REFERENCES

1. Yadav, G. D.; Doshi, N. S. "Synthesis of Linear Phenyldodecanes by the Alkylation of Benzene with 1-Dodecene over Non-Zeolitic Catalysts", *Organic Process Research & Development*, **2002**, *6*, 263-272.
2. Weissermel, K.; Arpe, H. J. Industrial Organic Chemistry, New York, NY, USA: VCH Publisher,**1997**.
3. Modler, R. F.; Willhalm, R.; Yoshida, Y. "CEH Marketing Research Report, LINEAR ALKYLATE SULFONATES", Chemical Economics Handbook-SRI International, California, 1-42, **1998**.
4. UOP Linear Alkylbenzene (LAB) Complex (online). Available from: http://www.uop.com [2004].
5. Scott, M. J.; Jones, M. N. "The biodegradation of surfactants in the environment", *Biochemica et Biophysica Acta,* **2000,** *1508,* 235-251.
6. Kikuchi, E.; Matsuda, T. "Shape Selective Acid Catalysis by Pillared Clays", *Catalysis Today,* **1988,** *2,* 297-307.
7. Clark, J. H. Catalysis of Organic Reactions by Supported Inorganic Reagents, USA, VCH Publishers, **1994**.
8. Kocal, J. A.; Vora, B. V.; Imai, T. "Production of linear alkylbenzenes", *Applied Catalysis A: General,* **2001,** *221,* 295-301.
9. Olson, A. C. "Alkylation of Aromatic with 1-Alkenes", *Industrial and Engineering Chemistry,* **1960,** *52,* 833-836.
10. Sivasanker, S.; Thangaraj, A. "Distribution of Isomers in the Alkylation of Benzene with Long-Chain Olefins over Solid Acid Catalysts", *Journal of Catalysis,* **1992,** *138,* 386-390.
11. González, F.; Pesquera, C.; Blanco, C.; Benito, I.; Mendioroz, S. "Synthesis and Characterization of Al-Ga Pillared Clays withh high Thermal and Hydrothermal Stability", *Inorg. Chem.,* **1992,** *31,* 727-731.

12. Bradley, S. M.; Kydd, R. A. "Ga_{13}, Al_{13}, $GaAl_{12}$, and Chromium-Pillared Montmorillonites: Acidity and Reactivity for Cumene Conversion", *Journal of Catalysis,* **1993,** *141,* 239-249.

13. Storaro, L.; Lenarda, M.; Ganzerla, R.; Rinaldi, A. "Preparation of hydroxy Al and Al/Fe pillared bentonites from concentrated clay suspensions", *Microporous Materials,* **1996,** *6,* 55-63.

14. Zurita, M. J. P.; Vitale, G.; de Goldwasser, M. R.; Rojas, D.; García, J. J. "Fe-pillared clay: a combination of zeolite shap selectivity and iron activity in the CO hydrogenation reaction", *Journal of Molecular Catalysis A: Chemical,* **1996,** *107,* 175-183

15. Mishra, T.; Parida, K. M. "Transition metal pillared clay: 3. A para selective catalyst for nitration of chlorobenzene", *Journal of Molecular Catalysis A: Chemical,* **1997,** *121,* 91-96.

16. Govea, L.; Steinfink, H. "Thermal stability and Magnetic properties of Fe-polyoxocation Intercalated Montmorillonite", *Chem. Mater,* **1997,** *9,* 894-856.

17. Meriaudeau, P.; Taarit, P.; Taarit, Y. B.**;** Thangaraj, A.; Almeida, J. L. G.; Naccache, C. "Zeolite based catalysts for linear alkylbenzene production: Dehydrogenation of long chain alkanes and benzene alkylation", *Catalysis Today,* **1997,** *38,* 243-247.

18. Price, P. M.; Clark, J. H.; Martin, K.; Macquarrie, D. J.; Bastock, T. W. "Enchanced Selectivity in the Preparation of Linear Alkylbenzenes Using Hexagonal Mesoporous Silica Supported Aluminium Chloride", *Organic Process Research & Development,* **1998,** *2,* 221-225.

19. Cao, Y.; Kessas, R.; Naccache, C.; Taarit, Y. B. "Alkylation of benezene with dodecene. The activity and selectivity of zeolite type catalysts as a function of the porous structure", *Applied Catalysis A: General,* **1999,** *184,* 231-238.

20. Lenarda, M.; Storaro, L.; Pellegrini, G.; Piovesan, L.; Ganzerla, R. "Solid acid catalysts from clays Part 3: benzene alkylation with ethylene catalyzed by aluminum and aluminum gallium pillared bentonites", *Journal of Molecular Catalysis A: Chemical*, **1999,** *145,* 237–244.

21. Okumura, K.; Nishigaki, K.; Niwa, M. "Prominent catalytic activity of Ga-containing MCM-41 in the Friedel-Crafts alkylation", *Microporous and Mesoporous Materials,* **2001,** *44-45,* 509-516.

22. Choudhary, V. R.; Jana, S. K. "Benzylation of benzene and substituted benzene by benzyl chloride over $InCl_3$, $GaCl_3$, $FeCl_3$ and $ZnCl_3$ supported on clays and Si-MCM-41", *Journal of Molecular Catalysis A: Chemical,* **2002,** *180,* 267-276.

23. Balci, S.; Gökçay, E. "Effects of drying methods and calcination temperatures on the physical properties of iron intercalated clays", *Materials Chemistry and Physic,* **2002,** *76,* 46-51.

24. Huerta, L.; Meyer, A.; Choren, E. "Synthesis, characterization and catalytic application for ethylbenzene dehydrogrnation of an iron pillared clay", *Microporous and Mesoporous Materials,* **2003,** *57,* 219-227.

25. Zhang, J.; Chen, B.; Li, C.; Zhu, Z.;Wen, L.; Min, E. "Kinetics of benzene alkylation with 1-dodecene over a supported tungstophosphoric acid catalyst", *Applied Catalysis A: General,* **2003,** *249,* 27–34.

26. Todorova, S.; Su, B.-L. "Propane as alkylating agent for benzene alkylation on bimetal Ga and Pt modified H-ZSM-5 catalysts: FTIR study of effect of pre-treatment conditions and the benzene adsorption", *Journal of Molecular Catalysis A: Chemical,* **2003,** *201,* 223–235.

27. Bigey, C.; Su, B.-L. "Propane as alkylating agent for alkylation of benzene on HZSM-5 and Ga-modified HZSM-5 zeolites", *Journal of Molecular Catalysis A: Chemical,* **2004,** *209,* 179–187.

28. Belver, C.; Bañares-Muñoz, M. A.; Vicente, M. A. "Fe-saponite pillared and impregnated catalysts I. Preparation and characterisation", *Applied Catalysis B: Environmental,* **2004,** *50,* 101-112.

29. Belaroui, L. S.; Millet, J. M. M.; Bengueddach, A. "Characterization of lalithe, a new bentonite-type Algerian clay, for intercalation and catalysts preparation", *Catalysis Today* **2004,** *89,* 279-286.

30. Drever, J. I. The geochemistry of natural water, Eaglewood Criffs, USA, Prentice-Hall, **1982**.

31. Shichi, T.; Takagi, K. “Clay minerals as photochemical reaction fields”, *Journal of Photochemistry and Photobiology C: Photochemistry Peviews I,* **2000,** 113-130.

32. Jean, F. L.; Georges, P. “Acidity in pillared clays: origin and catalytic manifestations”, *Topic in Catalysis 4*, **1997**, 43-56.

33. Moore, D. M.; Reynolds, Jr. R. C. X-Ray Diffraction and the Identifiation and Analysis of Clay Minerals, New York, USA**,** Oxford University Press, **1989**.

34. Michael, R.; Grace, S. T.; Vishnu, K. “The many ways of making annionic clays”, *Proc. Indian Acad. Sci. (Chem. Sci.)*, **2001**, *113*, 671-680.

35. Varma, R. S. “Clay and clay-supported reagents in organic synthesis”, *Tetrahedron,* **2002,** *58,* 1235-1255.

36. Robert, A. S.; Tom, P.; Gerhard, L.; Nick, G. “Pillared Clays and Pillared Layered solids (Technical Report)”,*Pure Appl. Chem.,* **1999,** *71*, 2367-2371.

37. Gonzalez, F.; Pesquera, C.; Blanco, C.; Benito, I.; Mendioroz, S. “Synthesis and Charaterization of Al-Ga Pillared Clays with High Thermal and Hydrothermal Stability ”, *Inorg. Chem.*, **1992,** *31,* 727-731.

38. Wade, Jr. L. G. Organic Chemistry, 3^{rd} ed, Eaglewood Cliffs, New Jersey, USA, Prentice-Hall, 774p, **1995.**

39. McMurry, J. Fundamentals of Organic Chemistry, 3^{rd} ed, California, USA, Books/Cole Publishing Company, A Division of Wadsworth, 152p, **1994**.

40. Loudon, G. M. Organic Chemistry, 3^{rd} ed, USA, The Benjamin/Cummings Publishing Company, 757p, **1995**.

41. Clark, J. H. Catalysis of Organic Reactions by Supported Inorganic Reagents, USA, VCH Publishers,**1994**.

42. Heylen, I.; Vansant, E, F. “The different in adsorption capacity between Fe-PILCs and modified Fe-BuA- and Fe-Zr-PILCs”, *Microporous Materials,* **1997,** *10,* 41-50.

43. Merinska, D.; Kovarova, L.; Kalendova, A.; Vaculik, J.; Weiss, Z.; Chmielova, M.; Malac, J.; Simonik, J. “Polypropylene nanoconposites based on the montmorillonite modified by octadecylamine and stearic acid co-intercalation”, *Journal of Polymer Engineering,* **2003,** *23,* 241-257.

44. Fontana, A.; Moser, E.; Rossi, F.; Campostrini, R.; Carturan, G. "Structure and dynamics of hydrogenated silica xerogel by Raman and Brillouin scattering", *Journal of Non-Crystalline Solids* **1997,** *212,* 292-298.

45. Mishra, B. G.; Rao, G. R. "Physicochemical and catalytic properties of Zr-pillared montmorillonite with varying pillar density", *Microporous and Mesoporous Materials* **2004,** *70,* 43-50.

46. Zhan, Z.; Zeng, H. C. "A catalyst-free approach for sol-gel synthesis of highly mixed ZrO_2-SiO_2 oxides", *Journal of Non-Crystalline Solids,* **1999,** *243,* 26-38.

47. Maes, N.; Heylen, I.; Cool, P.; Vansant, E. F. "The relation between the synthesis of pillared clays and their resulting porosity", *Applied Clay Science,* **1997,** *12*, 43-60.

48. Swisher, R. D.; Kaelble, E. F.; Liu, S. K. "Capillary Gas Chromatography of Phenyldodecane Alkylation and Isomerization Mixtures", *Monsanto Chemical Co., Research Department, Inorganic Chemicals Division,* **1961,** *26,* 4066-4069.

49. Alul, H. R. "Control of Isomer Distribution of Straight-Chain Alkylbenzenes", *I&EC Product Research and Development,* **1968,** *7,* 7-11.

Appendices

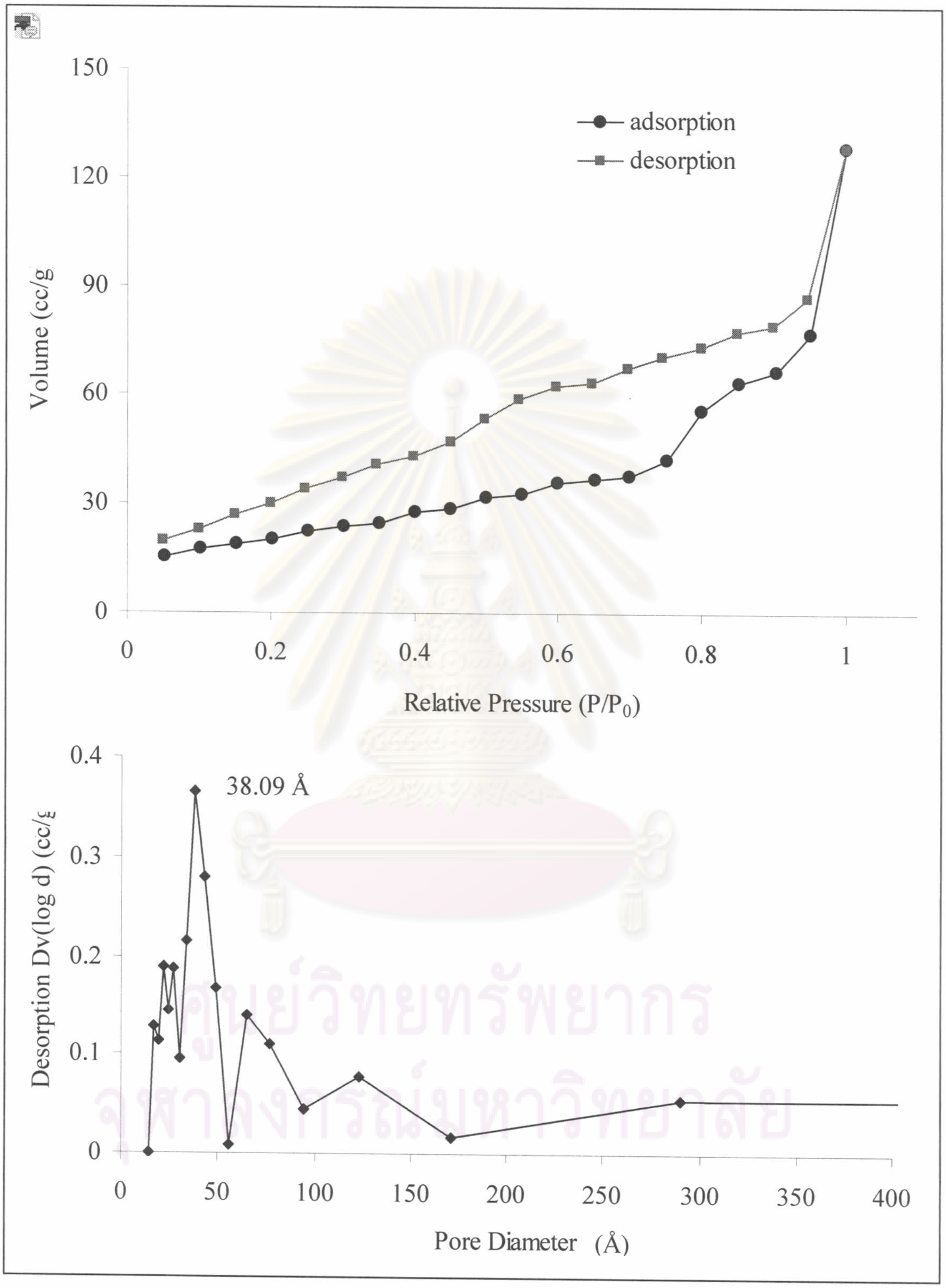

Figure A-1 N_2 adsorption-desorption isotherm and pore sizes distribution of hectorite.

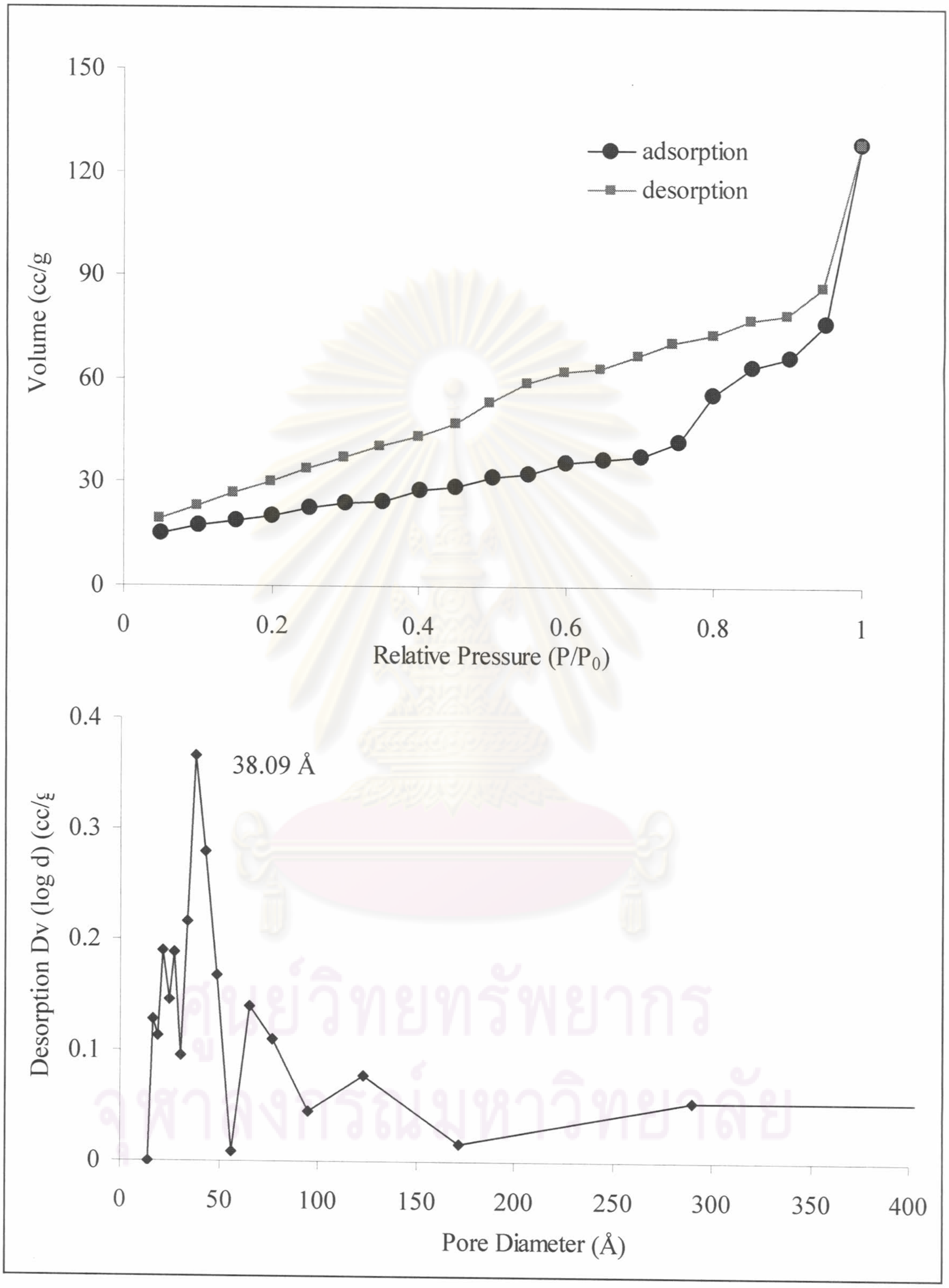

Figure A-2 N_2 adsorption-desorption isotherm and pore sizes distribution of $HFe_{0.5}$.

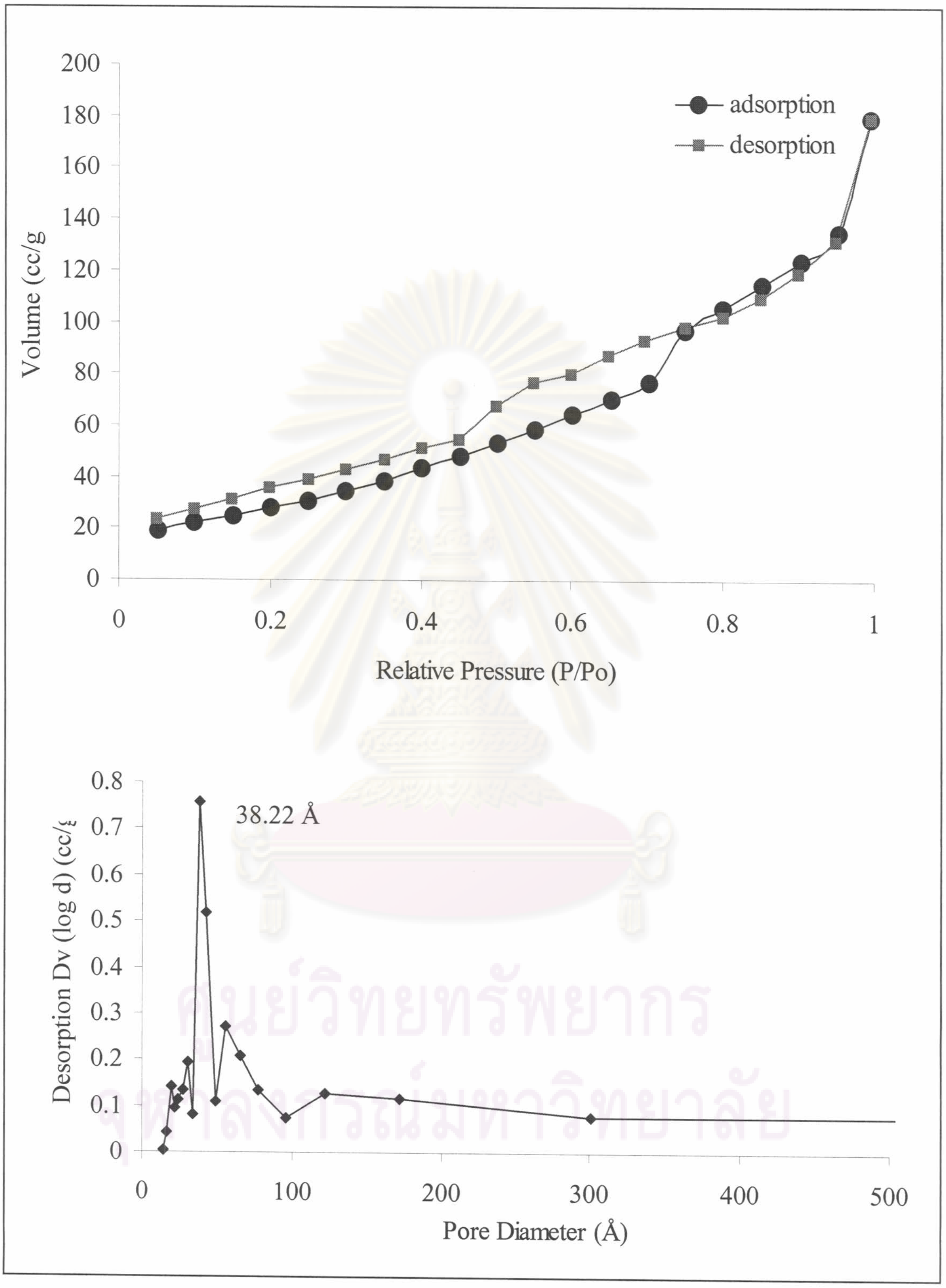

Figure A-3 N_2 adsorption-desorption isotherm and pore sizes distribution of HFe_1.

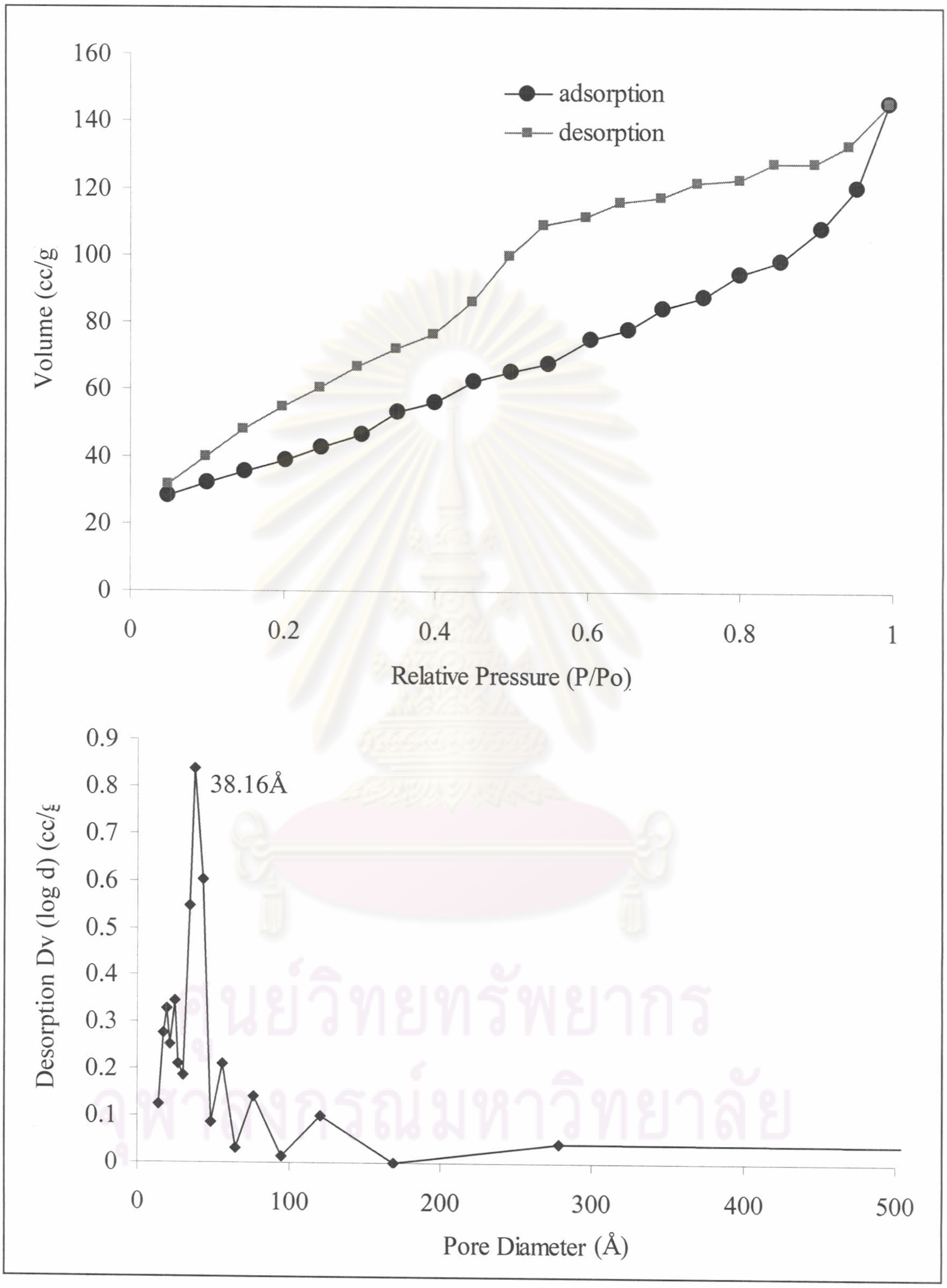

Figure A-4 N_2 adsorption-desorption isotherm and pore sizes distribution of HFe_5.

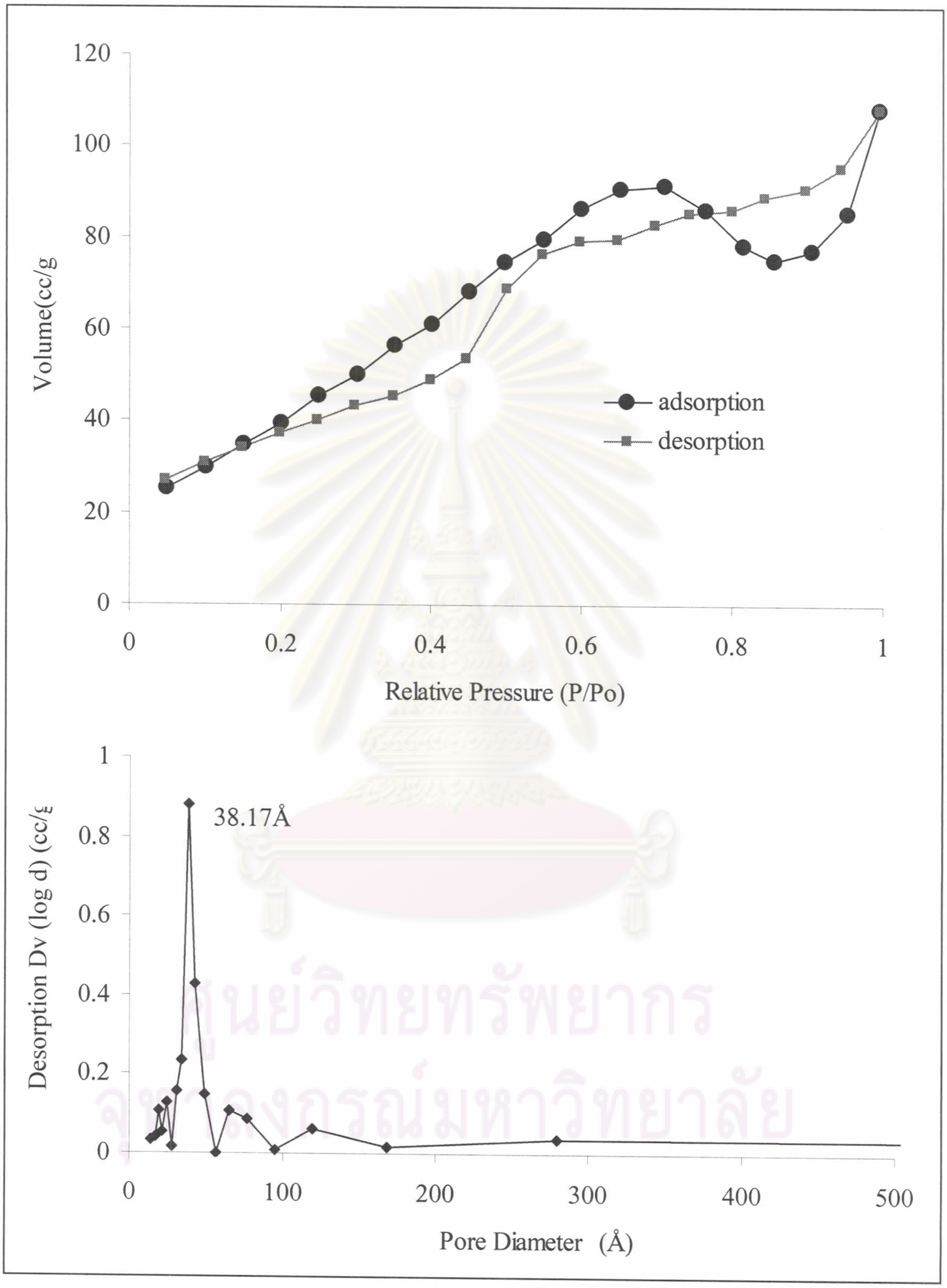

Figure A-5 N_2 adsorption-desorption isotherm and pore sizes distribution of HFe_{10}.

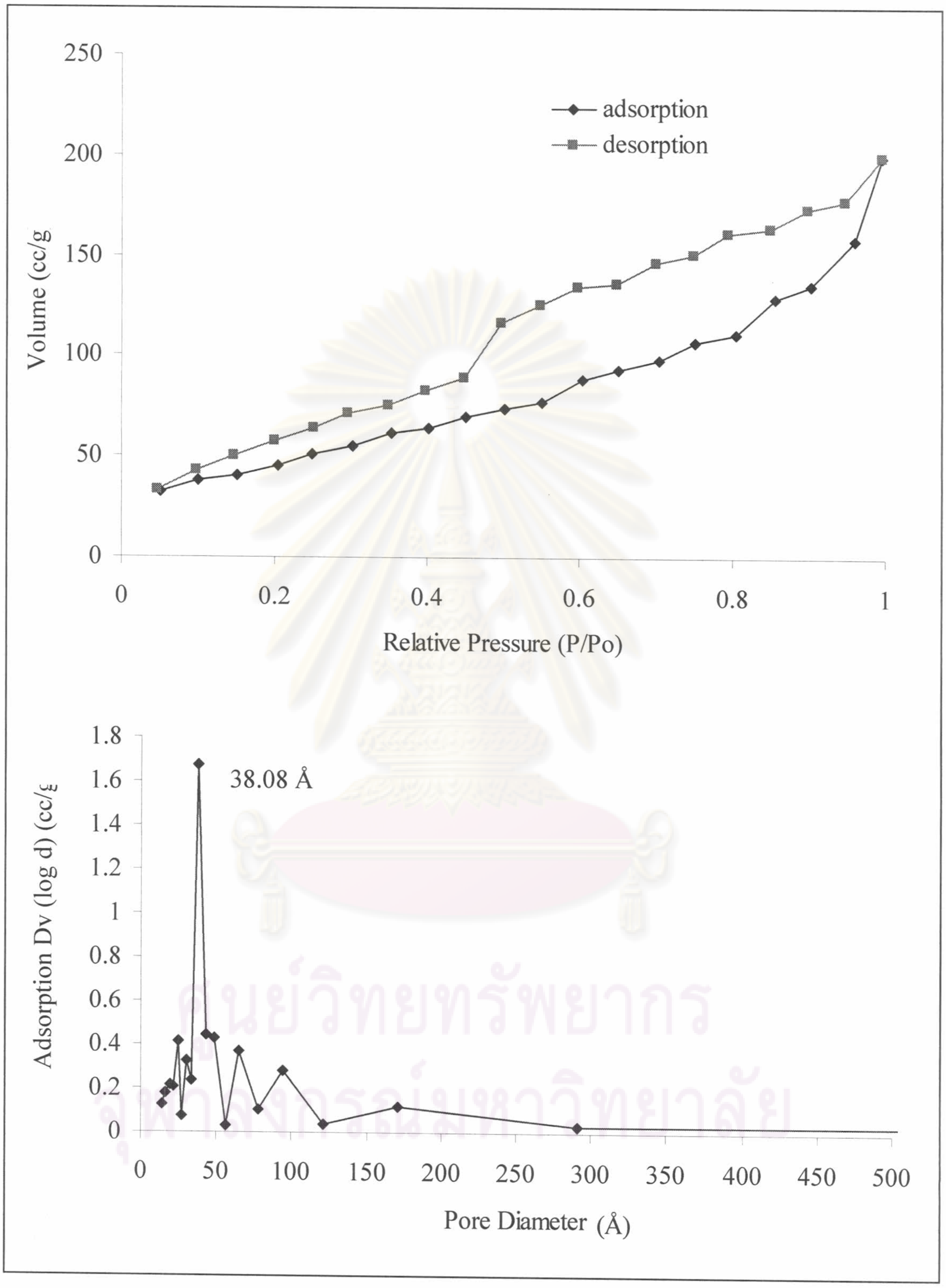

Figure A-6 N_2 adsorption-desorption isotherm and pore sizes distribution of HFe_{20}.

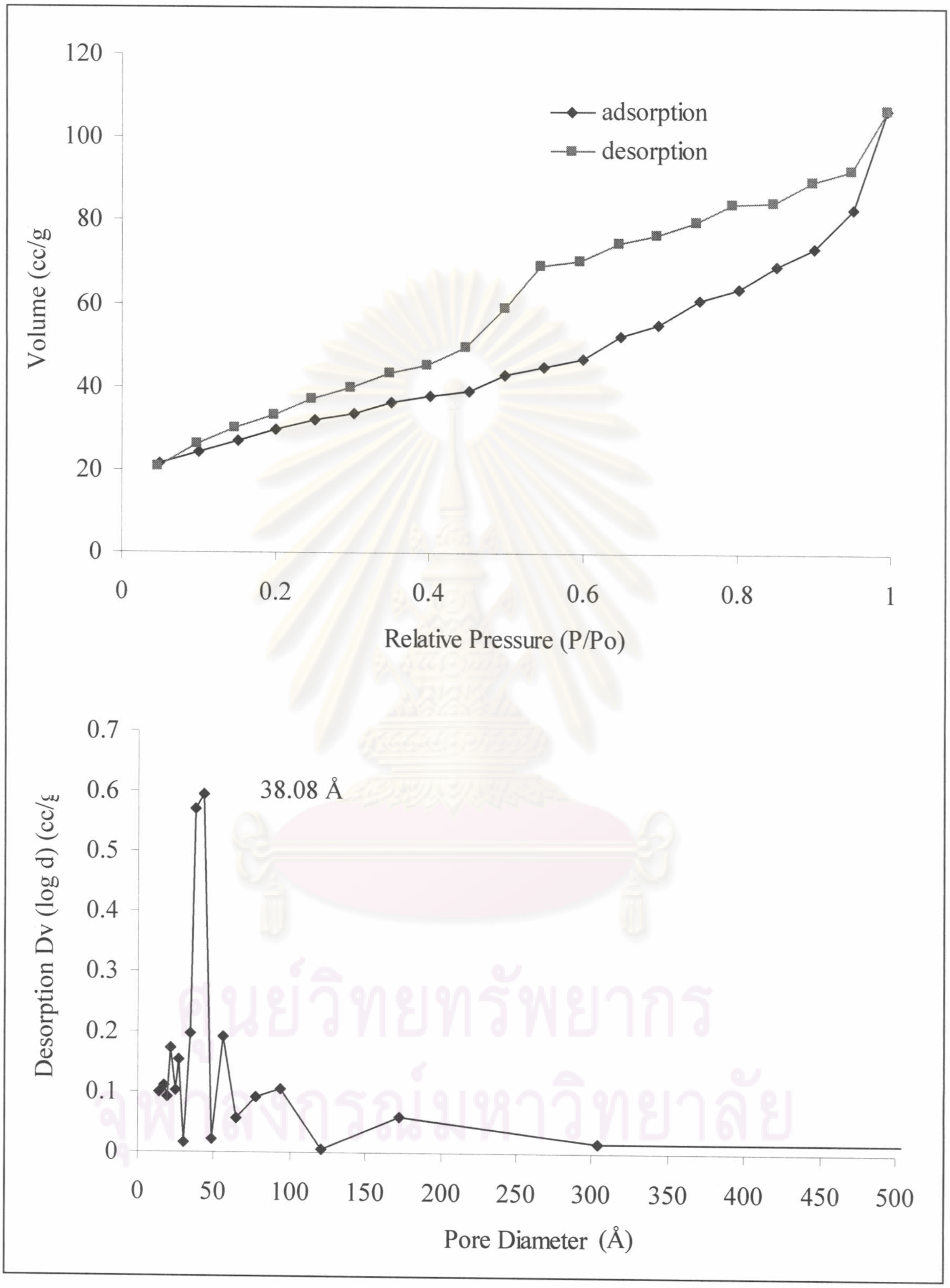

Figure A-7 N_2 adsorption-desorption isotherm and pore sizes distribution of HFe_{240}.

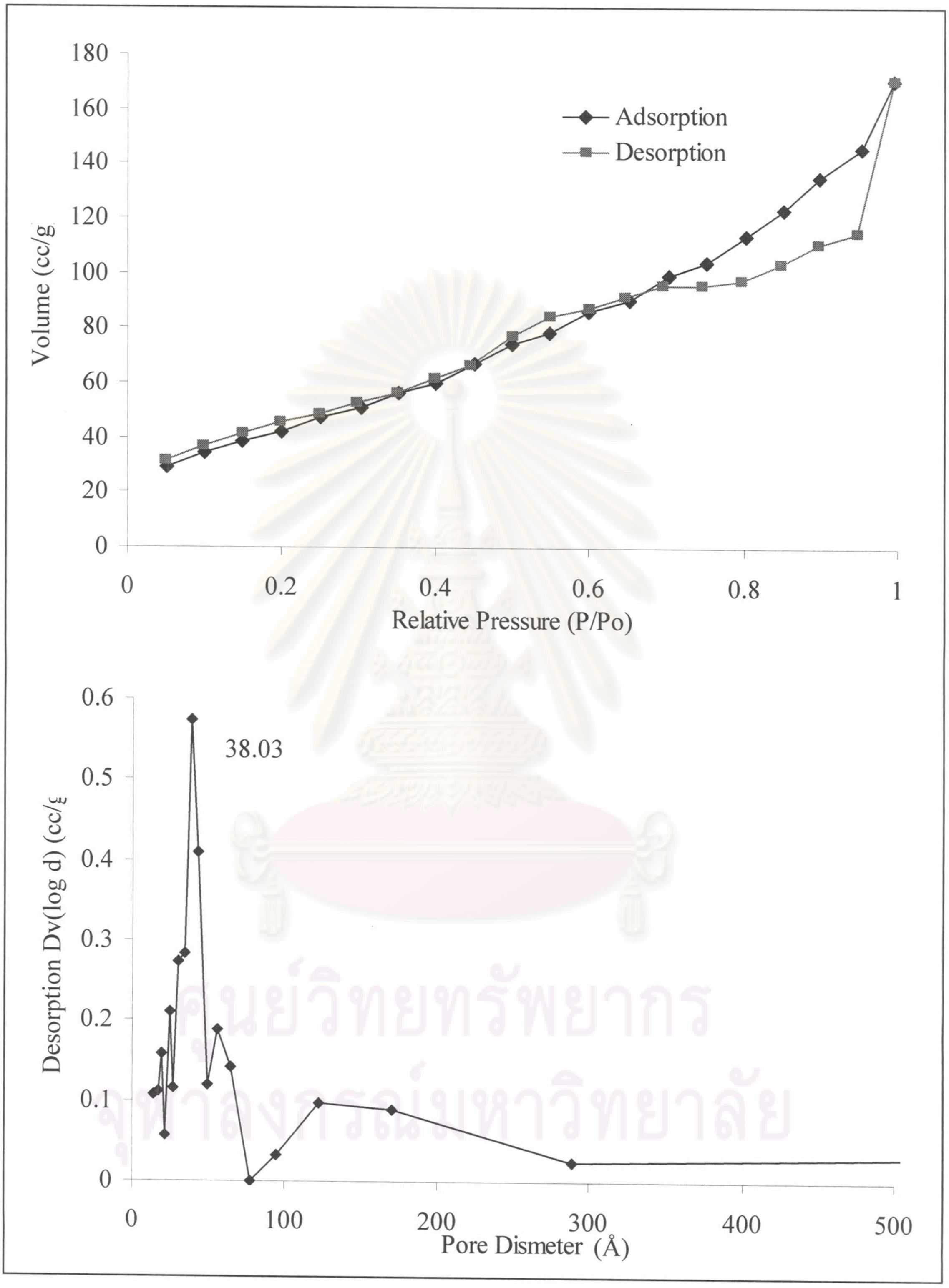

Figure A-8 N_2 adsorption-desorption isotherm and pore sizes distribution of $HFe_{10}Ga_1$.

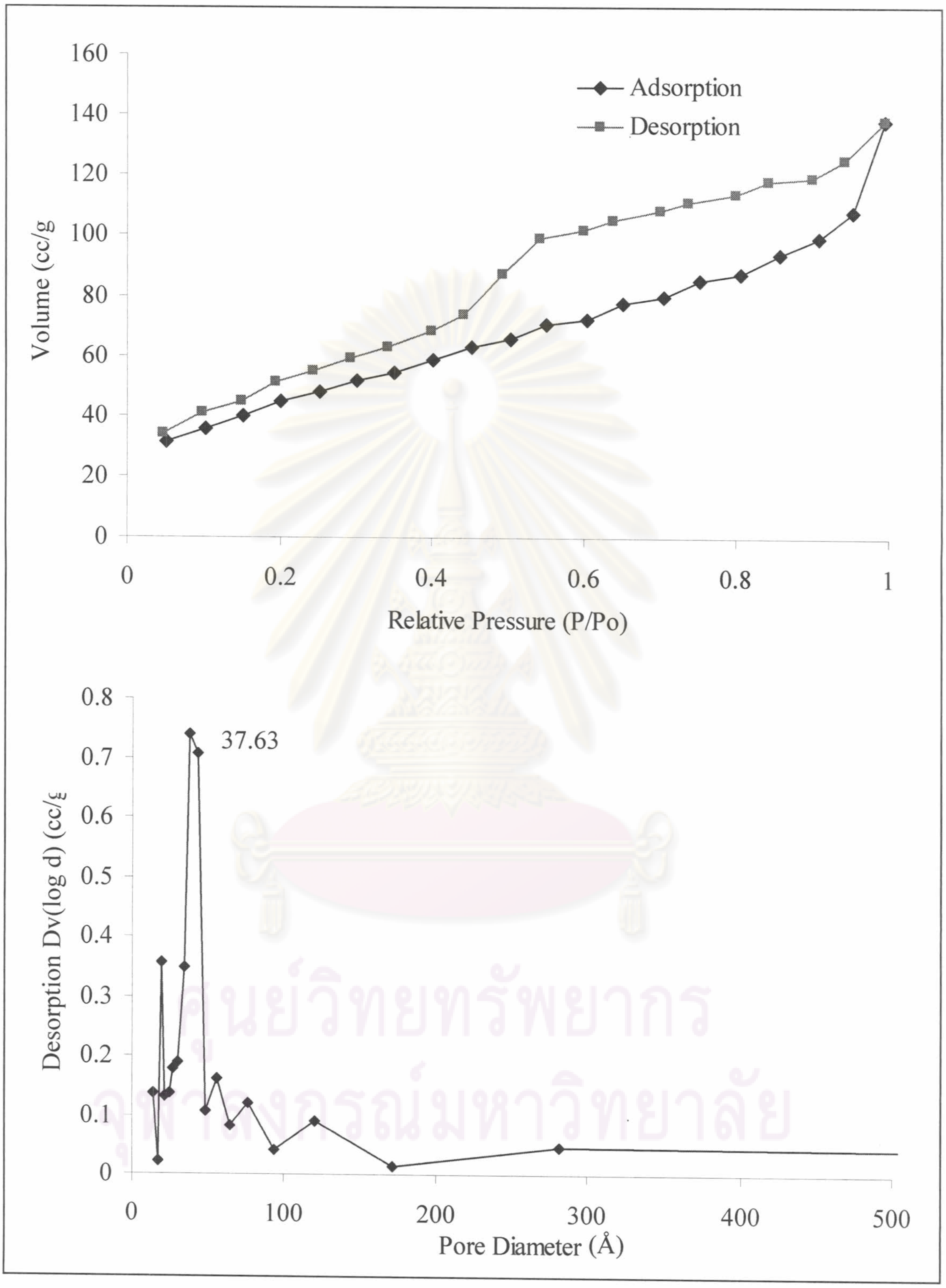

Figure A-9 N_2 adsorption-desorption isotherm and pore sizes distribution of $HFe_{10}Ga_1I$.

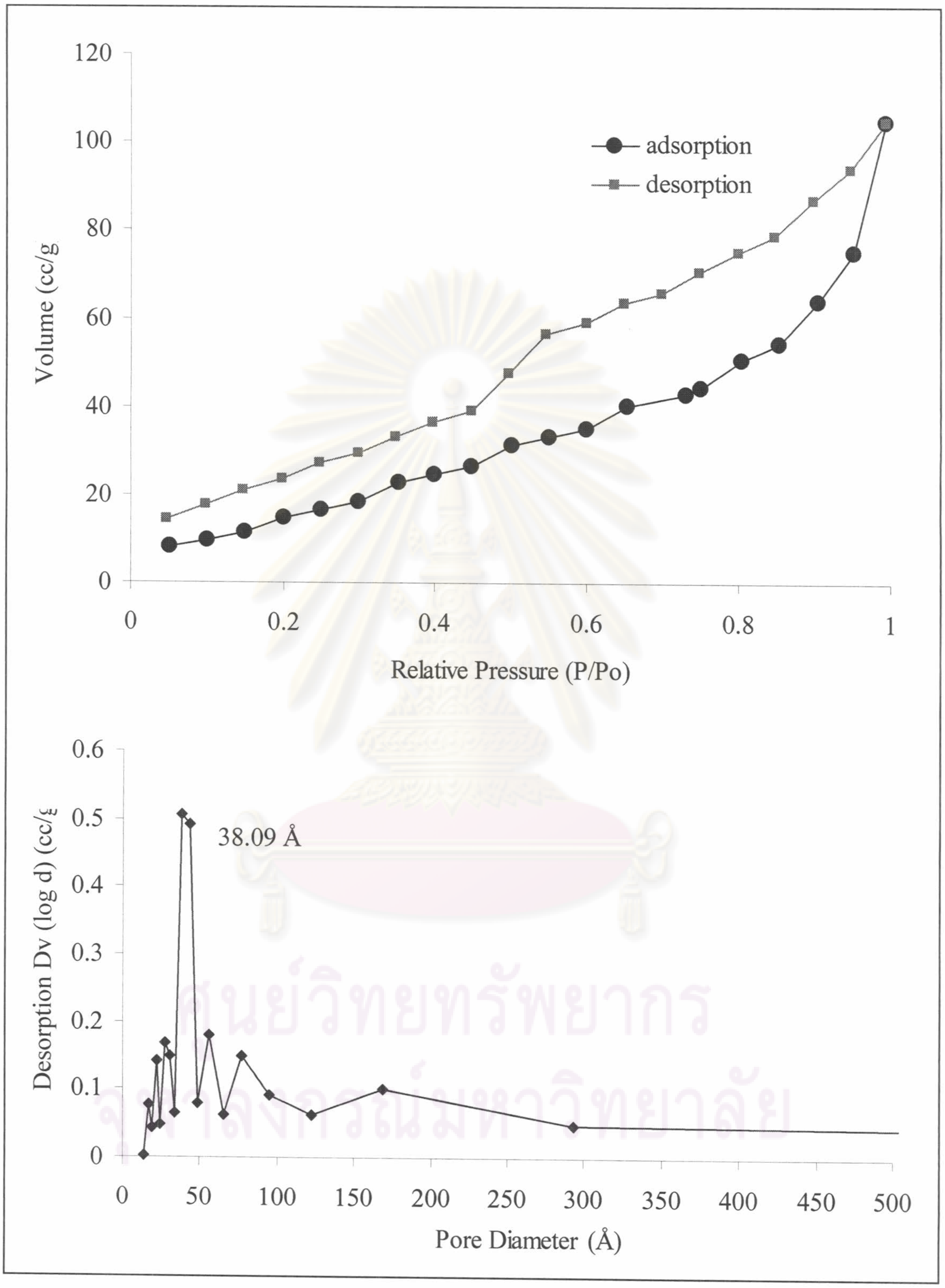

Figure A-10 N_2 adsorption-desorption isotherm and pore sizes distribution of bentonite.

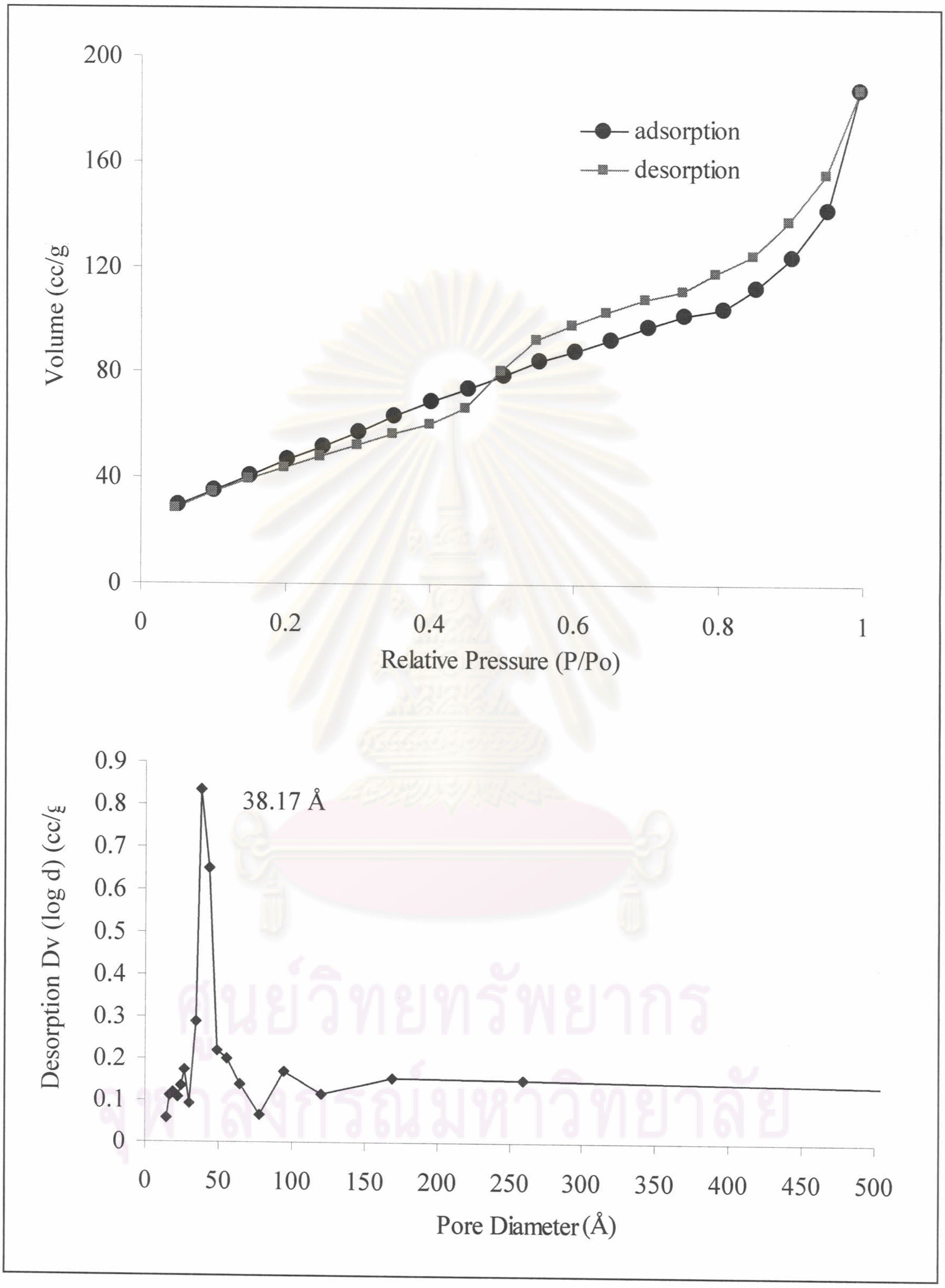

Figure A-11 N_2 adsorption-desorption isotherm and pore sizes distribution of BFe_5.

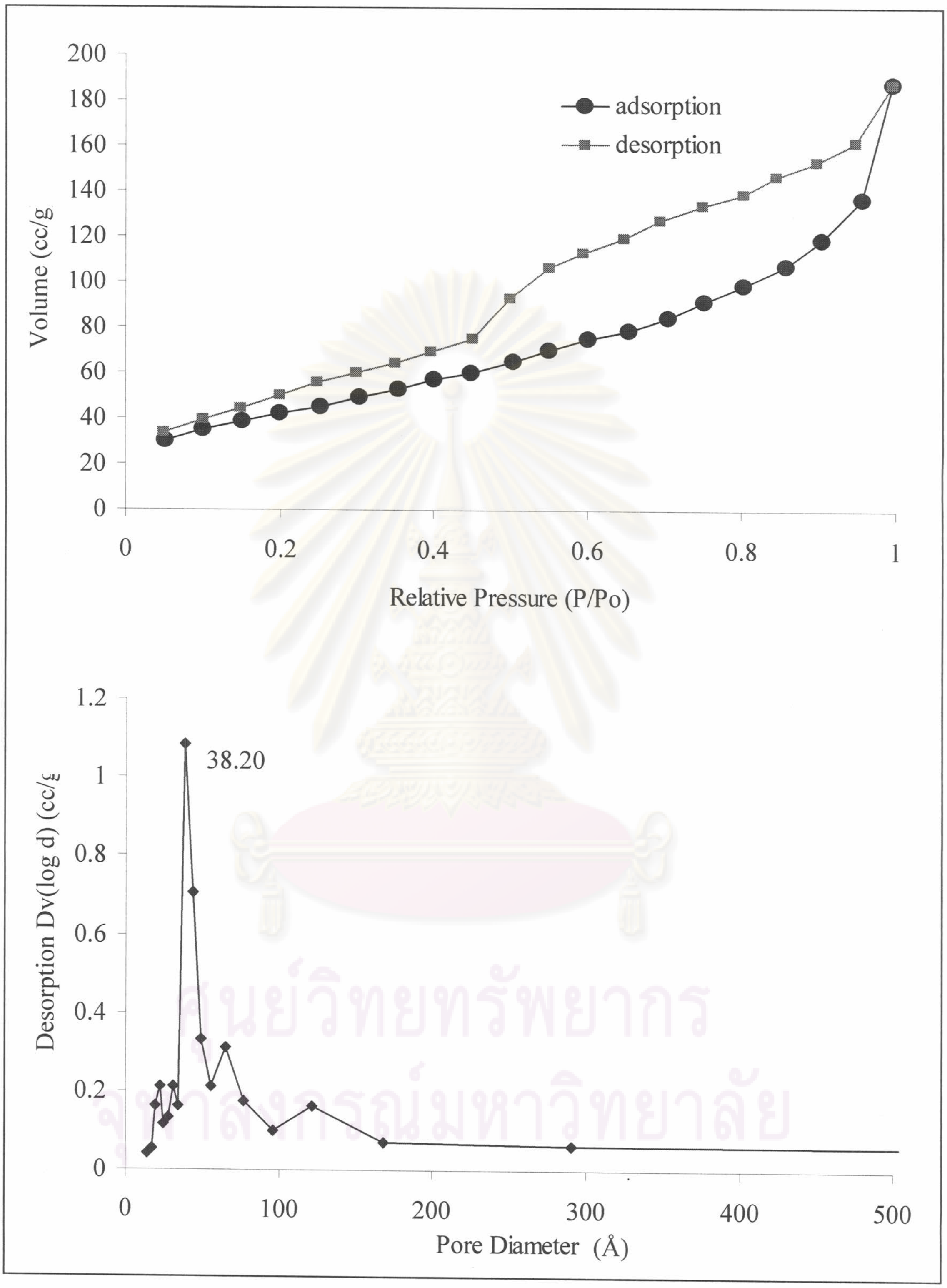

Figure A-12 N_2 adsorption-desorption isotherm and pore sizes distribution of BFe_{10}.

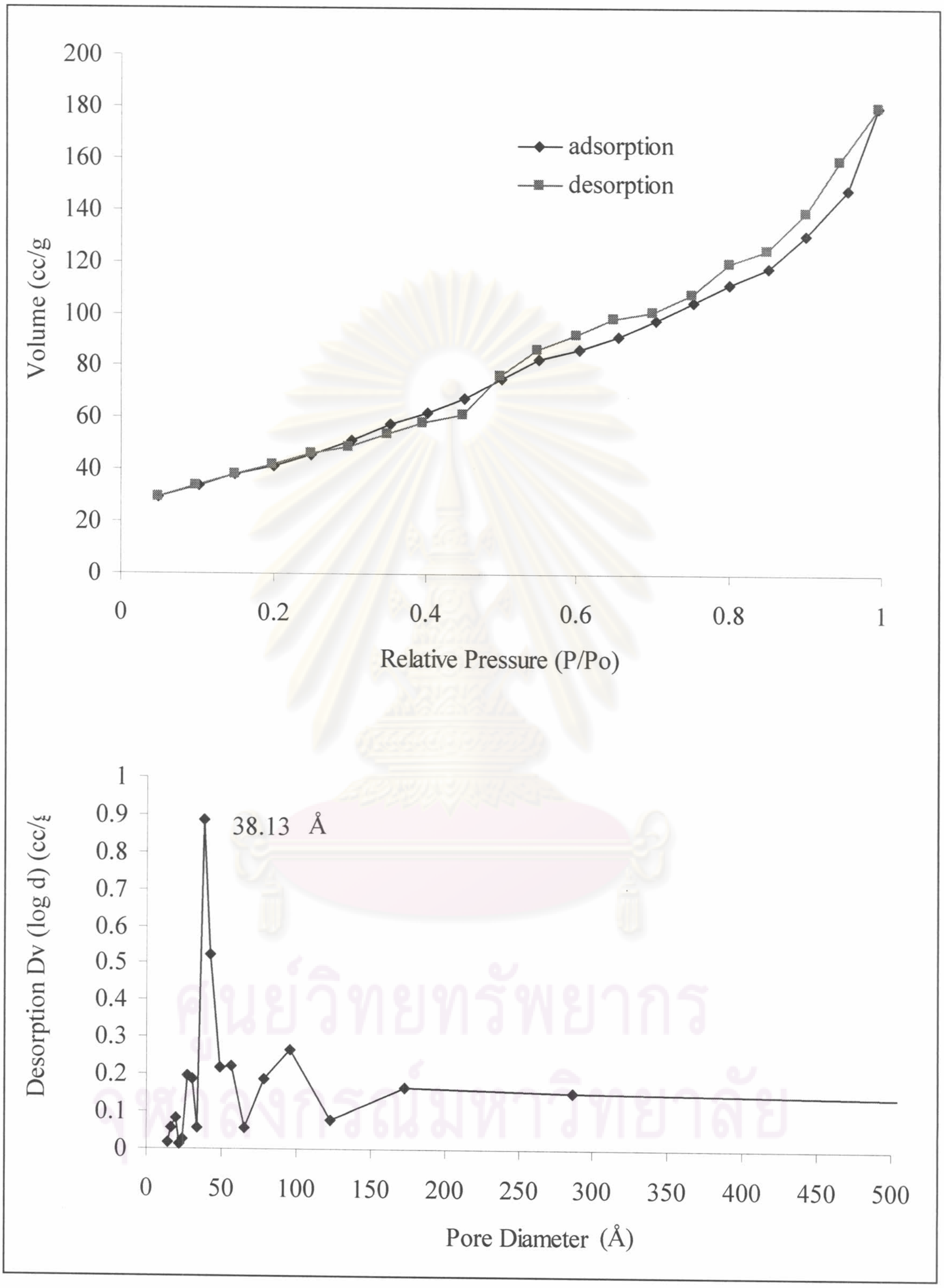

Figure A-13 N_2 adsorption-desorption isotherm and pore sizes distribution of BFe_{20}.

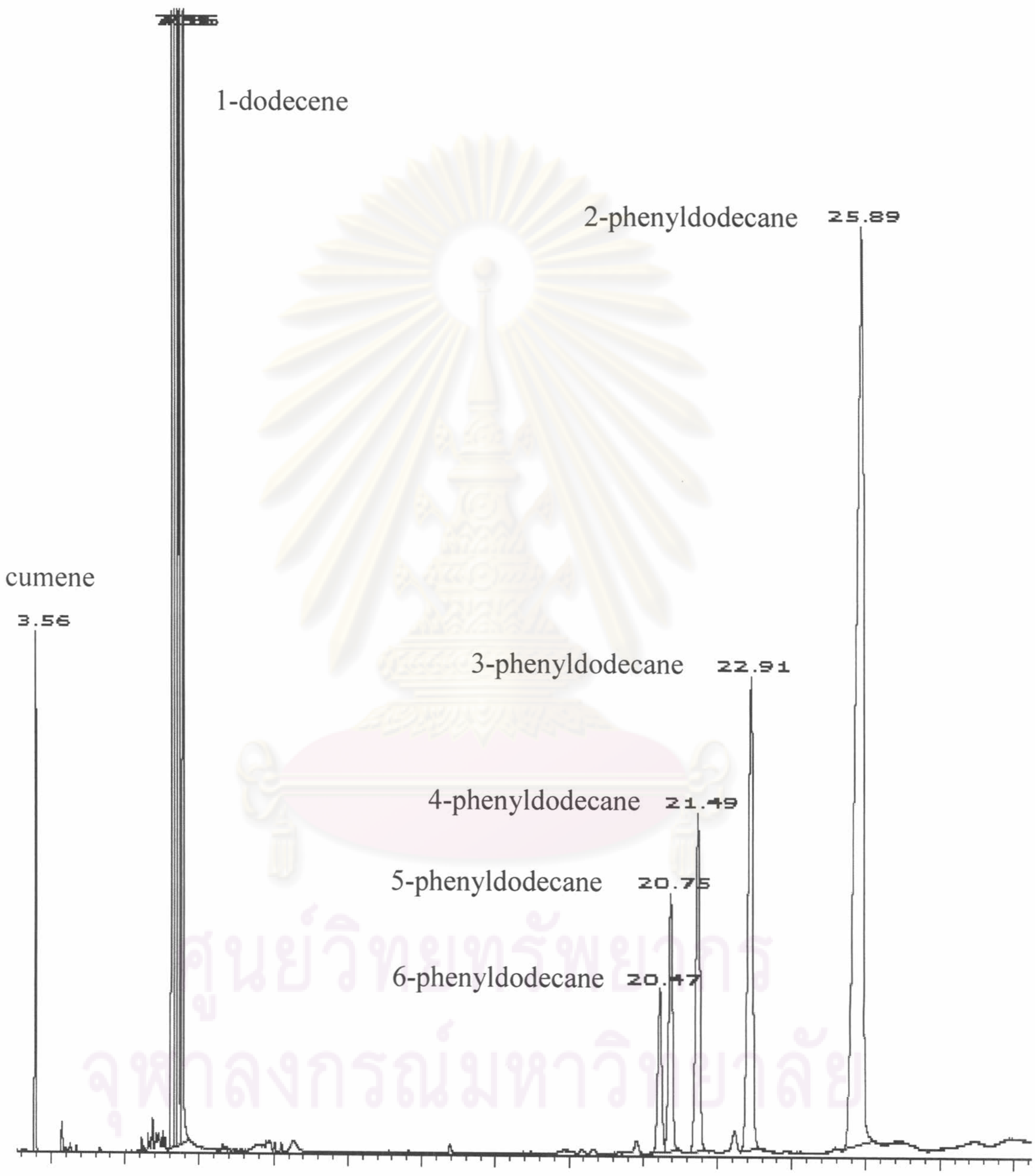

Figure A-14 A gas chromatogram of liquid product from alkylation of benzene with 1-dodecene.

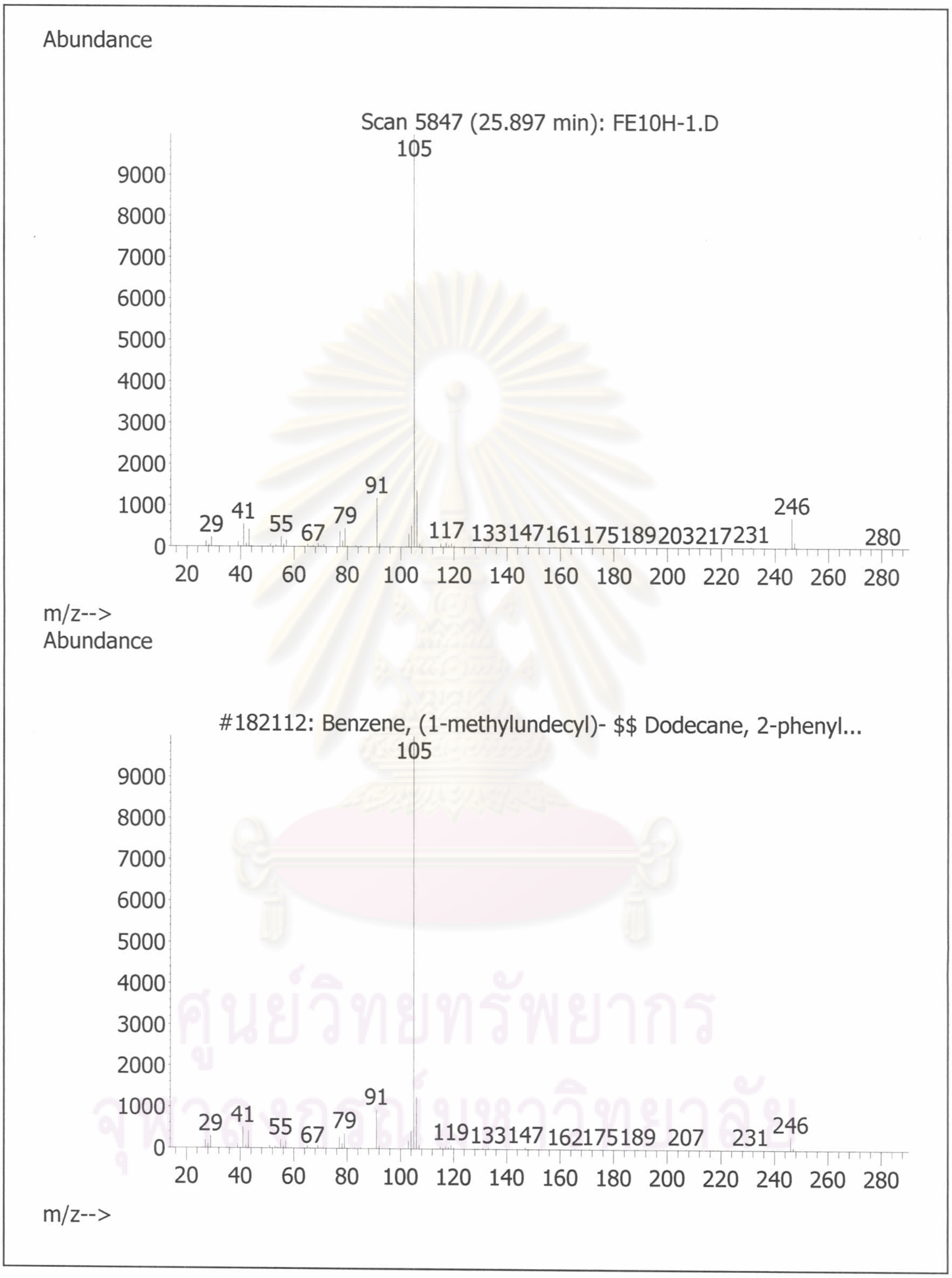

Figure A-15 Mass spectrum of liquid product at t_R = 25.897s (top) and 2-phenyldodecane in library (bottom).

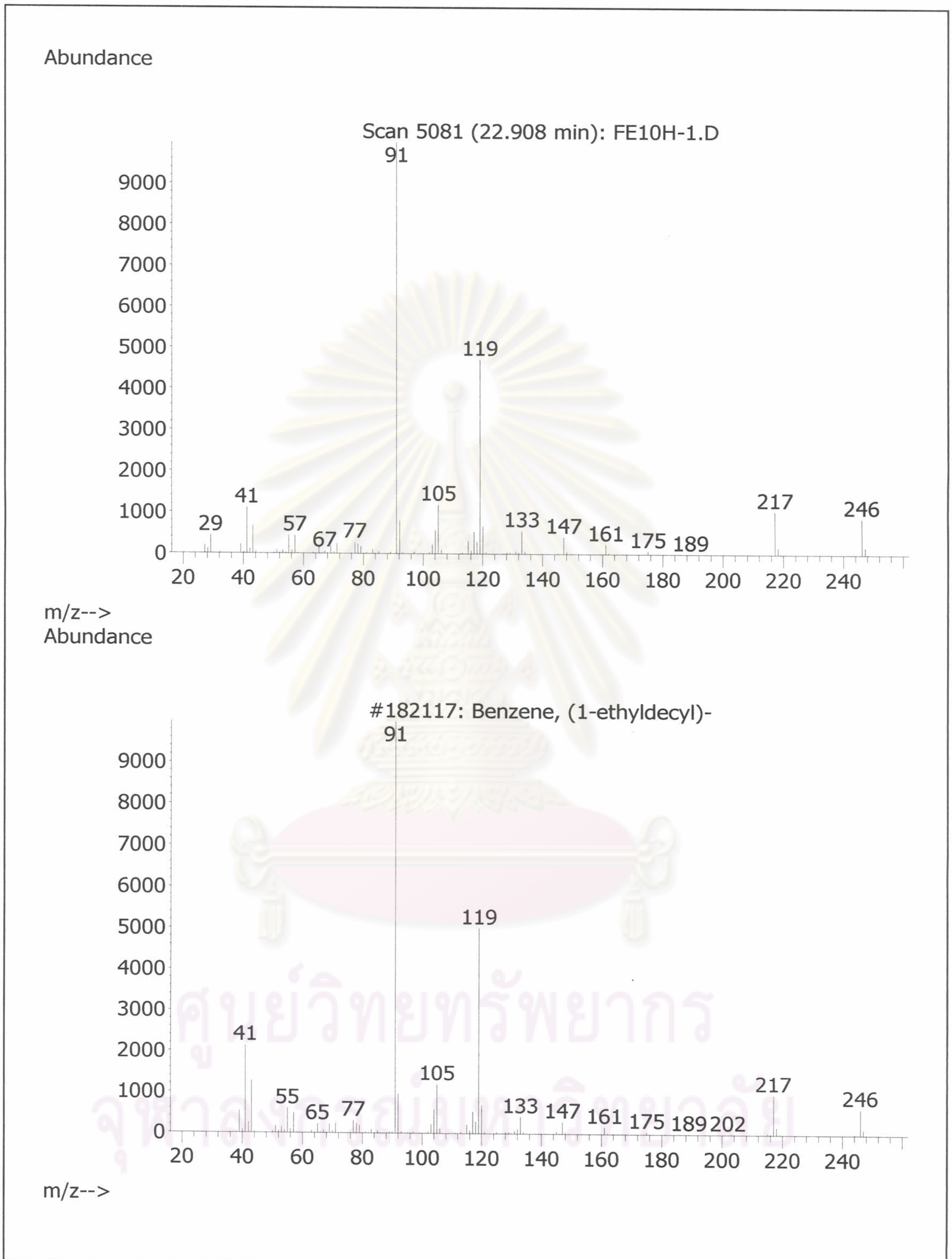

Figure A-16 Mass spectrum of liquid product at t_R = 22.908s (top) and 3-phenyldodecane in library (bottom).

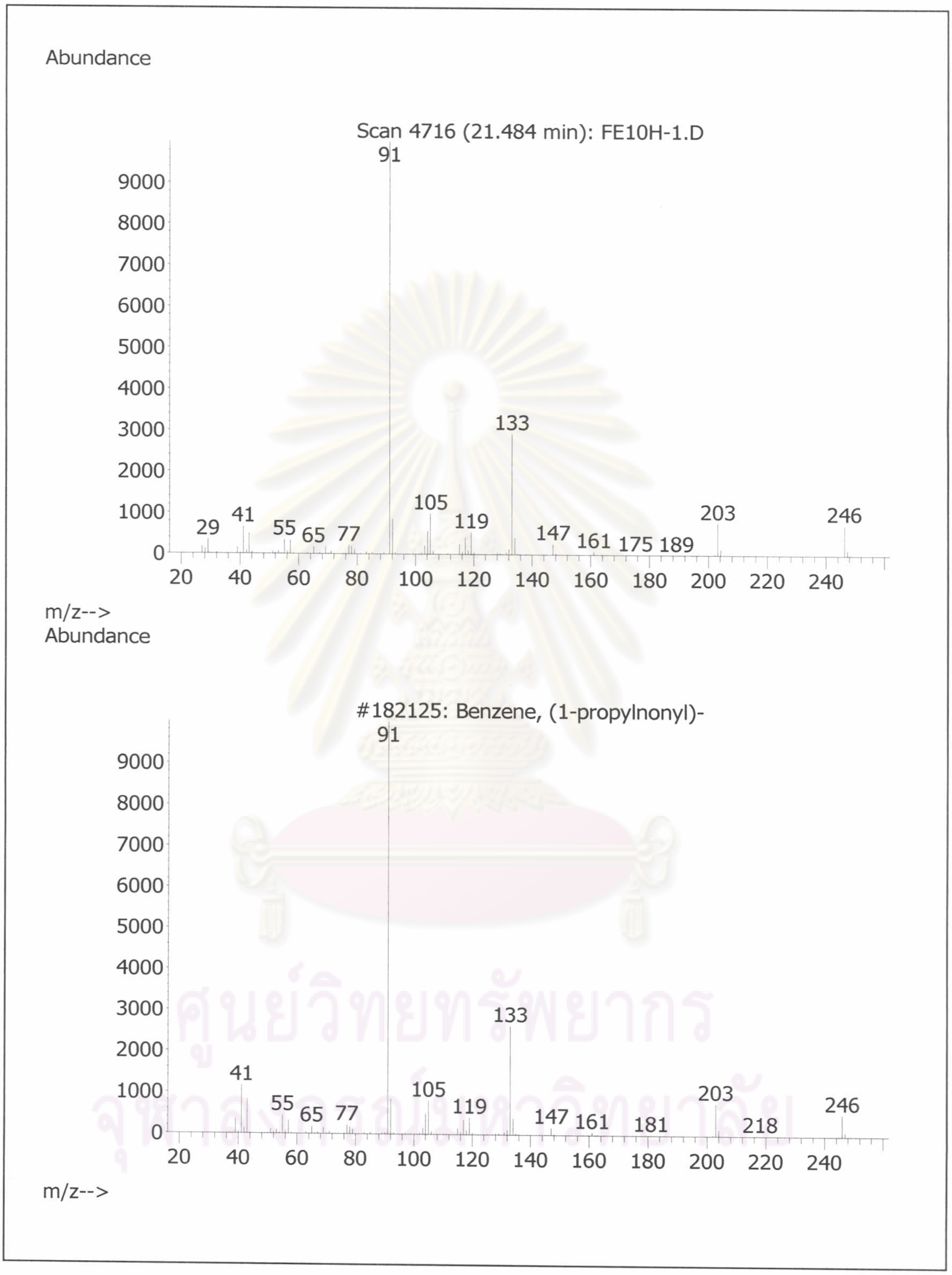

Figure A-17 Mass spectrum of liquid product at t_R = 21.484s (top) and 4-phenyldodecane in library (bottom).

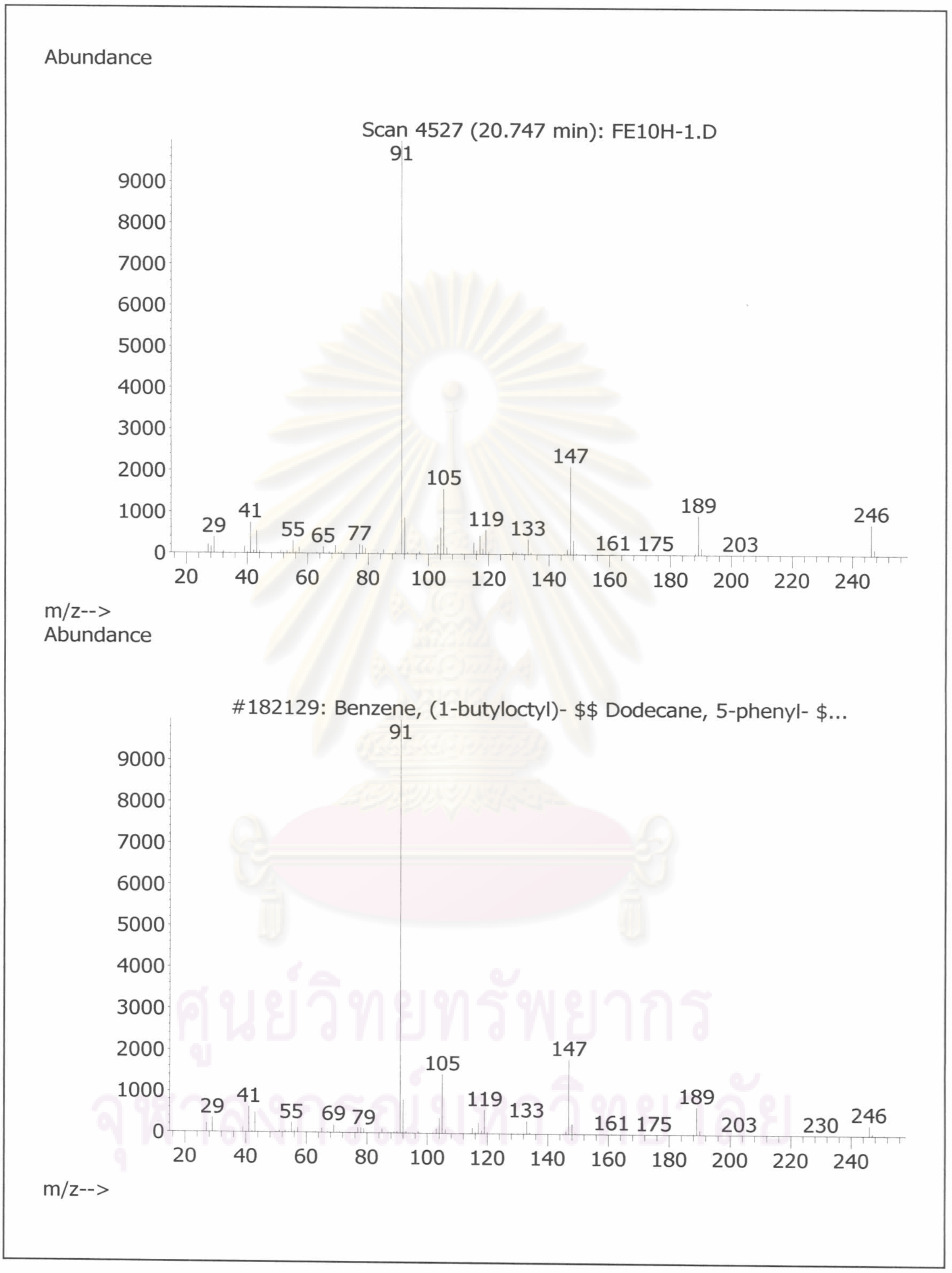

Figure A-18 Mass spectrum of liquid product at t_R = 20.747s (top) and 5-phenyldodecane in library (bottom).

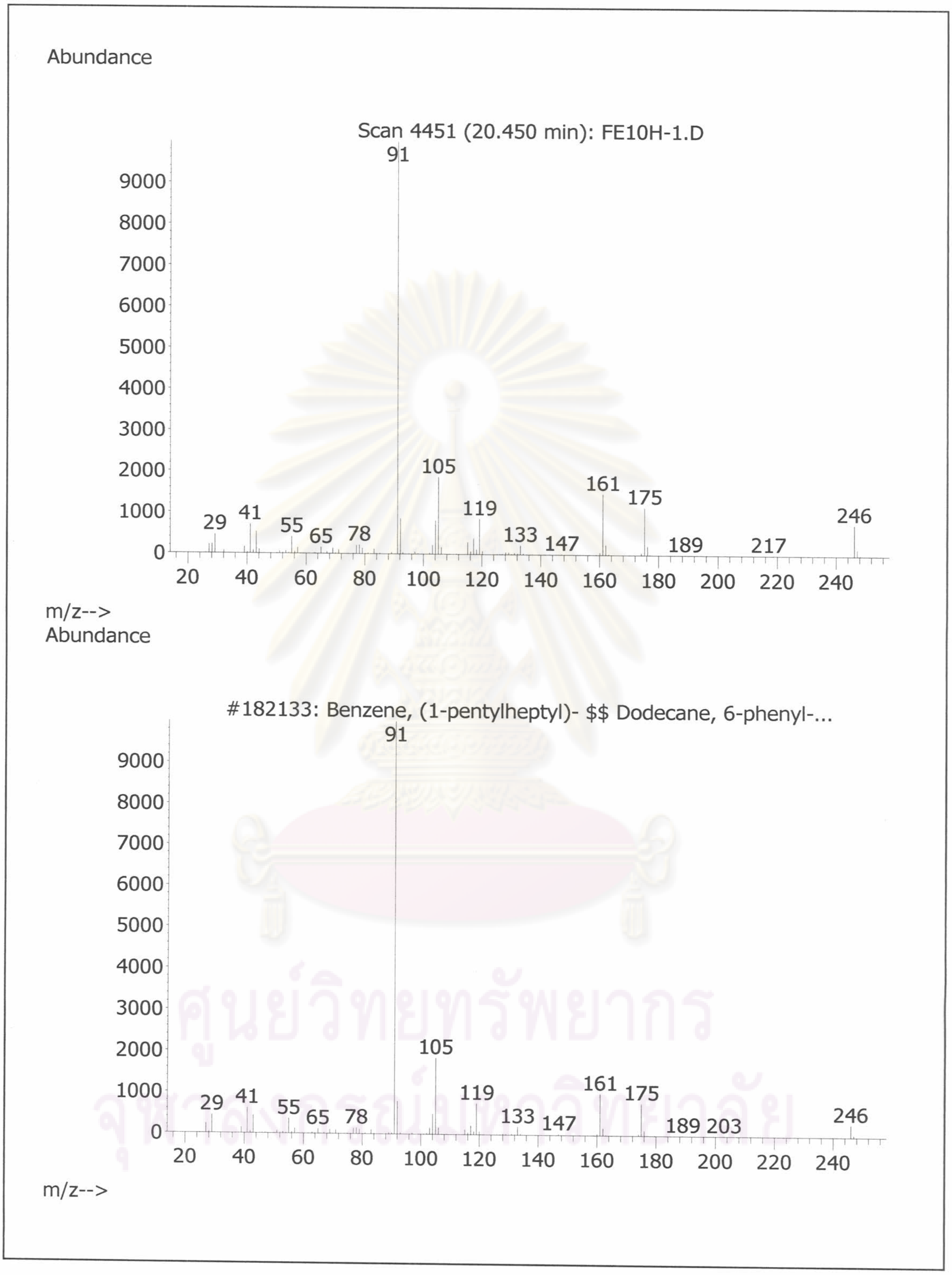

Figure A-19 Mass spectrum of liquid product at t_R = 20.450s (top) and 6-phenyldodecane in library (bottom).

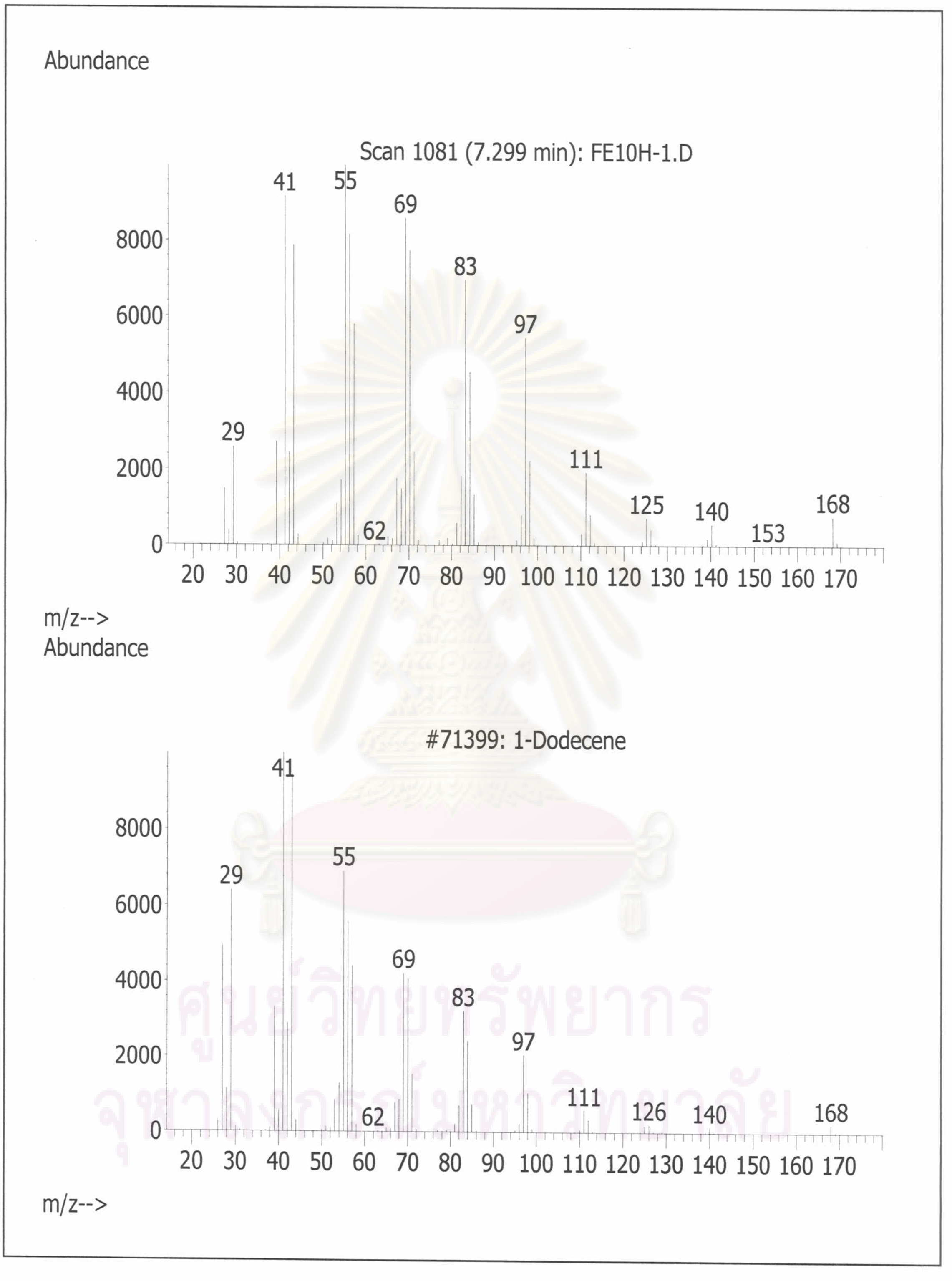

Figure A-20 Mass spectrum of liquid product at t_R = 7.30s (top) and 1-dodecane in library (bottom).

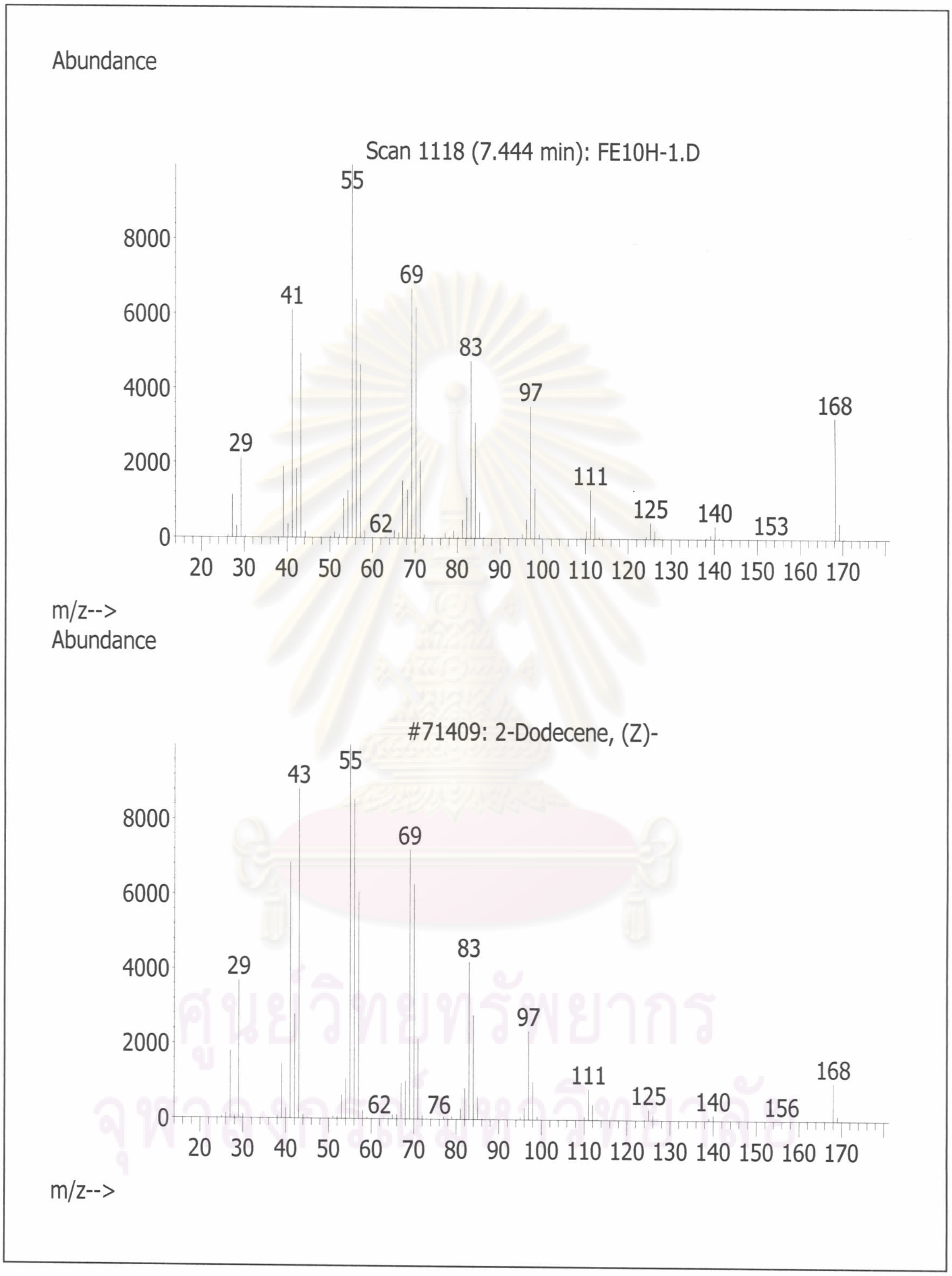

Figure A-21 Mass spectrum of liquid product at t_R = 7.44s (top) and 2-dodecane in library (bottom).

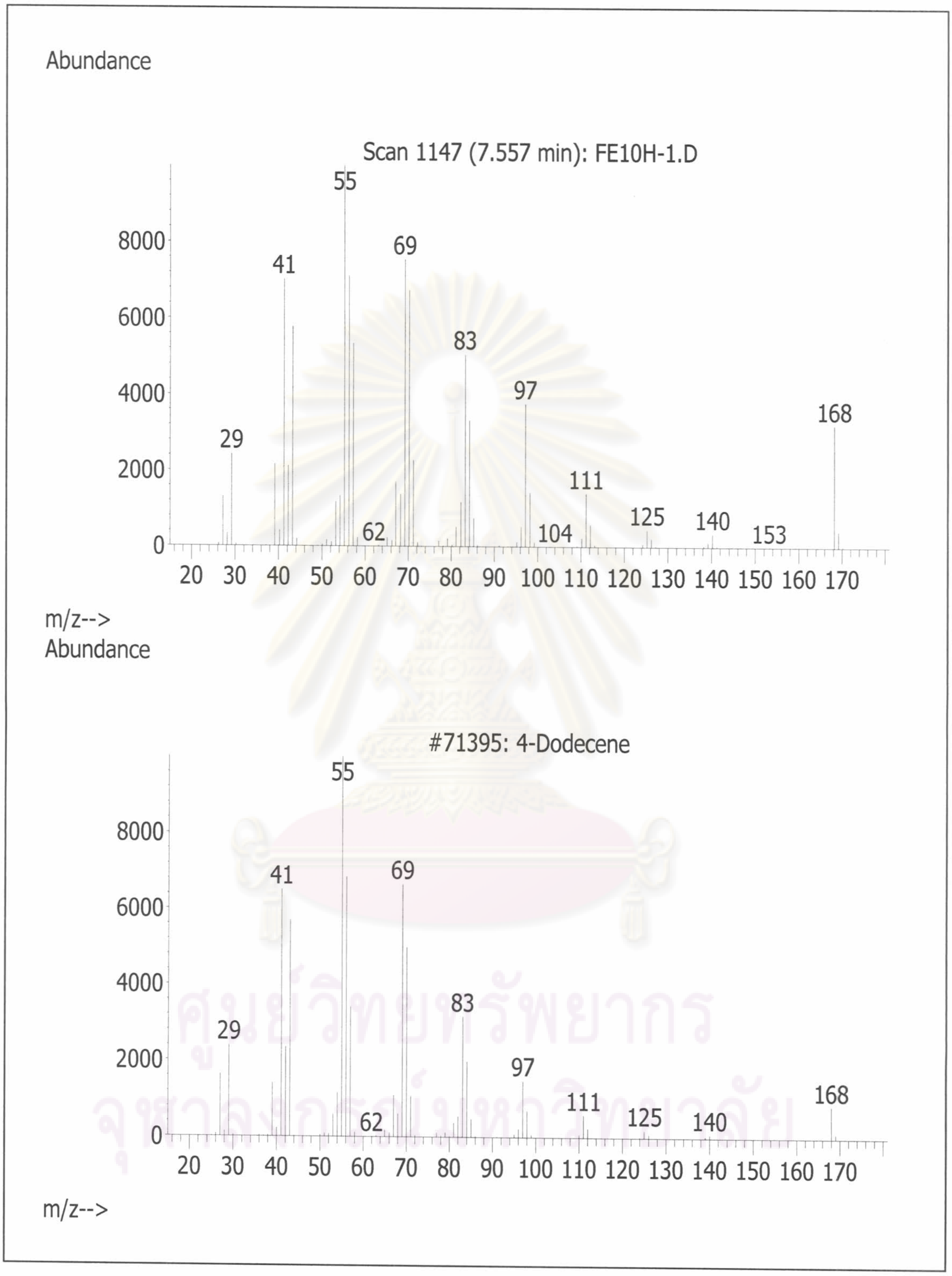

Figure A-22 Mass spectrum of liquid product at t_R = 7.56s (top) and 4-dodecane in library (bottom).

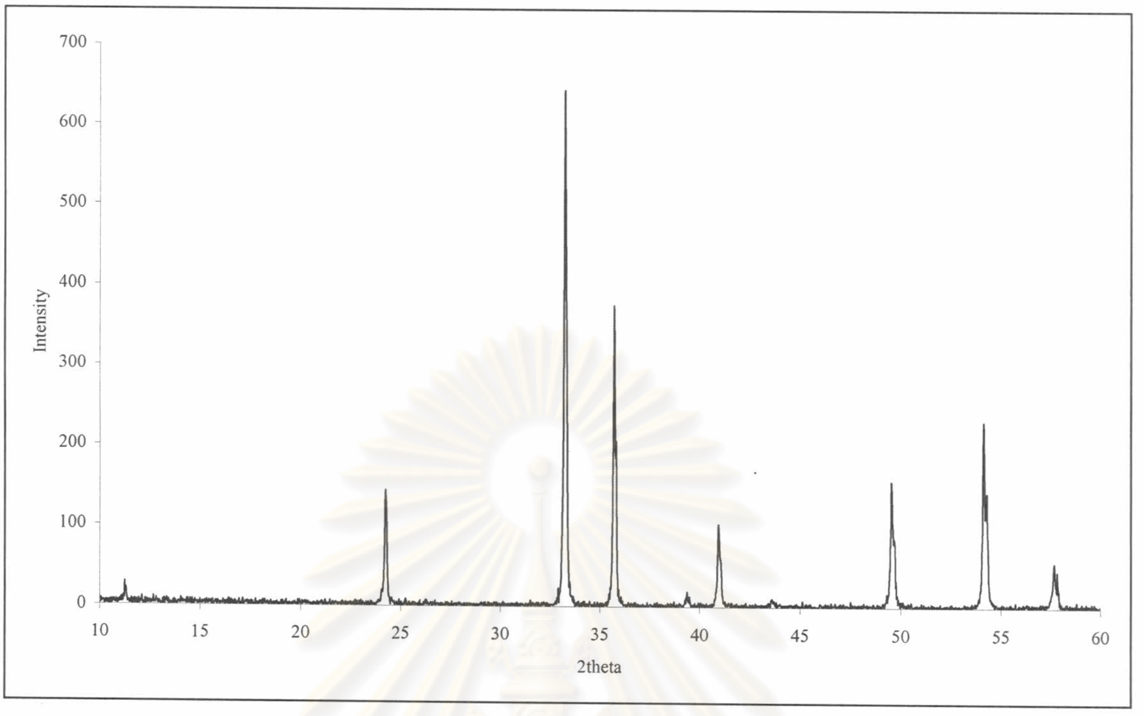

Figure A-23 XRD pattern of iron oxide (Fe_2O_3, hematite)

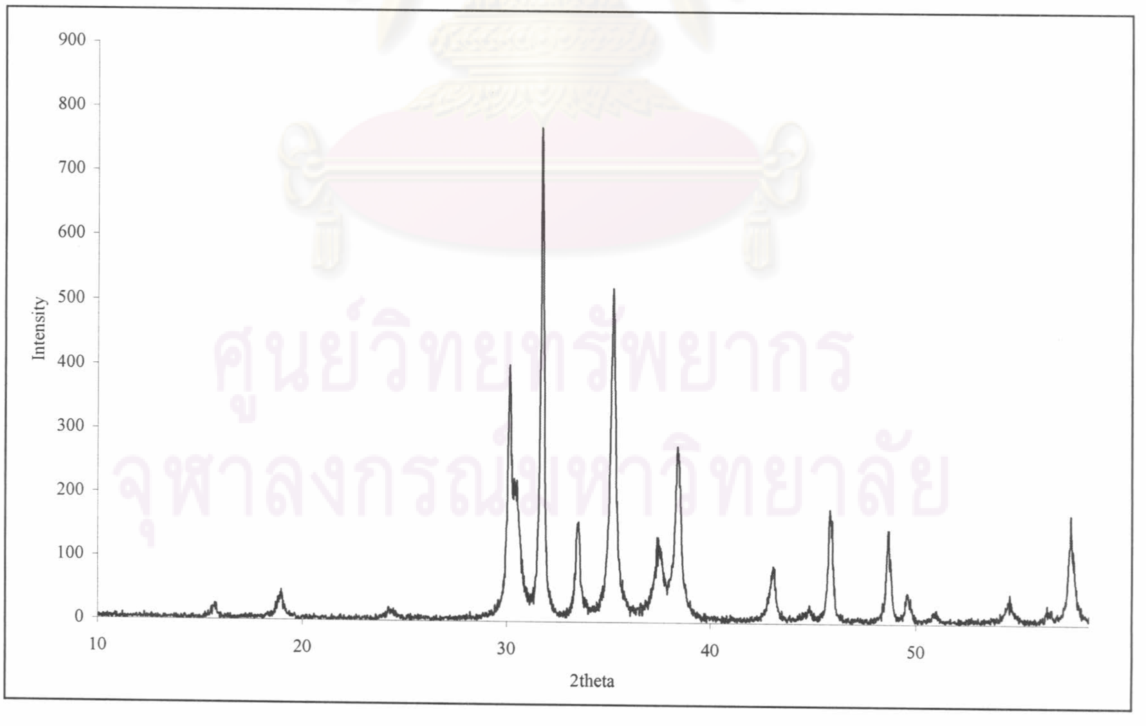

Figure A-24 XRD pattern of gallium oxide (Ga_2O_3).

Table A-1 The d_{001} spacing of hectorites treated with 2M, 5M NaCl and 5M NaOH

Number of exchange	d_{001} (Å)		
	2M NaCl	5M NaCl	5M NaOH
0(Hectorite)	12.29		
1	12.38	13.00	13.11
3	13.33	14.20	14.34
4	-	14.48	15.01
5	12.62	14.67	14.96
6	-	14.40	14.82

Calculation of %Conversion

$$\%\text{conversion} = \frac{A_{\text{before}} - A_{\text{after}}}{A_{\text{before}}} \times 100$$

A_{before} = area of 1-dodecene peak before reaction

A_{after} = area of 1-dodecene peak after reaction

Calculation of %Selectivity

$$\%\text{selectivity} = \frac{\text{mol}_{\text{interest}}}{\text{mol}_{\text{total products}}} \times 100$$

$\text{mol}_{\text{interest}}$ = mol of interested product

$\text{mol}_{\text{total products}}$ = total mol of products

$$\text{mol}_{\text{interest}} = \frac{A_{\text{interest}} \times C_{\text{std}} \times \text{mol}_{\text{std}}}{A_{\text{std}} \times C_{\text{interest}}}$$

A_{interest} = area of interested peak

A_{std} = area of internal standard

C_{std} = carbon effective number of the component in standard

C_{std} = carbon effective number of the component in product

mol_{std} = mol of internal standard

$$mol_{std} = \frac{d \times V \times 10^{-6} \times 1000}{MW}$$

d = density of internal standard (g/cm^3)

V = volume of internal standard (μl)

MW = molecular weight of internal standard

VITAE

Mr. Tanawat Kanjanaboonmalert was born on October 28, 1979 in Bangkok, Thailand. He received a Bachelor Degree of Science in Chemistry from Chulalongkorn University in 2002. Since then, he has been a graduate student in major of Inorganic Chemistry, Faculty of Science, Chulalongkorn University. During his graduate studies towards the Master's Degree, he also receives a teaching assistantship from Department of Chemistry, Faculty of Science in 2003, and a research grant from the Graduate School, Chulalongkorn University. He also joins the international conferences and presents his thesis work in the poster form.

Poster Topics

1. Kanjanaboonmalert, T.; Sukpirom, N.; Chaianansutcharit, S. "SYNTHESIS AND CATALYTIC ACTIVITY OF IRON OXIDES PILLARED HECTORITE", the 30th Congress on Science and Technology of Thailand, Bangkok, Thailand, 2004.

2. Kanjanaboonmalert, T.; Sukpirom, N.; Chaianansutcharit, S. "ALKYLATION OF BENZENE WITH 1-DODECENE OVER Fe-PILLARED CLAYS", the International Conference on Smart Materials-'04 (Smart/Intelligent Materials and Nanotechnology) Faculty of Science, Chiang Mai University, Chiang Mai, Thailand, 2004.