

## REFERENCES

- [1] Liška, I. Fifty years of solid-phase extraction in water analysis—historical development and overview. *Journal of Chromatography A* 885(1-2) (2000): 3-16.
- [2] León-González, M. E. and Pérez-Arribas, L. V. Chemically modified polymeric sorbents for sample preconcentration. *Journal of Chromatography A* 902(1) (2000): 3-16.
- [3] Akelah, A. and Moet, A. *Functionalized Polymers and Their Applications* 1<sup>st</sup> ed. Chapman and Hall, 1990.
- [4] Morris, L. R.; Mock, R. A.; Marshall, C. A. and Howe, J. H. Synthesis of some amino acid derivatives of styrene. *Journal of the American Chemical Society* 81(2) (1959): 377-181.
- [5] Feng, M.; Does, L. V. D. and Bantjes, A. Iron (III) chelating resins. V. Cross-linked copolymers of 1-(β-acrylamidoethyl)-3-hydroxy-2-methyl-4(1H)pyridinone (AHMP) and N,N-dimethylacrylamide (DMAA) for iron (III) chelation studies. *Journal of Applied Polymer Science* 52(1) (1994): 21-28.
- [6] Kawakami, Y.; Sugiura, T., Mizutani, Y. and Yamashita, Y. Enantioselective ester synthesis in the presence of optically active polymers. *Journal of Polymer Science: Polymer Chemistry Edition* 18(10) (1980): 3009-3020.
- [7] Merrifield, R. B. Solid phase peptide. I. the synthesis of a tetrapeptide. *Journal of the American Chemical Society* 85(14) (1963): 2149-2154.
- [8] F.J. Rodríguez-Plasencia, F. J.; Navarro-Villoslada, F.; Pérez-Arribas, L.V.; León-González, M. E. and Polo-Díez, L.M. Preconcentration of triazine herbicides from water by an ion chromatography column and determination by gas chromatographymass spectrometry. *Journal of Chromatography A* 760(2) (1997): 314-318.
- [9] León-González. M. E. and Pérez-Arribas, L. V. Chemically modified polymeric sorbents for sample preconcentration. *Journal of Chromatography A* 902(1) (2000): 3-16.
- [10] Masqué, N.; Galiá, M.; Marcé, R.M. and Borrull, F. Chemically modified polymeric resin used as sorbent in a solid phase extraction process to

- determine phenolic compounds in water. Journal of Chromatography A 771(1-2) (1997): 55-61.
- [11] Sun, J. J. and Fritz, J. S. Chemically modified polymeric resins for high-performance liquid chromatography. Journal of Chromatography A 522 (1990): 95-105.
- [12] Masqué, N.; Galiá, M.; Marcé, R.M. and Borrull, F. Solid-phase extraction of phenols and pesticides in water with a modified polymeric resin. The Analyst 122 (1997): 425-428.
- [13] Masqué, N.; Galiá, M.; Marcé, R.M. and Borrull, F. New chemically modified polymeric resin for solid-phase extraction of pesticides and phenolic compounds from water. Journal of Chromatography A 803 (1998): 147-155.
- [14] Masqué, N.; Galiá, M.; Marcé, R.M. and Borrull, F. Influence of chemical modification of polymeric resin on retention of polar compounds in solid-phase extraction. Chromatographia 50 (1999): 21-26.
- [15] Alder, A. D.; Longo, F. R. and Finarelli, J. D. A simplified synthesis for meso-tetraphenylporphine. Journal of Organic Chemistry 32(2) (1967): 476.
- [16] Gibson, H. W. and Bailey, F. C. Chemical Modification of Polymers. 13. Sulfonation of Polystyrene Surfaces. Macromolecules 13(1) (1980): 34-41.
- [17] Wang, C. C. and Wang, C. C. Adsorption characteristics of metal complexes by chelated copolymers with amino group. Reactive & Functional Polymers 66(3) (2006): 343-356.
- [18] Memon, S.; Uysal, G. and Yilmaz, M. Syntheses and binding properties of polymeric calyx[4]crown-4. Reactive & Functional Polymers 47(3) (2001): . 165-174.
- [19] Dwyer, F. P. and Mellor, D. P. Chelating agents and metal chelates London: Academic Press, 1964.
- [20] Bell C. F. Principles and applications of metal chelation New York: Oxford University Press, 1977.
- [21] Mark, R. L. The hard soft [Lewis] acid base principle [Online]. (1999-2006). Available from: [http://www.metasynthesis.com/webbook/43\\_hsab/HSAB.html](http://www.metasynthesis.com/webbook/43_hsab/HSAB.html) [2004, November 4]
- [22] Silverstein, R. M.; Bassler, G. C. and Morrill, T. C. Spectrometric Identification of Organic Compounds New York: John Wiley & Sons Inc, 1991.

- [23] Pasuknirat, S. differences in FTIR spectrum of miscible and phase separated polymer blend of polystyrene acrylonitrile copolymer(SAN) and poly(methyl methacrylate)(PMMA). Master's Thesis, Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University., 2002.
- [24] Sintasanai, K. Preparation of poly(hydroxamic acid)-g-polyethylene and study of its metal binding properties. Master's degree, Department of Chemistry (Polymer Science and Technology), Faculty of Science, Mahidol University., 2005.
- [25] Grasselli, J. G.; Snavely, M. K. and Bulkin, B. J. Chemical application of Raman Spectroscopy New York: John Wiley & Sons, 1981.
- [26] Ingle, J. D. and Crouch, S.R. Spectrochemical Analysis. Prentice-Hall International, Inc. 1988: 507.
- [27] Li, Y.; Fan, Y.; and Ma, J. Thermal, physical and chemical stability of porous polystyrene-type beads with different degrees of crosslinking. Polymer degradation and stability 73(1) (2001) 163-167.
- [28] Bruch, M. D. and Fatunmbi, H. O. Nuclear magnetic resonance analysis of silica gel surfaces modified with mixed, amine-containing ligands. Journal of Chromatography A 1021(1-2) (2003): 61-70.
- [29] Camel, V. Solid phase extraction of trace elements. Spectrochimica Acta Part B: Atomic Spectroscopy 58(7) (2003): 1177-1233.
- [30] Schwarzenbach, R. P.; Gschwend, P. M.; and Imboden, D. M. Environmental Organic Chemistry New York: John Wiley & Sons, 1993.
- [31] Carson, M. C. Ion-pair solid-phase extraction. Journal of Chromatography A 885(1-2) (2000): 343-350.
- [32] Bilba, D.; Bejan, D. and Tafan, L. Chelating sorbents in inorganic chemical analysis. Croatica Chemica Acta 71(1) (1998): 155-178.
- [33] Mahmoud, M. E. Silica gel-immobilized Eriochrome black-T as a potential solid phase extractor for zinc(II) and magnesium(II) from calcium(II). Talanta 45(2) (1997): 309-315.
- [34] Pesavento, M.; Biesuz, R. and Cortina, J. L. Sorption of metal ions on a weak acid cation-exchange resin containing carboxylic groups. Analytica Chimica Acta 298(2) (1994): 225-232.

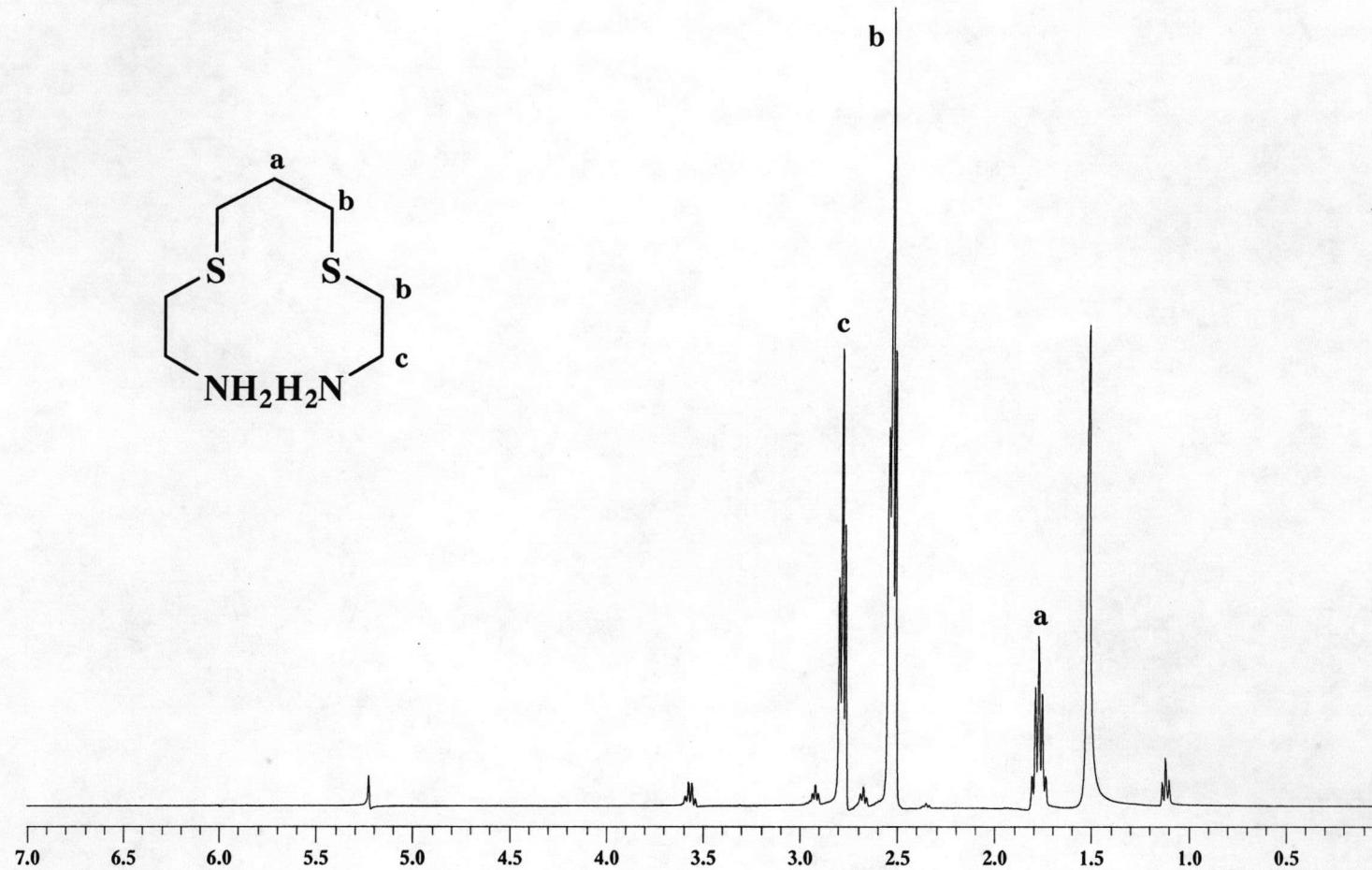
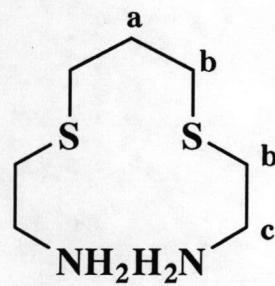
- [35] Pesavento, M.; Biesuz, R.; Gallorini, M. and Profumo, A. Sorption mechanism of trace amounts of divalent metal ions on a chelating resin containing iminodiacetate groups. *Analytical Chemistry* 65(18) (1993): 2522-2527.
- [36] Kumagai, H.; Inoue, Y.; Yokoyama, T.; Suzuki, T. M. and Suzuki, T. Chromatographic selectivity of rare earth elements on iminodiacetate-type chelating resins having spacer arms of different lengths: importance of steric flexibility of functional group in a polymer chelating resin. *Analytical Chemistry* 70(19) (1998): 4070-4073.
- [37] Seneviratne, J. and Cox, J. A. Sol-gel materials for the solid phase extraction of metals from aqueous solution. *Talanta* 52(5) (2000): 801-806.
- [38] Qu, R.; Sun, C.; Wang, C.; Ji, C.; Sun, Y.; Guan, L.; Yu, M. and Cheng, G. Preparation and metal binding behavior of poly(4-vinylbenzyl 2-hydroxethyl) sulfoxide and sulfone. *European Polymer Journal* 41(7) (2005): 1525-1530.
- [39] Trochimczuk, A. W.; Kolarz, B. N. and Jermakowicz-Bartkowiak, D. Metal ion uptake by ion-exchange/chelating resins modified with cyclohexene oxide and cyclohexene sulphide. *European Polymer Journal* 37(3) (2001): 559-564.
- [40] Jain, V. K.; Handa, A.; Pandya, R.; Shrivastav, P. and Agrawal, Y. K. Polymer supported calix[4]arene-semicarbazone derivative for separation and preconcentration of La(III), Ce(III), Th(IV) and U(VI). *Reactive & Functional Polymers* 51(2-3) (2002): 101-110.
- [41] Pathak, R. and Rao, G. N. Preparation and analytical properties of a chelating resin functionalized with 1-hydrazinophthalazine ligand. *Talanta* 44(8) (1997): 1447-1453.
- [42] Meltida, P.; Sanghamitra, K.; Gladis, J. M.; Naidu, G. R. K. and Rao, T. P. Amberlite XAD-4 functionalized with succinic acid for the solid phase extractive preconcentration and separation of uranium(VI). *Talanta* 65(1) (2005): 192-200.
- [43] Prabhakaran, D. and Subramanian, M. S. A new chelating sorbent for metal ion extraction under high saline conditions. *Talanta* 59(6) (2003): 1227-1236.
- [44] Venkatesh, G. and Singh, A. K. 2-{[1-(3,4-Dihydroxyphenyl)methylidene] amino} benzoic acid immobilized Amberlite XAD-16 as metal extractant. *Talanta* 67(1) (2005): 187-194.

- [45] Kim, Y. S.; In, G.; Han, C. W. and Choi, J. M. Studies on synthesis and application of XAD-4-salen chelate resin for separation and determination of trace elements by solid phase extraction. *Microchemical Journal* 80(2) (2005): 151-157.
- [46] Lemos, V. A.; Santos, J. S.; Nunes, L. S. Carvalho, M. B.; Baliza, P. X. and Yamaki, R. T. Amberlite XAD-2 functionalized with Nitroso R salt: synthesis and application in an online system for preconcentration of cobalt. *Analytica Chimica Acta* 494(1-2) (2003): 87-95.
- [47] Lemos, V. A.; Baliza, P. X.; Yamaki, R. T.; Rocha, M. E. and Alves, A. P. O. Synthesis and application of a functionalized resin in on-line system for copper preconcentration and determination in foods by flame atomic absorption spectrometry. *Talanta* 61(5) (2003): 675-682.
- [48] Tewari, P. K. and Singh, A. K. Synthesis, characterization and applications of pyrocatechol modified amberlite XAD-2 resin for preconcentration and determination of metal ions in water samples by flame atomic absorption spectrometry (FAAS). *Talanta* 53(4) (2001): 823-833.
- [49] Tewari, P. K. and Singh, A. K. Preconcentration of lead with Amberlite XAD-2 and Amberlite XAD-7 based chelating resins for its determination by flame atomic absorption spectrometry. *Talanta* 56(4) (2002): 735-744.
- [50] Rodríguez, I.; Llompart, M. P. and Cela, R. Solid-phase extraction of phenols. *Journal of Chromatography A* 885(1) (2000): 291-304.
- [51] Yu, J. C.; Jiang, Z. T.; Liu, H. Y.; Yu, J. and Zhang, L.  $\beta$ -Cyclodextrin epichlorohydrin copolymer as a solid-phase extraction adsorbent for aromatic compounds in water sample. *Analytica Chimica Acta* 477(1) (2003): 93-101.
- [52] Choudhury, S. B.; Ray, D. and Chakravorty, A. Sulfur-Ligated Nickel Oxidation States. Chemistry of a Family of  $Ni^zS_2N_4$  ( $z = +2, +3, +4$ ) Complexes Incorporating Hexadentate Thioether-Imine-Oxime Binding. *Inorganic Chemistry* 30 (1991): 4354-4360.
- [53] Frechet, J. M.; and Schuerch, C. Solid-Phase Synthesis of Oligosaccharides. I. Preparation of the Solid Support. Poly[*p*-(1-propen-3-ol-1-yl)styrene] *Journal of the American Chemical Society* 93 (1971): 492-496.
- [54] Kaiser, E.; Colescott, R. L.; Bossinger, C. D.; and Cook, P. I. Color test for detection of free terminal amino groups in the solid-phase synthesis of peptides. *Analytical Biochemistry* 34 (1970): 595-598.

- [55] Sarin, V. K.; Kent, S. B. H.; Tam, J. P.; and Merrifield, R. B. Quantitative Monitoring of solid-phase peptide synthesis by the ninhydrin reaction. Analytical Biochemistry 117 (1981) 147-157.
- [56] Shriver, D.F. and Atkins, P.W. Inorganic Chemistry 3<sup>rd</sup> ed. Oxford: Oxford University Press, 1999.
- [57] Cotton, F. A.; Wilkinson, G.; Murillo, C. A. and Bochmann, M. Advanced Inorganic Chemistry 6<sup>th</sup> ed. New York: John Wiley & Sons, 1993.

## **APPENDICES**

**APPENDIX A  $^1\text{H-NMR}$ ,  $^{13}\text{C-NMR}$  and FTIR of chelating ligands.**



**Figure A.1**  $^1\text{H}$ -NMR spectrum of AEPE in  $\text{CDCl}_3$ .

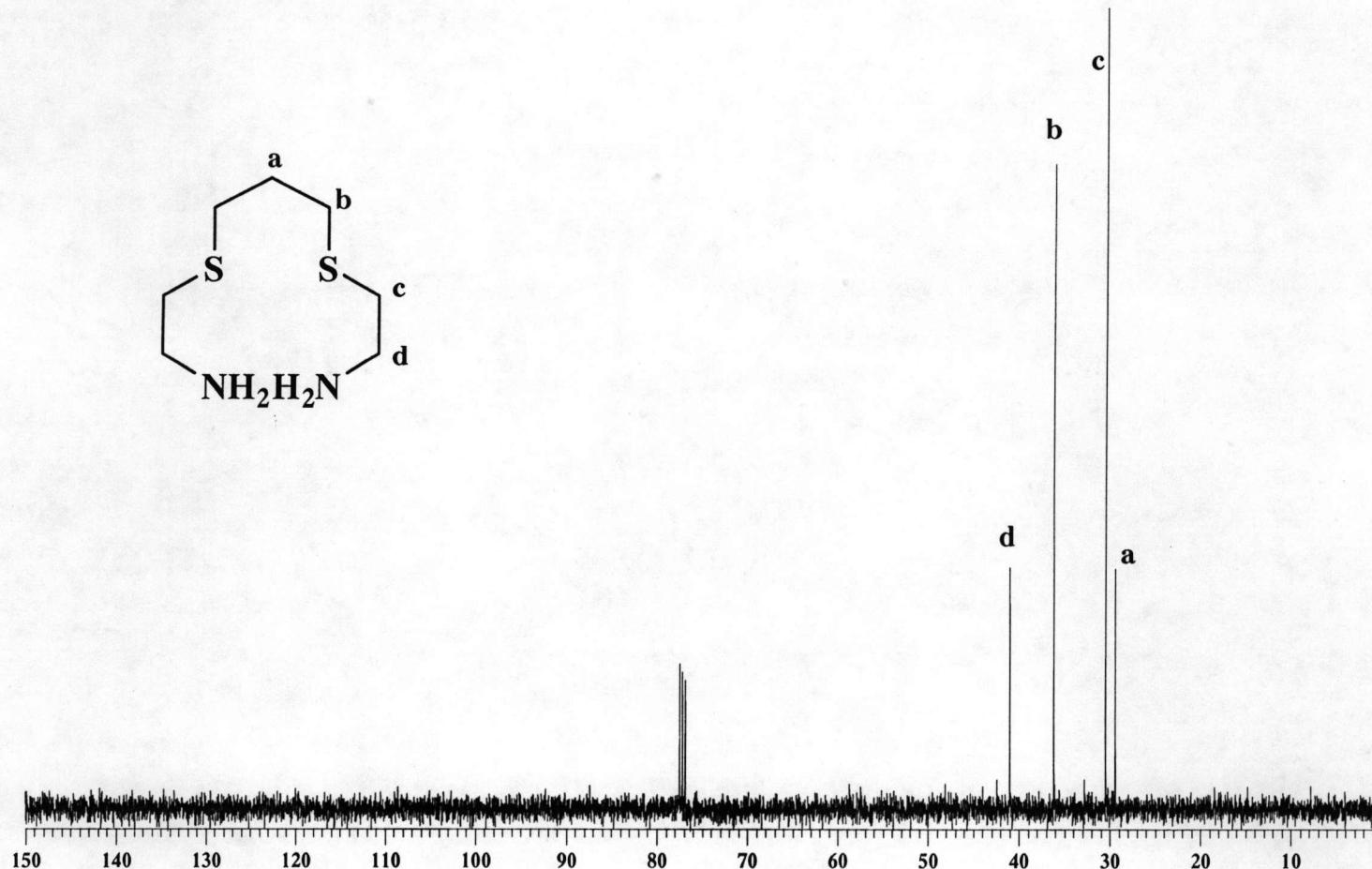


Figure A.2  $^{13}\text{C}$ -NMR spectrum of AEPE in  $\text{CDCl}_3$ .

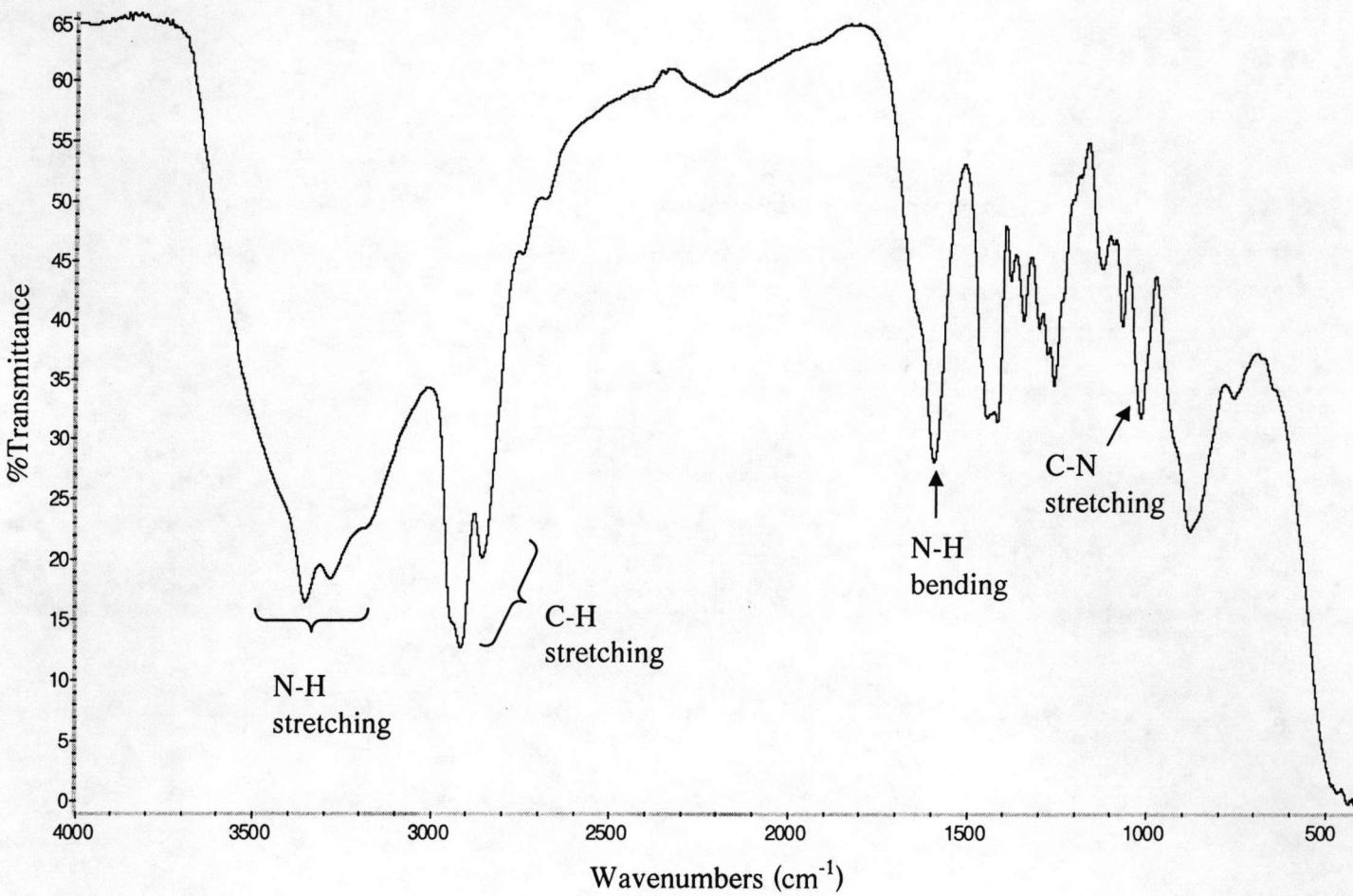
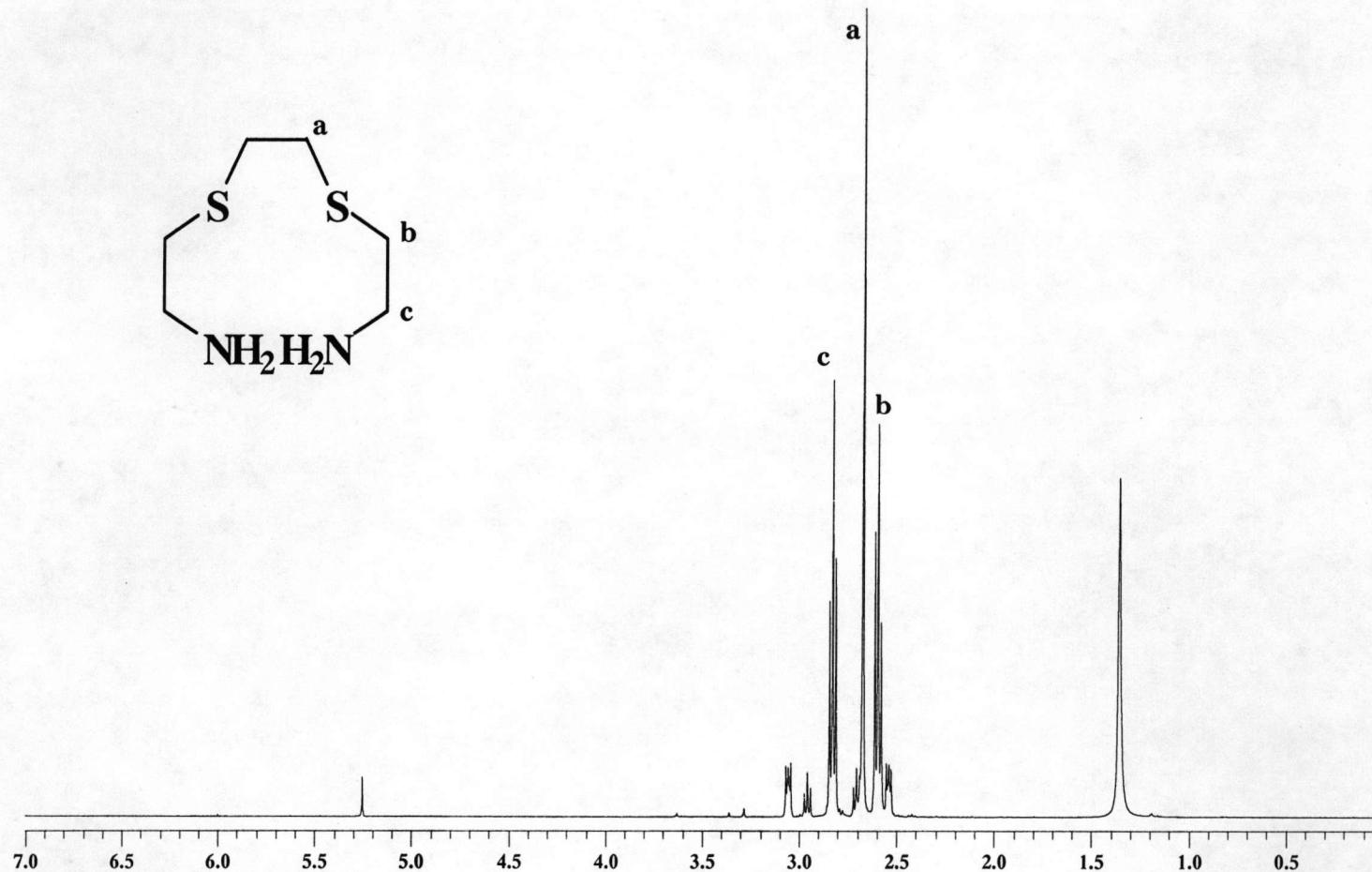
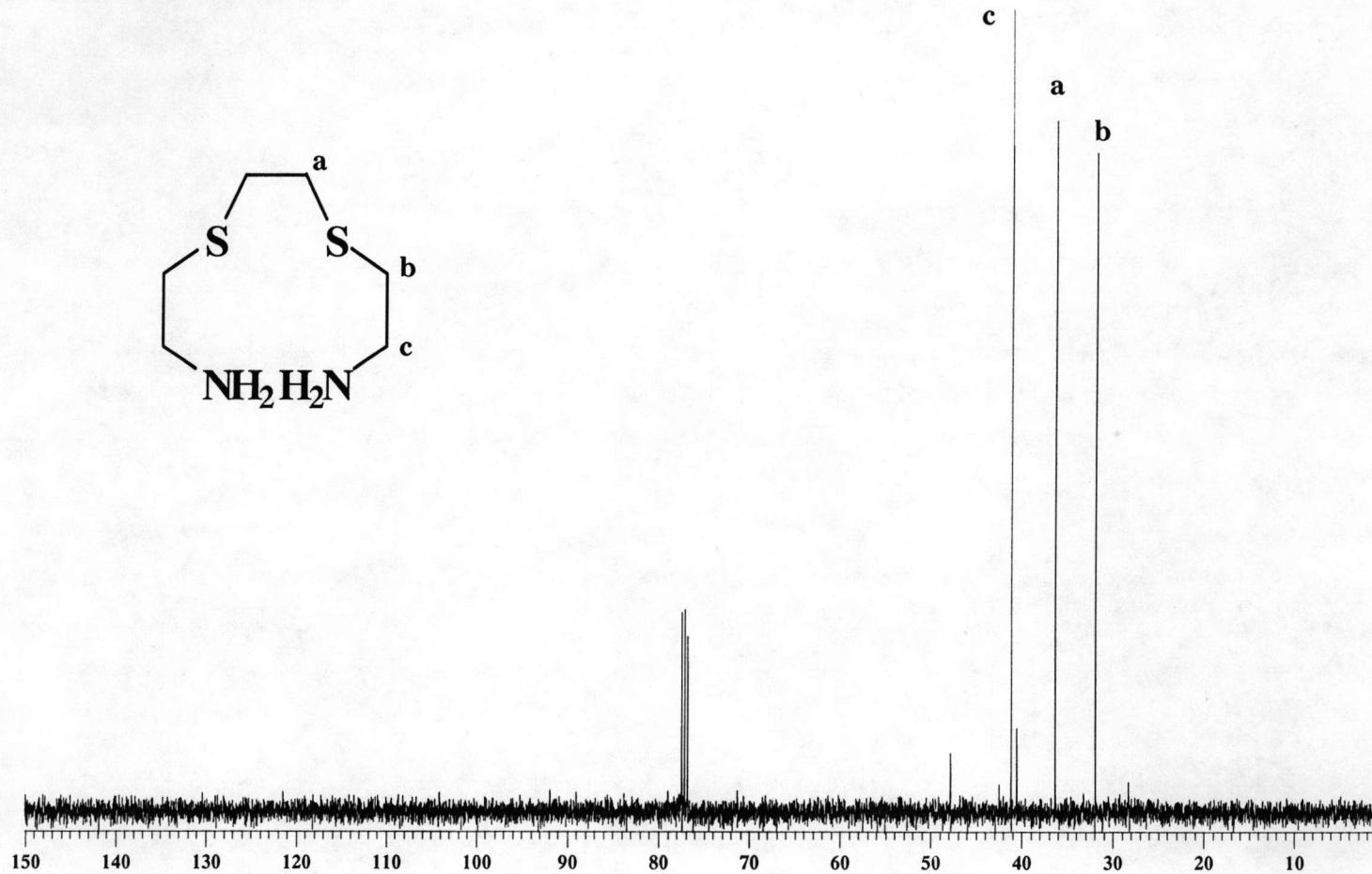
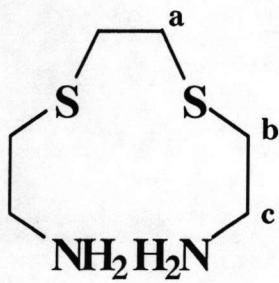


Figure A.3 FT-IR spectrum of AEPE.



**Figure A.4**  $^1\text{H}$ -NMR spectrum of AEEE in  $\text{CDCl}_3$ .



**Figure A.5** <sup>13</sup>C-NMR spectrum of AEEE in CDCl<sub>3</sub>.

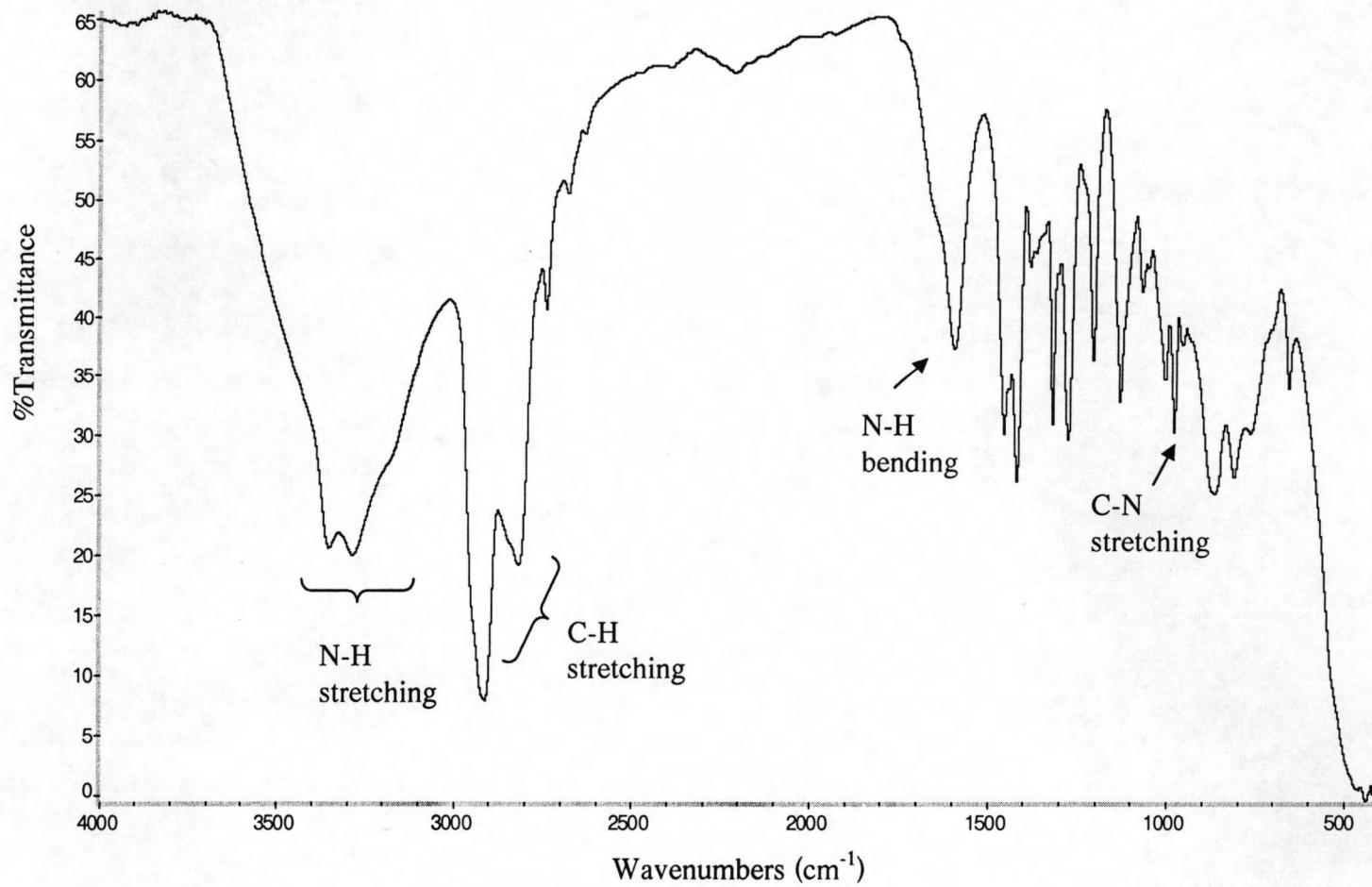


Figure A.6 FT-IR spectrum of AEEE.

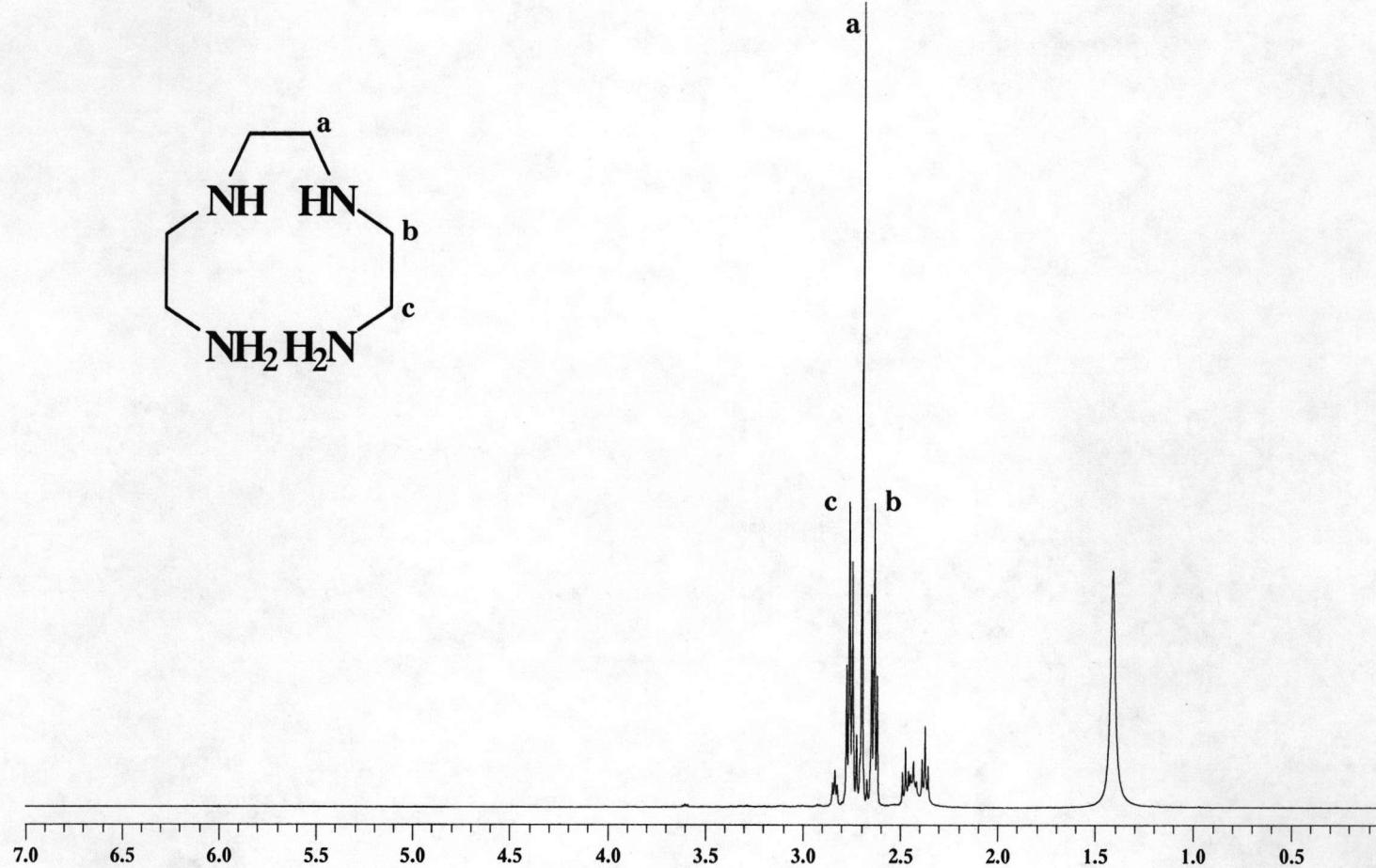
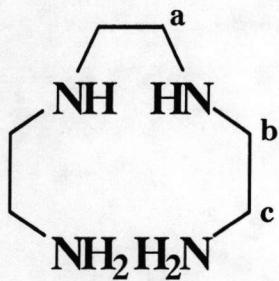


Figure A.7  $^1\text{H}$ -NMR spectrum of TETA in  $\text{CDCl}_3$ .

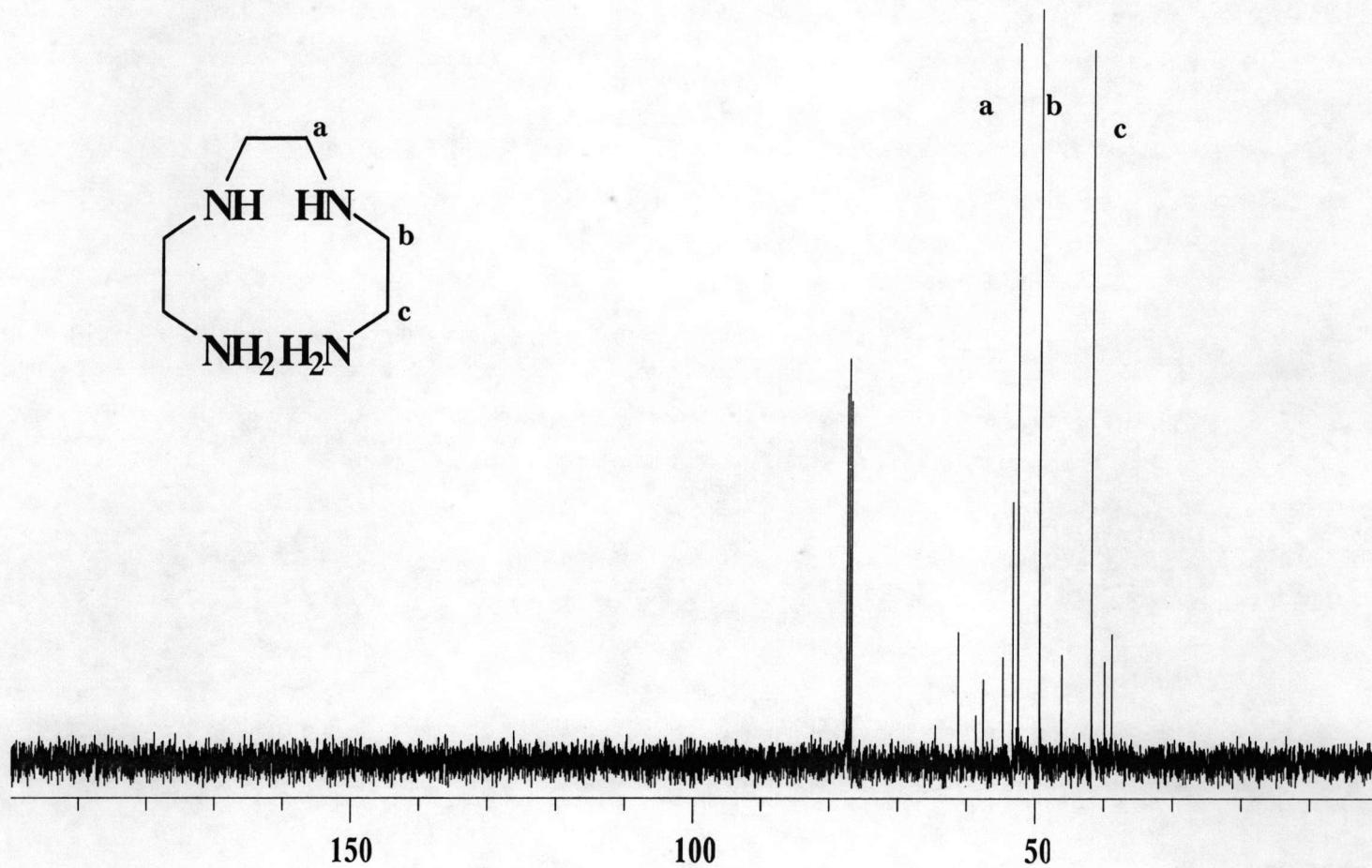


Figure A.8  $^{13}\text{C}$ -NMR spectrum of TETA in  $\text{CDCl}_3$ .

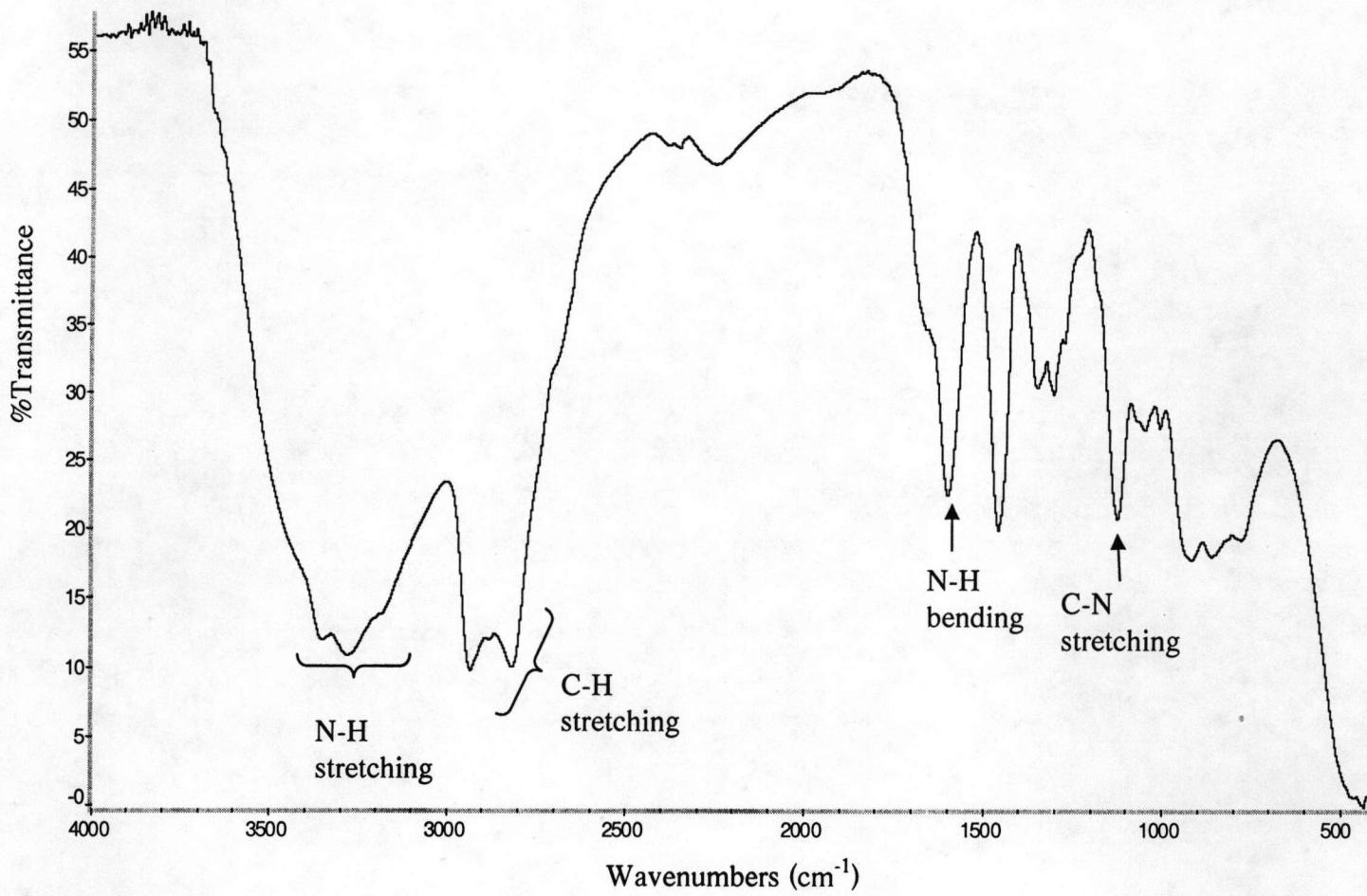


Figure A.9 FTIR spectrum of TETA.

## VITA

Mr. Pradit Nutthanara was born on August 11, 1981 in Ratchaburi, Thailand. He received his Bachelor Degree of Science in Chemistry from Chulalongkorn University in 2004. After that, he has been a graduate student in the Program of Petrochemistry and Polymer Science, Faculty of Science, Chulalongkorn University and a member of Environmental Analysis Research Unit. He finished his postgraduate study with the Master degree of Science in 2007.

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