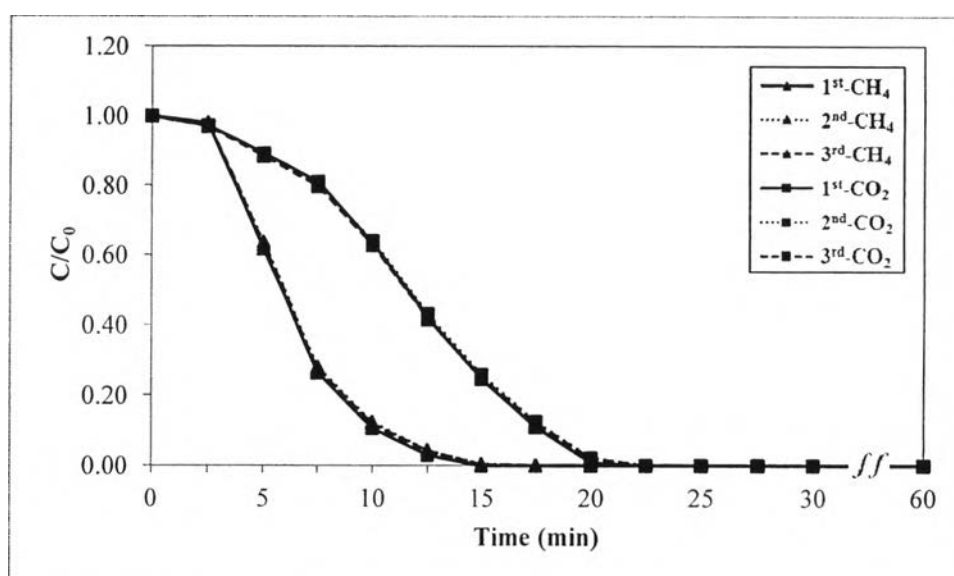
Figure B15 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC treated by sulfuric acid with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
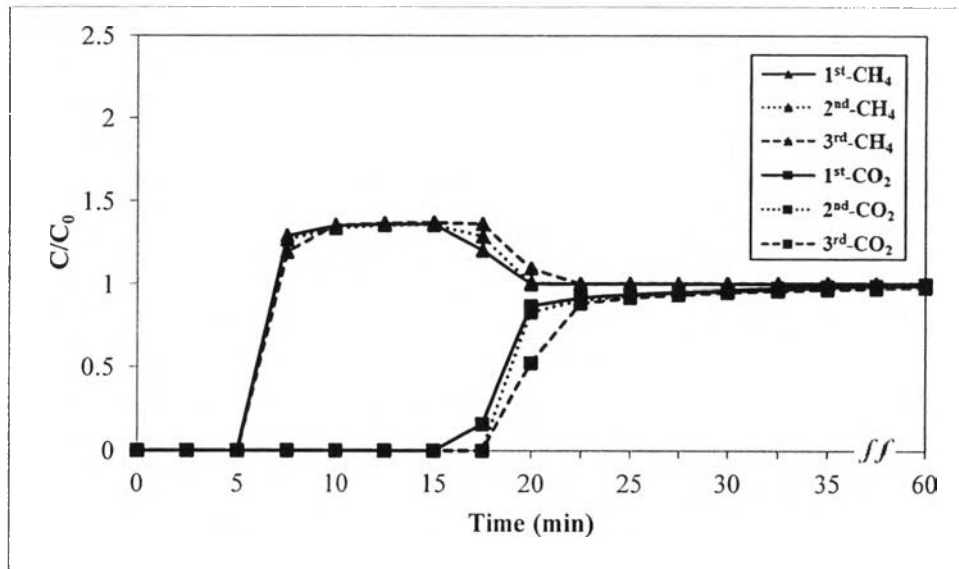

Figure B16 Three desorption cycles of methane and carbon dioxide from the CSAC treated by sulfuric acid with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.

Figure B17 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the CSAC treated by potassium hydroxide with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.

Figure B18 Three desorption cycles of methane and carbon dioxide from the CSAC treated by potassium hydroxide with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.

Figure B19 Breakthrough curves of methane and carbon dioxide from the 3-cycle adsorption process on the untreated PSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.
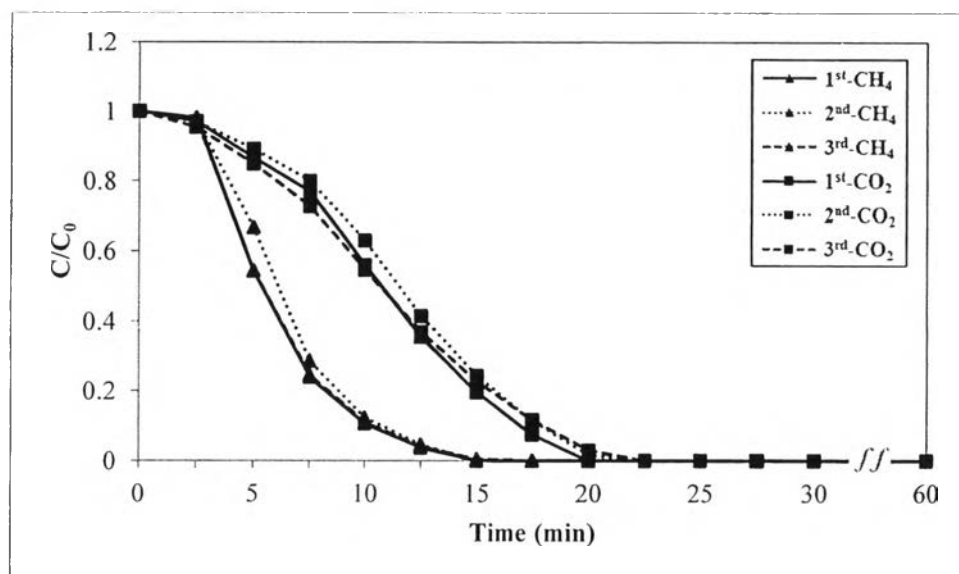
Figure B20 Three desorption cycles of methane and carbon dioxide from the untreated PSAC with the initial concentration of methane at 10 vol% and carbon dioxide at 10 vol% at room temperature.

CURRICULUM VITAE

Name: Ms. Chompunick Sitthirawiphong

Date of Birth: November 18, 1988

Nationality: Thai

University Education:

2007-2010   Bachelor of Science, Petrochemical Technology, Faculty of Science, King Mongkut' s Institute of Technology Ladkrabang, Bangkok, Thailand

Presentations and Proceedings:

1. Sitthirawiphong, C., Siangsai, A., Rangsunvigit, P., Kulprathipanja, S., and Kitiyanan, B. (2013, April 1-5) Effects of Carbon Dioxide on Methane Adsorption on Activated Carbons in a Packed Bed Column. Poster presented at 2013 MRS Spring Meeting & Exhibit, San Francisco, California, USA.

2. Sitthirawiphong, C., Rangsunvigit, P., Kulprathipanja, S., and Kitiyanan, B. (2013, April 23) Effect of Carbon Dioxide on Methane Adsorption on Coconut Shell Activated Carbon in a Packed Bed Column. Proceedings of The 4th Research Symposium on Petroleum, Petrochemicals and Advanced Materials and The 19th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.