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APPENDICES

Appendix A Calculation for Molar Concentration of Nitric Acid

From; $$M = \frac{\% \times 10 \times d}{Mw} \quad \text{(A1)}$$

Where,

M = molar concentration, M

% = percentage of nitric acid, %

d = density of nitric acid, g/cm^3

Mw = molecular weight of nitric acid, g/mol

70 % of nitric acid; $$M = \frac{\% \times 10 \times d}{Mw}$$

$$= \frac{70 \times 10 \times 1.41}{63.01}$$

$$= 15.66$$

From; $$M_1V_1 = M_2V_2 \quad \text{(A2)}$$

where,

V_1, V_2 = volume of nitric acid, cm^3

10 cm^3 of 10 M nitric acid; $15.66 \times V_1 = 10 \times 10$

$$V_1 = 6.39$$

6.39 cm^3 of 70 % (15.66 M) nitric acid was mixed with 3.61 cm^3 of deionized water to obtain 10 cm^3 of 10 M nitric acid.

Appendix B N$_2$ Adsorption/desorption Isotherms at -196 °C

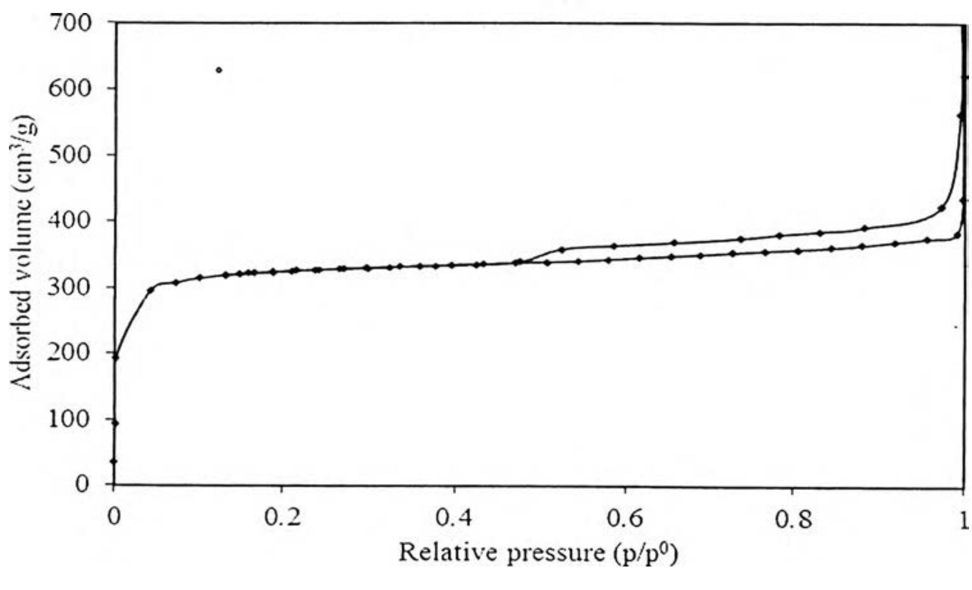

Figure B1 N$_2$ adsorption/desorption isotherm of AC.

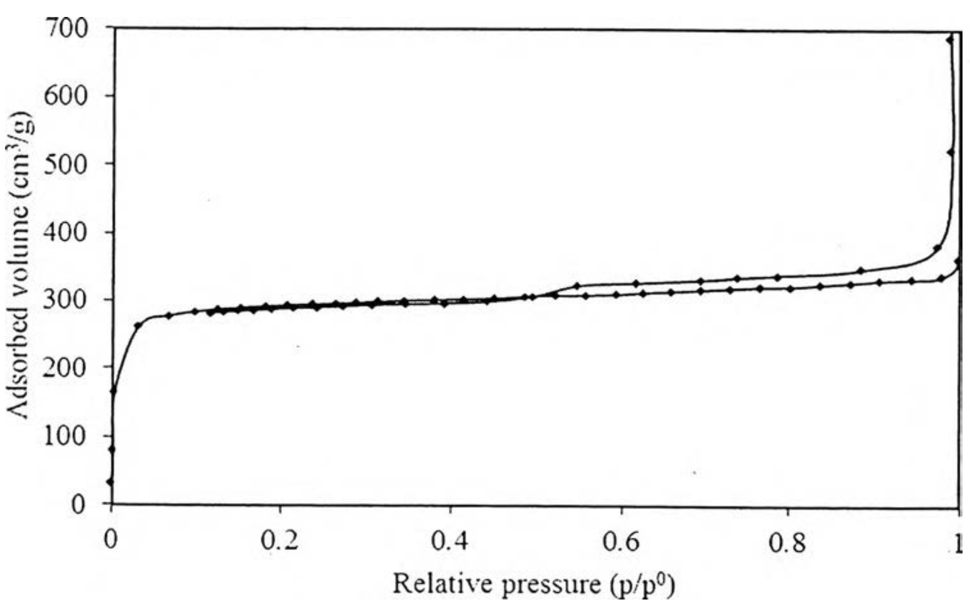

Figure B2 N$_2$ adsorption/desorption isotherm of ACO10-6.

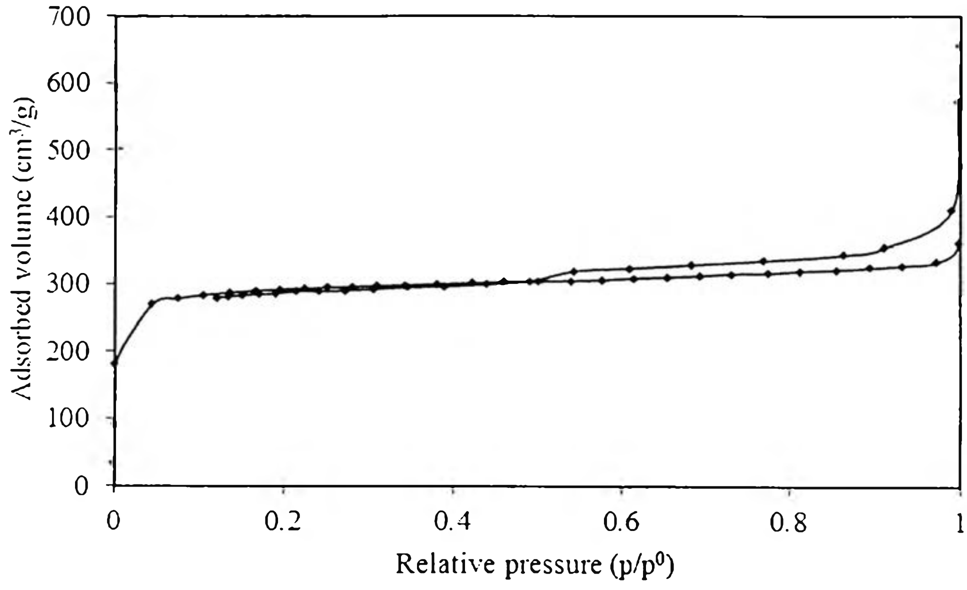

Figure B3 N_2 adsorption/desorption isotherm of ACO10-8.

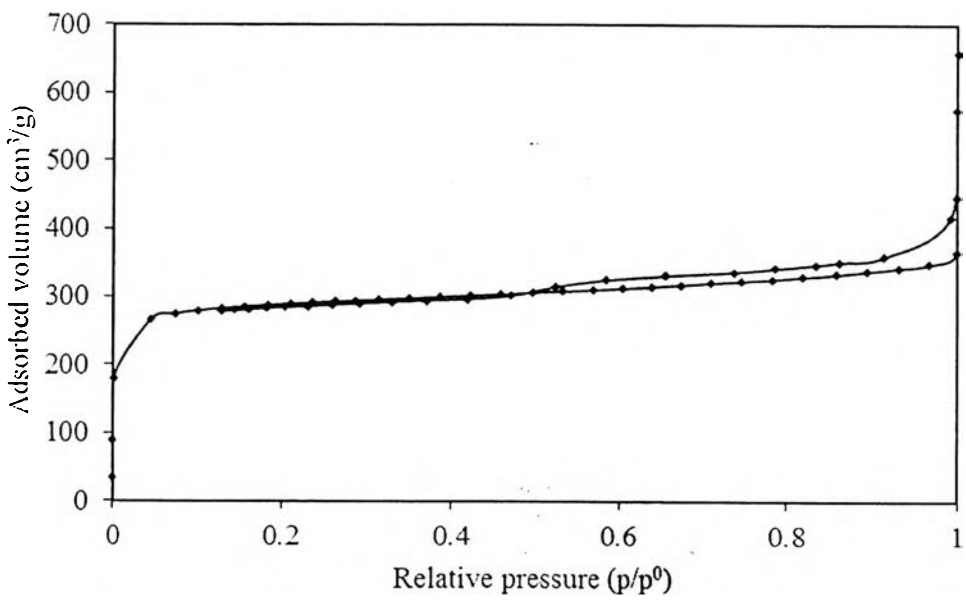

Figure B4 N_2 adsorption/desorption isotherm of ACO10-12.

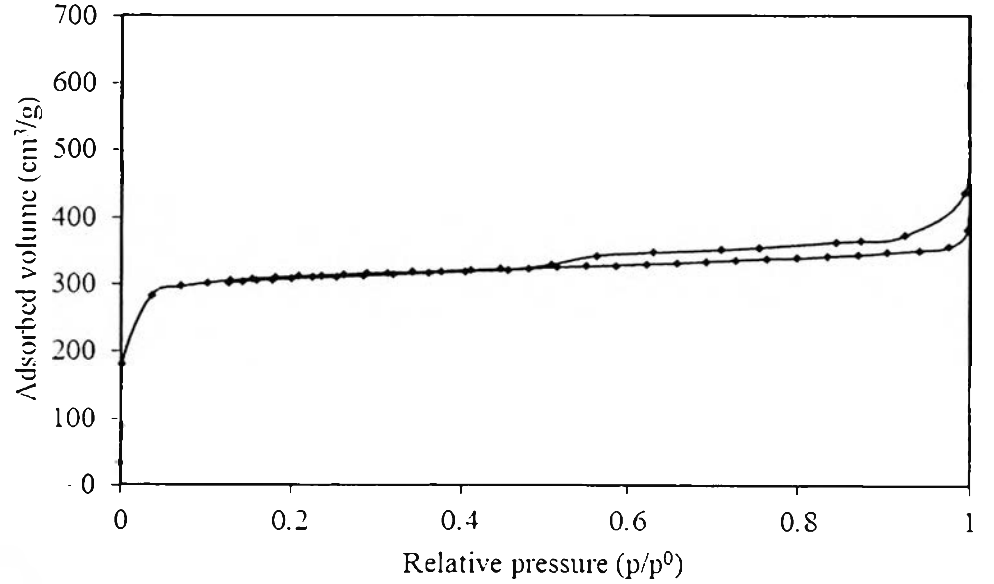

Figure B5 N_2 adsorption/desorption isotherm of ACN400.

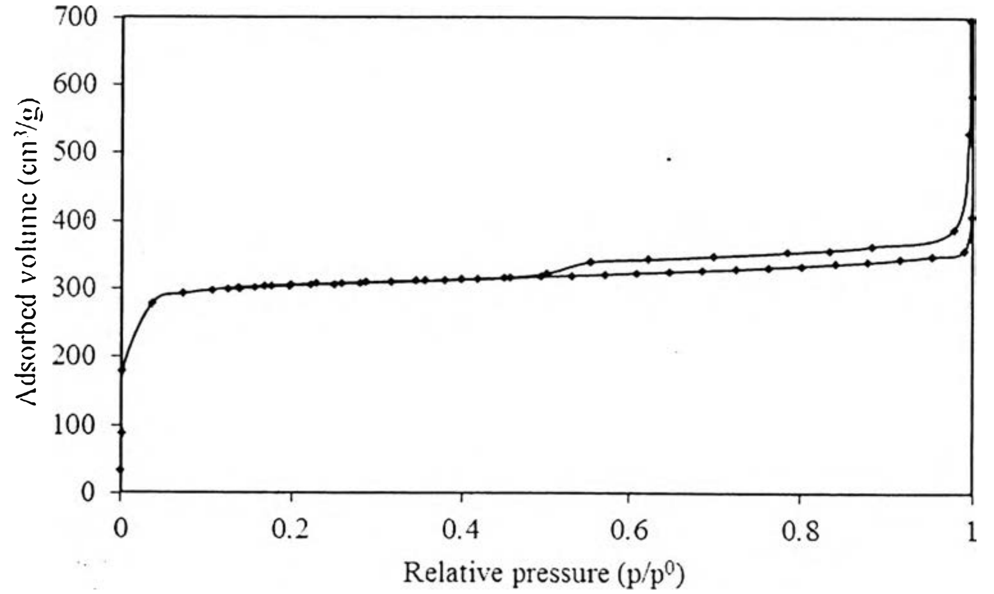

Figure B6 N_2 adsorption/desorption isotherm of ACN600.

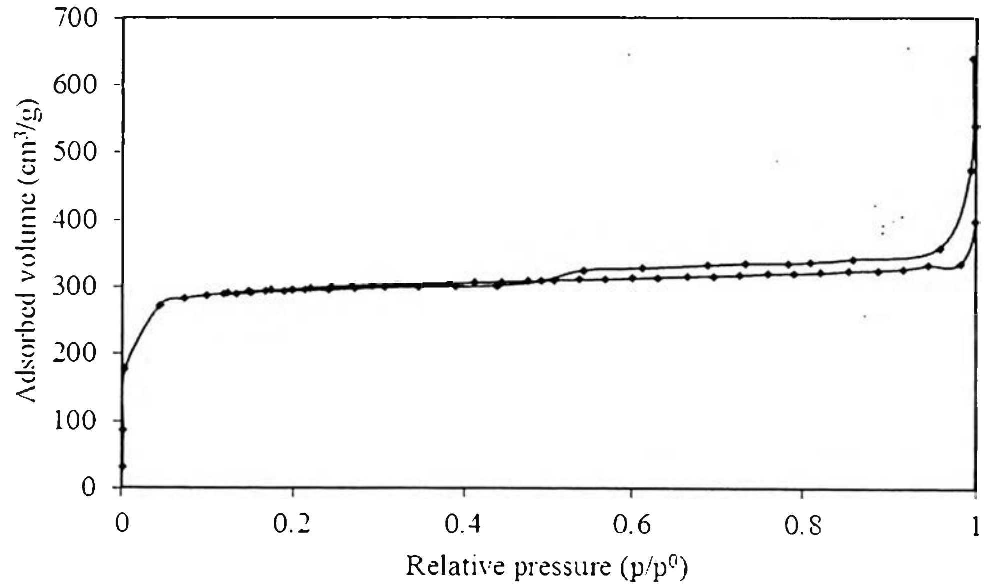

Figure B7 N_2 adsorption/desorption isotherm of ACN800.

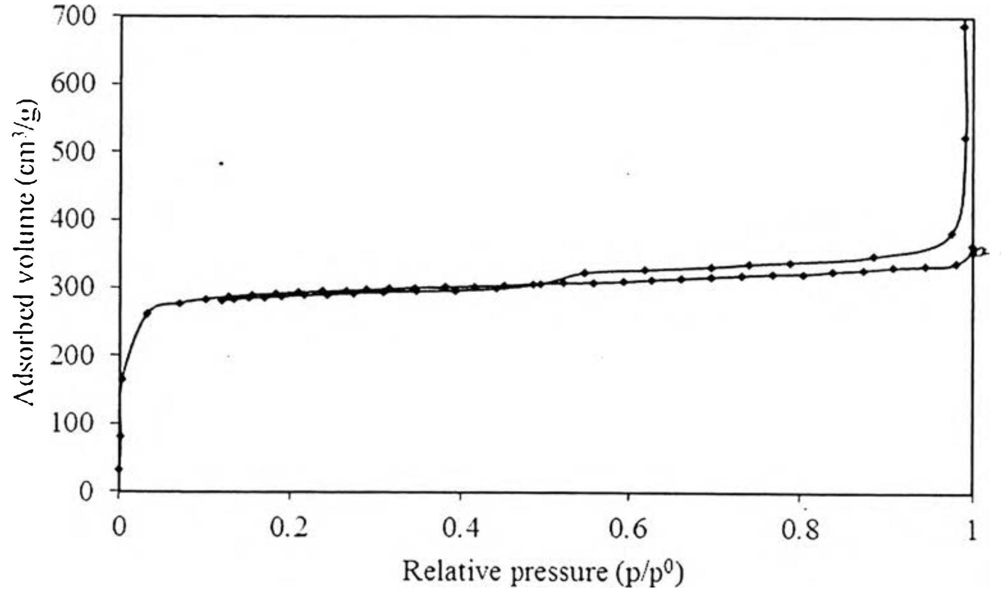

Figure B8 N_2 adsorption/desorption isotherm of ACO10-6/N400.

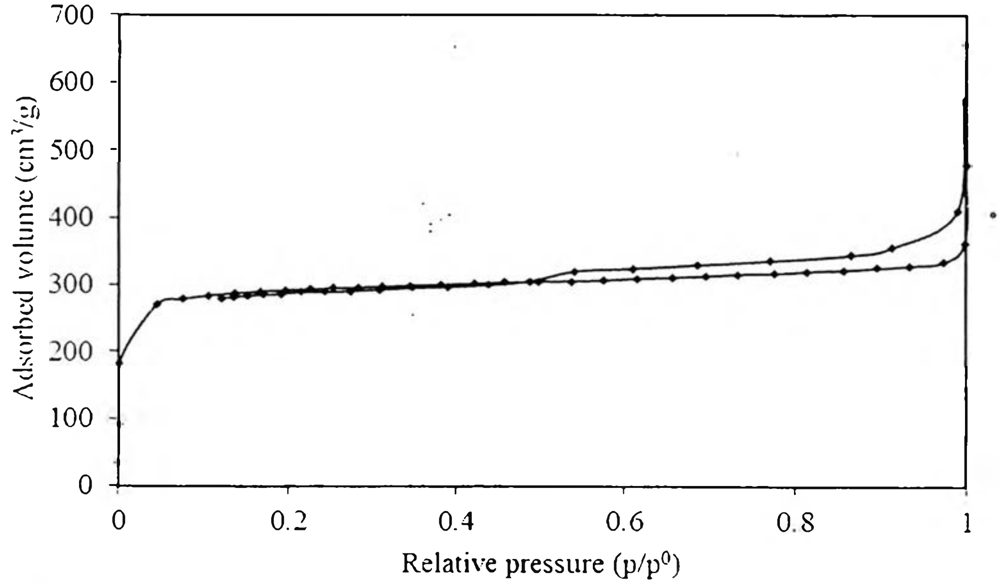

Figure B9 N_2 adsorption/desorption isotherm of ACO10-8/N400.

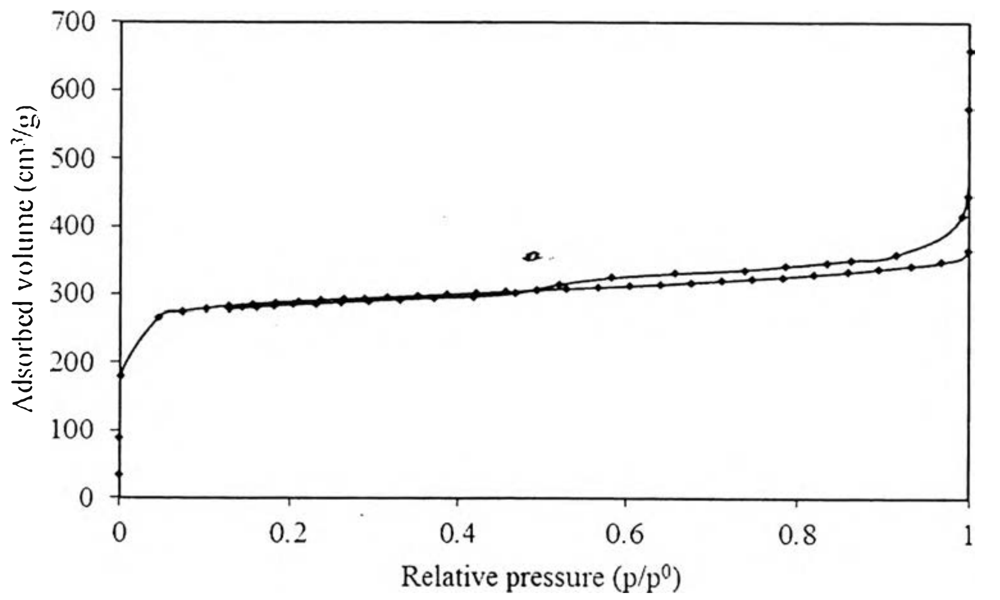

Figure B10 N_2 adsorption/desorption isotherm of ACO10-12/N400.

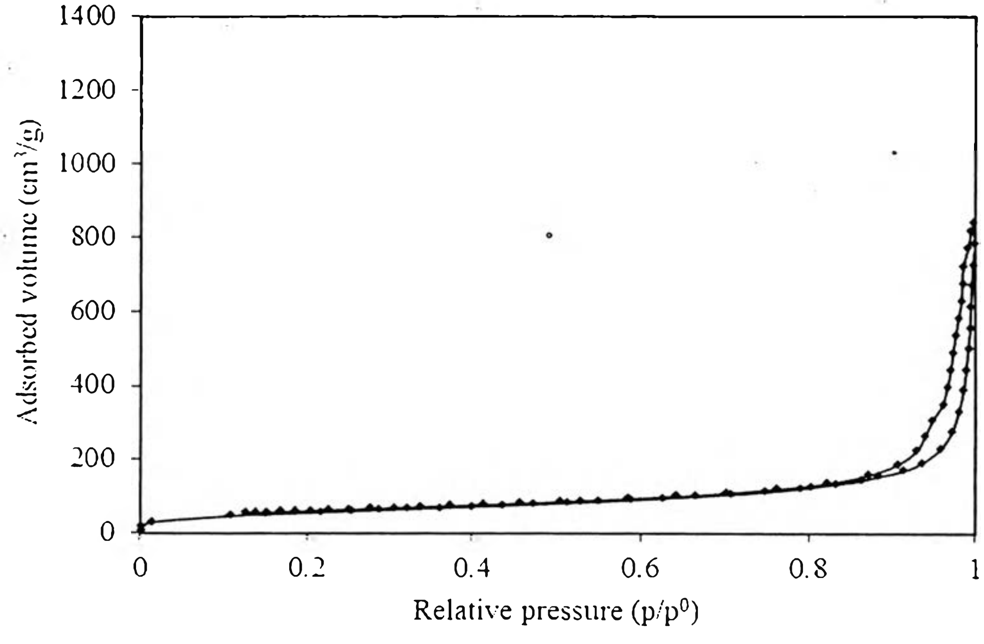

Figure B11 N_2 adsorption/desorption isotherm of CB.

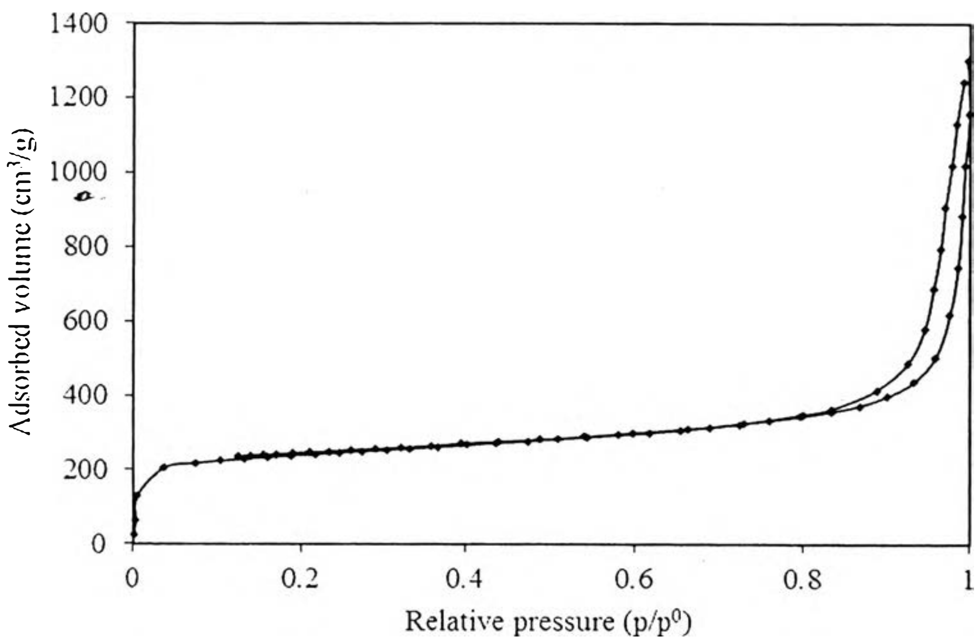

Figure B12 N_2 adsorption/desorption isotherm of ACB.

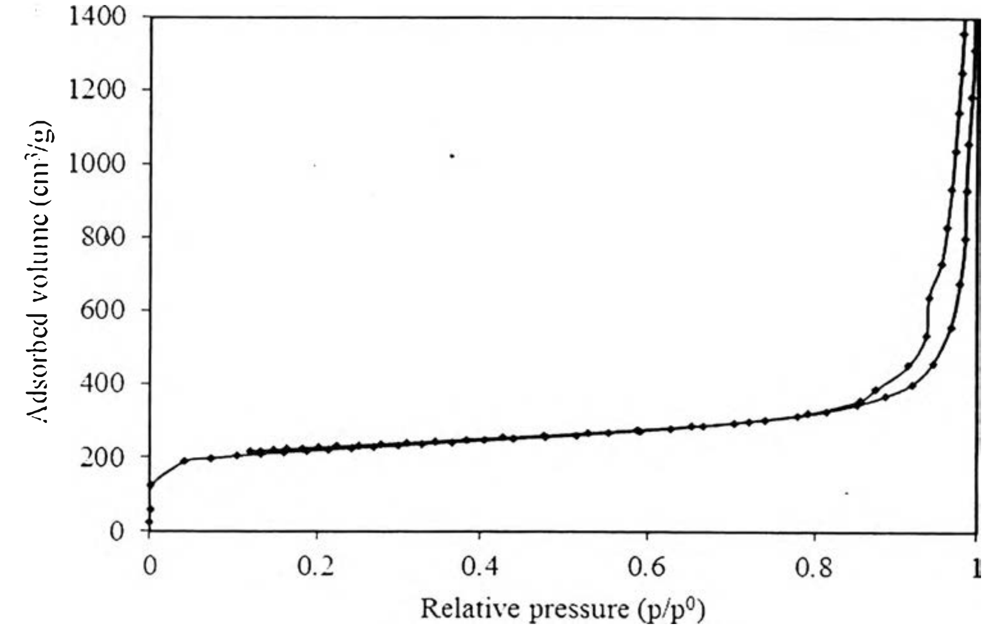

Figure B13 N_2 adsorption/desorption isotherm of ACBO10-12.

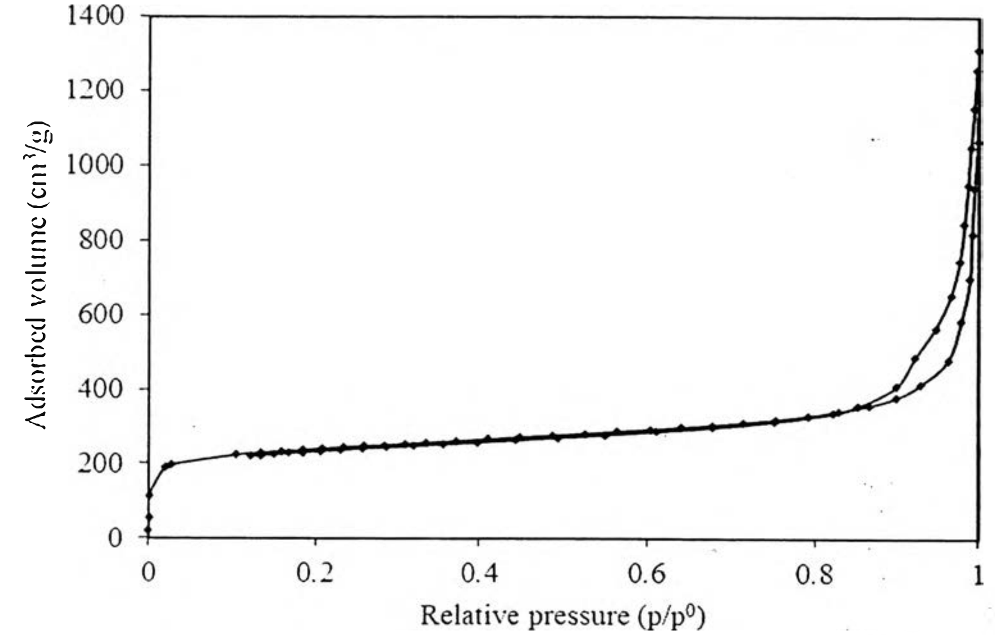

Figure B14 N_2 adsorption/desorption isotherm of ACBN400.

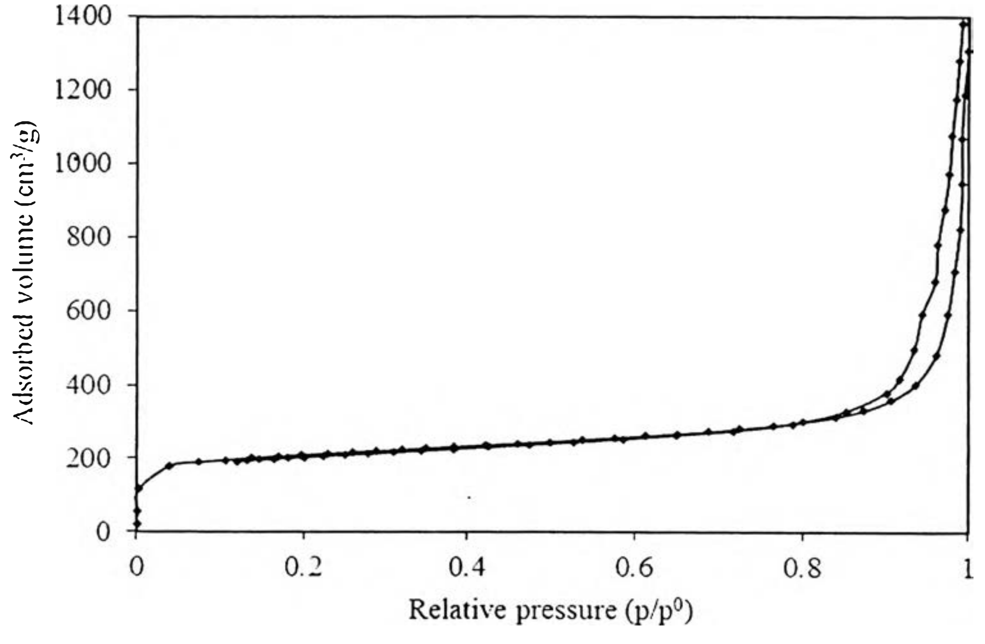

Figure B15 N_2 adsorption/desorption isotherm of ACBO10-12/N400.

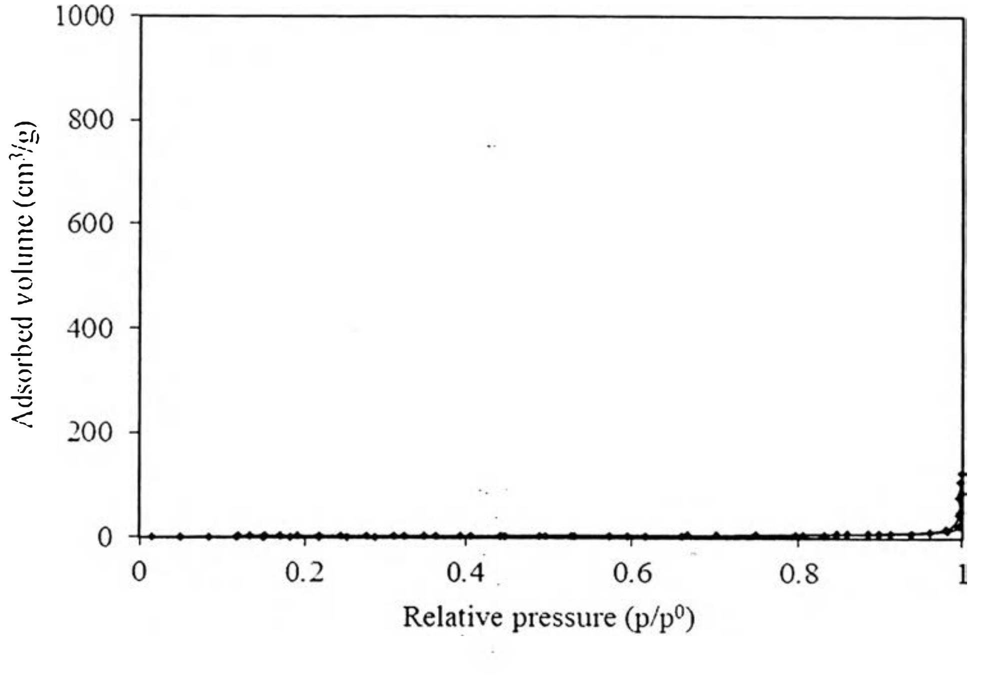

Figure B16 N_2 adsorption/desorption isotherm of CP.

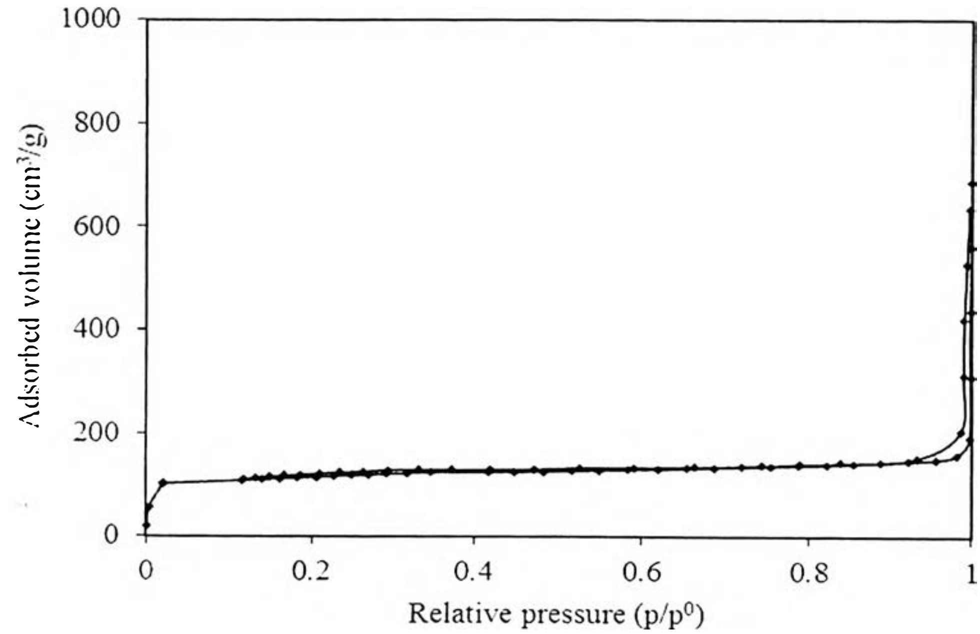

Figure B17 N_2 adsorption/desorption isotherm of ACP.

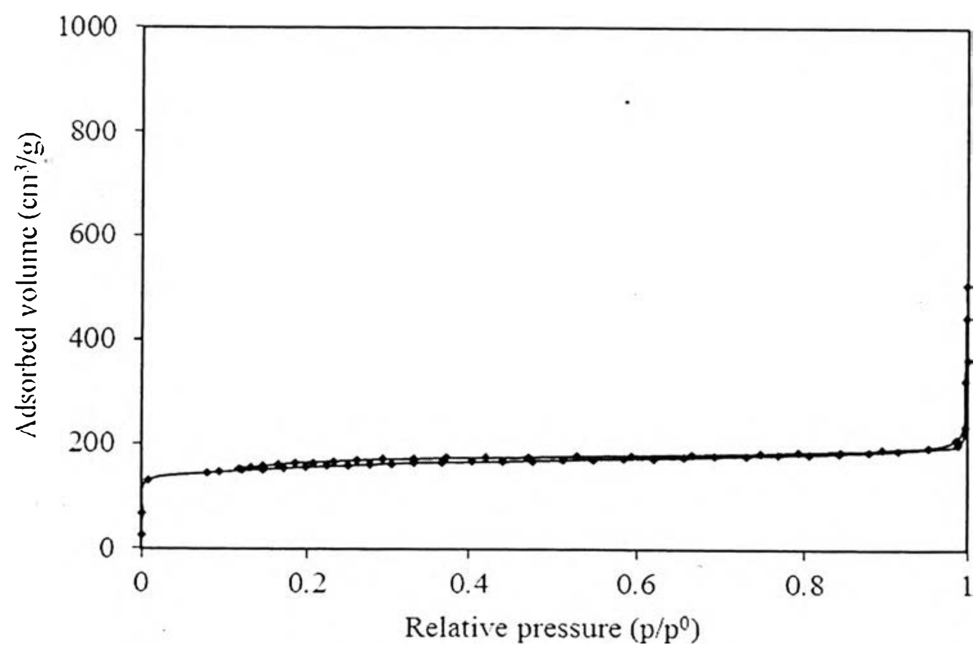

Figure B18 N_2 adsorption/desorption isotherm of ACPO10-12.

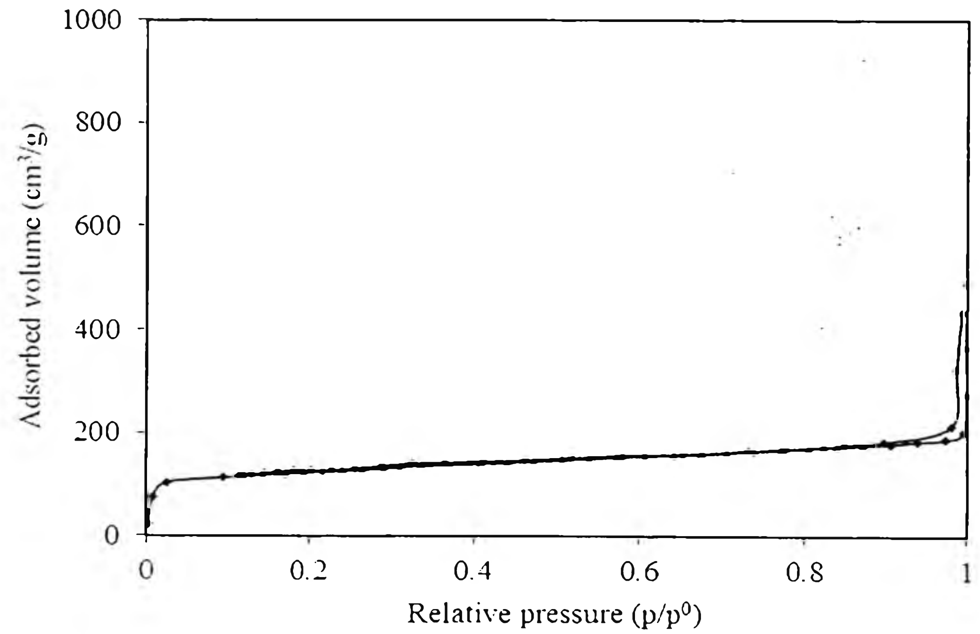

Figure B19 N_2 adsorption/desorption isotherm of ACPN400.

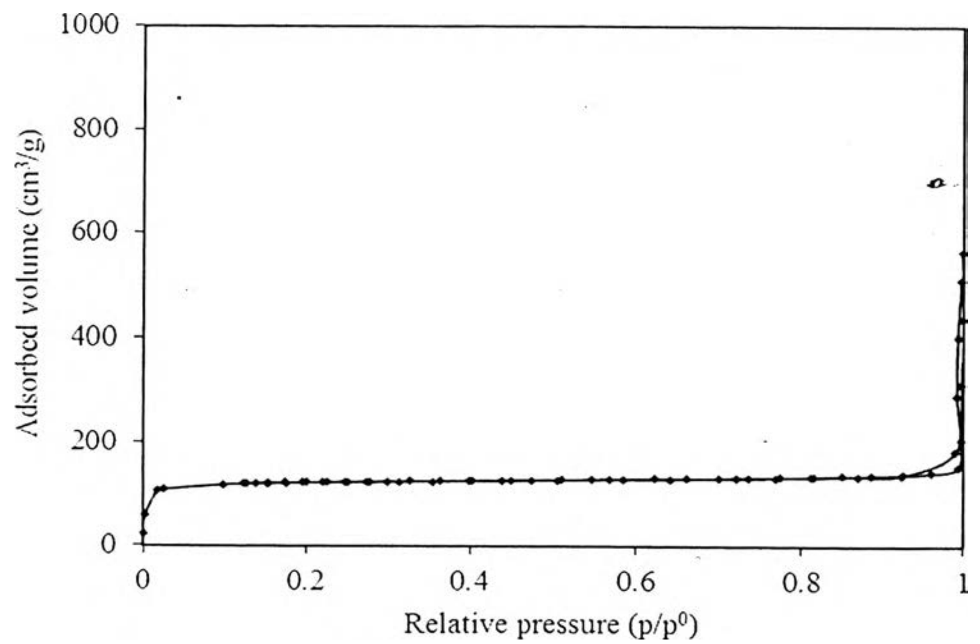

Figure B20 N_2 adsorption/desorption isotherm of ACPO10-12/N400.

Appendix C Pore Size Distribution Calculated by Horvath Kawazoe (HK) Method

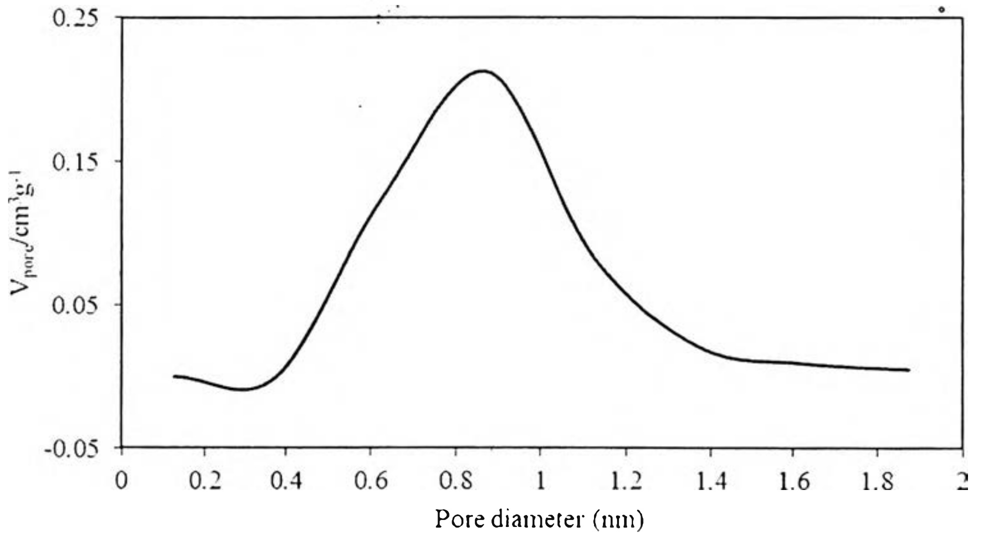

Figure C1 Pore size distribution of AC.

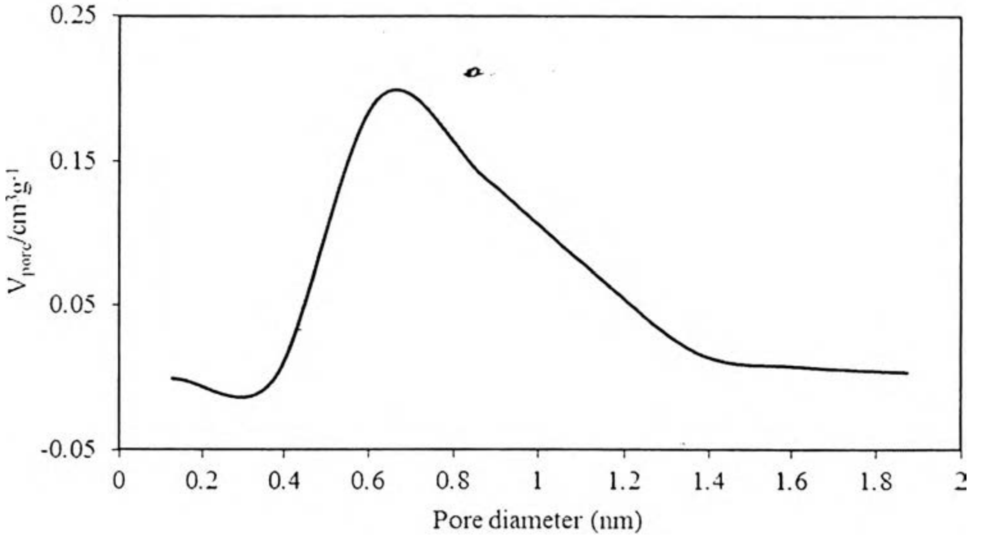

Figure C2 Pore size distribution of ACO10-6.

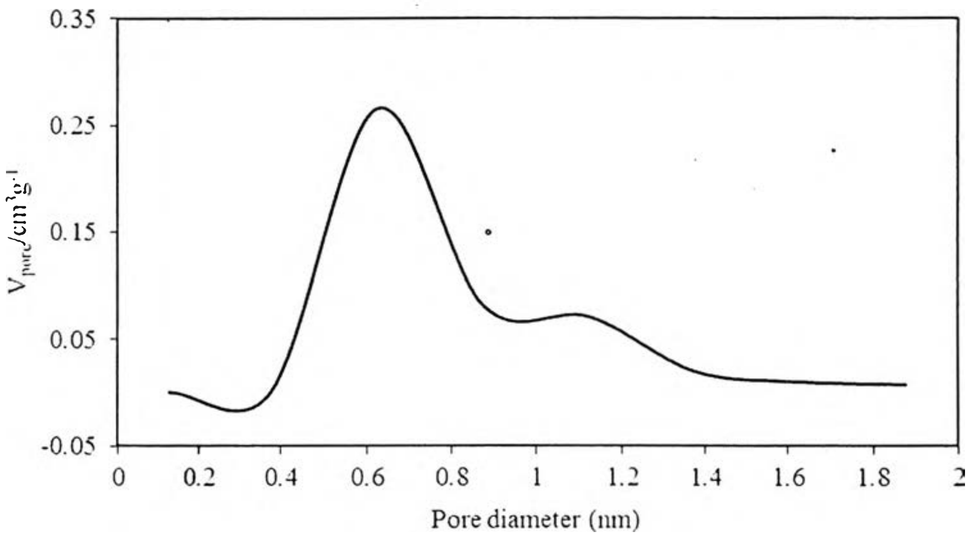

Figure C3 Pore size distribution of ACO10-8.

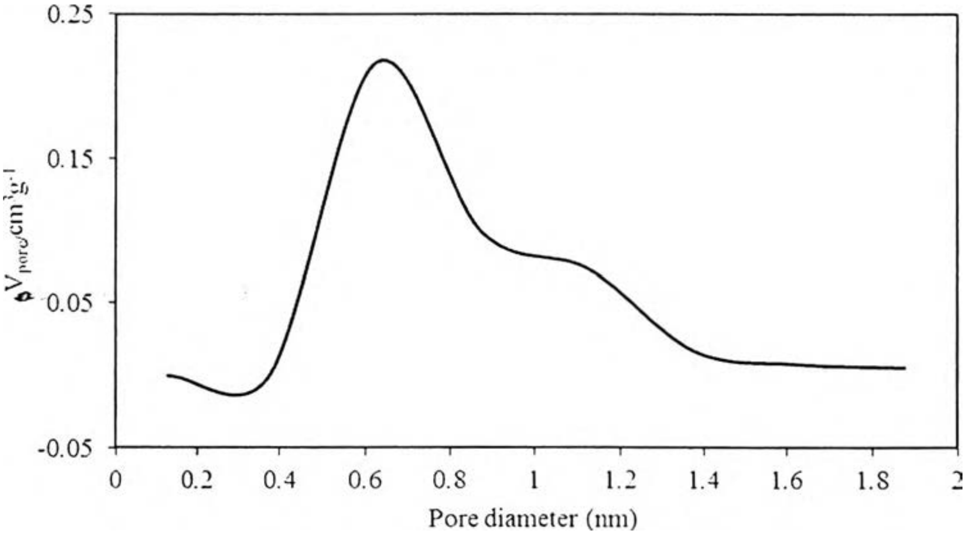

Figure C4 Pore size distribution of ACO10-12.

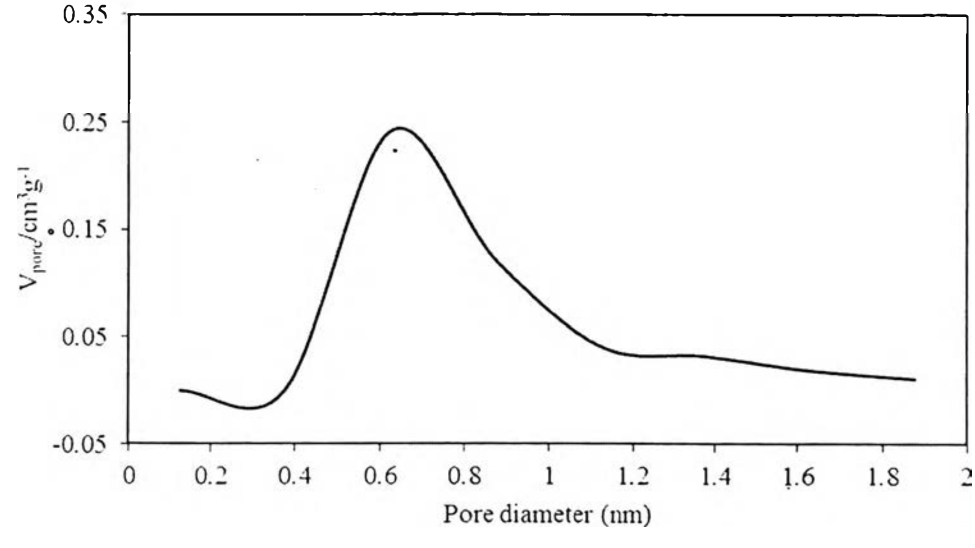

Figure C5 Pore size distribution of ACN400.

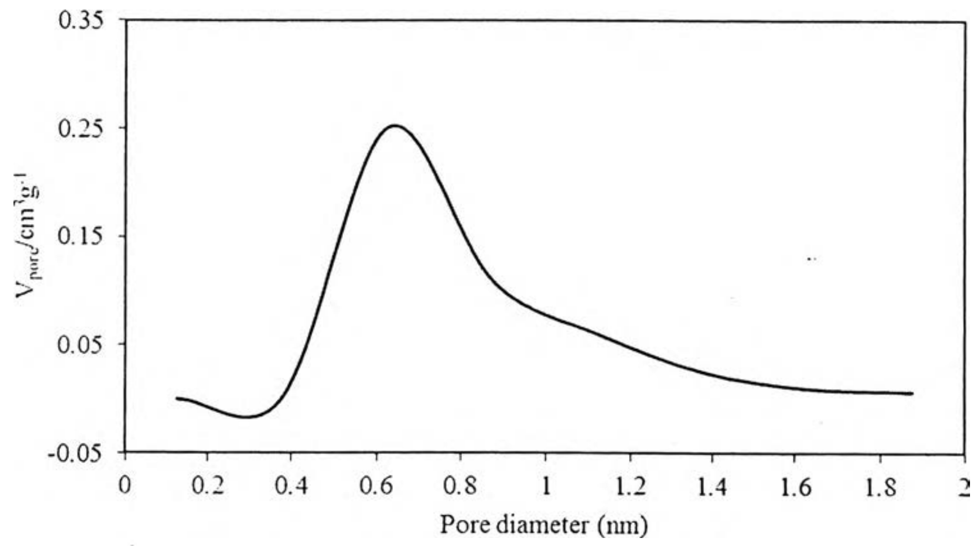

Figure C6 Pore size distribution of ACN600.

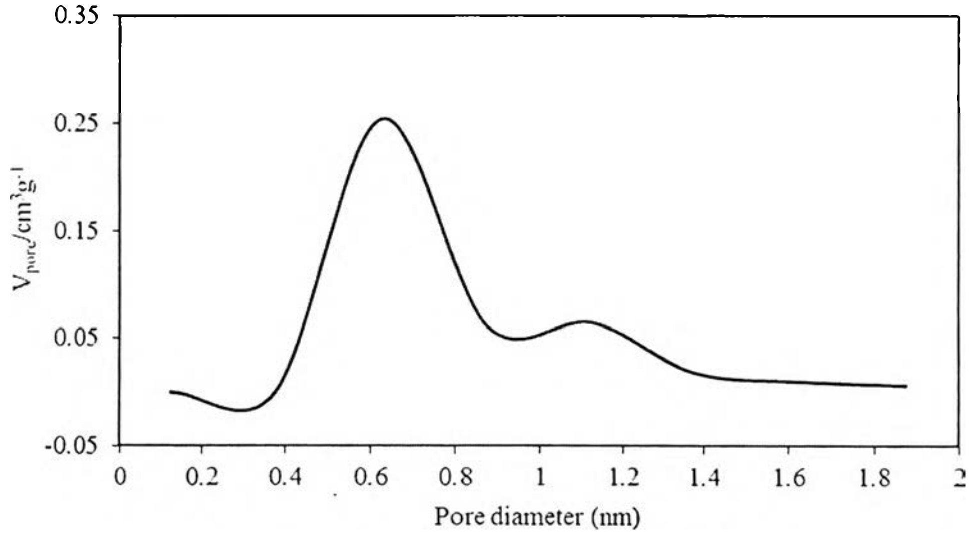

Figure C7 Pore size distribution of ACN800.

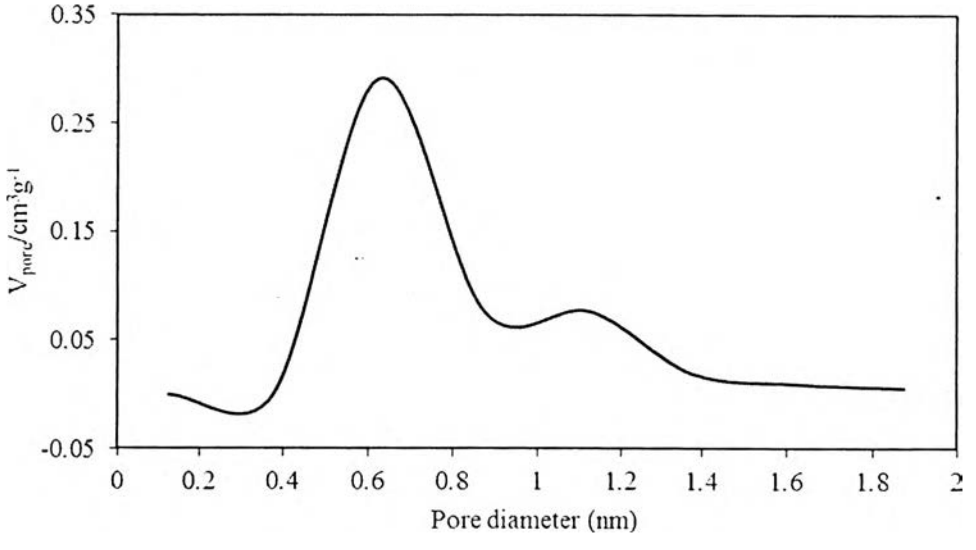

Figure C8 Pore size distribution of ACO10-6/N400.

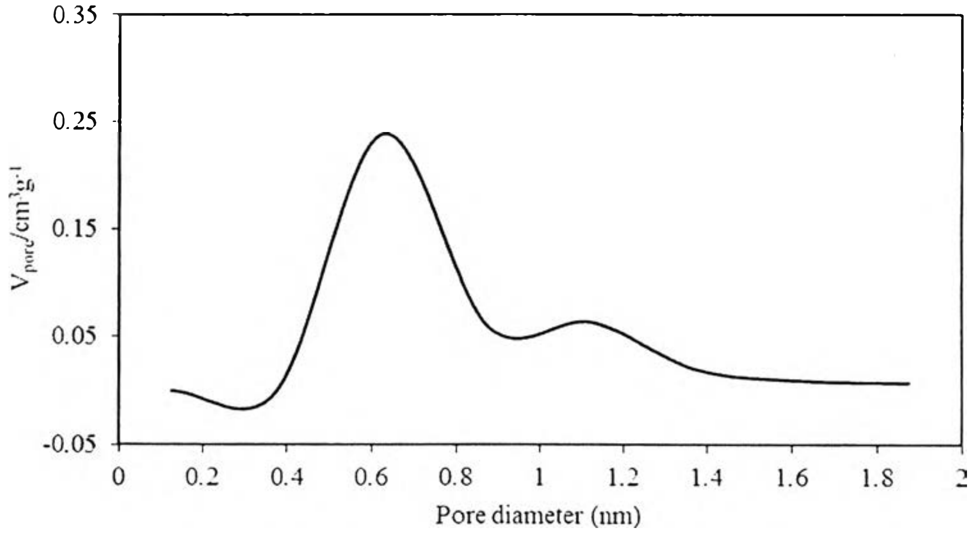

Figure C9 Pore size distribution of ACO10-8/N400.

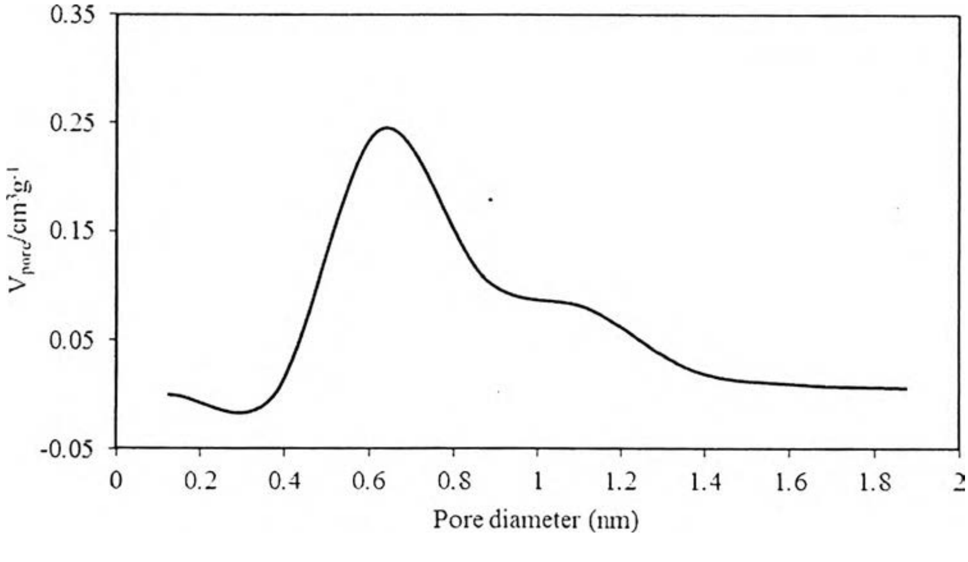

Figure C10 Pore size distribution of ACO10-12/N400.

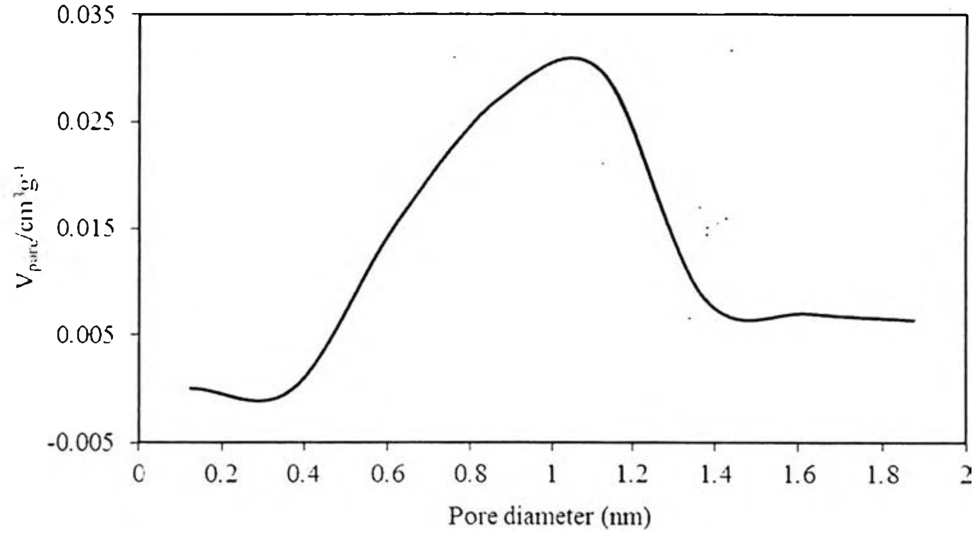

Figure C11 Pore size distribution of CB.

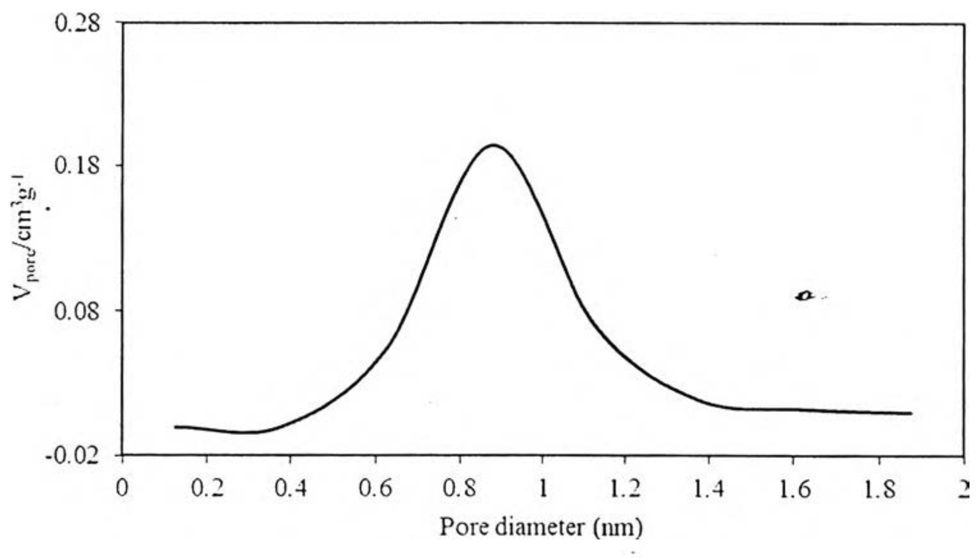

Figure C12 Pore size distribution of ACB.

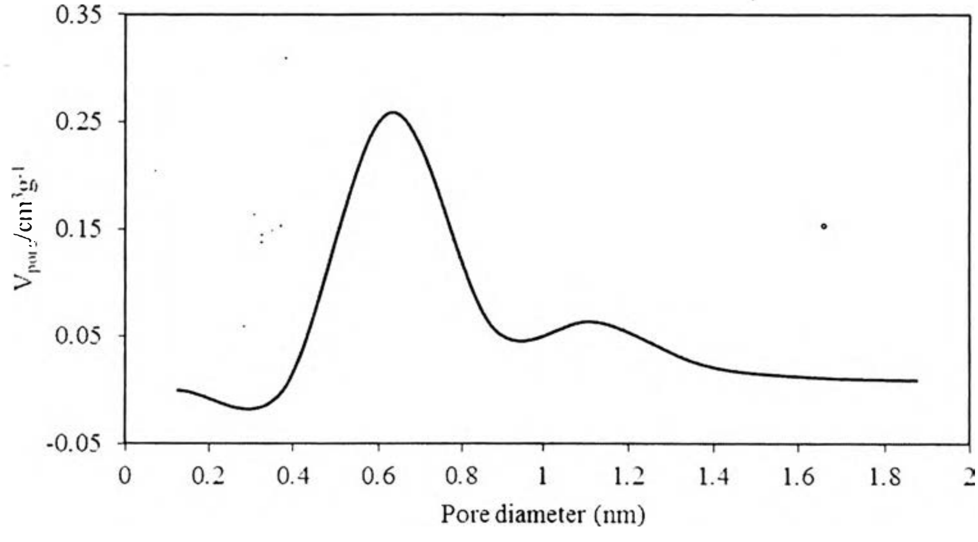

Figure C13 Pore size distribution of ACBO10-12.

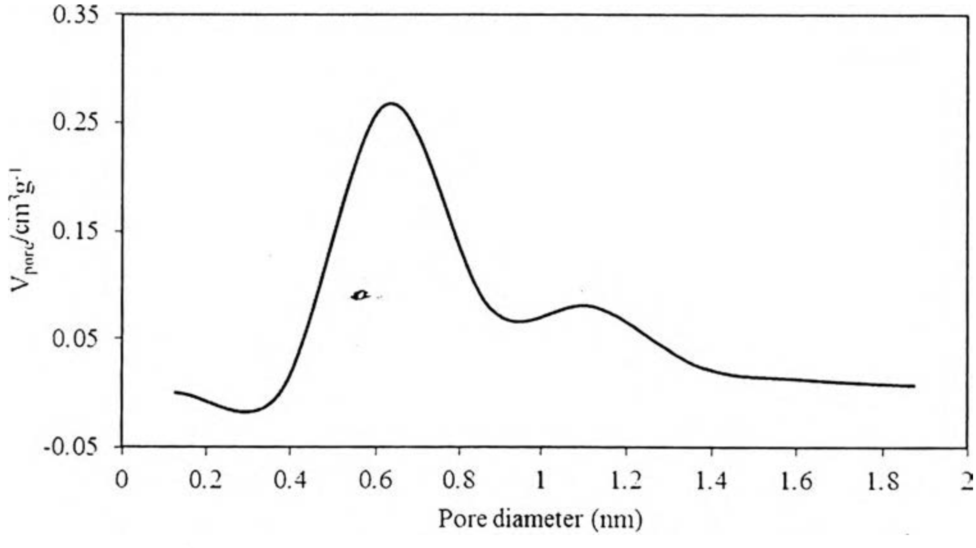

Figure C14 Pore size distribution of ACBN400.

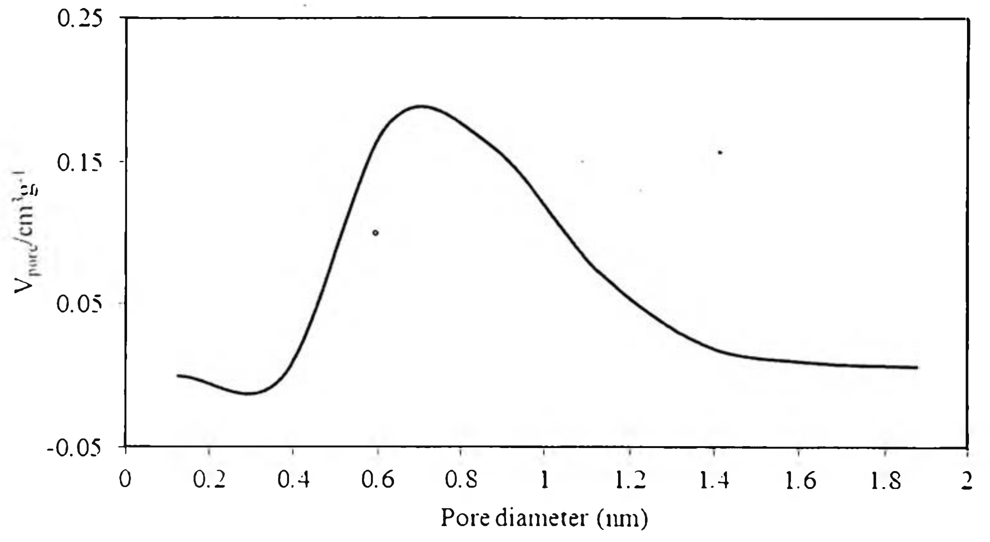

Figure C15 Pore size distribution of ACBO10-12/N400.

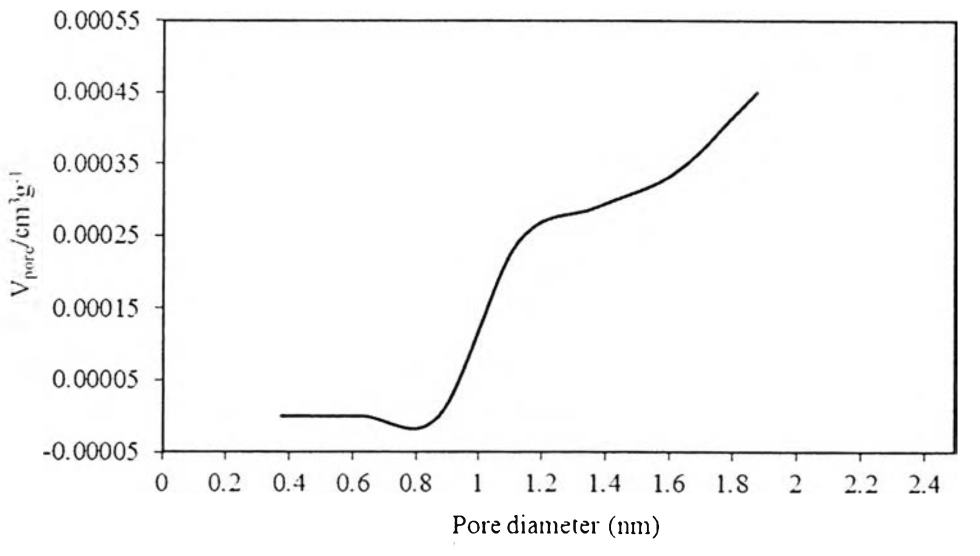

Figure C16 Pore size distribution of CP.

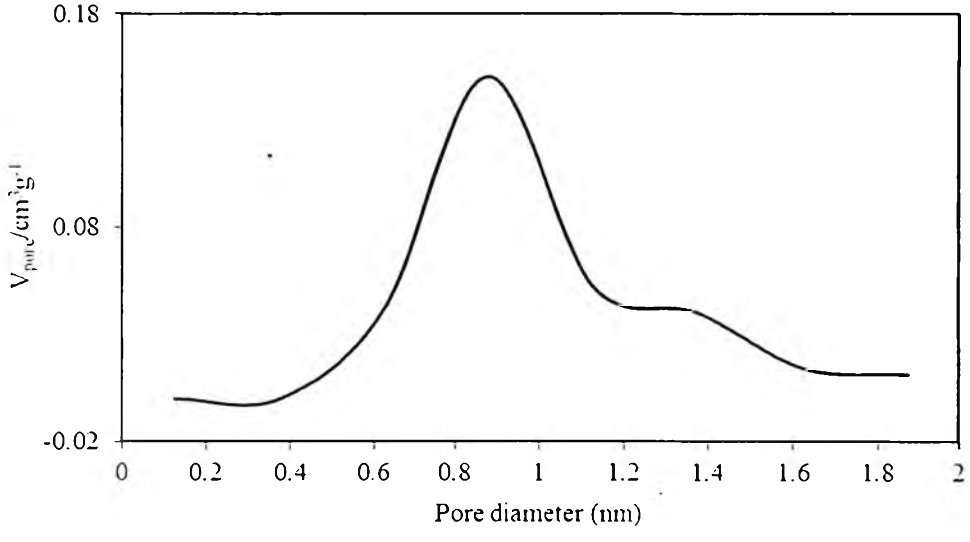

Figure C17 Pore size distribution of ACP.

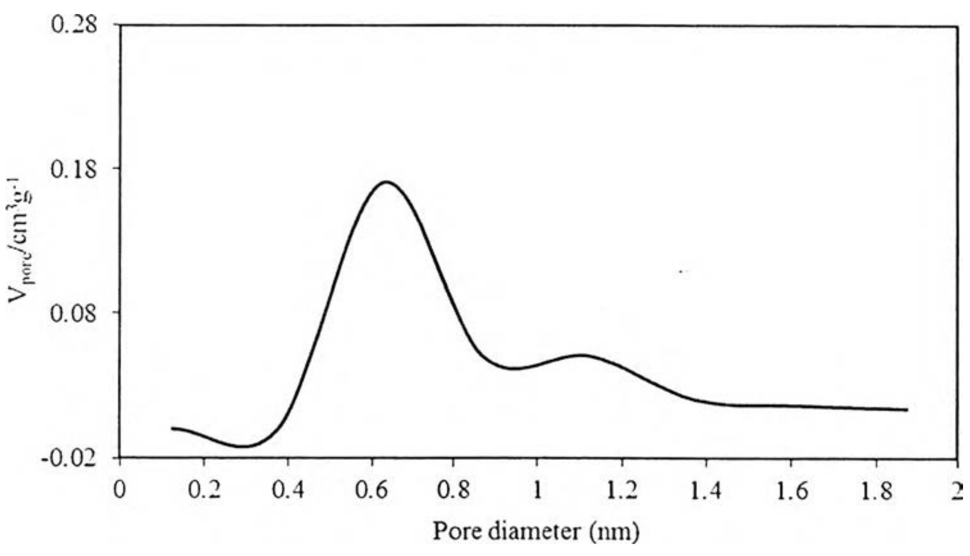

Figure C18 Pore size distribution of ACPO10-12.

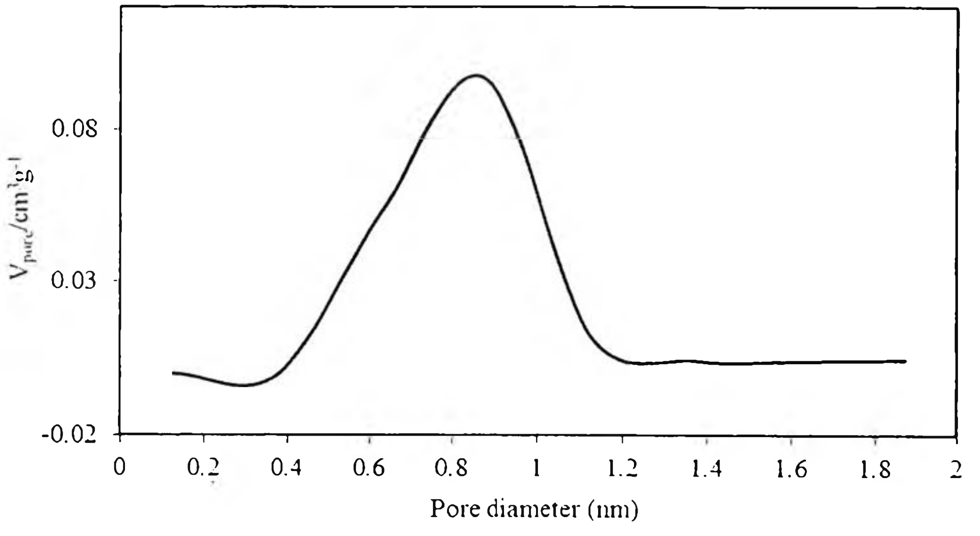

Figure C19 Pore size distribution of ACPN400.

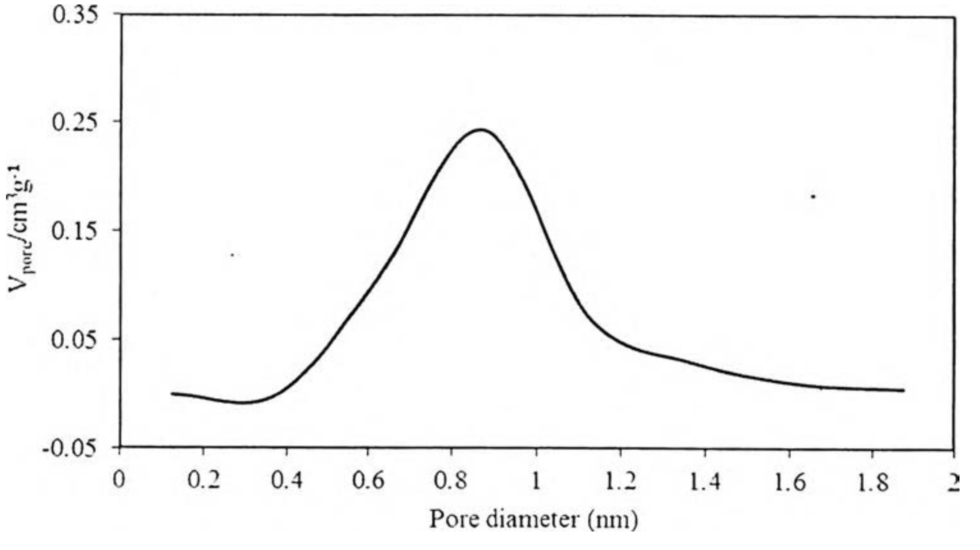

Figure C20 Pore size distribution of ACPO10-12/N400.

Appendix D The Deconvolution of C1s XPS Spectra

Table D1 Assigned binding energies for C1s XPS spectra

Region	Peak	Position (eV)	Assignment
C1s	1	284.3±0.1	Graphite
	2	285.0±0.1	Aliphatics
	3	285.4±0.2	Carbons linked to nitrogen
	4	285.8±0.1	Hydroxyl, Ether
	5	286.6±0.2	Carbonyl
	6	289.2	Esters, Lactones, Anhydrides, Acids, Hydroxyl

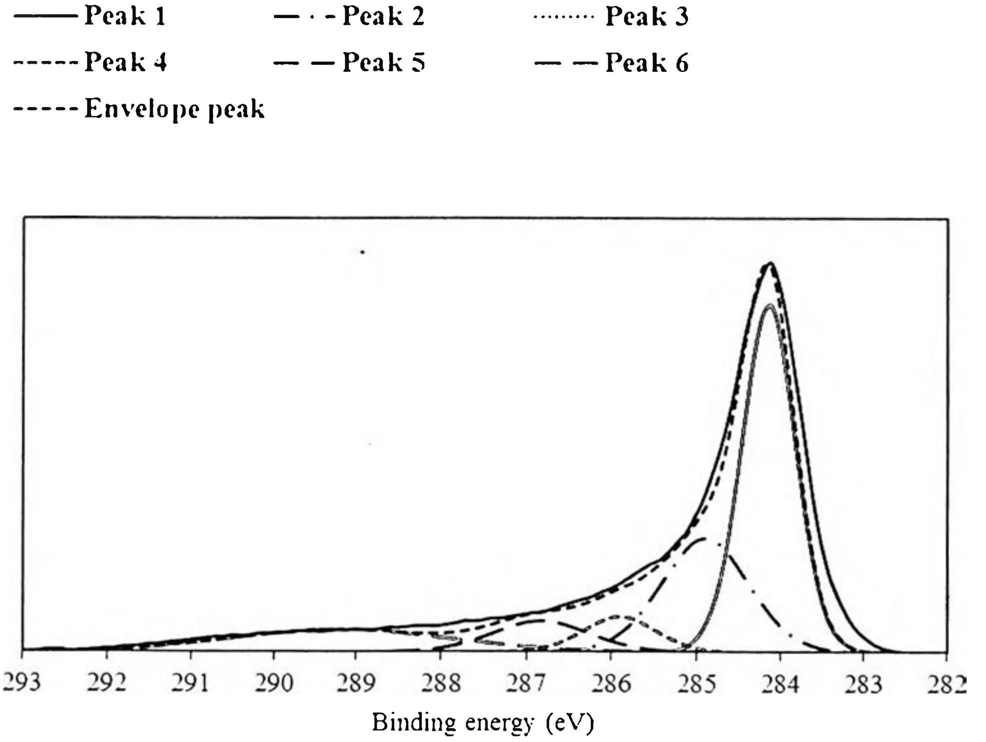

Figure D1 C1s XPS spectra of AC.

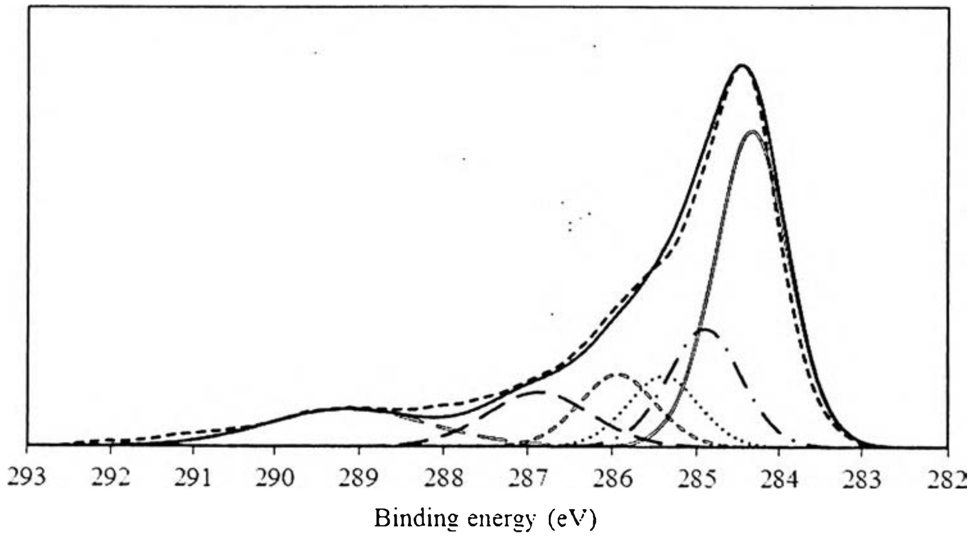

Figure D2 C1s XPS spectra of ACO10-6.

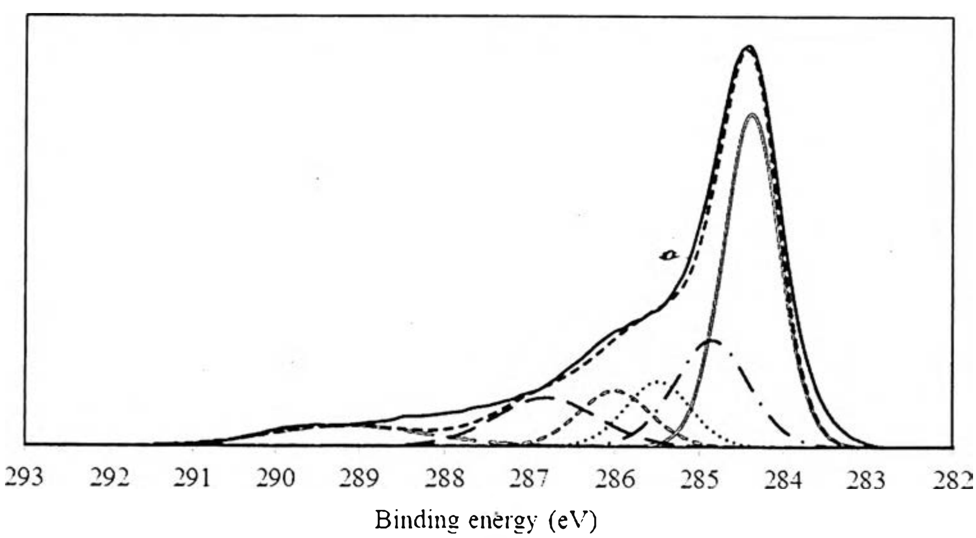

Figure D3 C1s XPS spectra of ACO10-8.

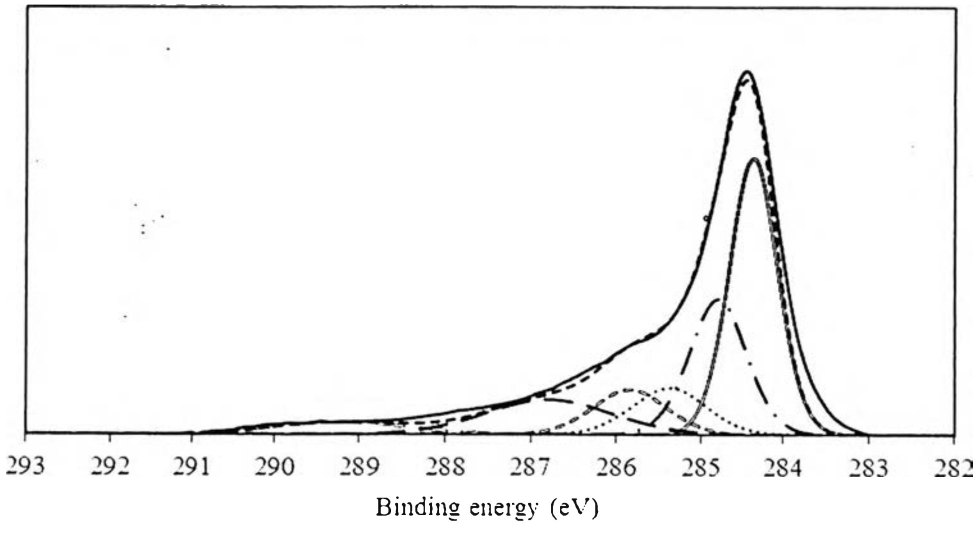

Figure D4 C1s XPS spectra of ACO10-12.

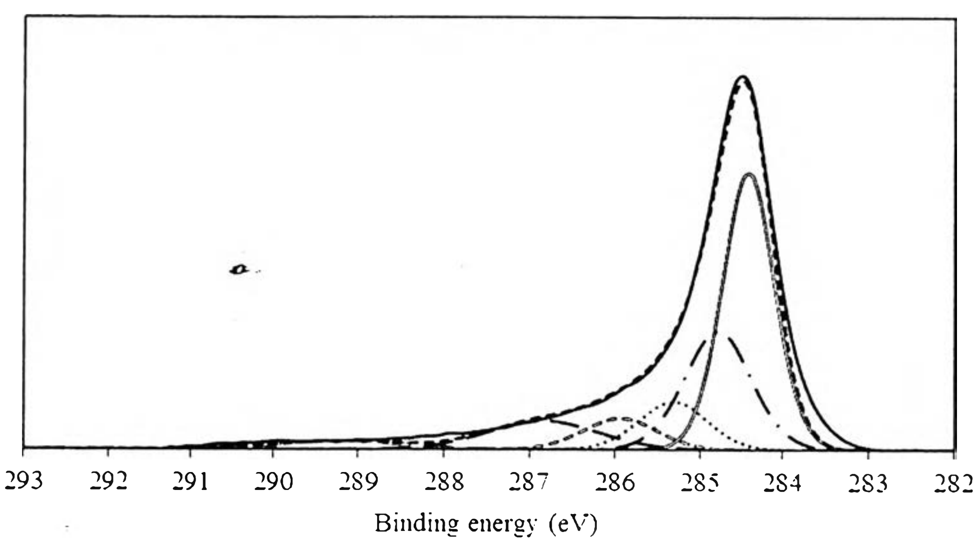

Figure D5 C1s XPS spectra of ACN400.

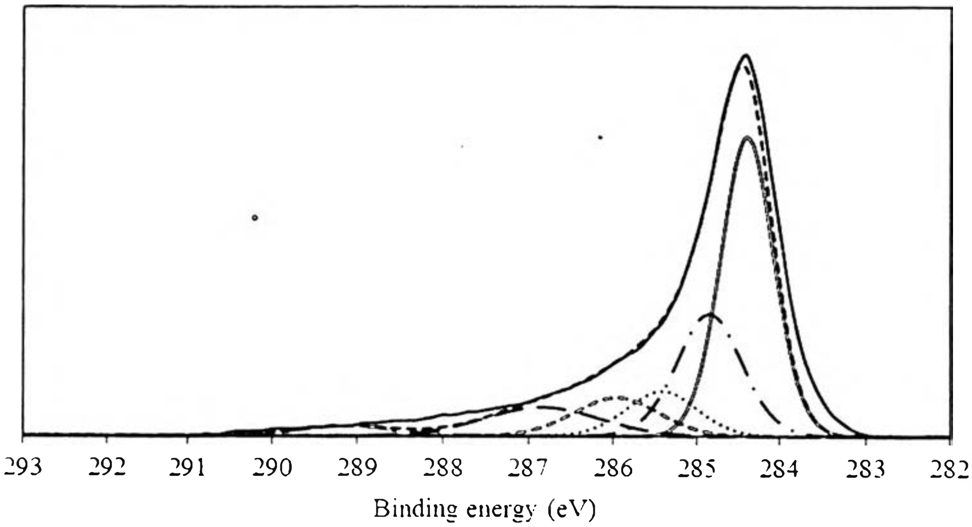

Figure D6 C1s XPS spectra of ACN600.

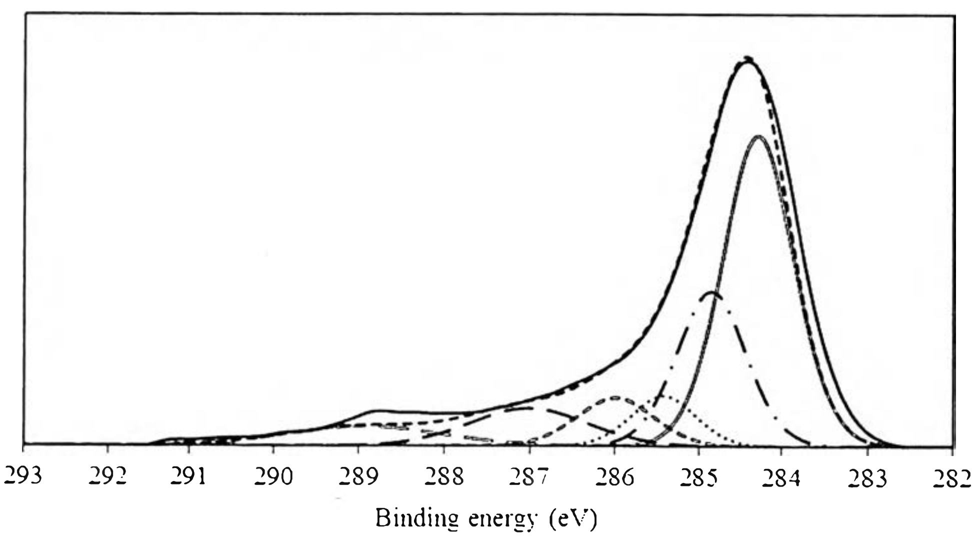

Figure D7 C1s XPS spectra of ACN800.

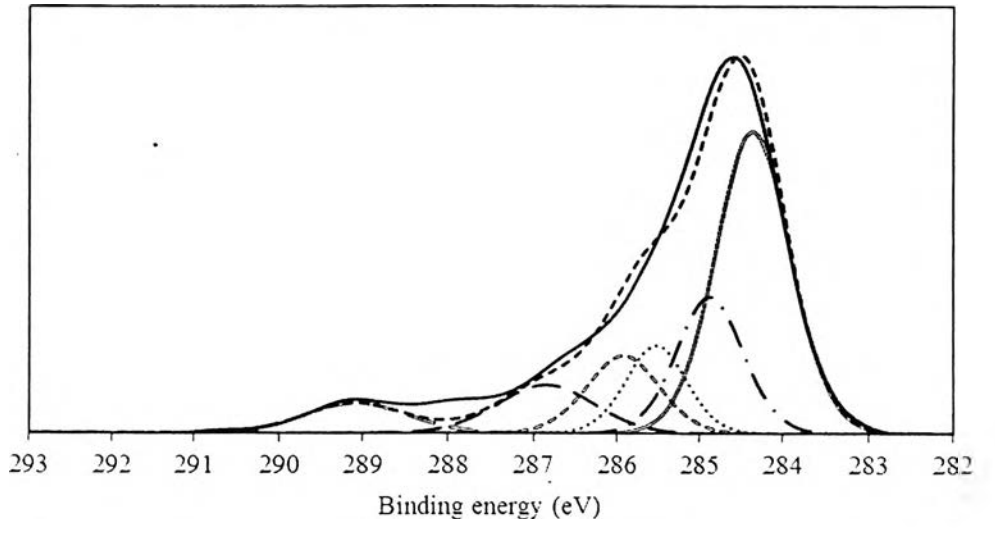

Figure D8 C1s XPS spectra of ACO10-6/N400.

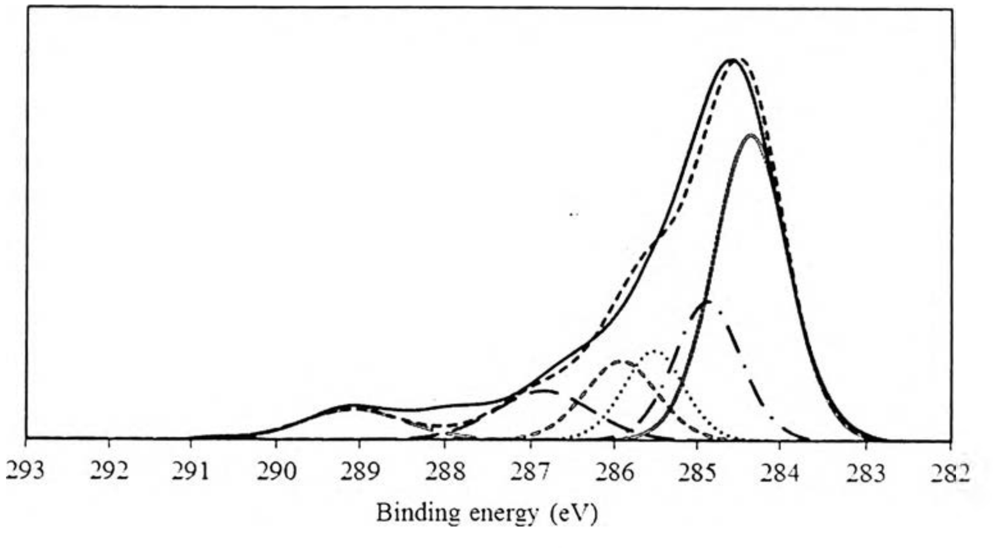

Figure D9 C1s XPS spectra of ACO10-8/N400.

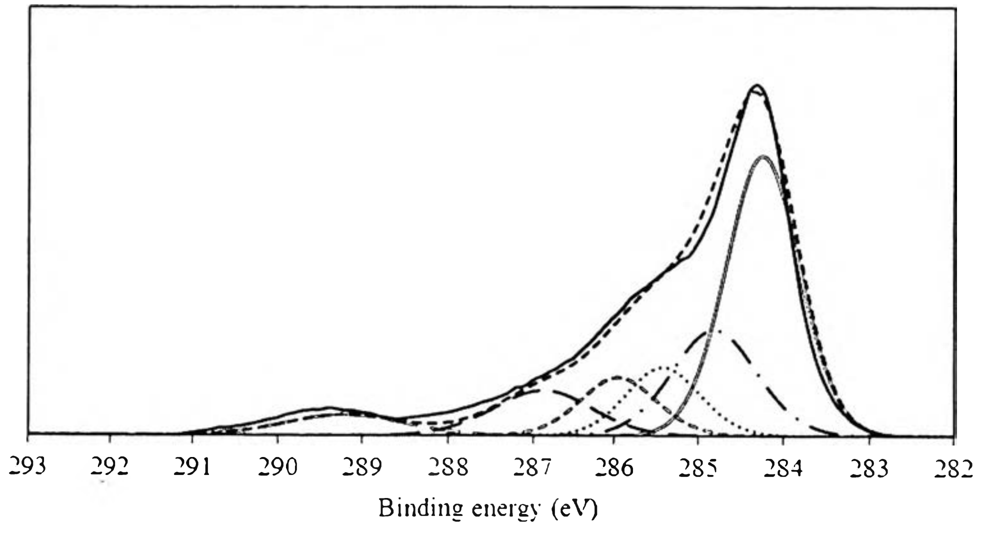

Figure D10 C1s XPS spectra of ACO10-12/N400.

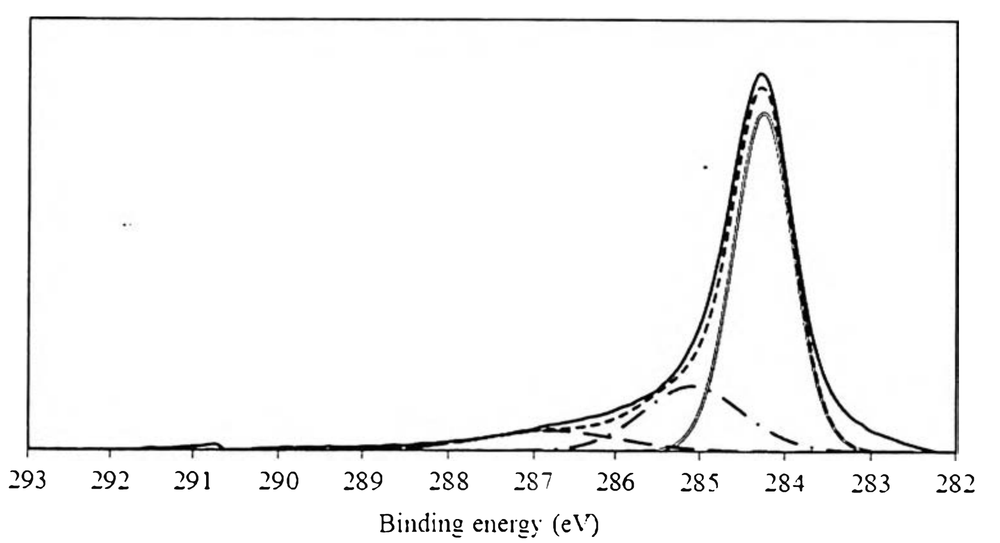

Figure D11 C1s XPS spectra of CB.

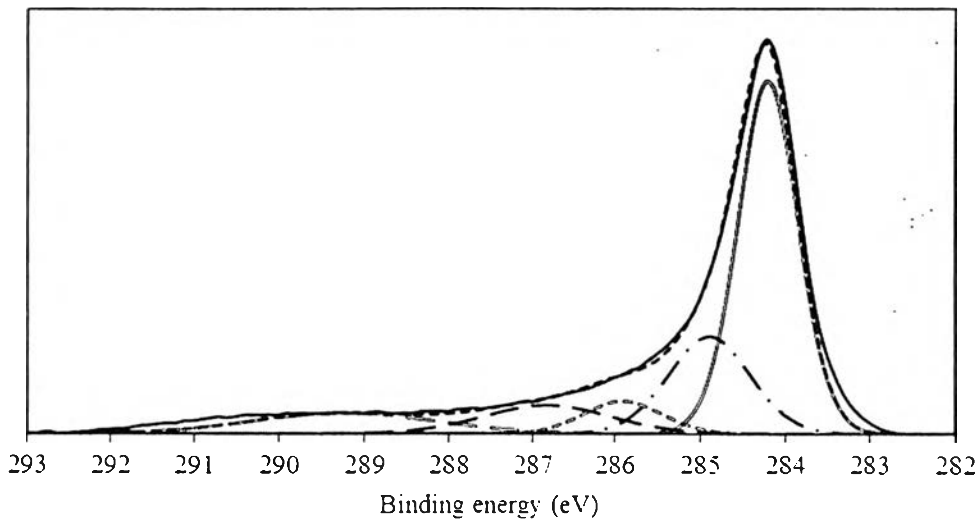

Figure D12 C1s XPS spectra of ACB.

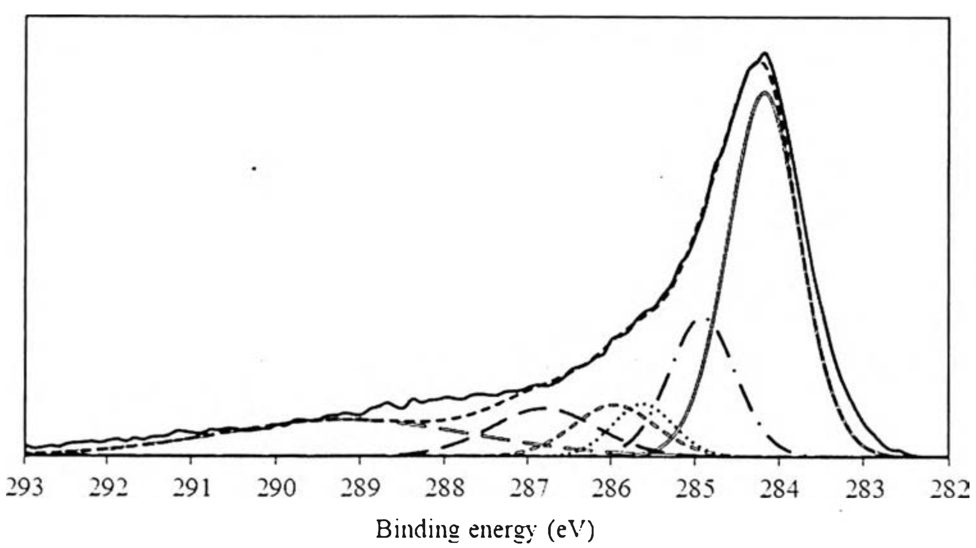

Figure D13 C1s XPS spectra of ACBO10-12.

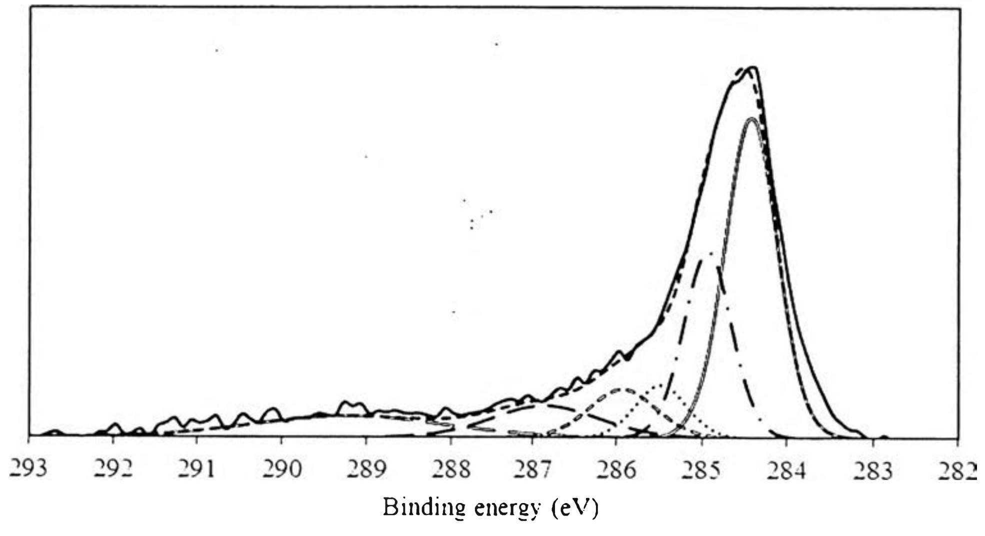

Figure D14 C1s XPS spectra of ACBN400.

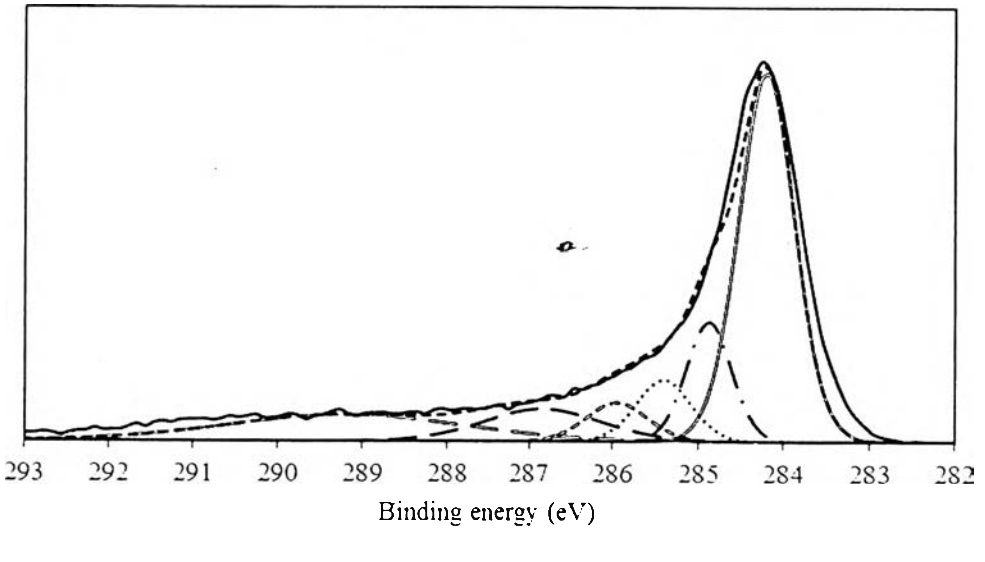

Figure D15 C1s XPS spectra of ACBO10-12/N400.

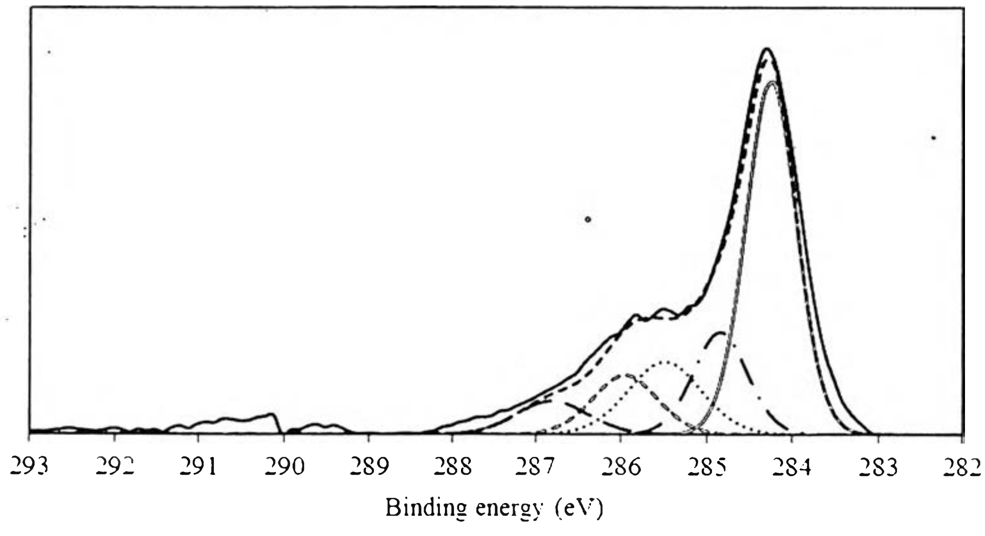

Figure D16 C1s XPS spectra of CP.

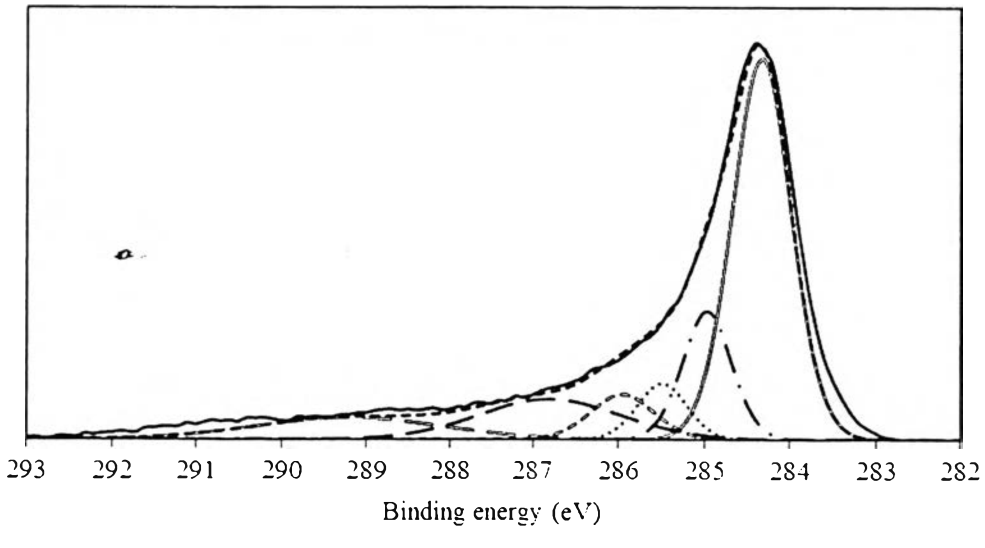

Figure D17 C1s XPS spectra of ACP.

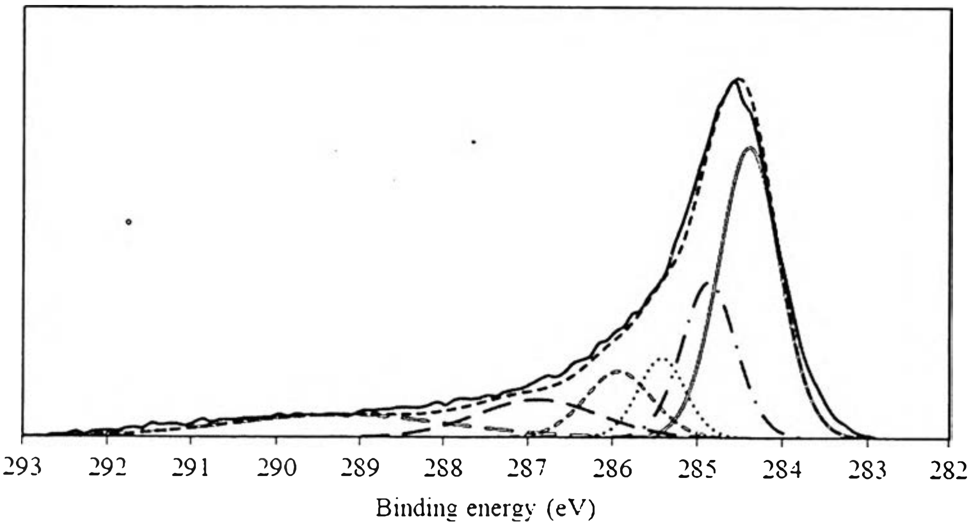

Figure D18 C1s XPS spectra of ACPO10-12.

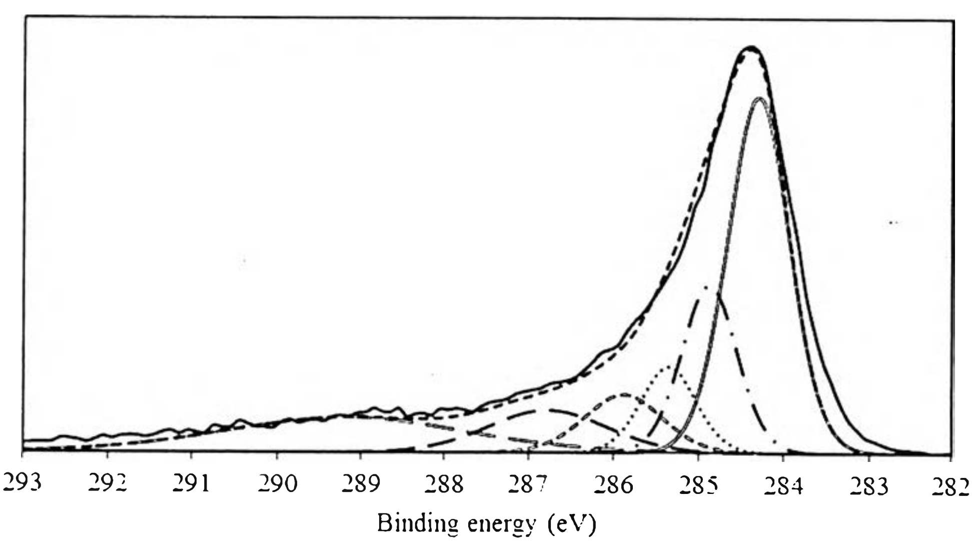

Figure D19 C1s XPS spectra of ACPN400.

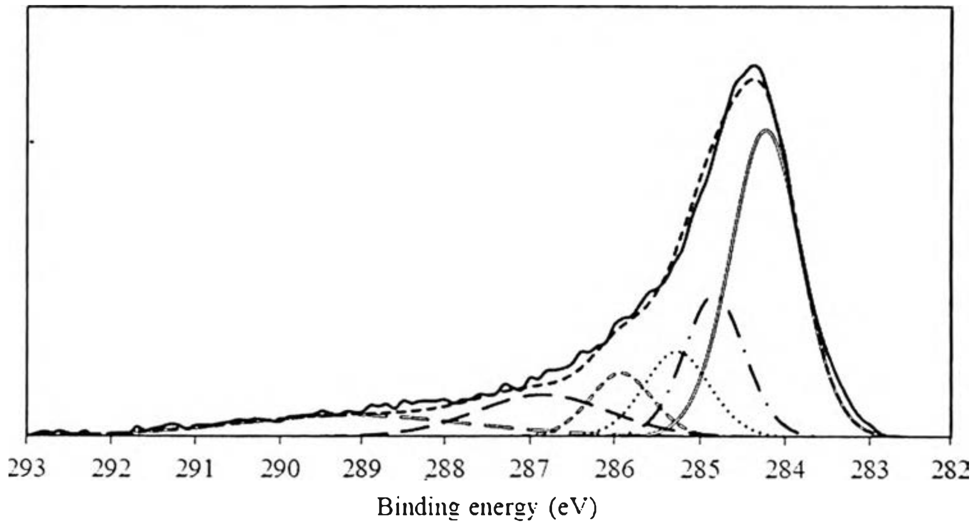

Figure D20 C1s XPS spectra of ACPO10-12/N400.

Appendix E The Deconvolution of O1s XPS Spectra

Table E1 Assigned binding energies for O1s XPS spectra

Region	Peak	Position (eV)	Assignment
O1s	1	530.3	Oxides
	2	531.3±0.1	Carbonyl, Carboxyl
	3	532.1±0.1	Ketones, Lactones, Acids, Esters
	4	532.9±0.1	Hydroxyl, Carboxyl
	5	533.6±0.1	Hydroxyl attached to aromatic ring, oxygen in bridge (esters)
	6	534.9±0.1	Adsorbed water

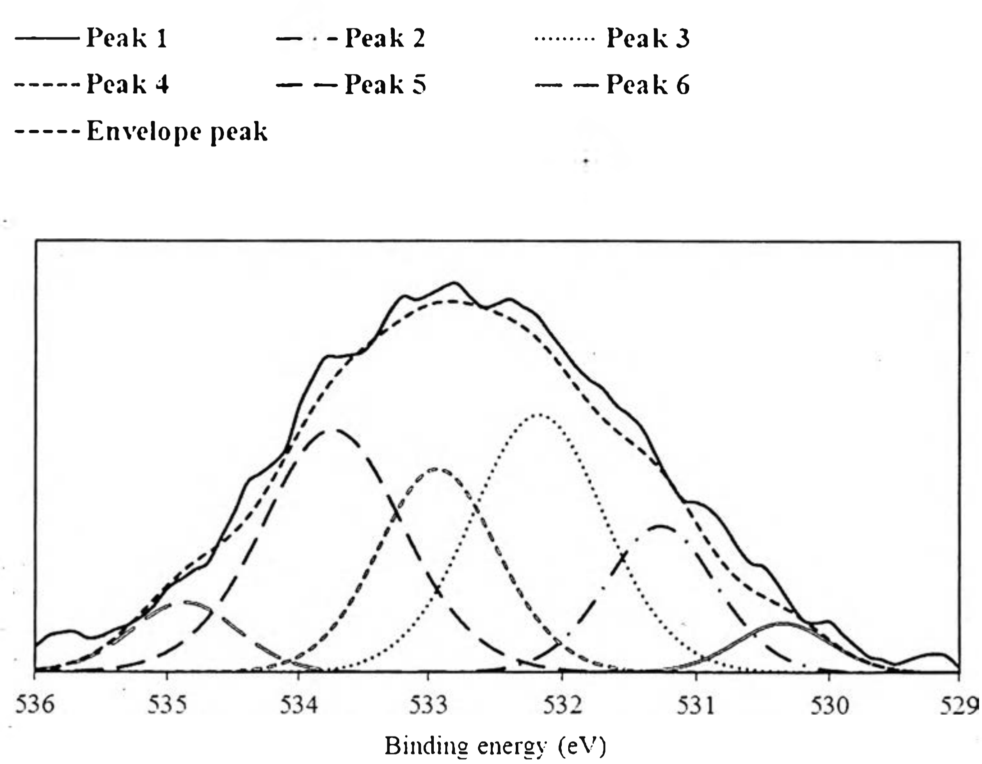

Figure E1 O1s XPS spectra of AC.

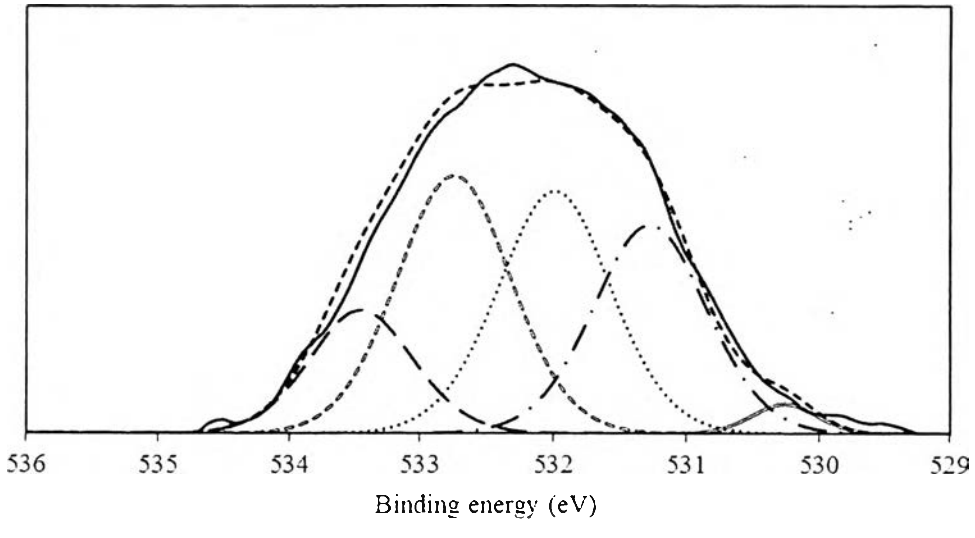

Figure E2 O1s XPS spectra of ACO10-6.

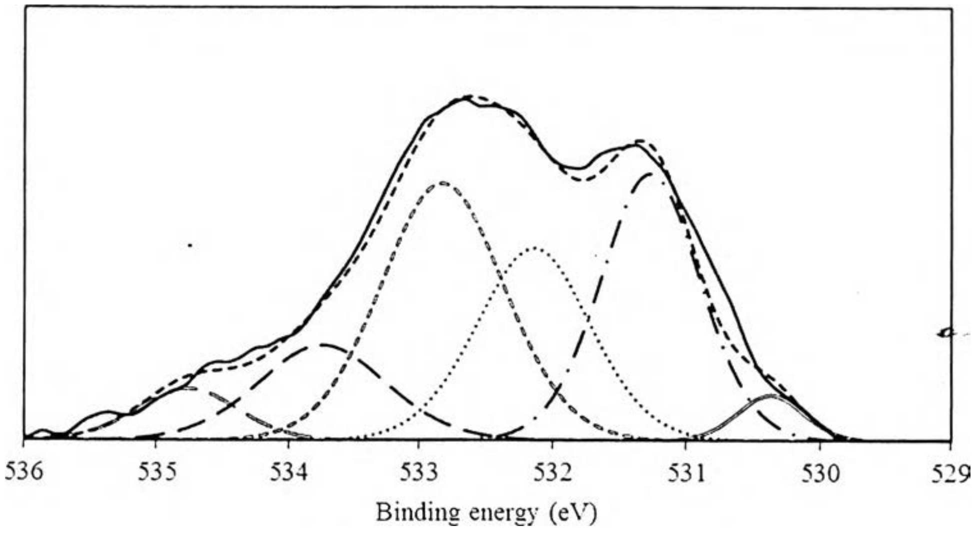

Figure E3 O1s XPS spectra of ACO10-8.

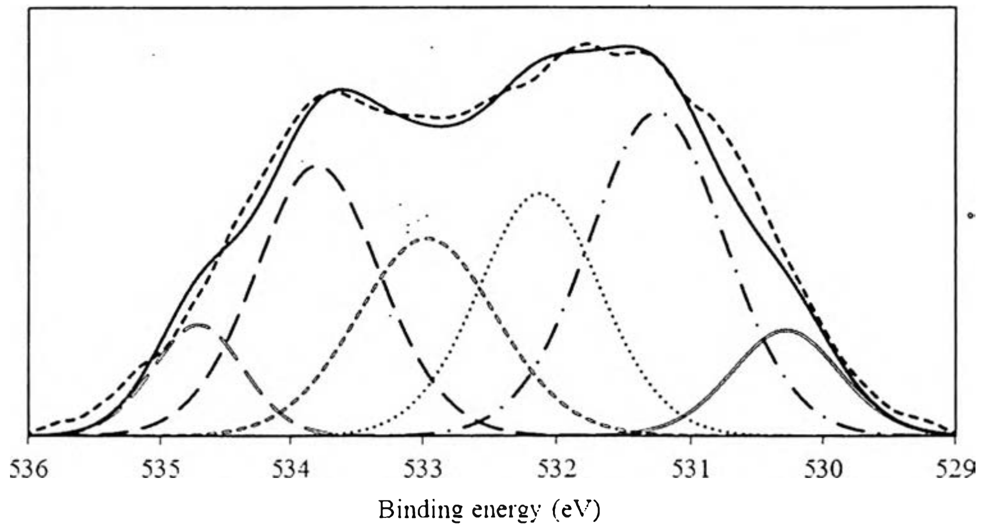

Figure E4 O1s XPS spectra of ACO10-12.

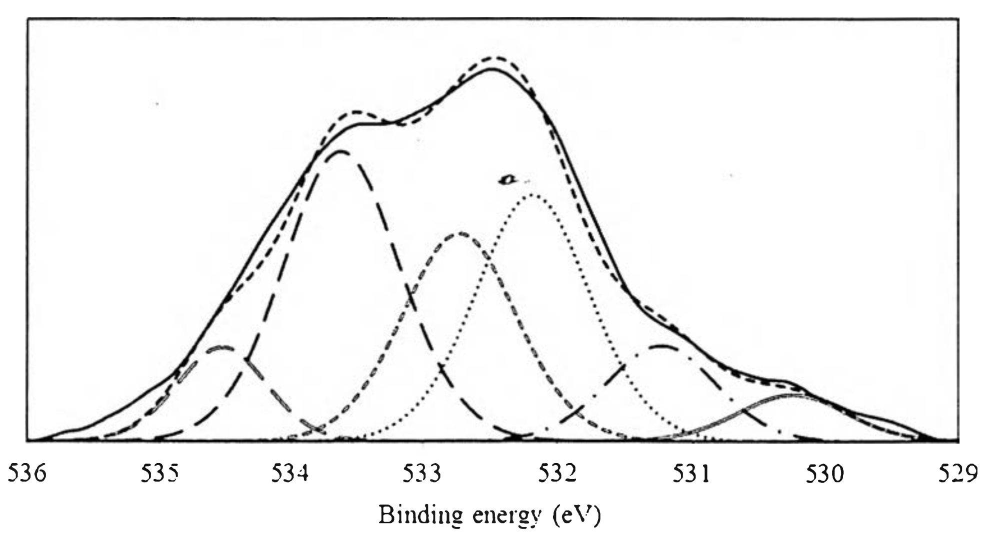

Figure E5 O1s XPS spectra of ACN400.

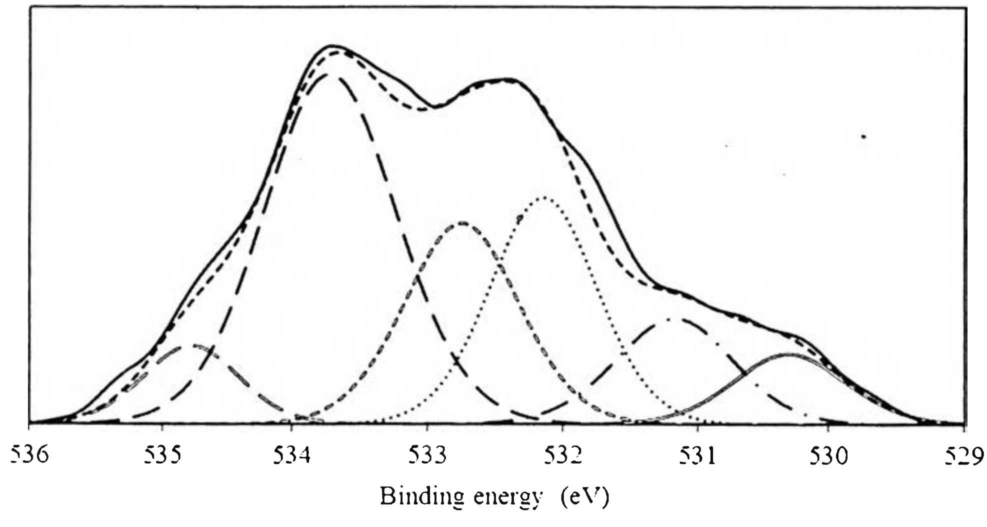

Figure E6 O1s XPS spectra of ACN600.

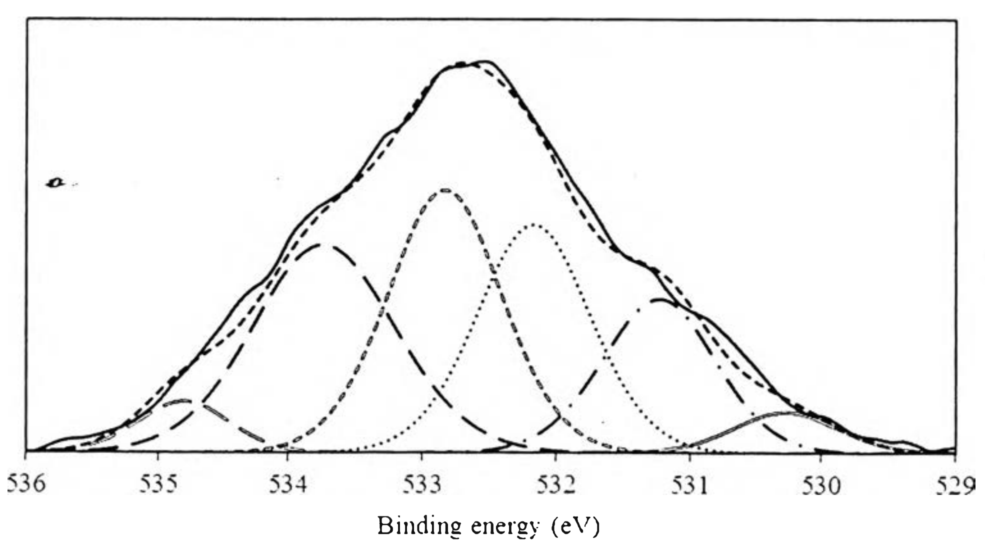

Figure E7 O1s XPS spectra of ACN800.

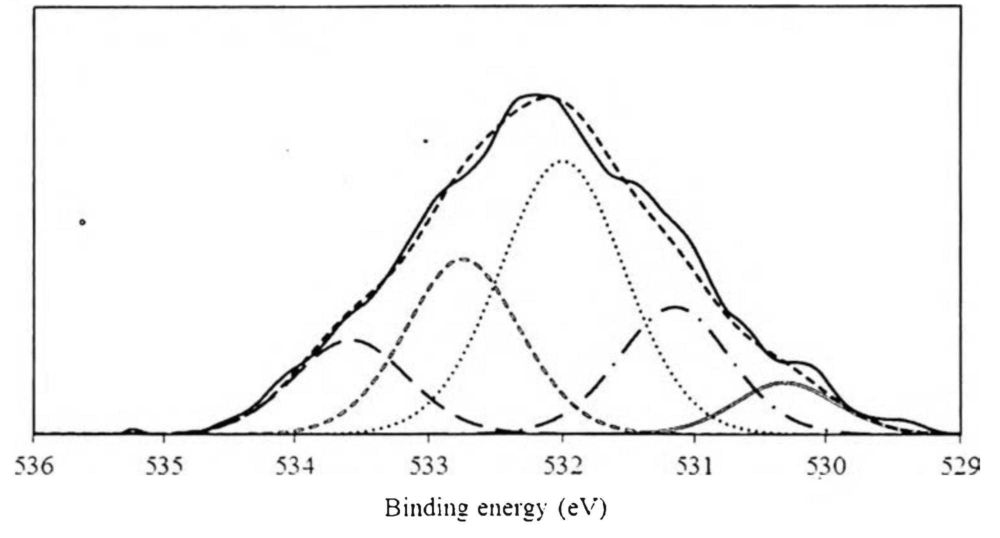

Figure E8 O1s XPS spectra of ACO10-6/N400.

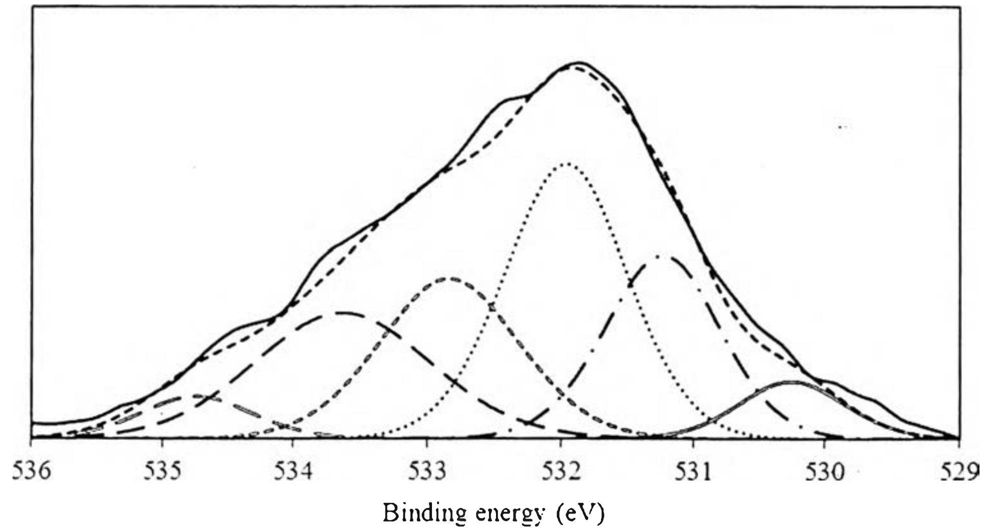

Figure E9 O1s XPS spectra of ACO10-8/N400.

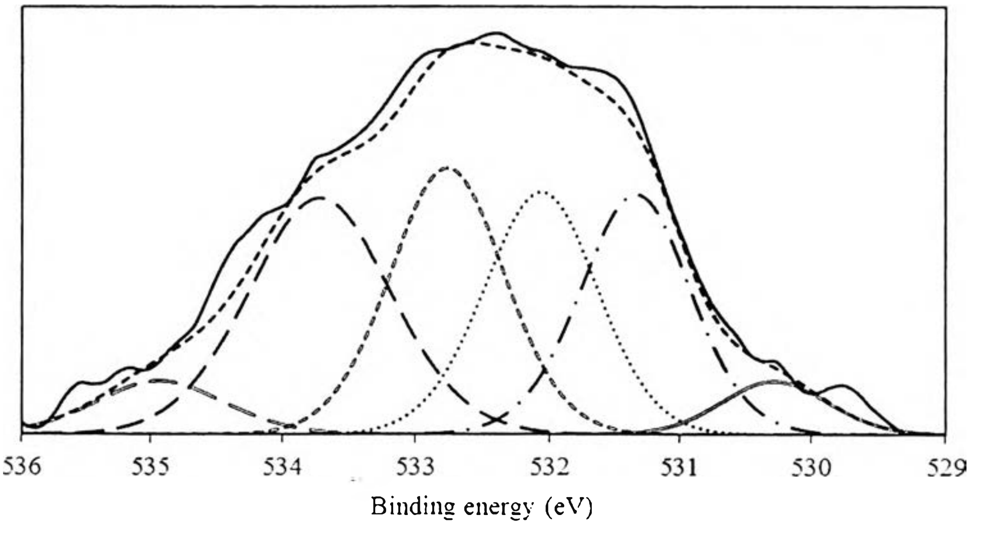

Figure E10 O1s XPS spectra of ACO10-12/N400.

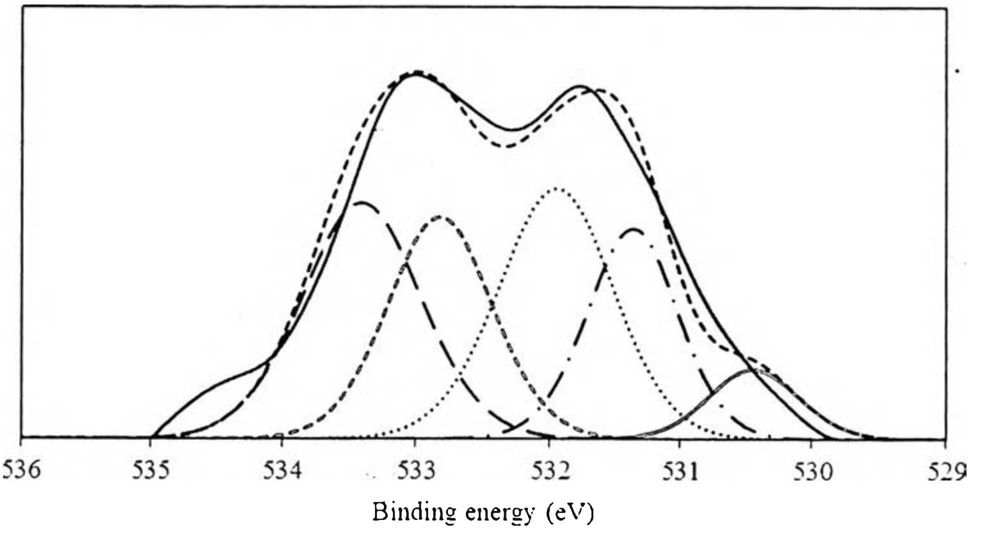

Figure E11 O1s XPS spectra of ACB.

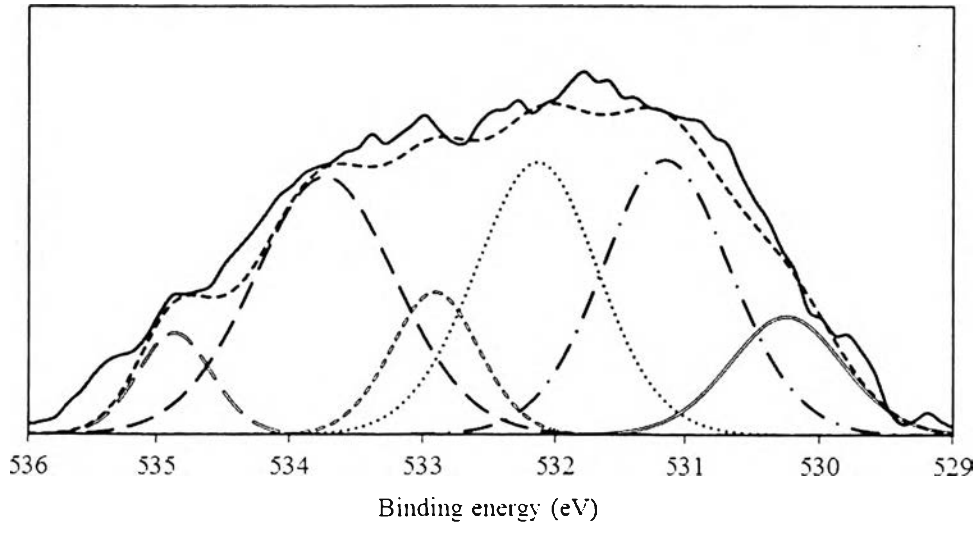

Figure E12 O1s XPS spectra of ACBO10-12.

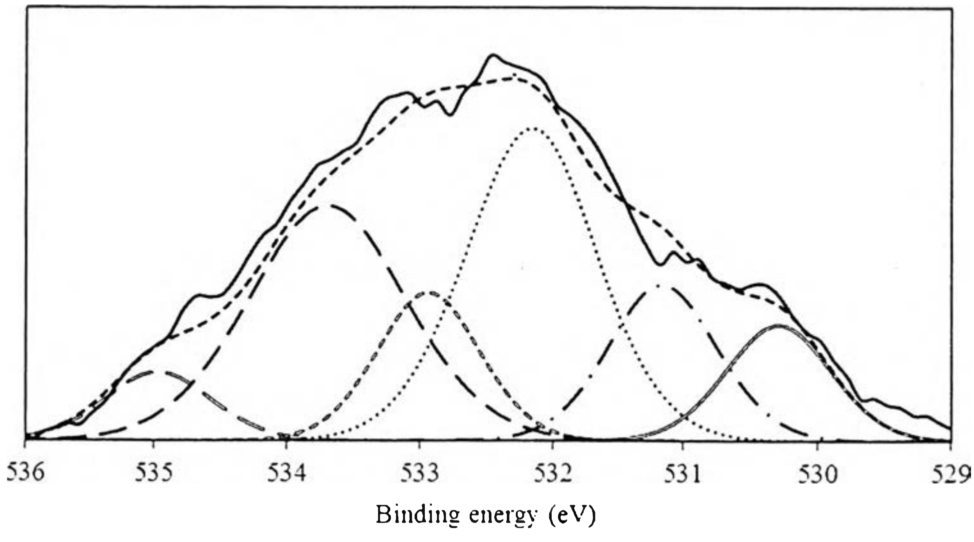

Figure E13 O1s XPS spectra of ACBN400.

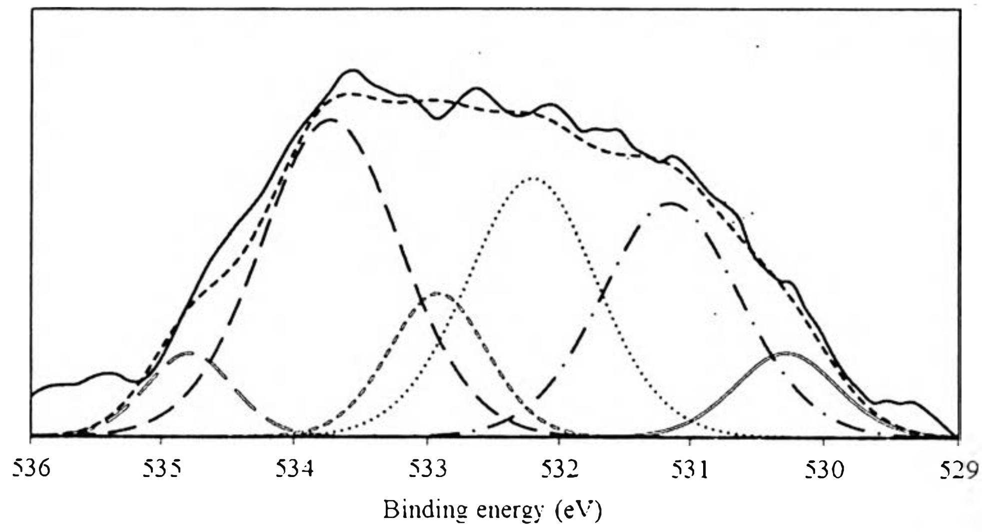

Figure E14 O1s XPS spectra of ACBO10-12/N400.

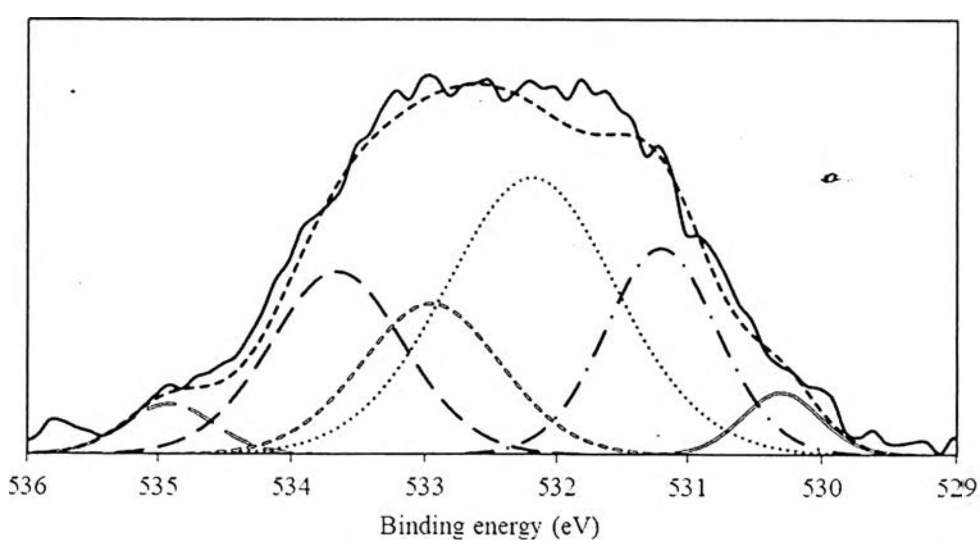

Figure E15 O1s XPS spectra of ACP.

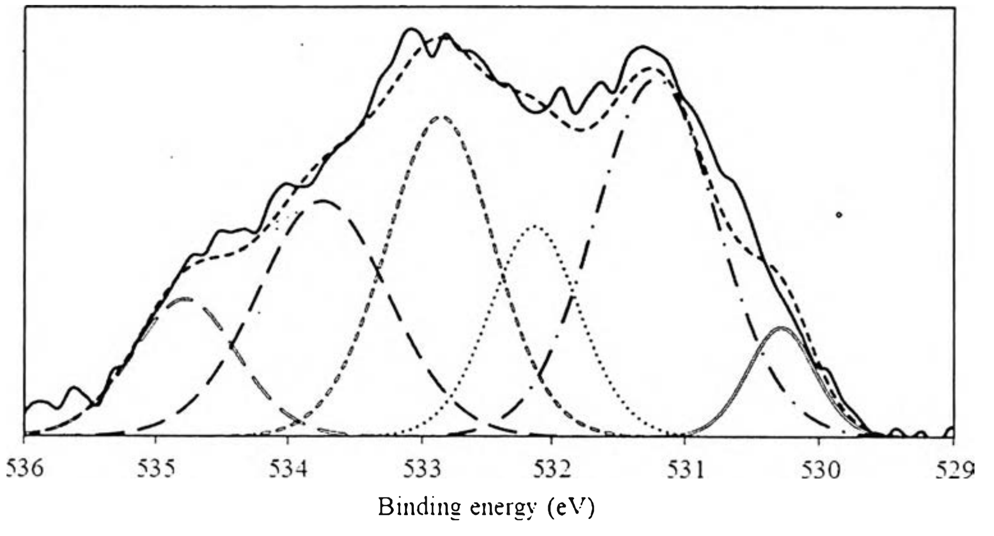

Figure E16 O1s XPS spectra of ACPO10-12.

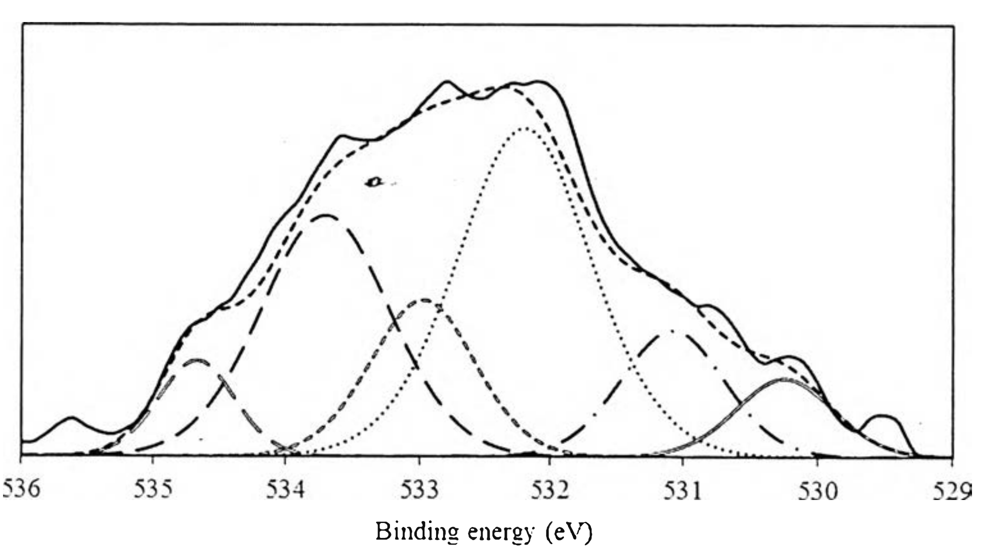

Figure E17 O1s XPS spectra of ACPN400.

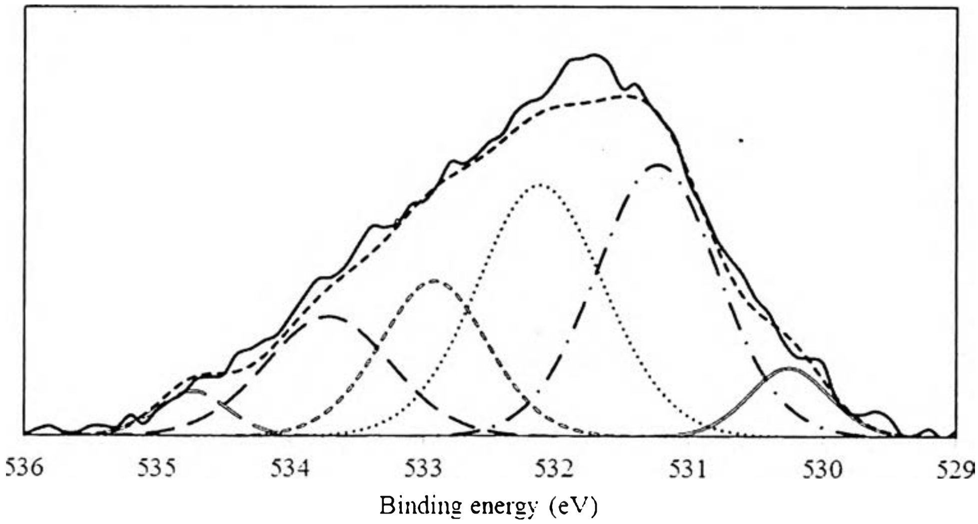

Figure E18 O1s XPS spectra of ACPO10-12/N400.

Appendix F The Deconvolution of N1s XPS Spectra.

Table F1 Assigned binding energies for N1s XPS spectra

Region	Peak	Position (eV)	Assignment
N1s	1	398.1±0.1	Pyridinic
	2	398.9±0.1	Pyridinic, Imine
	3	399.8±0.2	Imine, Amide, Amine
	4	400.7±0.2	Pyrrolic, Pyridonic
	5	401.4±0.3	Quaternary nitrogen
	6	402.8±0.2	Pyridine-N-oxide

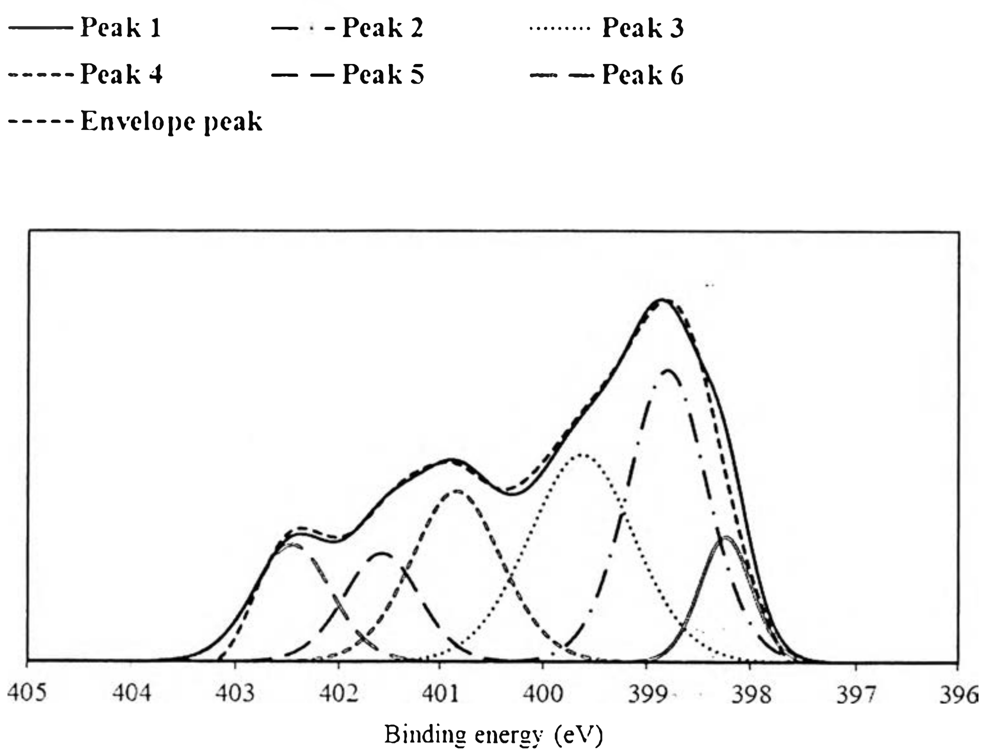

Figure F1 N1s XPS spectra of ACO10-6.

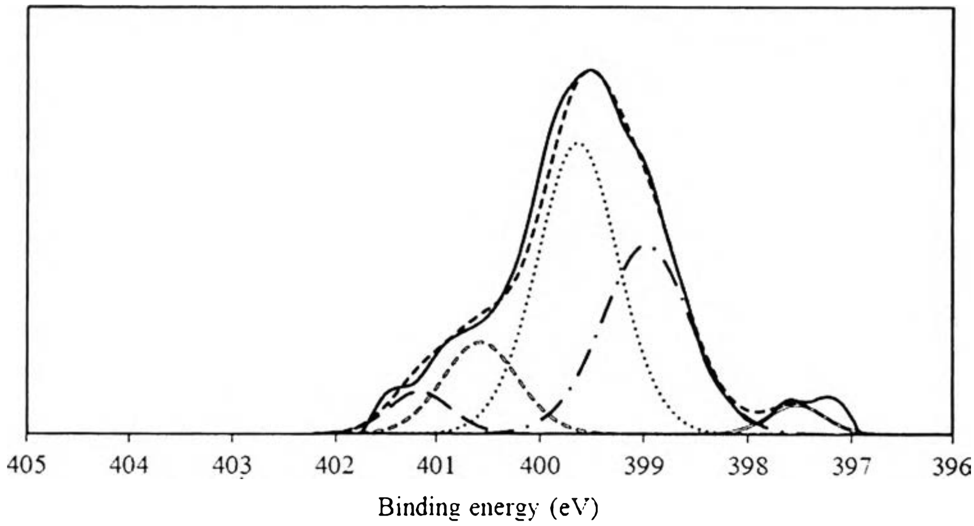

Figure F2 N1s XPS spectra of ACO10-8.

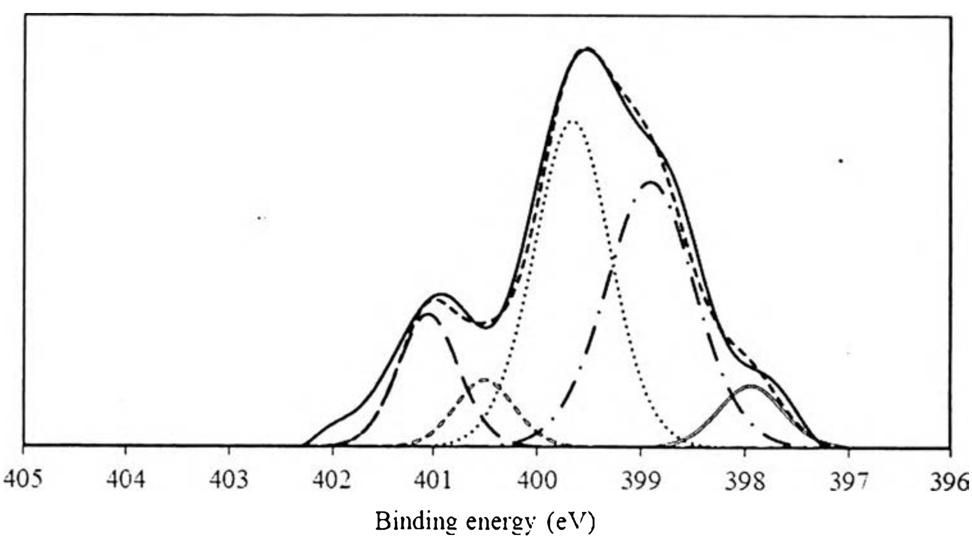

Figure F3 N1s XPS spectra of ACO10-12.

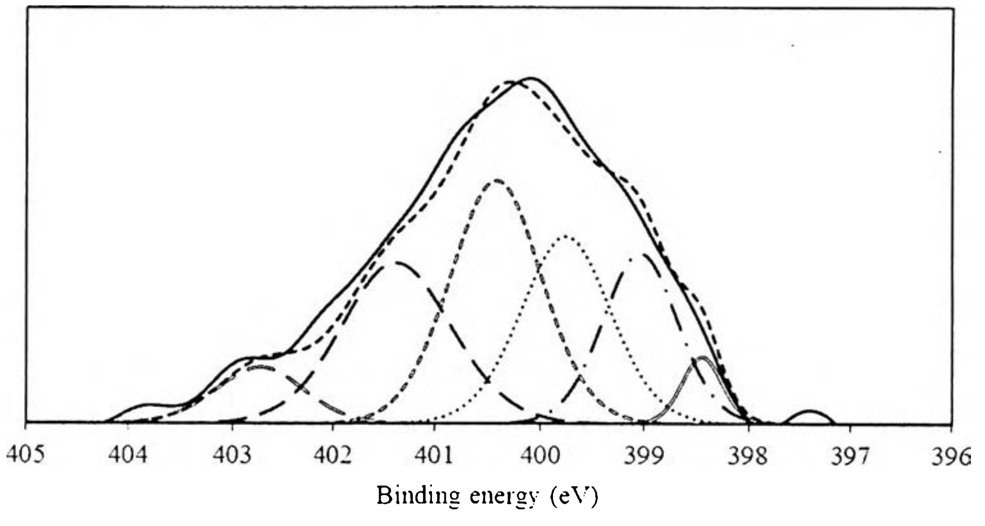

Figure F4 N1s XPS spectra of ACN400.

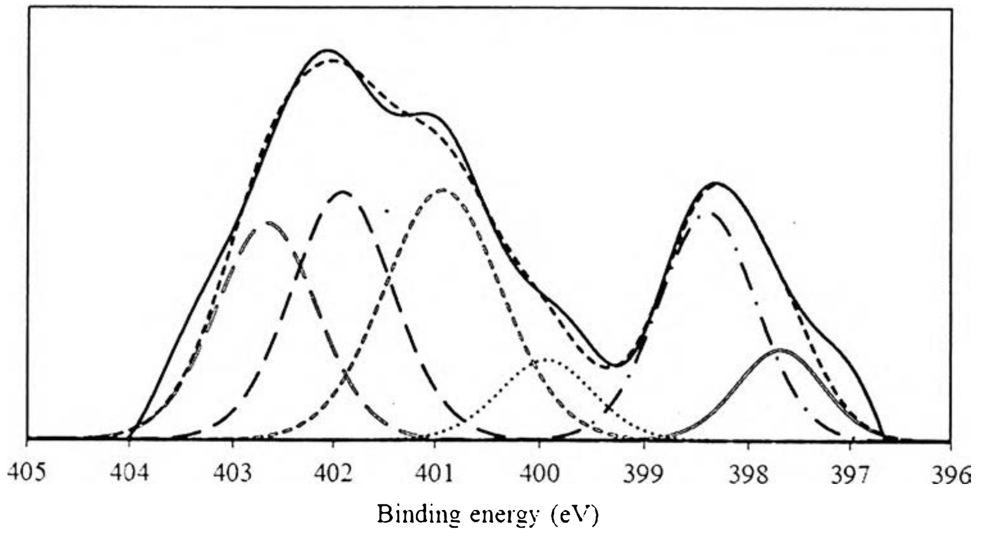

Figure F5 N1s XPS spectra of ACN600.

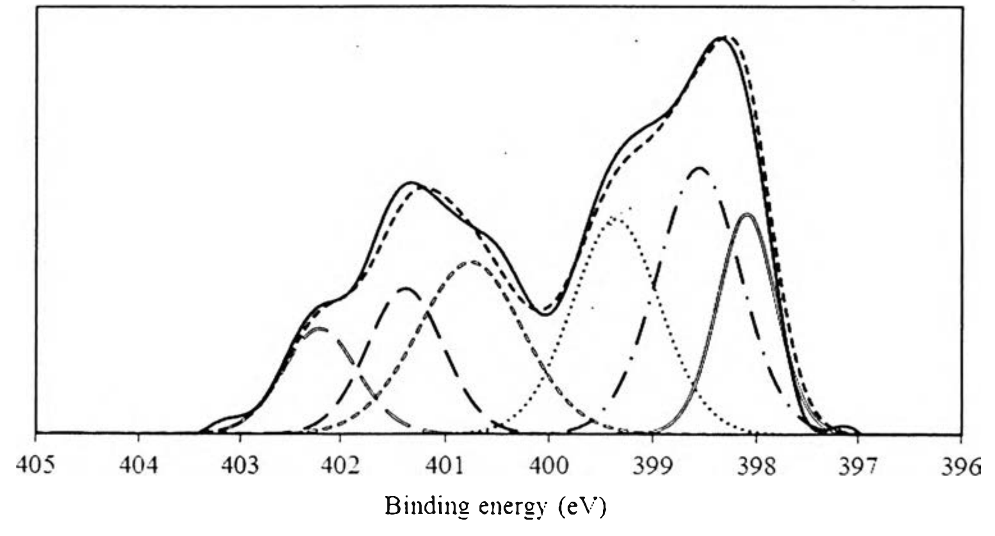

Figure F6 N1s XPS spectra of ACN800.

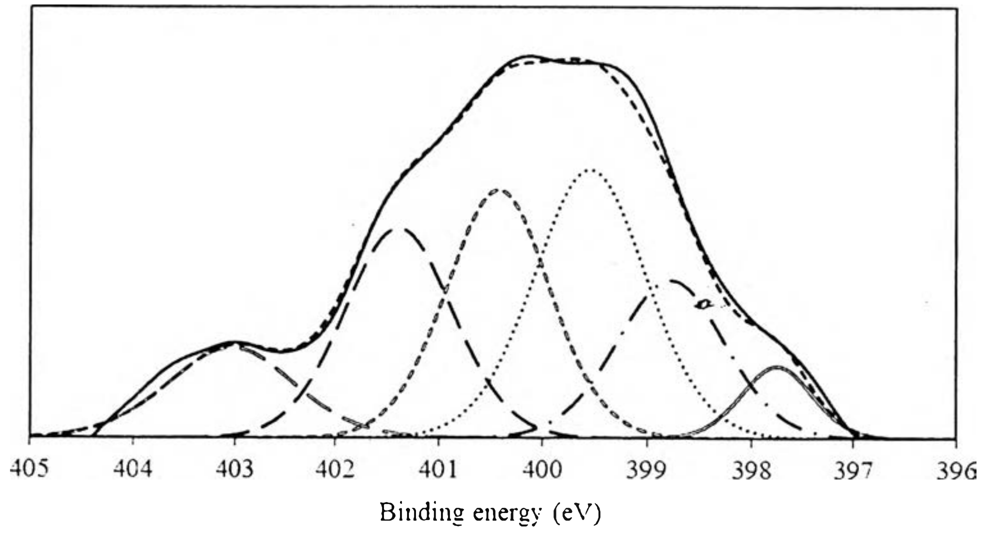

Figure F7 N1s XPS spectra of ACO10-6/N400.

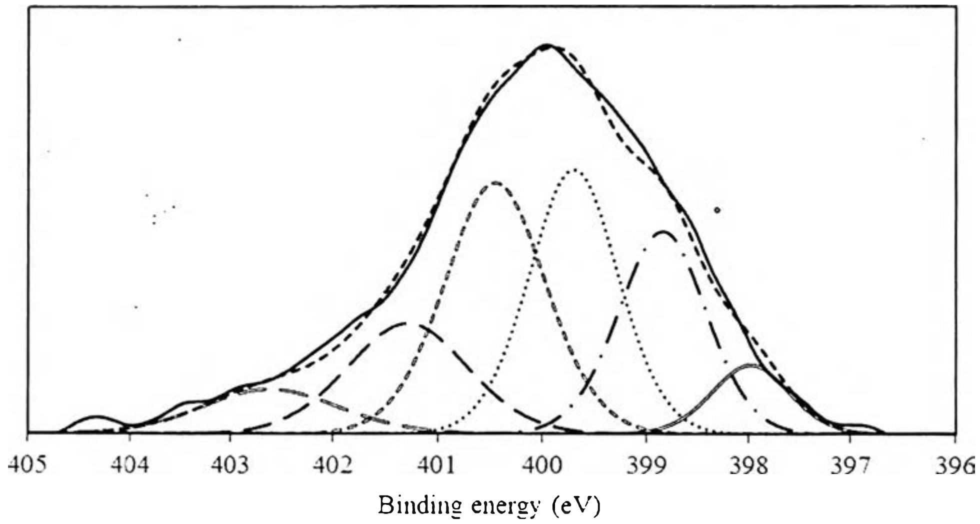

Figure F8 N1s XPS spectra of ACO10-8/N400.

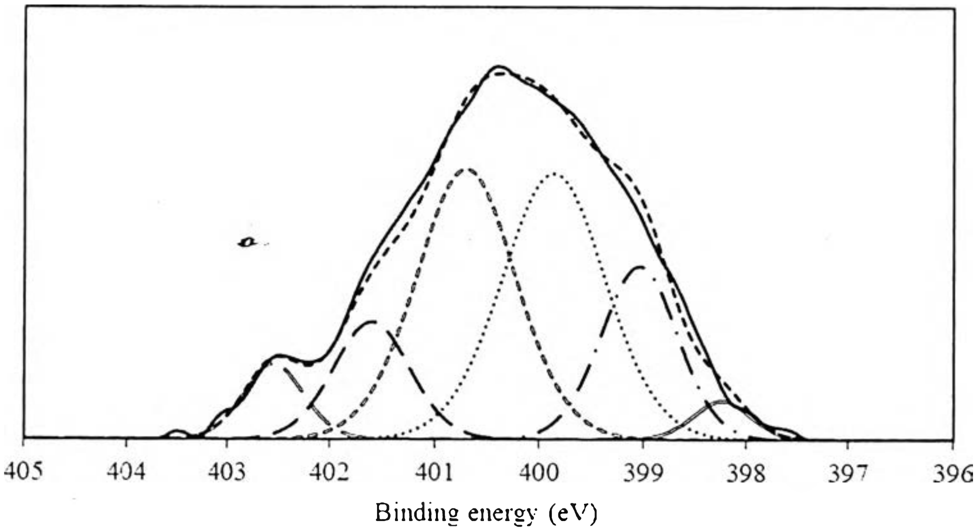

Figure F9 N1s XPS spectra of ACO10-12/N400.

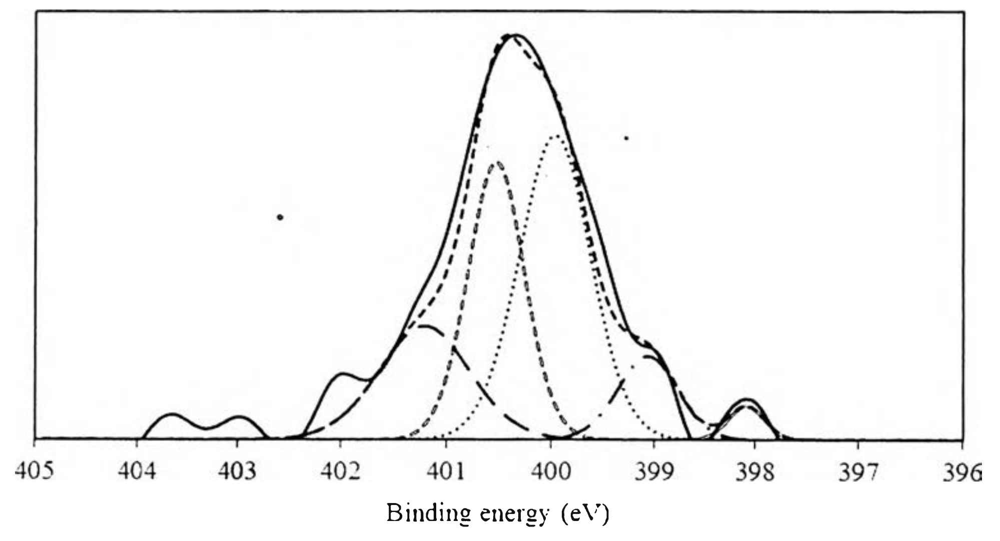

Figure F10 N1s XPS spectra of ACBO10-12.

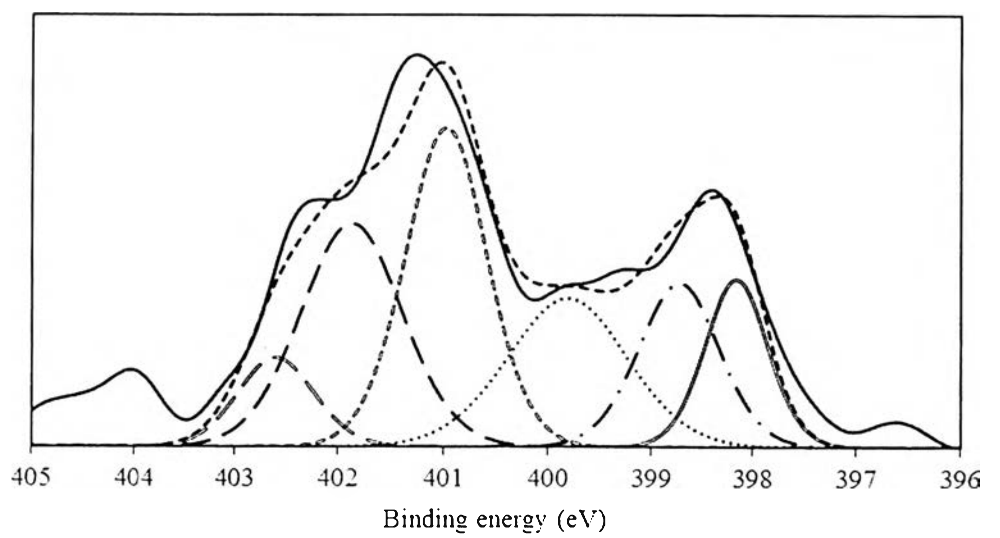

Figure F11 N1s XPS spectra of ACBN400.

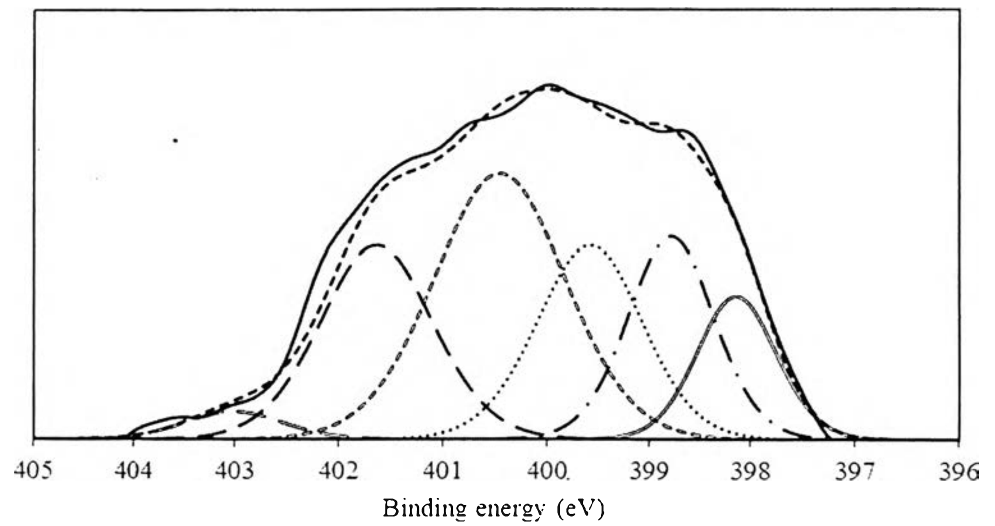

Figure F12 N1s XPS spectra of ACBO10-12/N400.

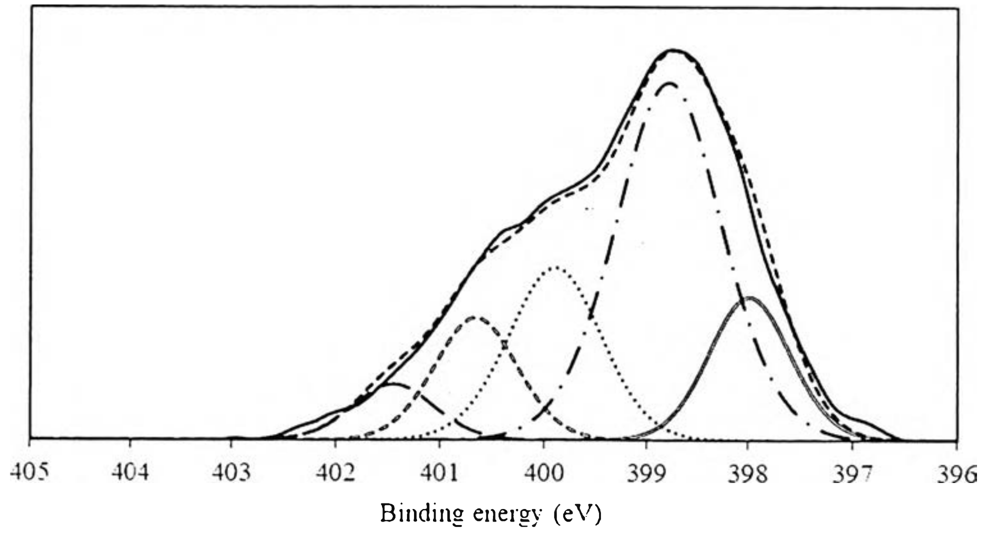

Figure F13 N1s XPS spectra of CP.

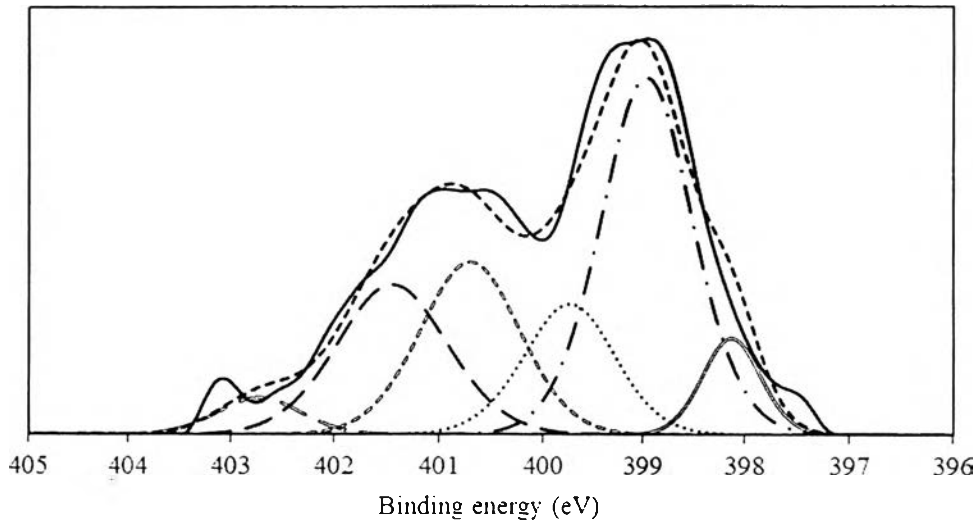

Figure F14 N1s XPS spectra of ACP.

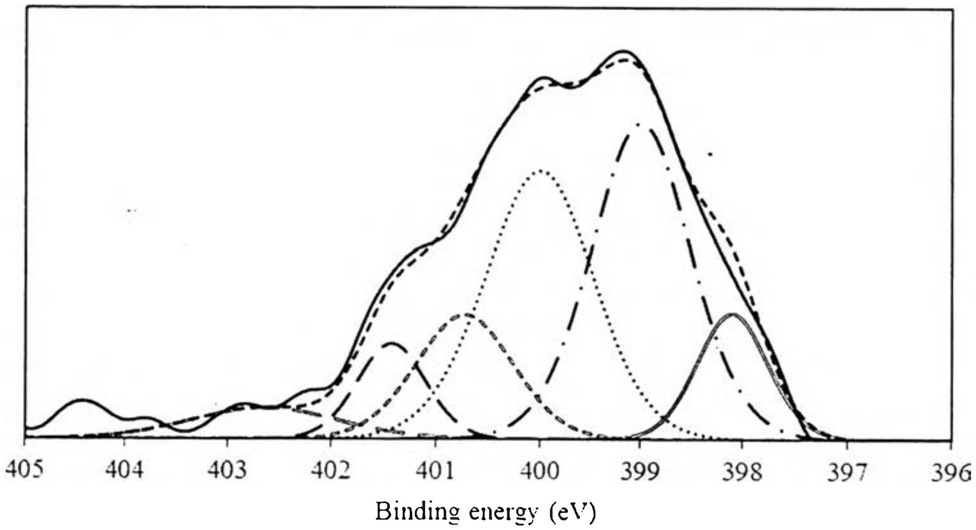

Figure F15 N1s XPS spectra of ACPO10-12.

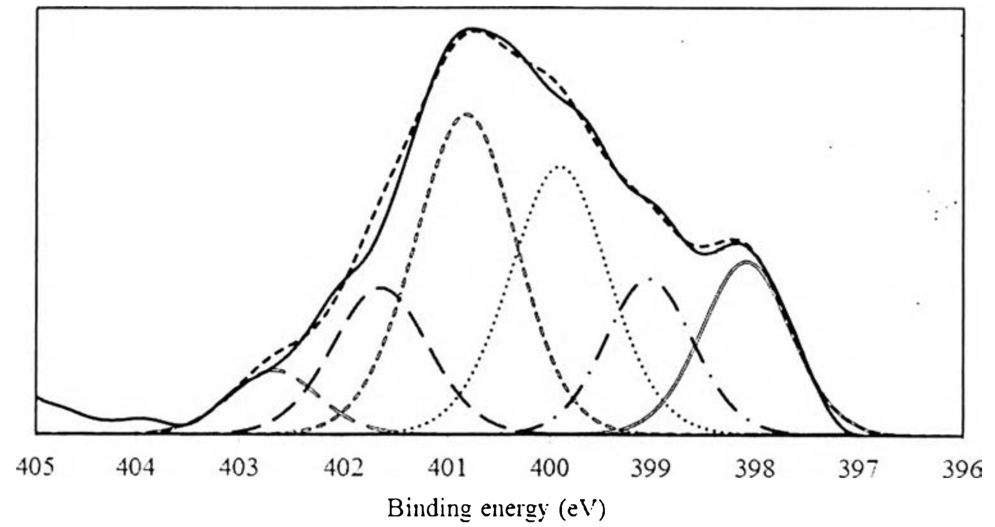

Figure F16 N1s XPS spectra of ACPN400.

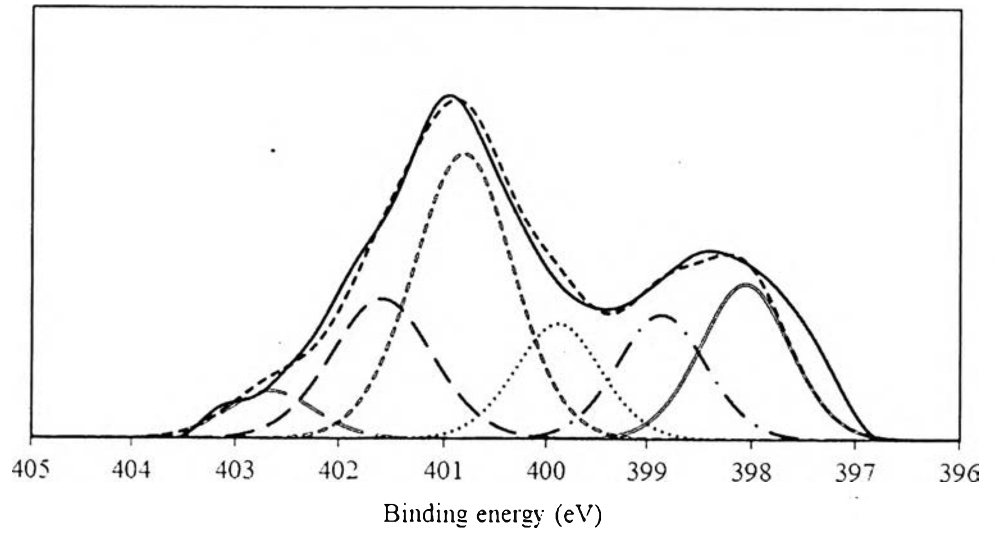

Figure F17 N1s XPS spectra of ACPO10-12/N400.

Appendix G CO_2 Adsorption/desorption Profiles at 40 °C and 1 atm

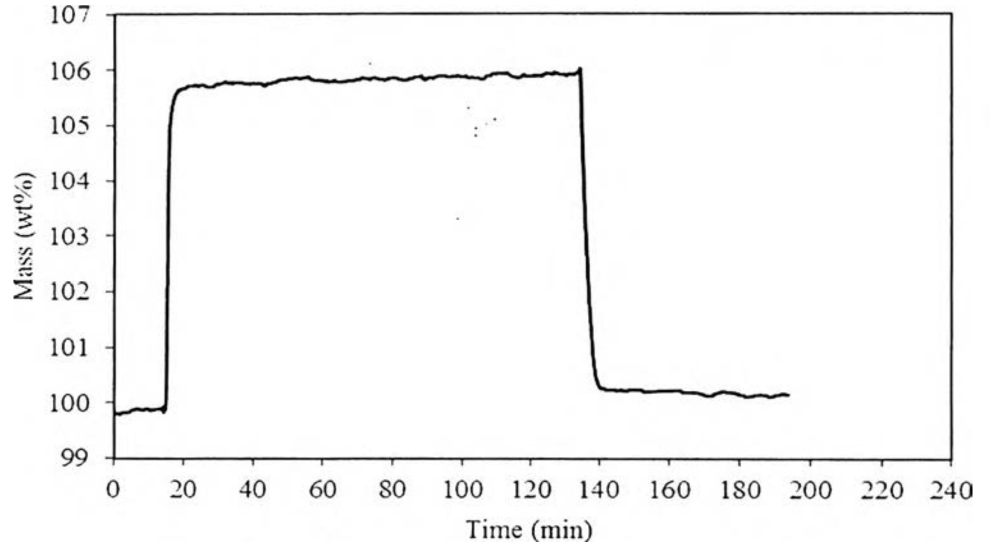

Figure G1 CO_2 adsorption/desorption profile of AC.

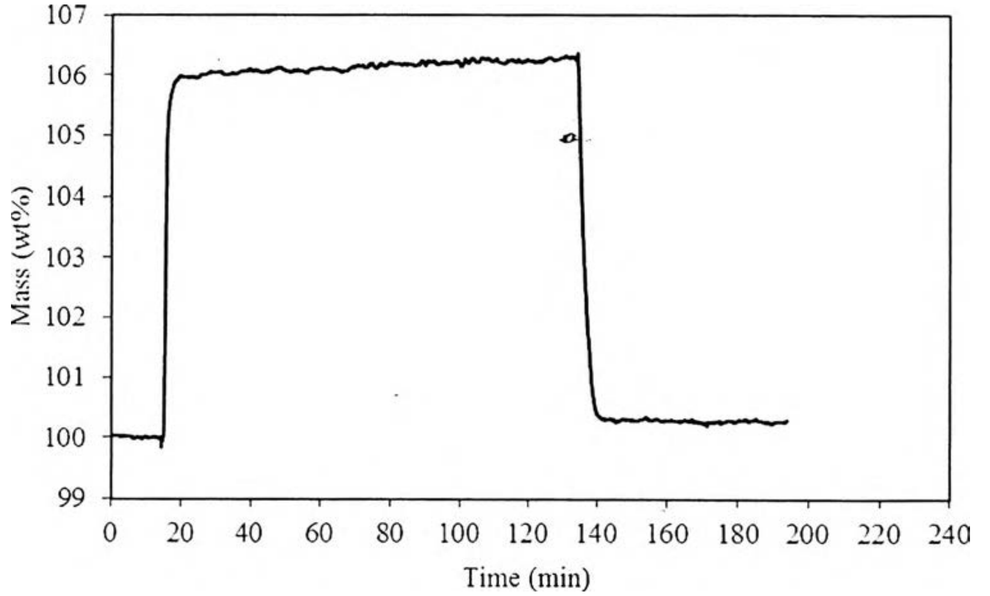

Figure G2 CO_2 adsorption/desorption profile of ACO10-6.

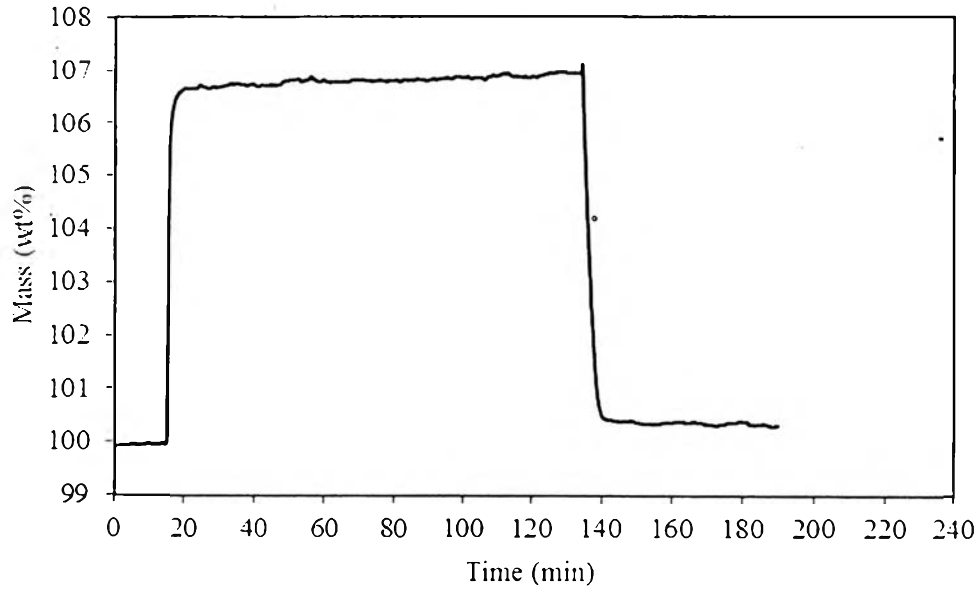

Figure G3 CO_2 adsorption/desorption profile of ACO10-8.

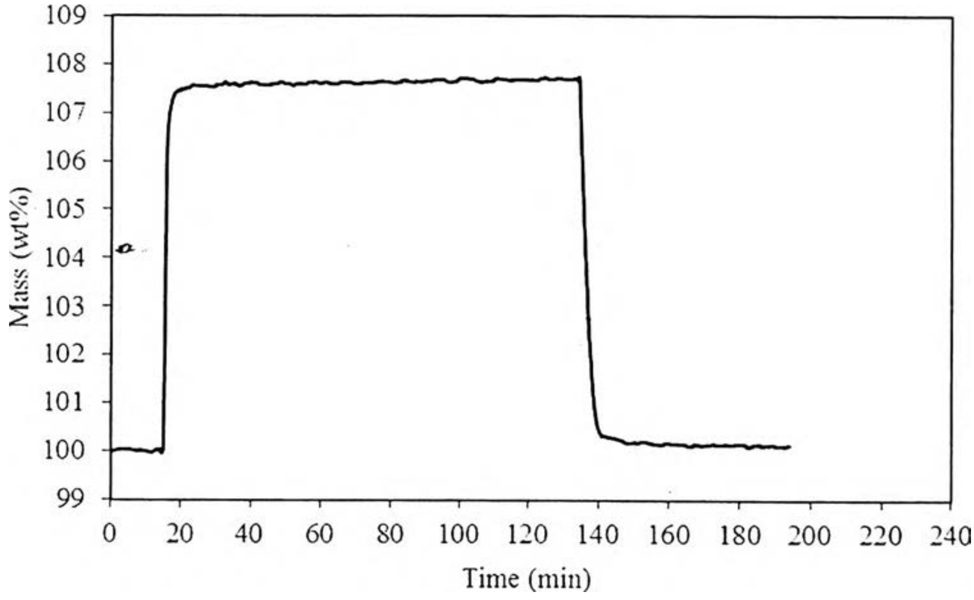

Figure G4 CO_2 adsorption/desorption profile of ACO10-12.

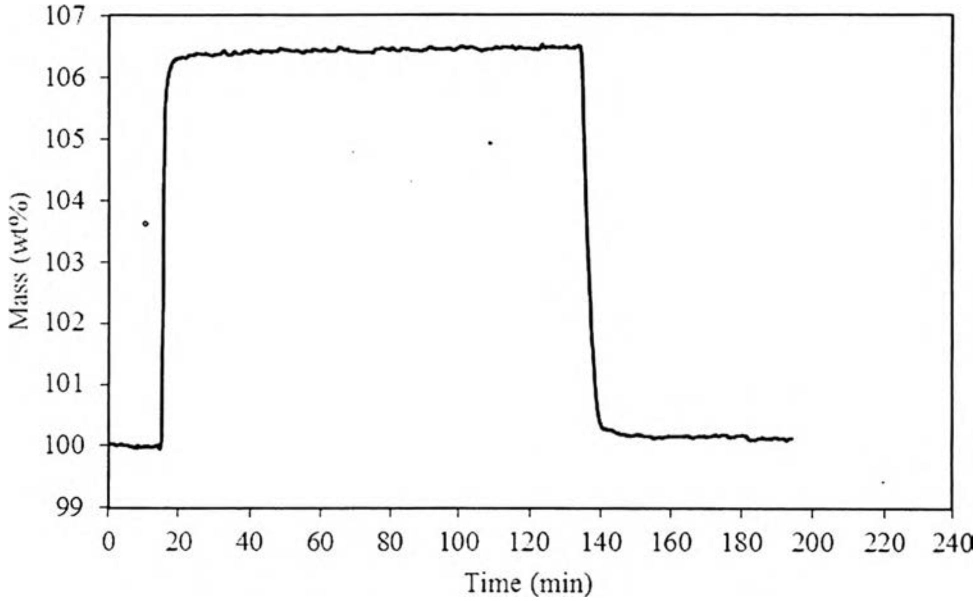

Figure G5 CO_2 adsorption/desorption profile of ACN400.

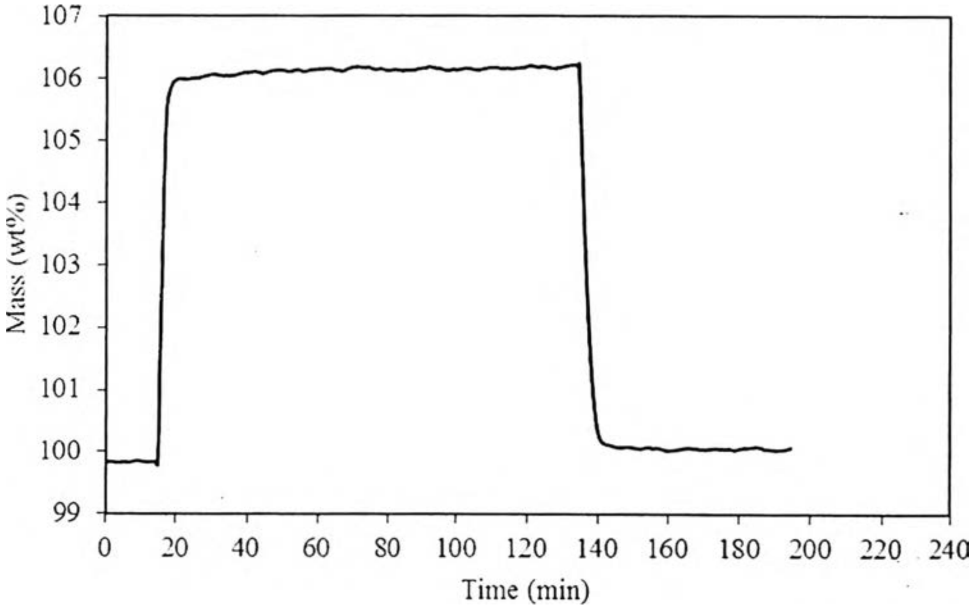

Figure G6 CO_2 adsorption/desorption profile of ACN600.

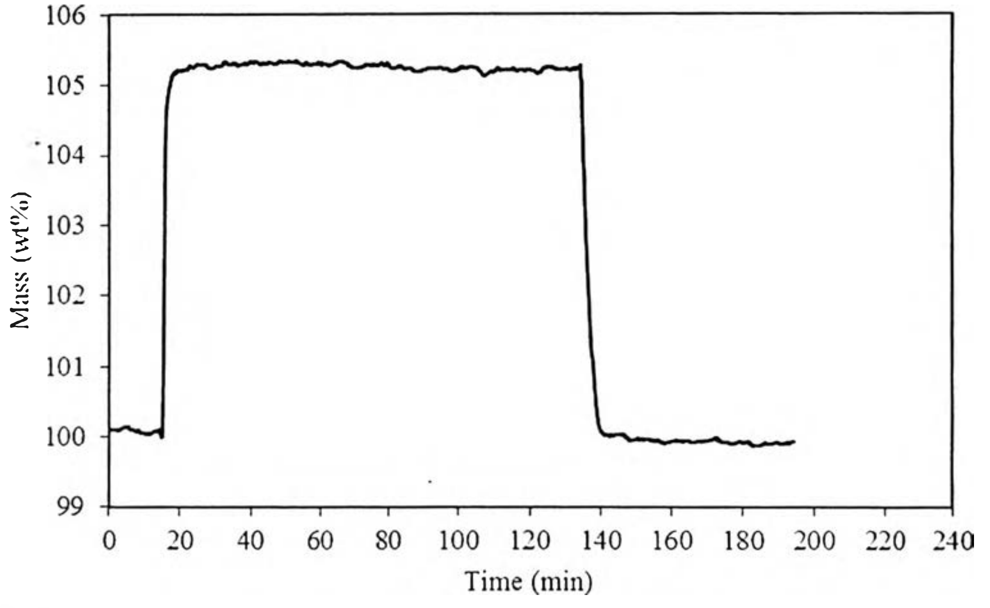

Figure G7 CO_2 adsorption/desorption profile of ACN800.

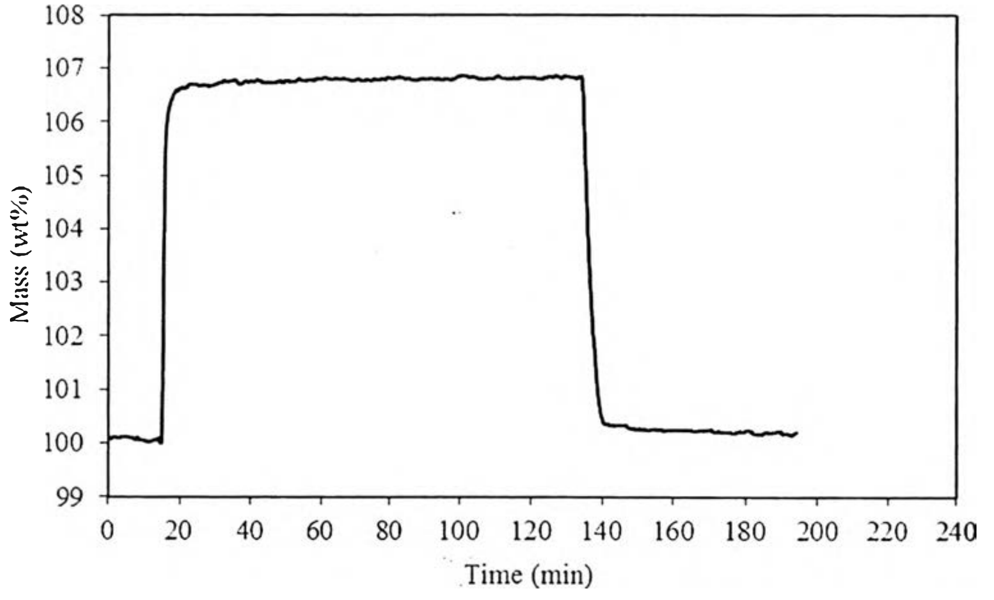

Figure G8 CO_2 adsorption/desorption profile of ACO10-6/N400.

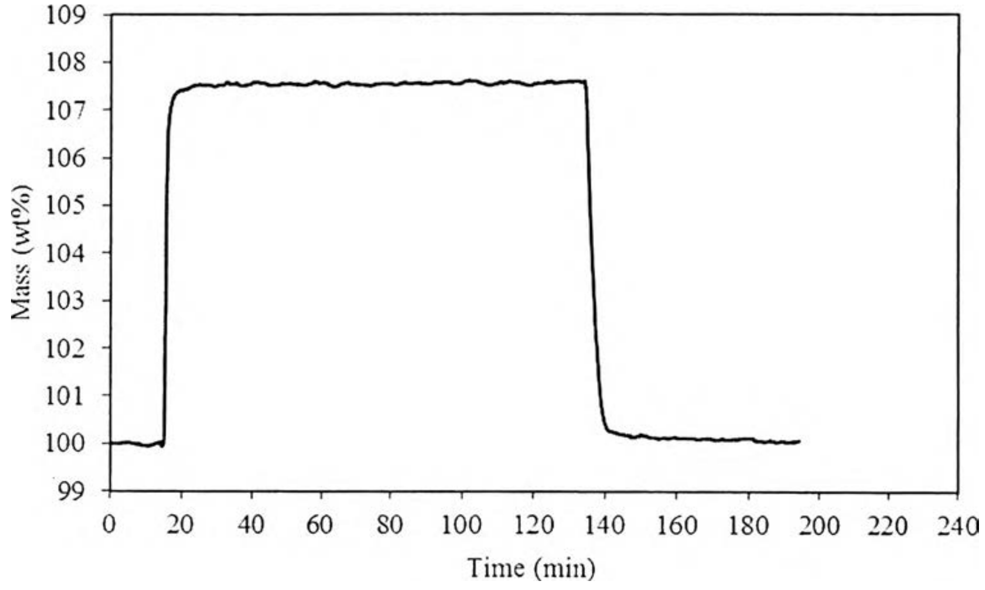

Figure G9 CO_2 adsorption/desorption profile of ACO10-8/N400.

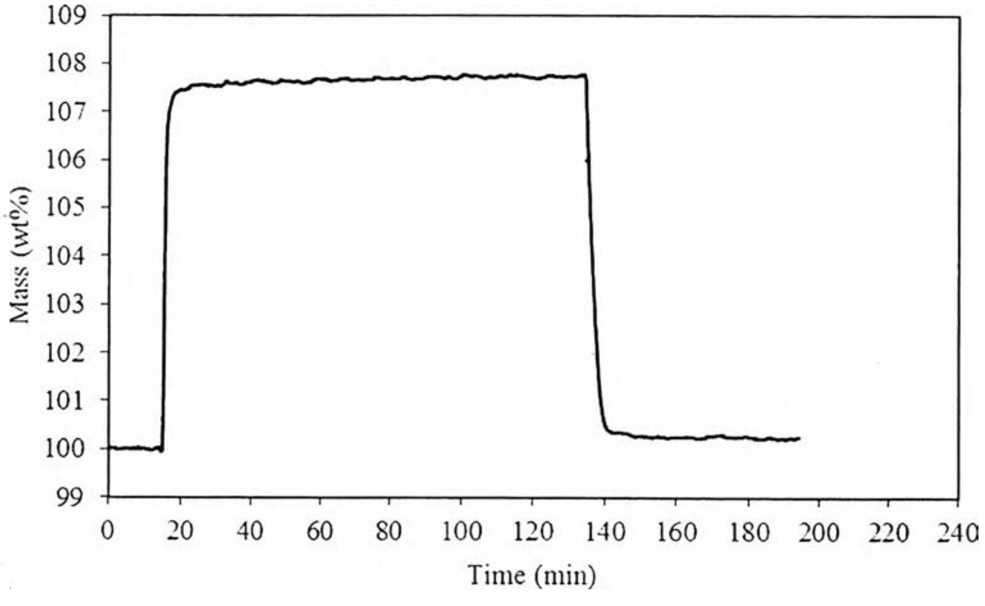

Figure G10 CO_2 adsorption/desorption profile of ACO10-12/N400.

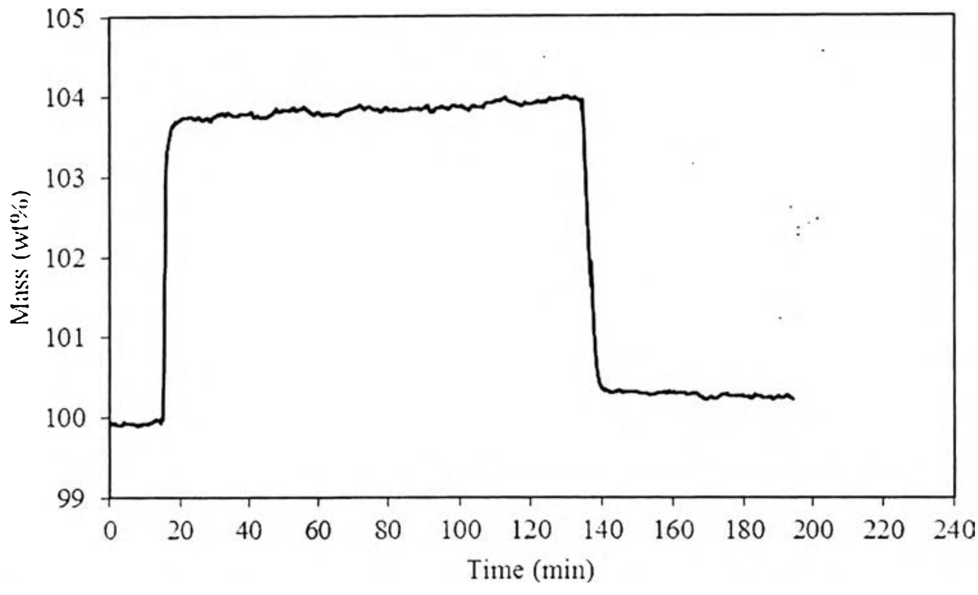

Figure G11 CO_2 adsorption/desorption profile of ACB.

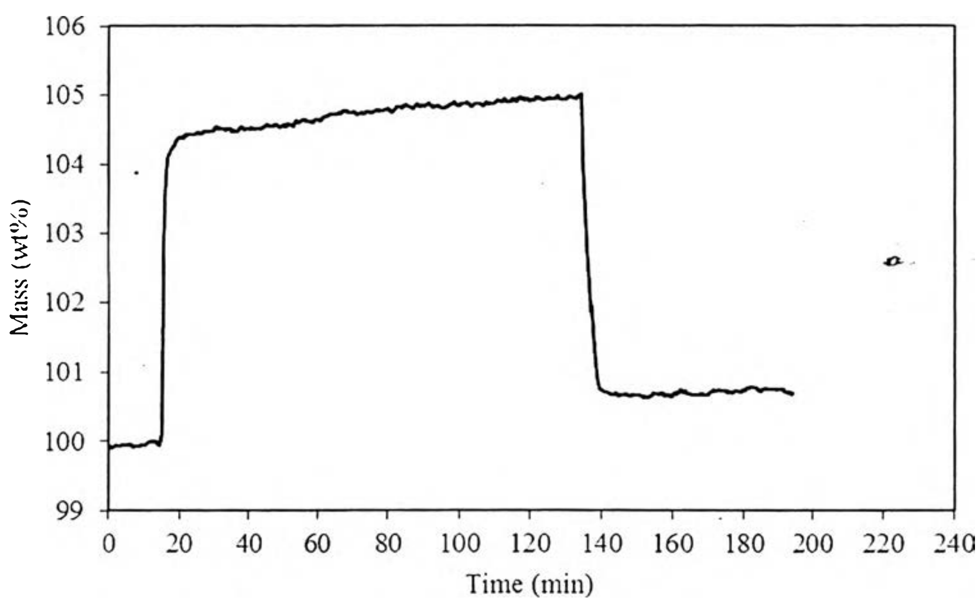

Figure G12 CO_2 adsorption/desorption profile of ACBO10-12.

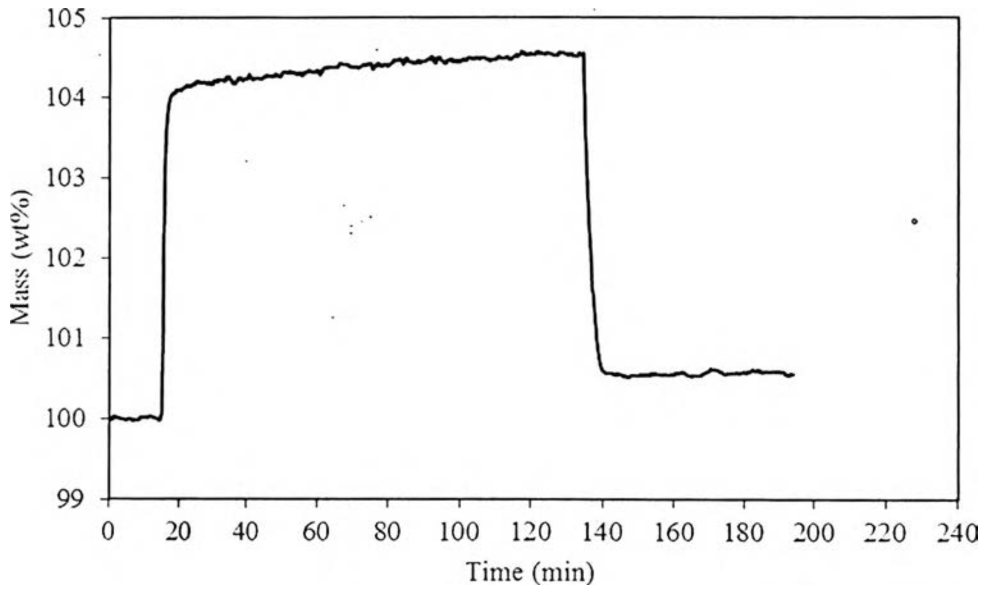

Figure G13 CO_2 adsorption/desorption profile of ACBN400.

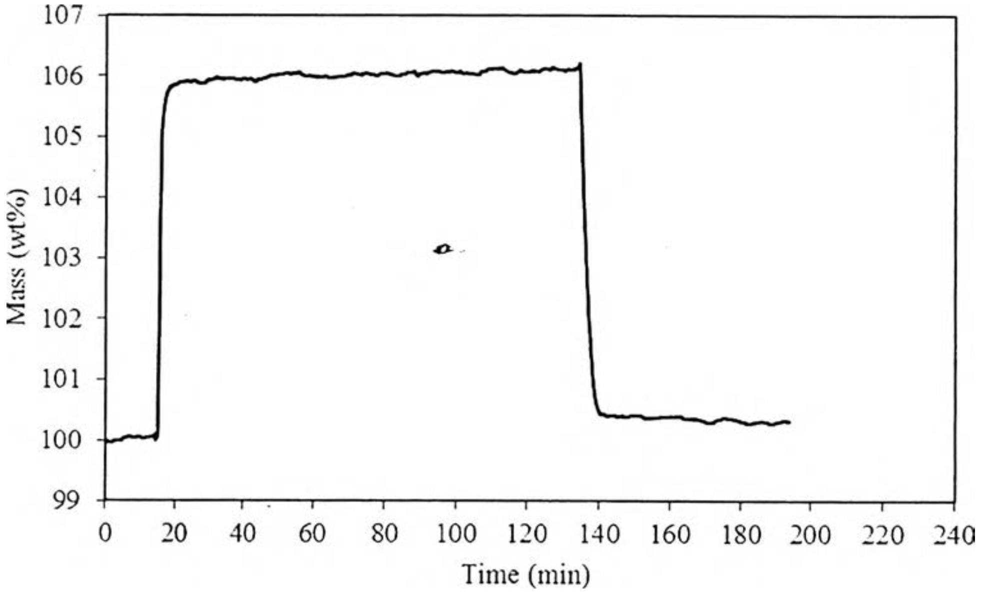

Figure G14 CO_2 adsorption/desorption profile of ACBO10-12/N400.

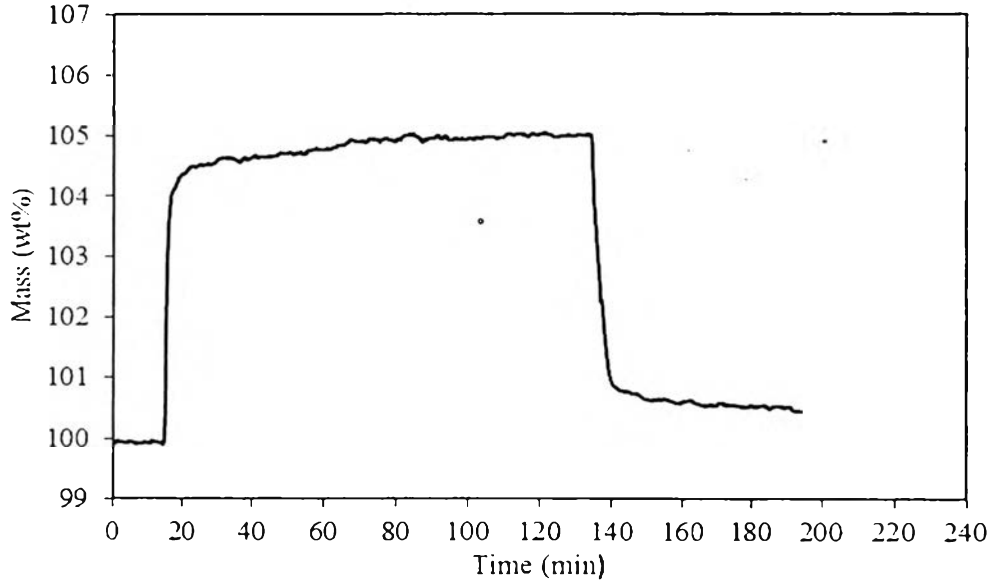

Figure G15 CO_2 adsorption/desorption profile of ACP.

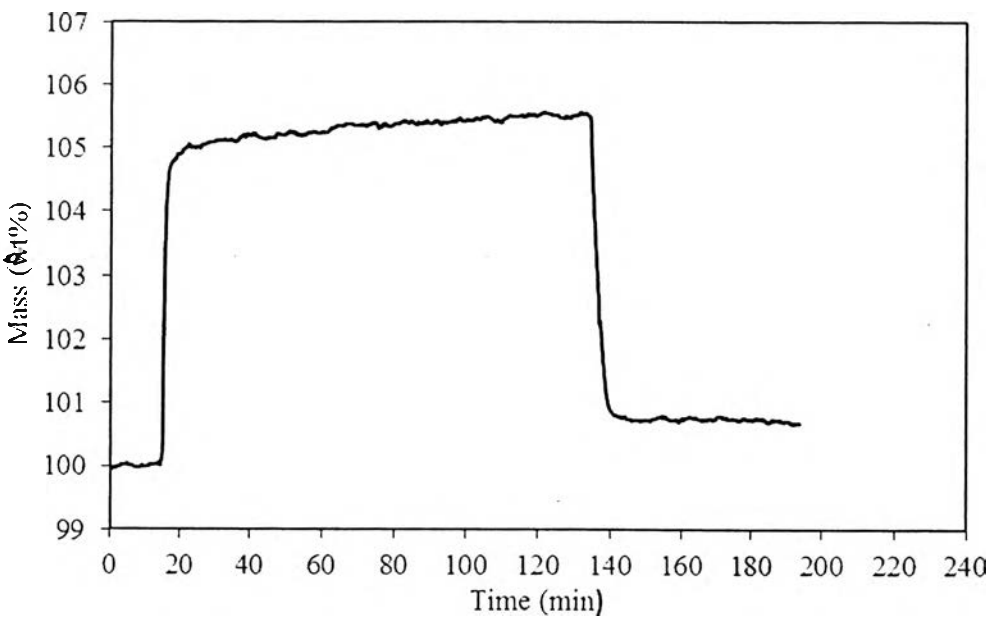

Figure G16 CO_2 adsorption/desorption profile of ACPO10-12.

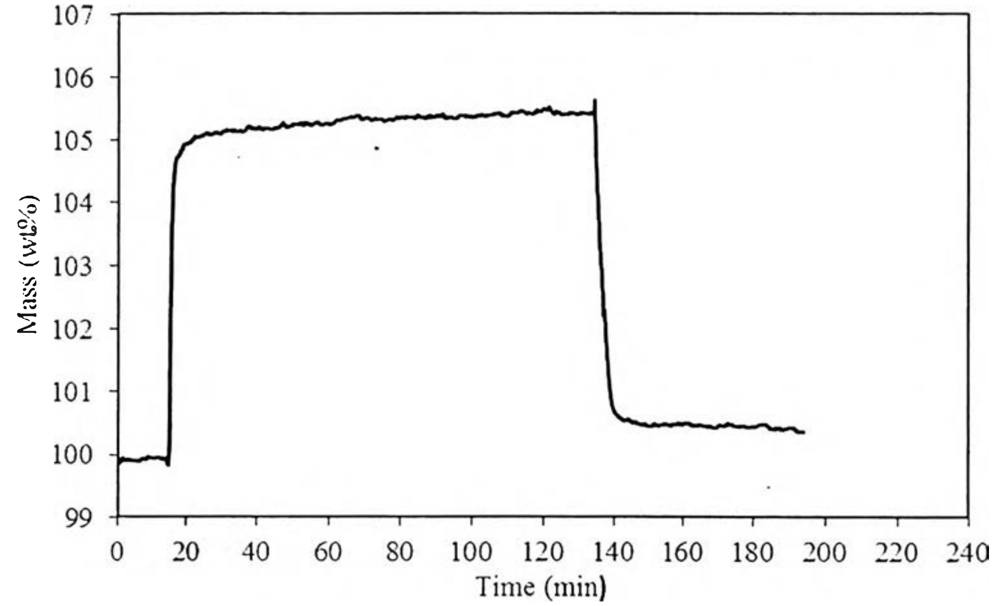

Figure G17 CO_2 adsorption/desorption profile of ACPN400.

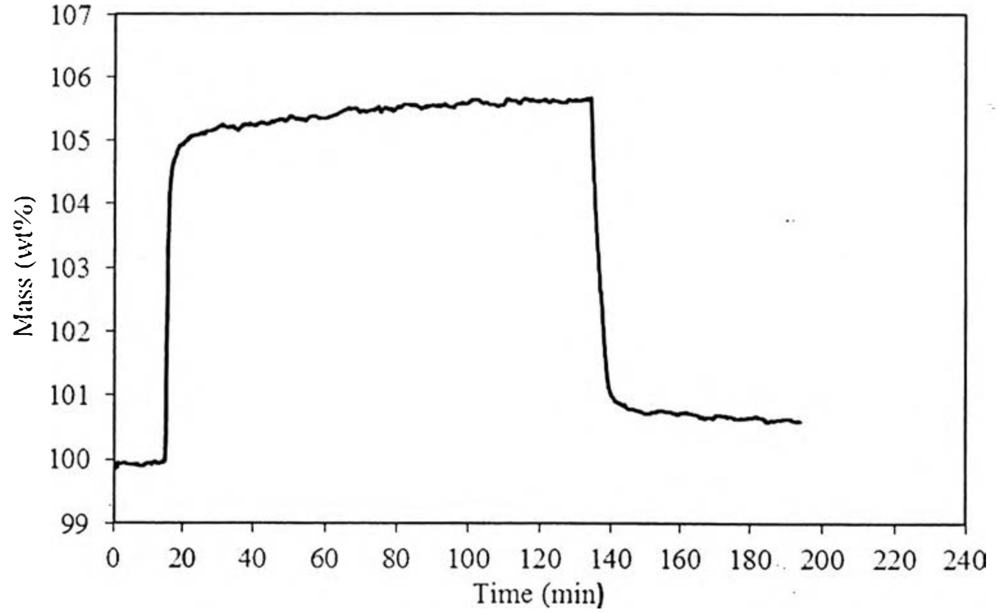

Figure G18 CO_2 adsorption/desorption profile of ACPO10-12/N400.

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Publication:

1. Thongwichit, N.; Li, O.L.; Yaowarat, W.; Saito, N.; and Suriyapraphadilok, U. (2015, April 30) Adsorption of carbon dioxide by solution plasma synthesized hetero-atom doped carbon nano spheres. Japanese Journal of Applied Physics (Submitted).

Proceedings:

1. Thongwichit, N.; and Suriyapraphadilok, U. (2015, April 21) Effects of surface treatment of activated carbon on its surface chemistry and textural characteristics. Proceeding of The 6th Research Symposium on Petroleum, Petrochemicals, and Advanced Materials and The 21th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Chulalongkorn University, Bangkok, Thailand.

Presentations:

1. Thongwichit, N.; and Suriyapraphadilok, U. (2015, January 23-26) Modification of carbon surface by oxidation and ammonia treatment for carbon dioxide adsorption. Paper presented at The 15th Internal Symposium on Biomimetic Materials Processing (BMMP-15), Nagoya University, Nagoya, Japan.

2. Thongwichit, N.; Li, O.L.; Saito, N.; and Suriyapraphadilok, U. (2015, March 26-31) Carbon nano spheres by solution plasma process for CO_2 adsorption. Paper presented at The 7th Internal Symposium on Advanced Plasma Science and Its Applications for Nitrides and Nanomaterials and The 8th Internal Conference on Plasma-Nano Technology & Science, Nagoya University, Nagoya, Japan.
3. Thongwichit, N.; and Suriyapraphadilok, U. (2015, August 16-10) Different approaches of surface treatment on activated carbon for CO_2 captured enhancement. Paper presented at The 250th American Chemical Society National Meeting & Exposition, Boston, United States of America.