

## REFERENCES

1. Lee, H. and Neville, K. Handbook of Epoxy Resin. New York : McGraw-Hill, 1967.
2. Clayton, A. and May, I. Epoxy Resins. Chemistry and Technology. New York : Marcel Dekker, 1988.
3. George Odian. Principles of Polymerization. New York : John Wiley & Sons, 1981.
4. Malcom. P. Stevens. Polymer Chemistry. New York : Oxford University Press, Inc., 1990.
5. Kurnoskin, A.V. Handbook of Applied Polymer Processing Technology. New York : Marcel Dekker, 1996.
6. Gary, C. "Cure Kinetics of a Low Epoxide/Hydroxyl Group Ratio Bisphenol-A Epoxy Resin Anhydride System by Infrared Absorption Spectroscopy," *J. Appl. Polym. Sci.* 1981, **26**, 4259-4278.
7. Steinmann, B. "Anhydride-Cured Epoxies via Chain Reaction. 1. The Phenyl Glycidyl Ether/ Phthalic Acid Anhydride System," *Macromolecules*. 1991, **24**, 4738-4744.
8. Kurnoskin, A.V. "Epoxy Chelate Copper-Containing Polymers : Their Chemistry and Production," *Polym.-Plast. Technol. Eng.* 1992, **31**(5&6), 505-525.
9. Lin, K.F.; Shu, W.Y.; and Wey, T.L. "Organotransition Metal Complexes as Additives for Epoxy Resins. 1. Their Effects on Toughness and Morphology of Epoxy Resins," *Polymer*. 1993, **34**(2), 277-279.
10. Lin, K.F.; Shu, W.Y.; and Wey, T.L. "Organotransition Metal Complexes as Additives for Epoxy Resins. 2. Interaction with Epoxy Resins," *Polymer*. 1993, **34**(10), 2162-2168.

11. Anand, M. and Srivastava, A.K. "Synthesis and Characterization of Epoxy Resins Containing Transition Metals," *Polymer*. 1993, **34**, 2860-2864.
12. Anand, M. and Srivastava, A.K. "Synthesis and Characterization of Epoxy Resins Containing Arsenic Acrylate," *Polym. Eng. Sci.* 1997, **37**(1), 183-187.
13. Kurnoskin, A.V. "Thermal Oxidative Destruction of Epoxy Polymer," *J.M.S. REV. Macromol. Chem. Phys.* 1995, **35**, 419.
14. Kurnoskin, A.V. "The Influence of Intracomplex Compounds of Copper and Cadmium on the Properties of Epoxy Amine System," *Polym. Eng. Sci.* 1992, **32**(14), 956-963.
15. Kurnoskin, A.V. "Metalliferous Epoxy-Chelate Polymers," *J.M.S.-REV. Macromol. Chem. Phys.* 1996, **36**(3), 457-599.
16. Kurnoskin, A.V. "Metalliferous Epoxy-Chelate Polymers. 1. Synthesis and Properties," *Polymer*. 1993, **34**(5), 1060-1067.
17. Kurnoskin, A.V. "Polymer Based on Epoxy Oligomers and Hardeners. Chelates of Metals with Aromatic and Heterocyclic Amine," *Ind. Eng. Chem. Res.* 1992, **31**, 524-529.
18. Kurnoskin, A.V. "Heat Resistant of Metal-Containing Epoxy Chelate Polymer," *Polym. Degrad. Stab.* 1992, **37**, 51-59.
19. Kurnoskin, A.V. "Diane Oligomer : Heat Resistant Increase by Metal Ions," *Polym.-Plast. Technol. Eng.* 1991, **30**(7), 737-750.
20. Kurnoskin, A.V. "Metal Salicyraldimines as Modifiers of Epoxy Polymers," *Polym.-Plast. Technol. Eng.* 1992, **31**(5&6), 441-450.
21. Kurnoskin, A.V. "Epoxy Polymer Modification with Metals," *Polymer Composites*. 1993, **14**(6), 481-490.
22. Tongraung, P. *Synthesis of Metal Containing Epoxy Polymer*. Master's Thesis, Department of Chemistry, Graduate School, Chulalongkorn University, 1997.

23. Matejka, L.; Lovy, J.; Pokorny, K.; Bouchal, K. and Dusek, K. "Curing Epoxy Resins with Anhydrides. Model Reactions and Reaction Mechanism," *J. Appl. Polym. Sci.* 1983, **21**, 2873-2885.
24. Boschel, D. and Fedtke, M. "Reaction Behavior of Resol and Novolac Model Compounds with Acid Anhydrides," *Angew. Makromol. Chem.* 1994, **220**, 163-176.
25. Boschel, D. and Fedtke, M. "Zur Hartung von Diandiglycidylether mit anhydridmodifizierten phenolischen Hartern und zu vergleichbaren in situ-Reaktionen," *Angew. Makromol. Chem.* 1996, **239**, 201.
26. Boschel, D.; Fedtke, M. and Geyer, W. "Investigation of Modified Phenolic Hardeners and Curing of An Epoxy Resin by TG-FTIR," *Polymer.* 1997, **38** (6), 1291-1296.

## **APPENDICES**

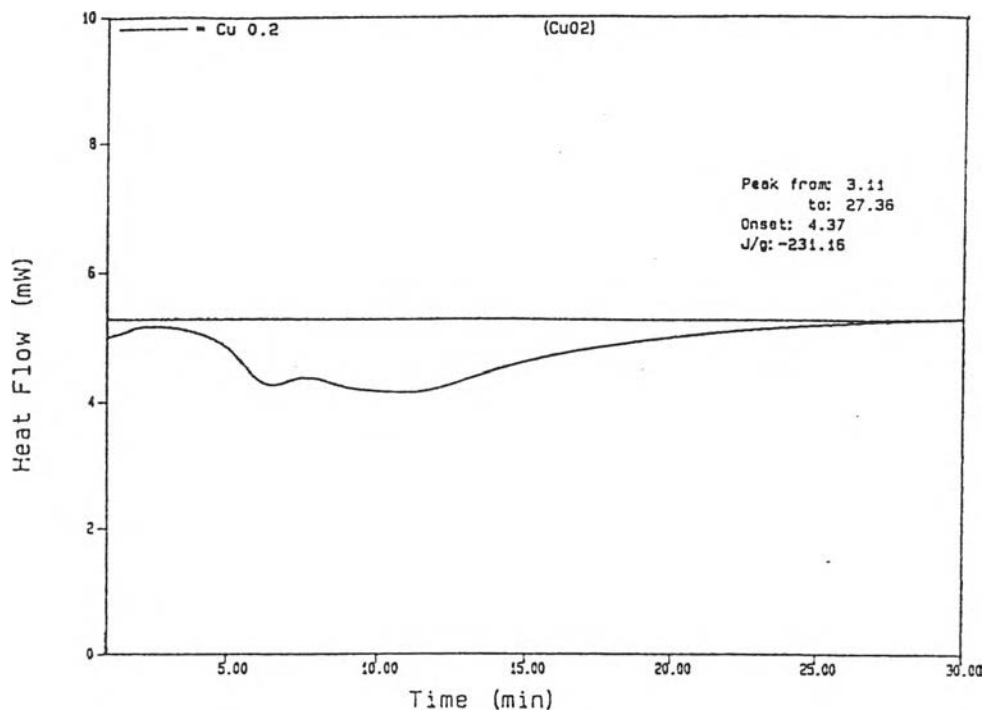


Figure A. 3.1 Isothermal (150 °C) DSC thermogram of CuL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1

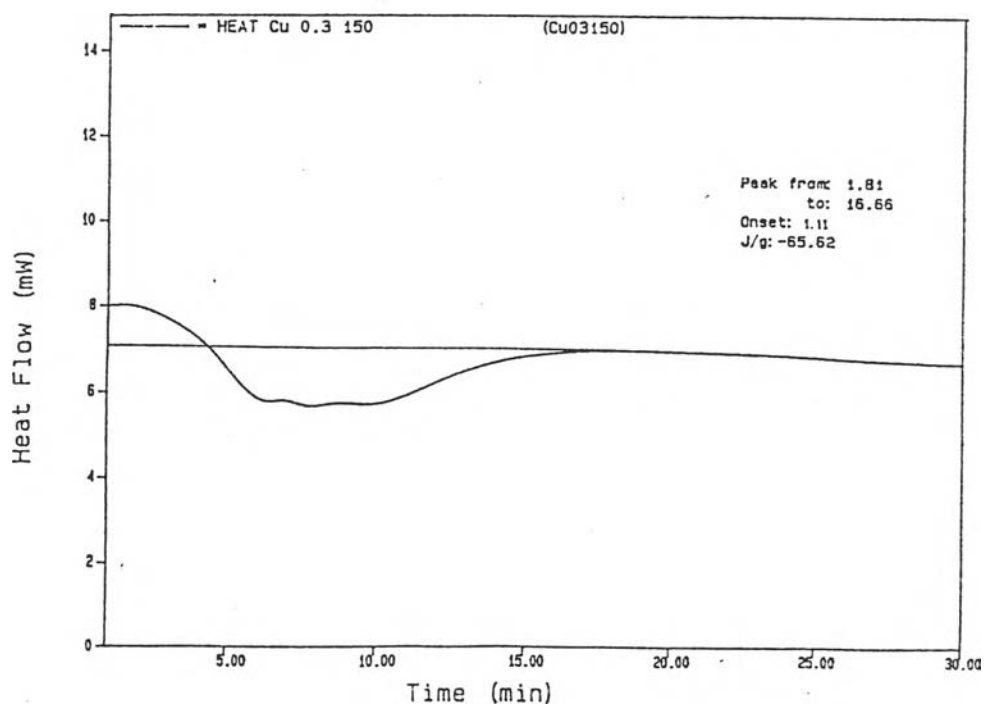


Figure A. 3.2 Isothermal (150 °C) DSC thermogram of CuL : MA : DGEBA at the mole ratio of 0.3 : 0.3 : 1

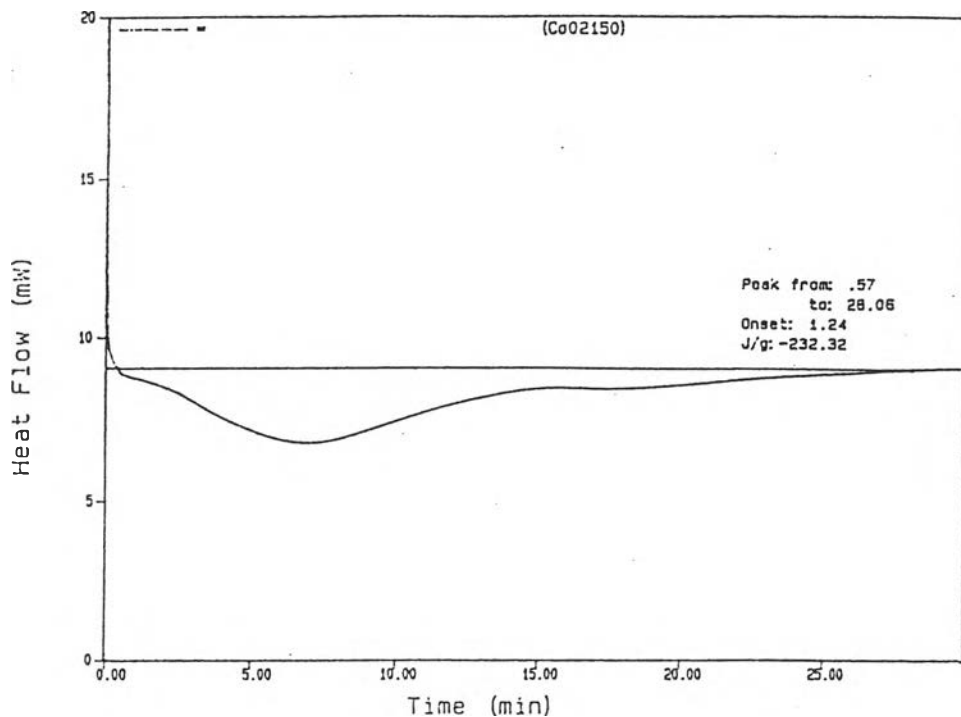


Figure A. 3.3 Isothermal (150 °C) DSC thermogram of CoL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1

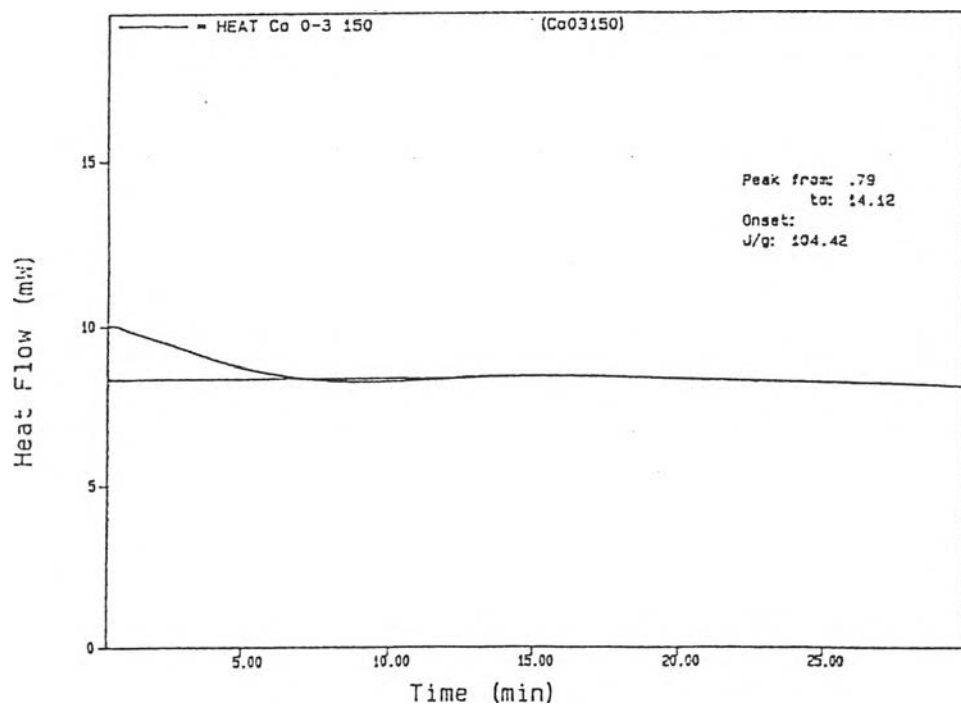


Figure A. 3.4 Isothermal (150 °C) DSC thermogram of CoL : MA : DGEBA at the mole ratio of 0.3 : 0.3 : 1

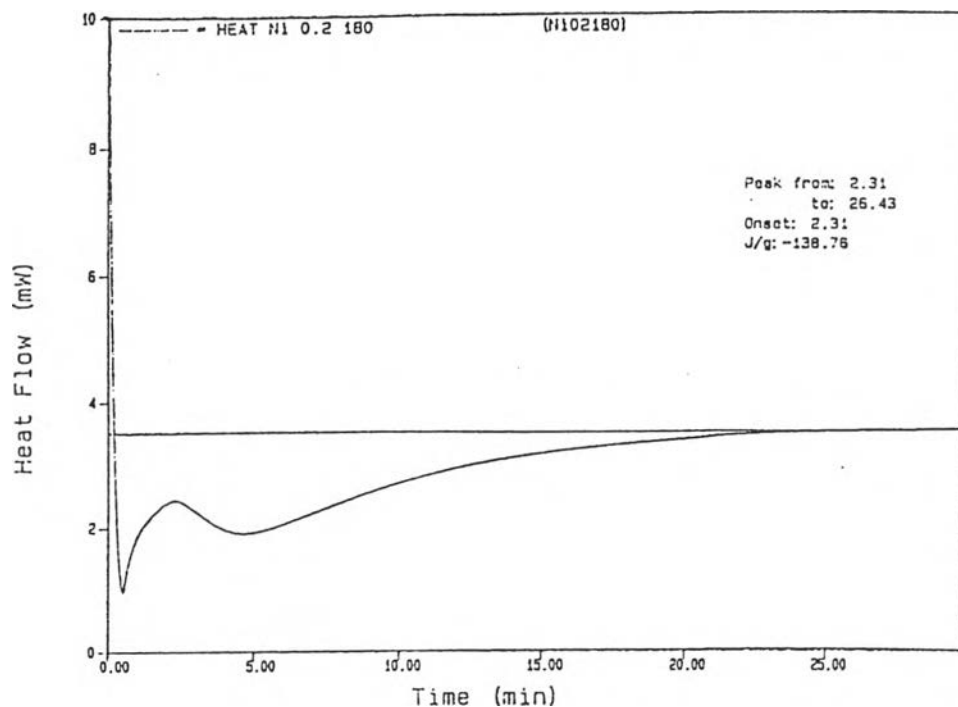


Figure A. 3.5 Isothermal (180 °C) DSC thermogram of NiL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1

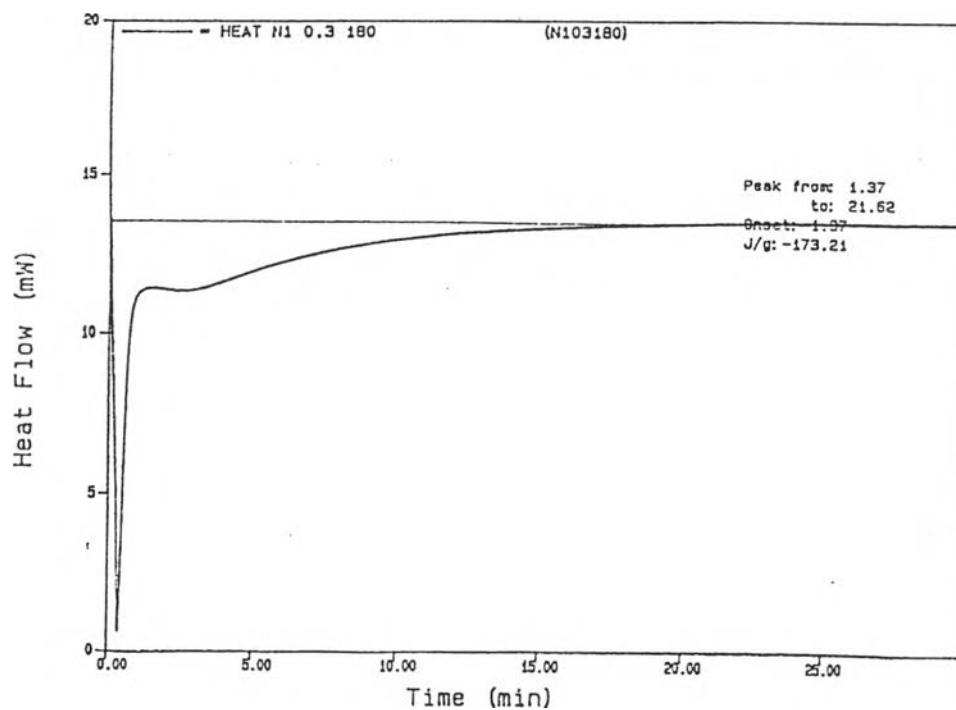


Figure A. 3.6 Isothermal (180 °C) DSC thermogram of NiL : MA : DGEBA at the mole ratio of 0.3 : 0.3 : 1

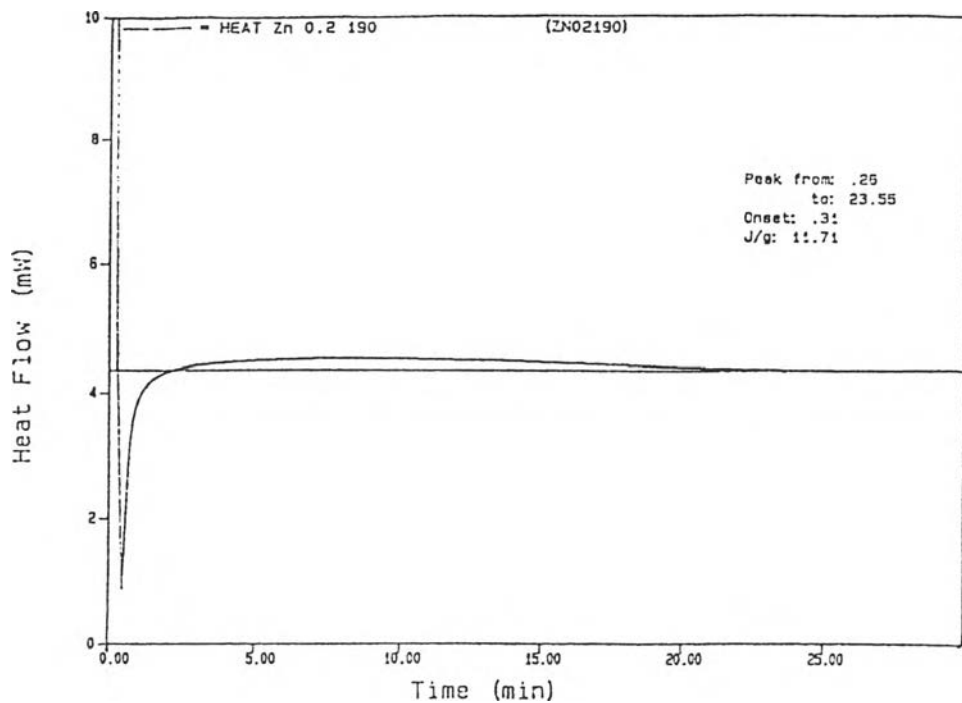


Figure A. 3.7 Isothermal (190 °C) DSC thermogram of ZnL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1

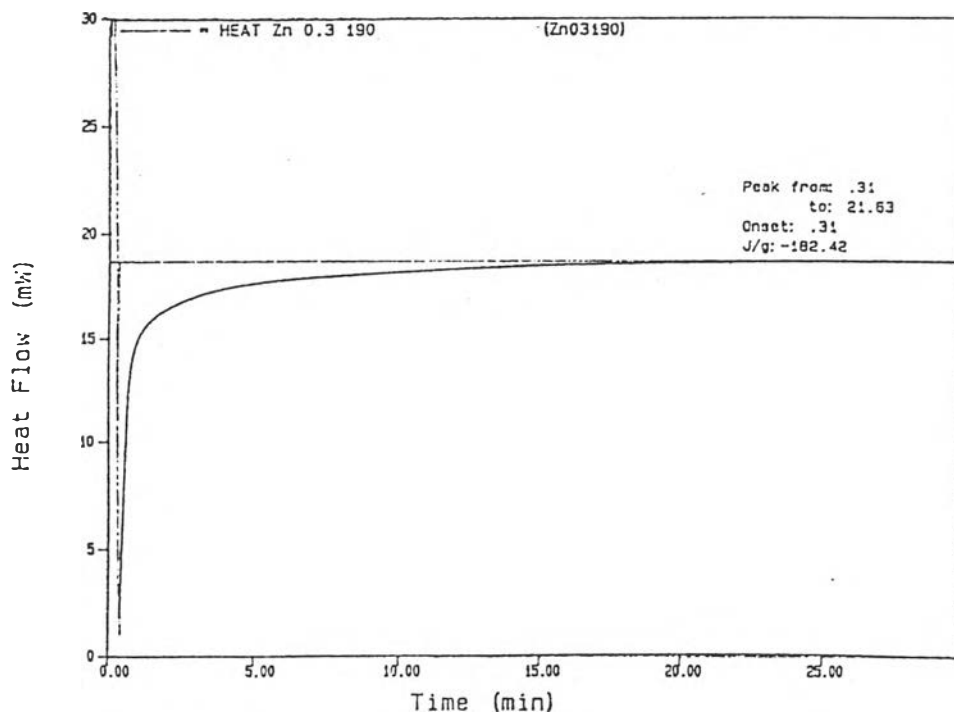


Figure A. 3.8 Isothermal (190 °C) DSC thermogram of ZnL : MA : DGEBA at the mole ratio of 0.3 : 0.3 : 1



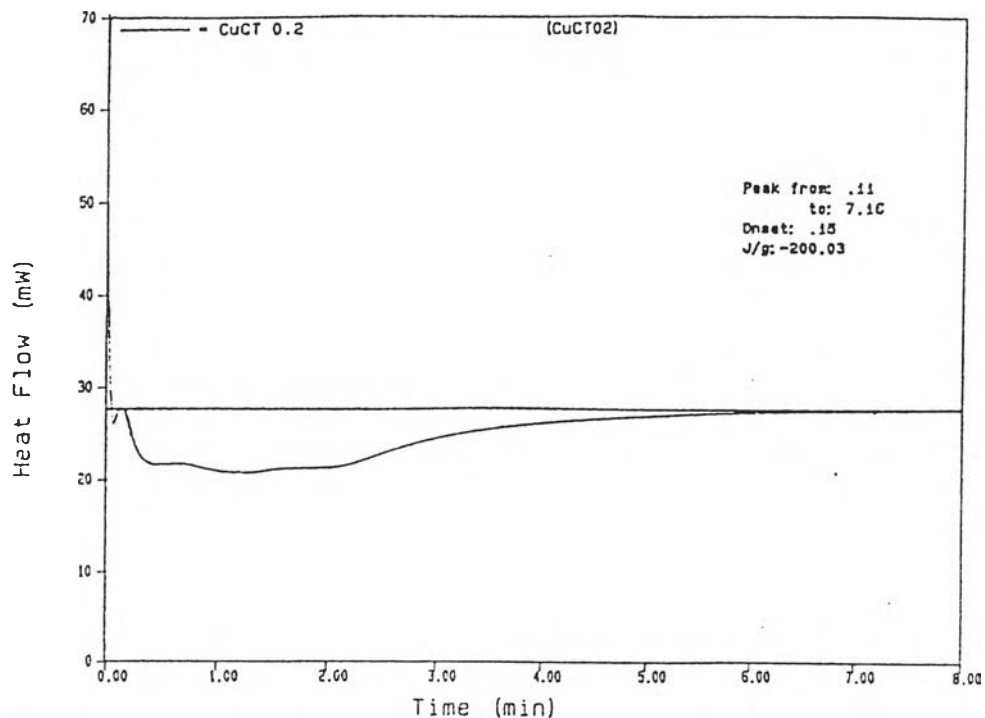


Figure A. 3.9 Isothermal (150 °C) DSC thermogram of CuL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1 and Bu<sub>4</sub>NOH was employed as a catalyst

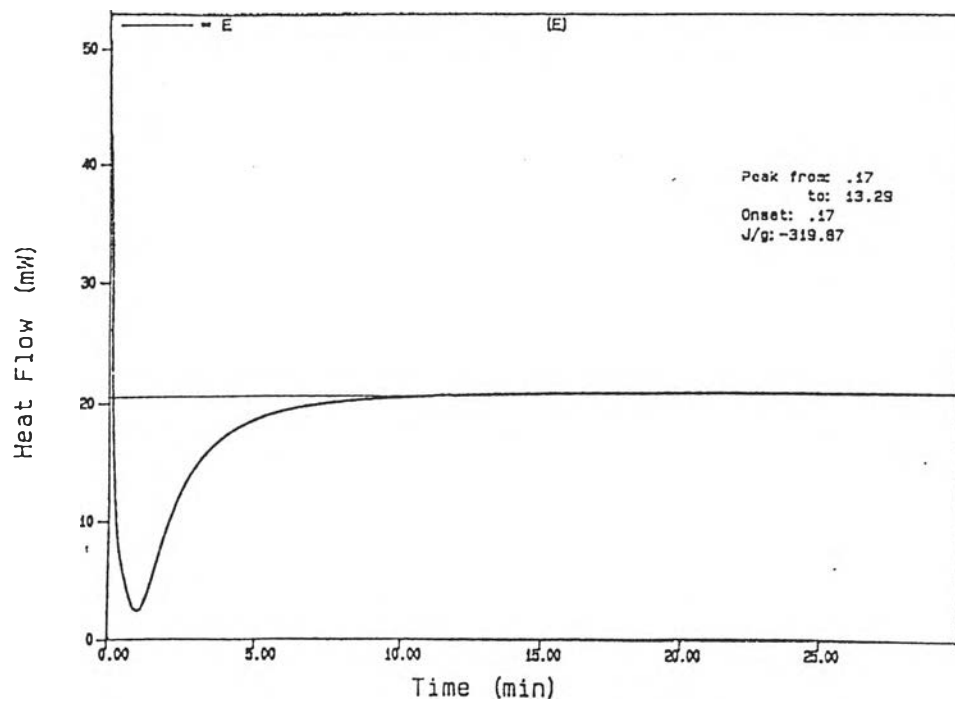


Figure A. 3.10 Isothermal (150 °C) DSC thermogram of DGEBA : MA at the mole ratio of 1 : 2.8 and BDMA was employed as a catalyst

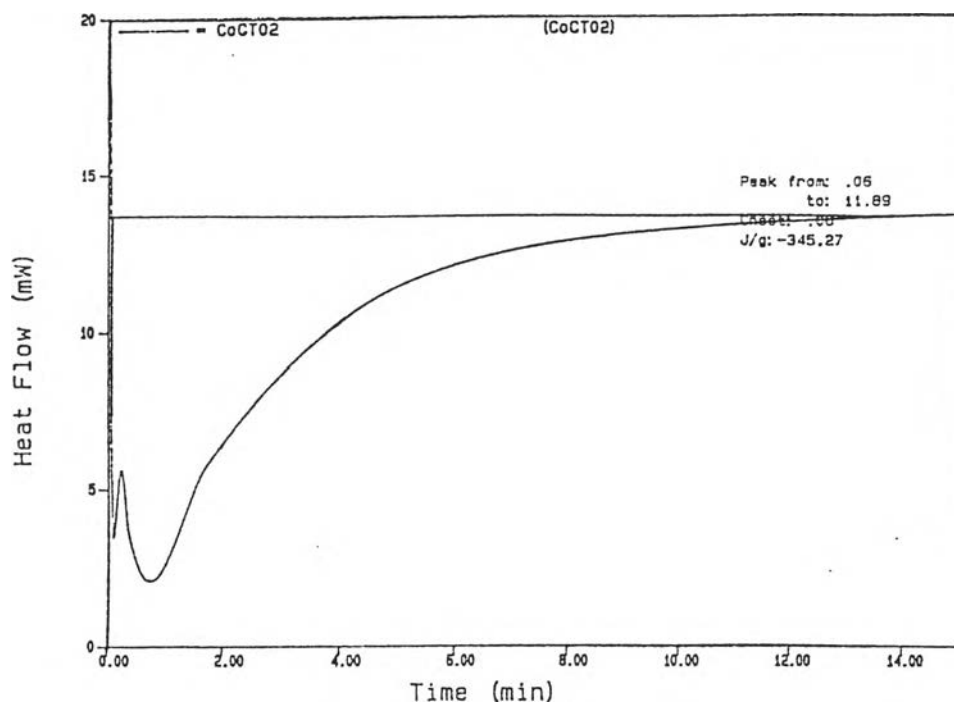


Figure A. 3.11 Isothermal (150 °C) DSC thermogram of CoL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

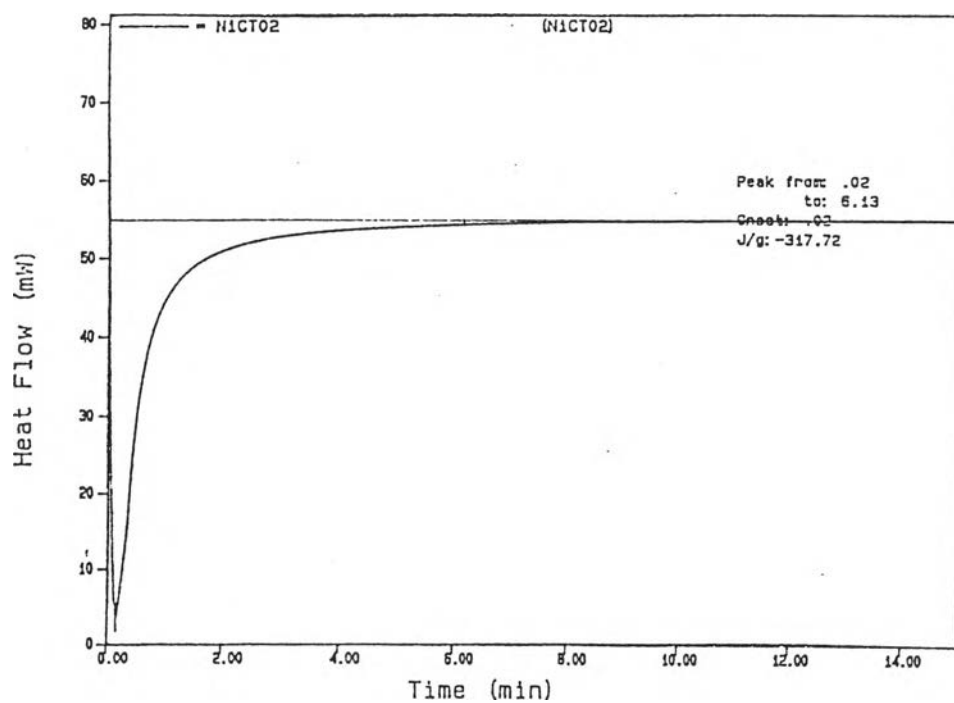


Figure A. 3.12 Isothermal (180 °C) DSC thermogram of NiL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

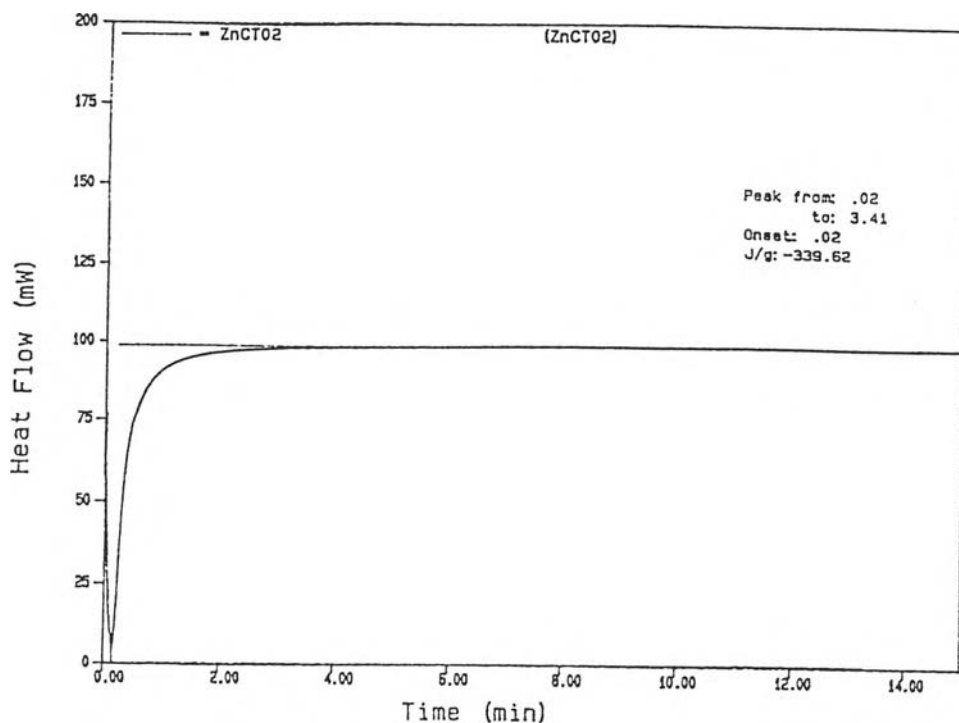


Figure A. 3.13 Isothermal (190 °C) DSC thermogram of ZnL : MA : DGEBA at the mole ratio of 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

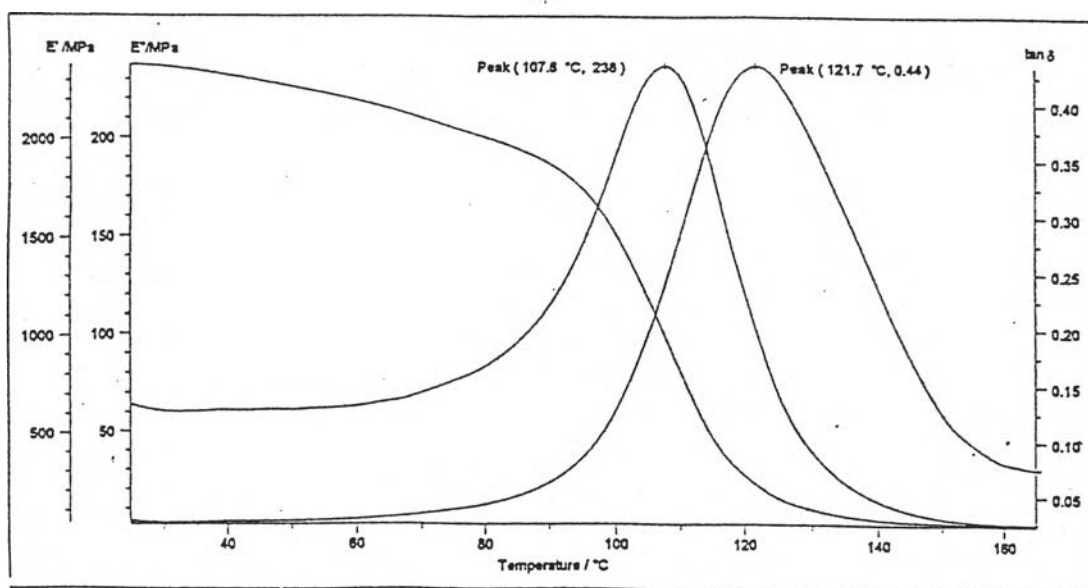


Figure A. 3.14 DMA thermogram of Cu-containing epoxy polymer at the mole ratio of CuL : MA : DGEBA 0.1 : 0.1 : 1

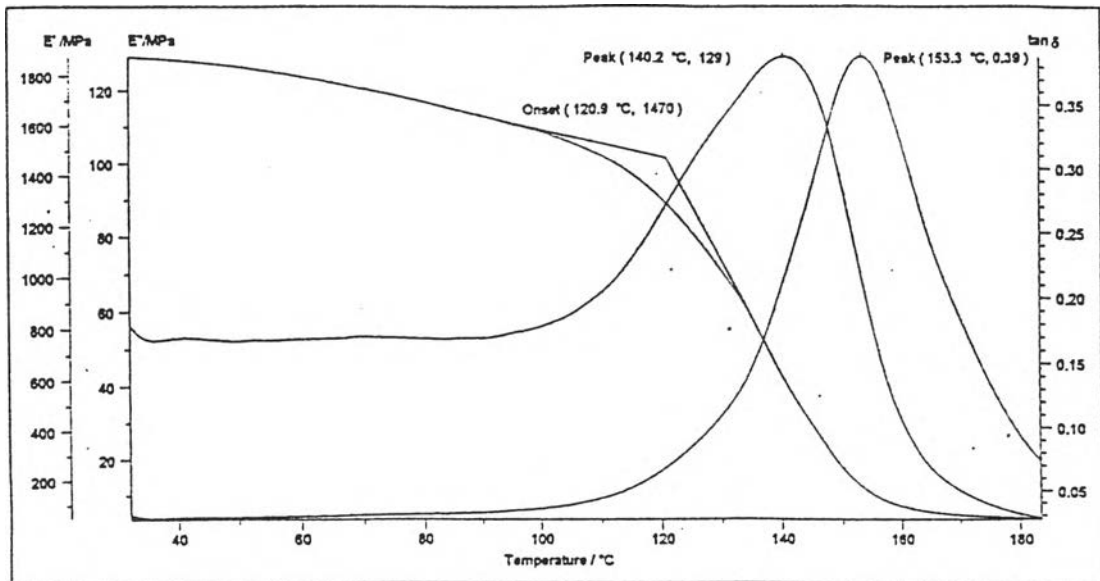


Figure A. 3.15 DMA thermogram of Cu-containing epoxy polymer at the mole ratio of CuL : MA : DGEBA 0.3 : 0.3 : 1

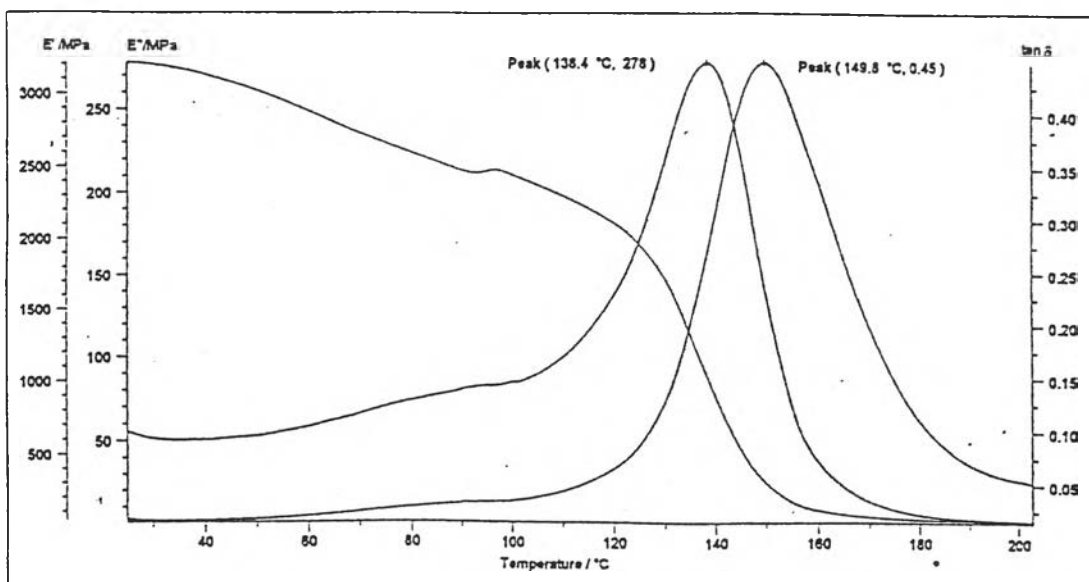


Figure A. 3.16 DMA thermogram of Cu-containing epoxy polymer at the mole ratio of CuL : MA : DGEBA 0.4 : 0.4 : 1

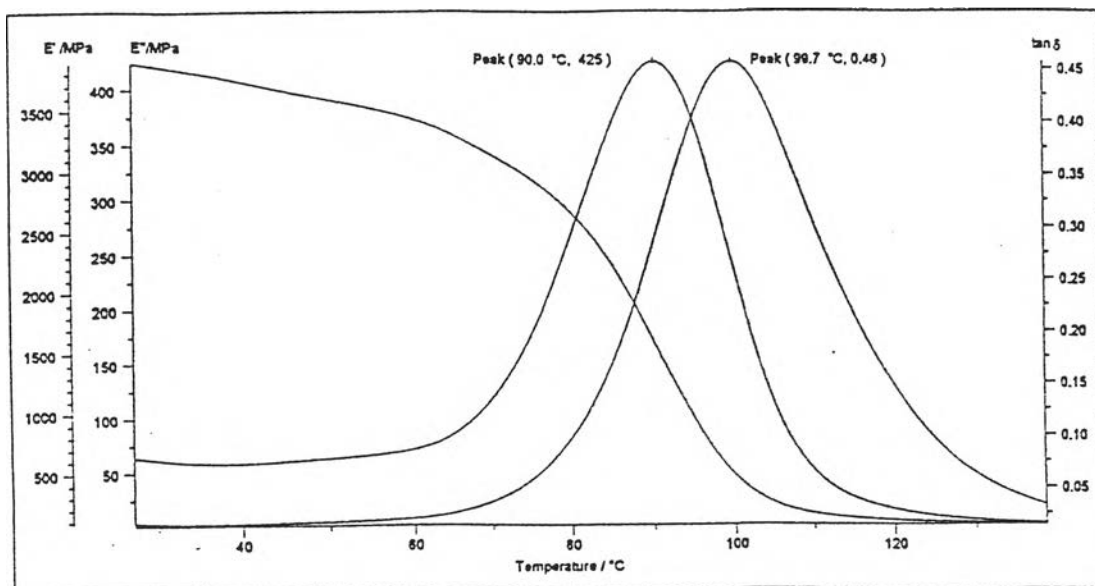


Figure A. 3.17 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.1 : 0.1 : 1

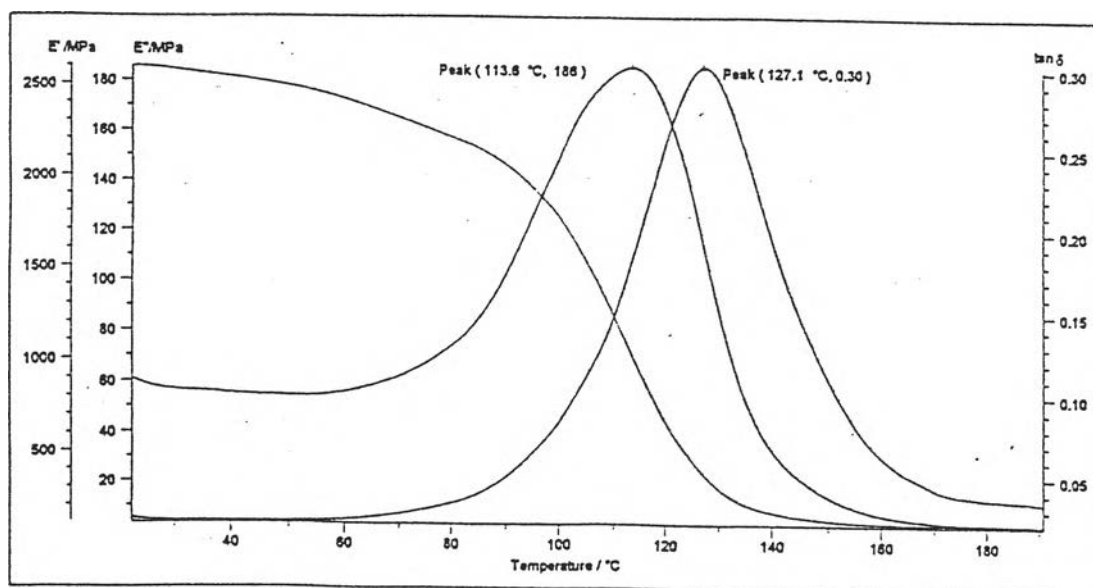


Figure A. 3.18 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.2 : 0.2 : 1

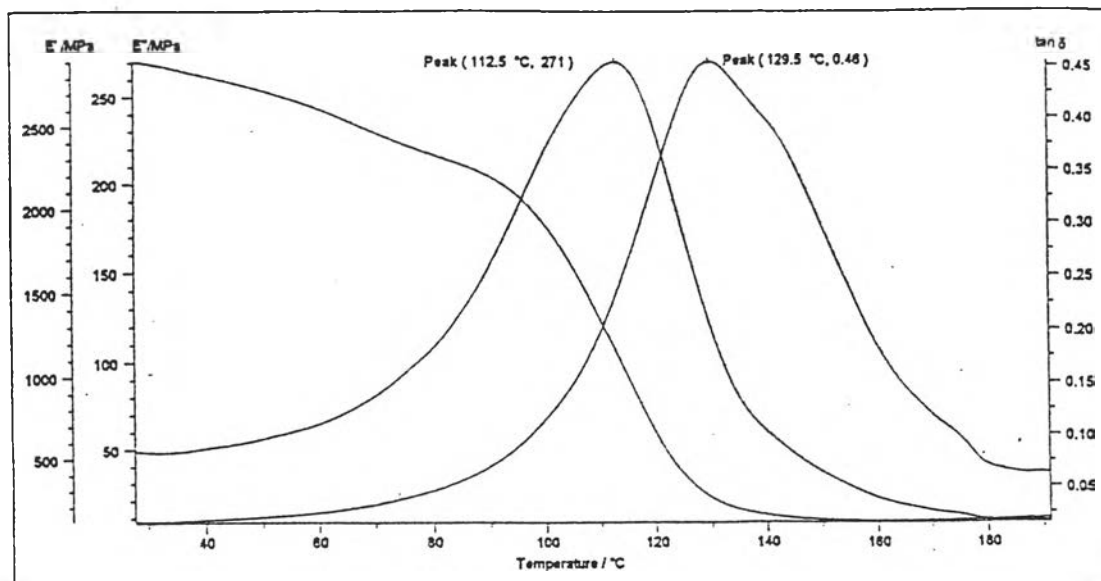


Figure A. 3.19 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.3 : 0.3 : 1

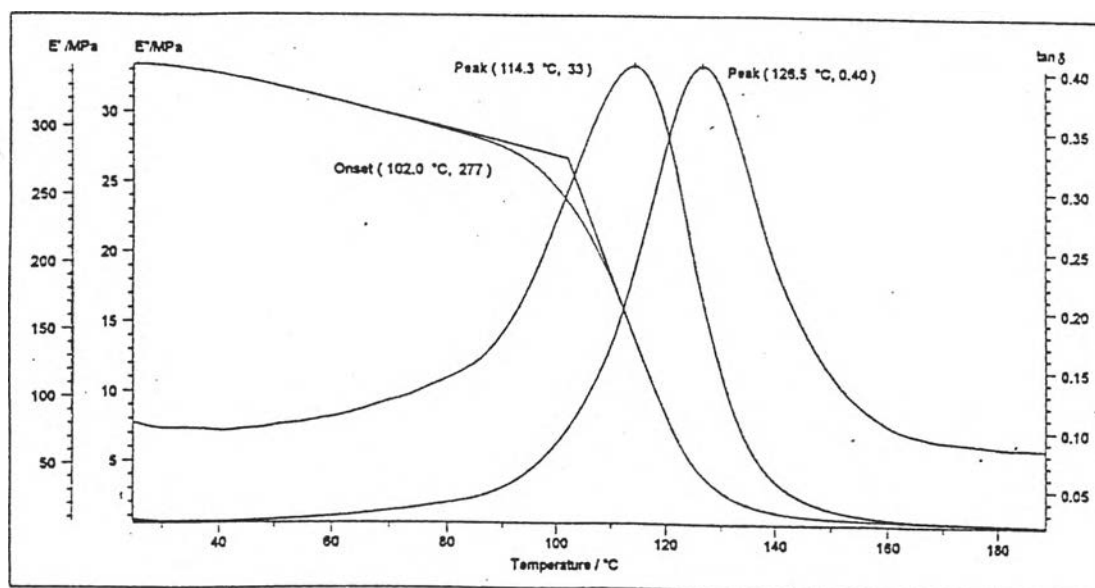


Figure A. 3.20 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.4 : 0.4 : 1

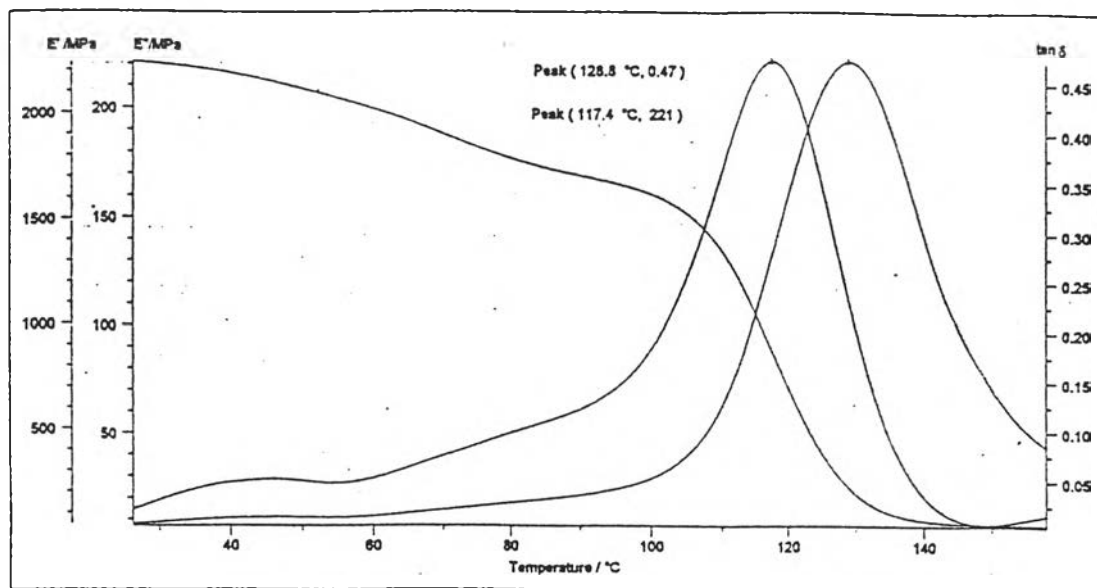


Figure A. 3.21 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.1 : 0.1 : 1

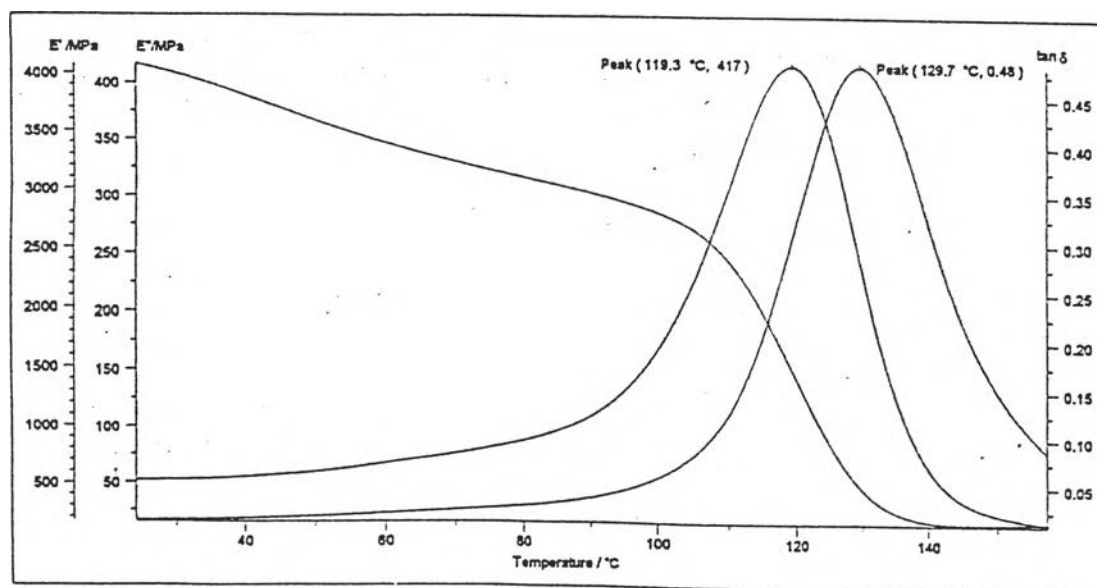


Figure A. 3.22 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.2 : 0.2 : 1

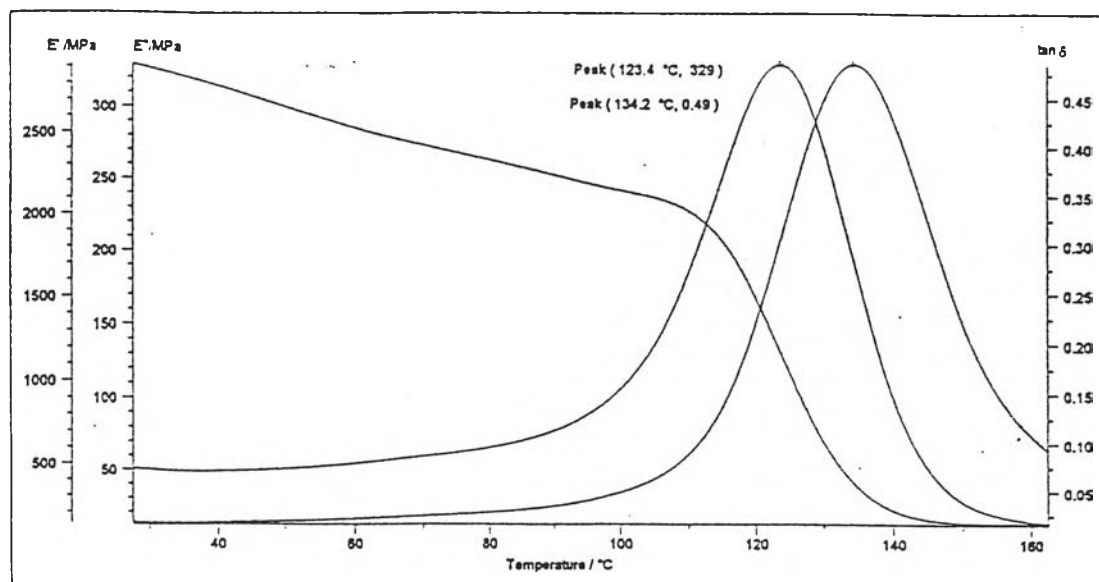


Figure A. 3.23 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.3 : 0.3 : 1

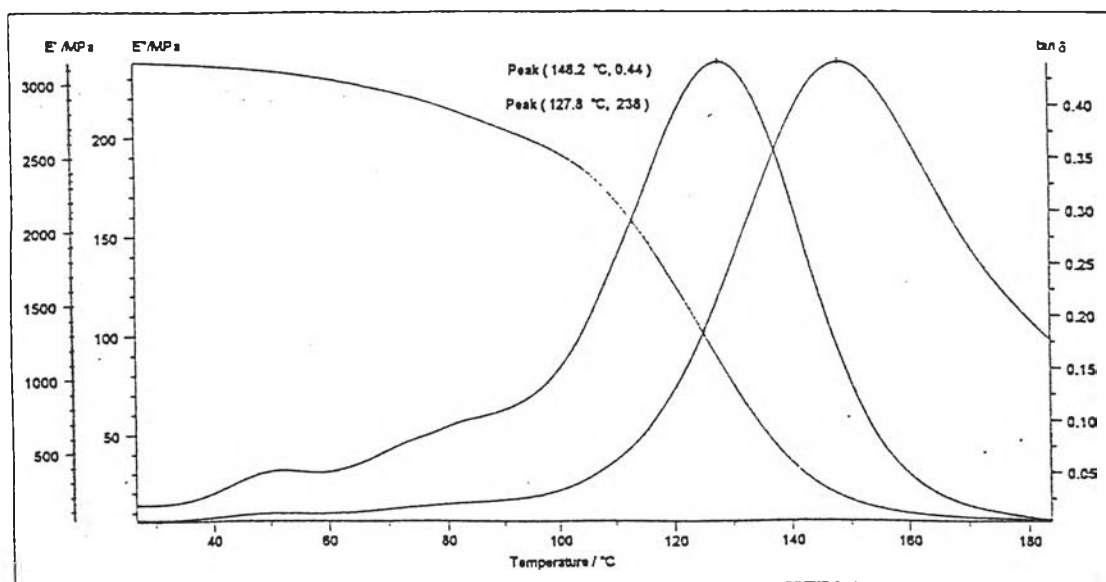


Figure A. 3.24 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.4 : 0.4 : 1



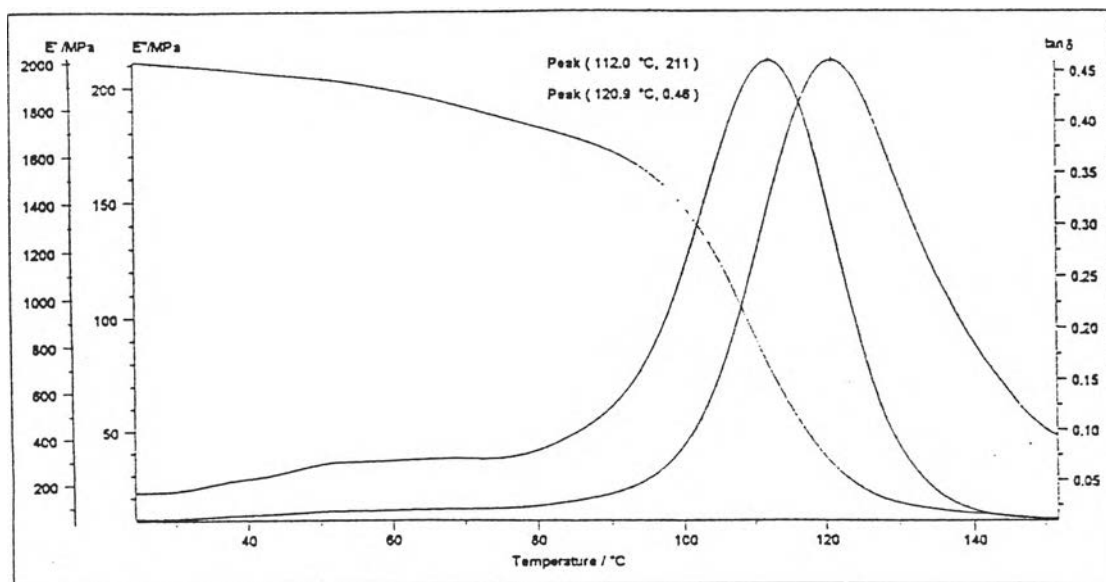


Figure A. 3.25 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.1 : 0.1 : 1

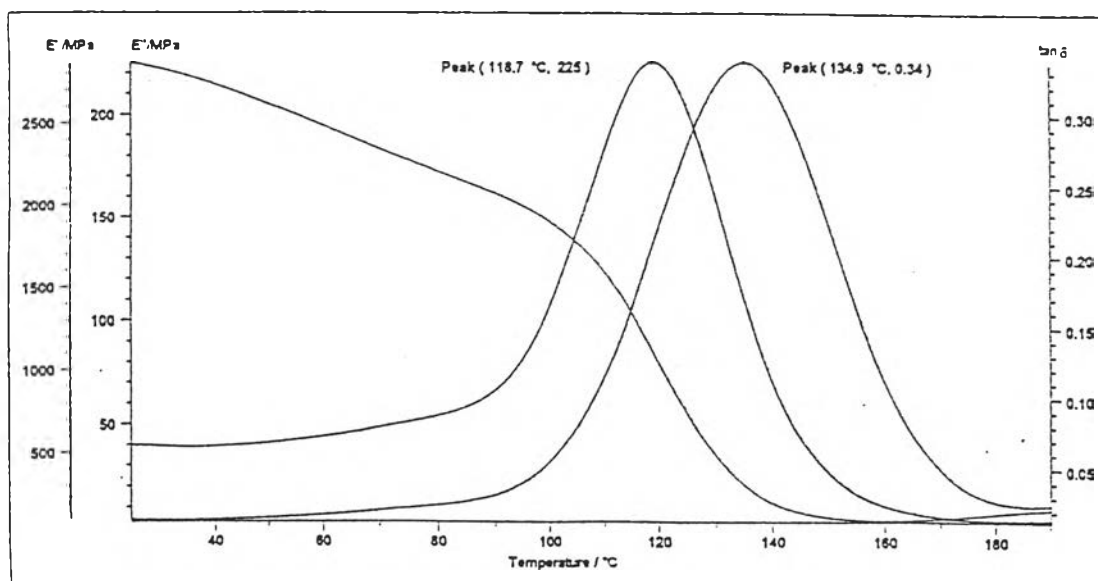


Figure A. 3.26 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.2 : 0.2 : 1

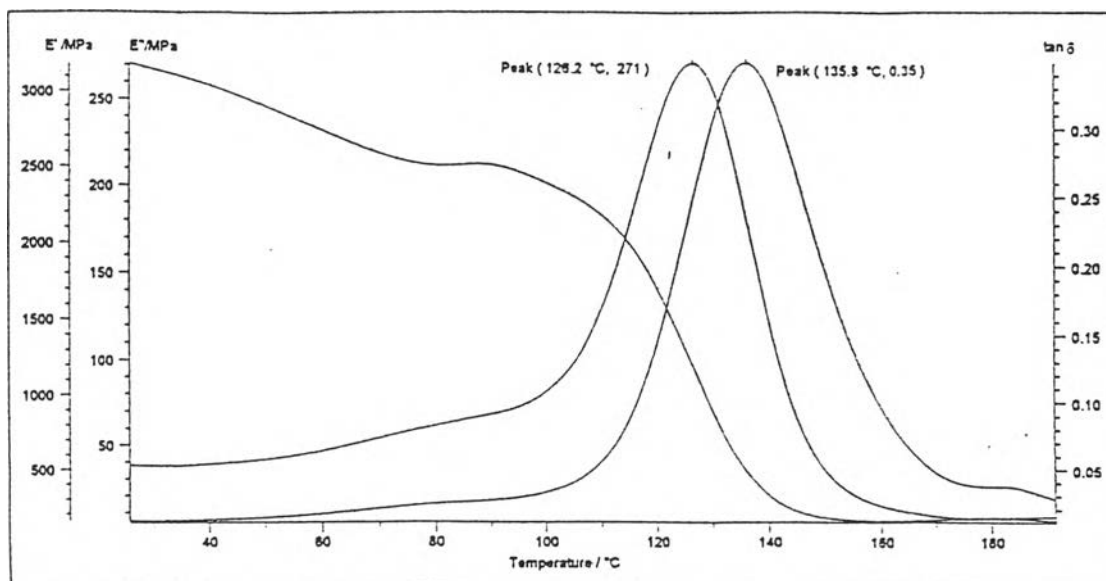


Figure A. 3.27 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.3 : 0.3 : 1

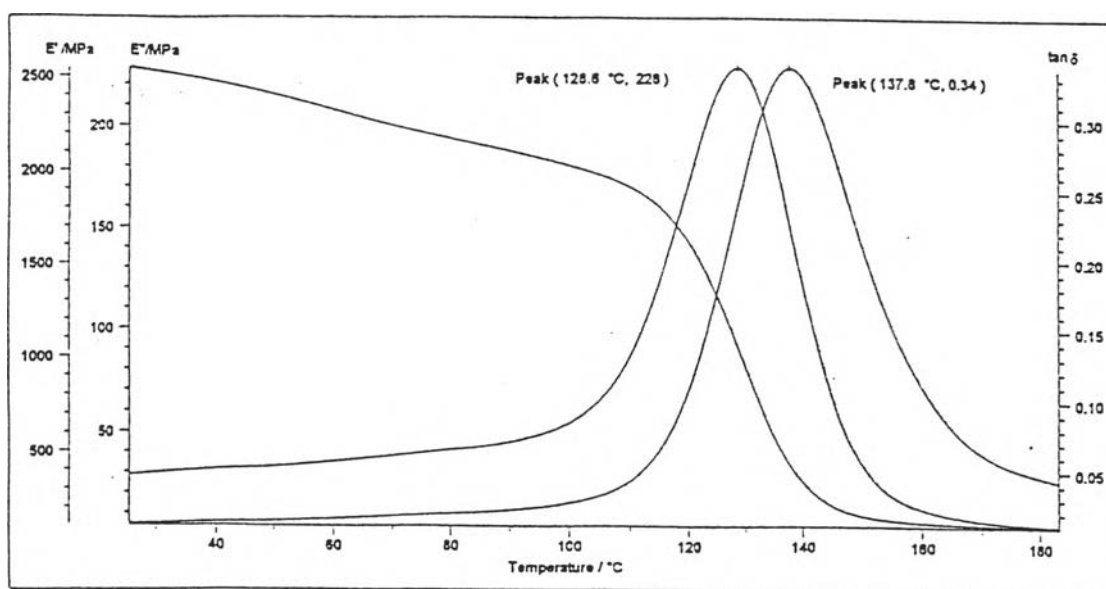


Figure A. 3.28 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.4 : 0.4 : 1

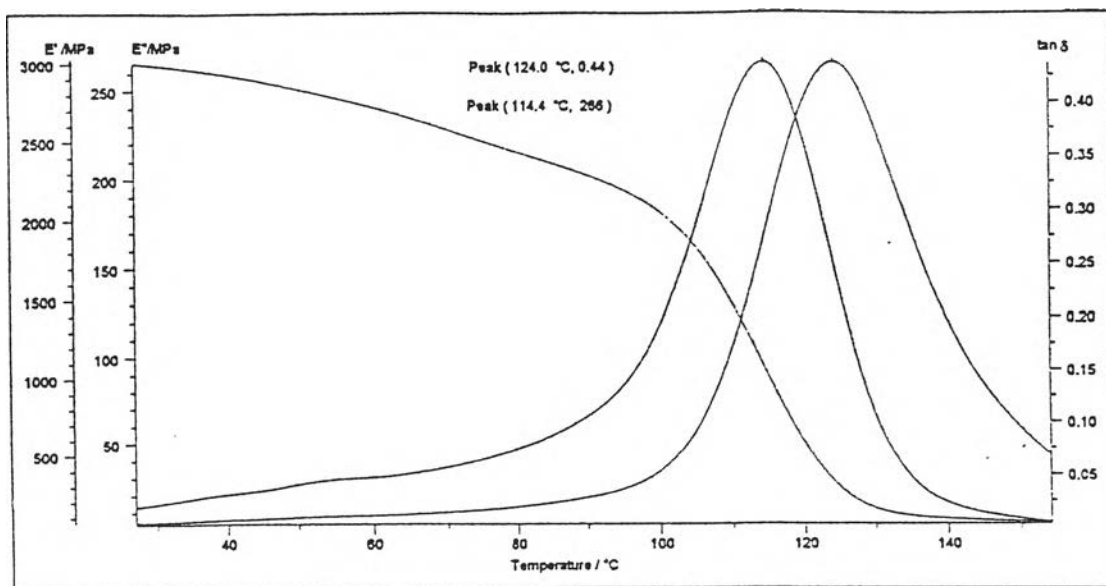


Figure A. 3.29 DMA thermogram of Cu-containing epoxy polymer at the mole ratio of CuL : MA : DGEBA 0.1 : 0.1 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

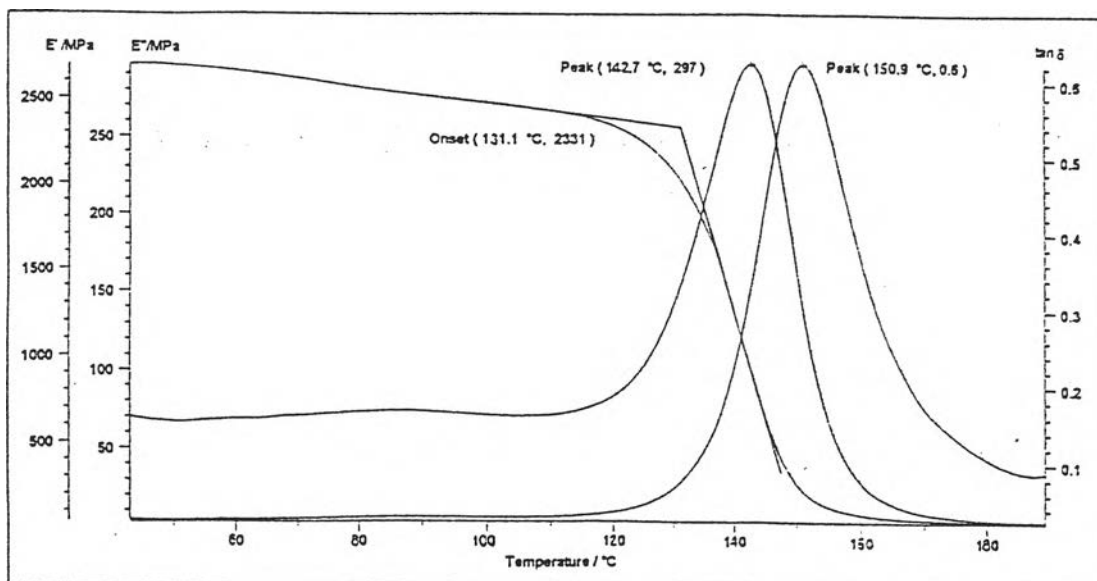


Figure A. 3.30 DMA thermogram of Cu-containing epoxy polymer at the mole ratio of CuL : MA : DGEBA 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

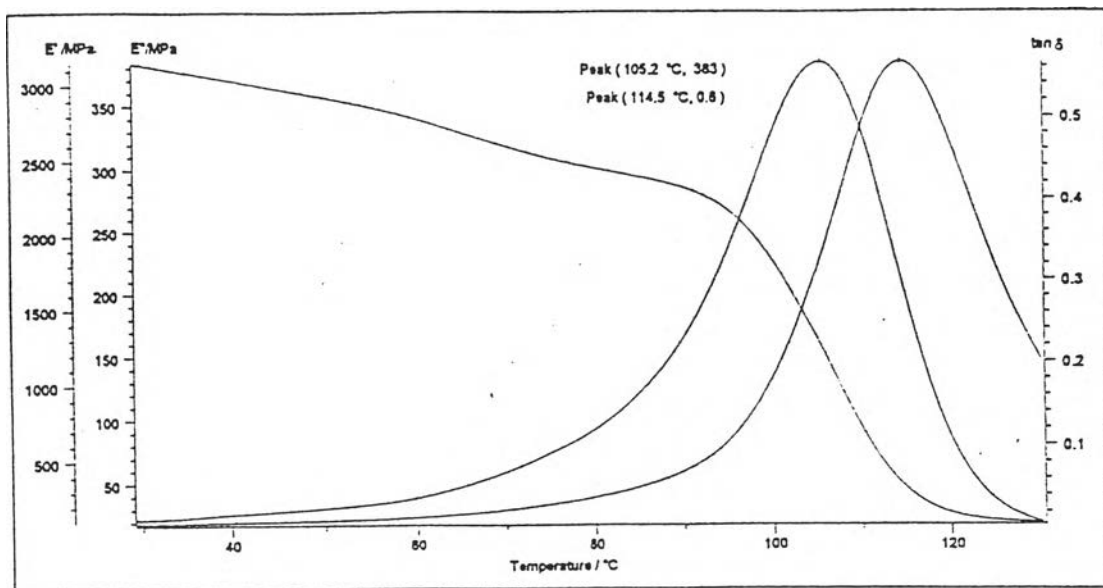


Figure A. 3.31 DMA thermogram of Cu-containing epoxy polymer at the mole ratio of CuL : MA : DGEBA 0.3 : 0.3 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

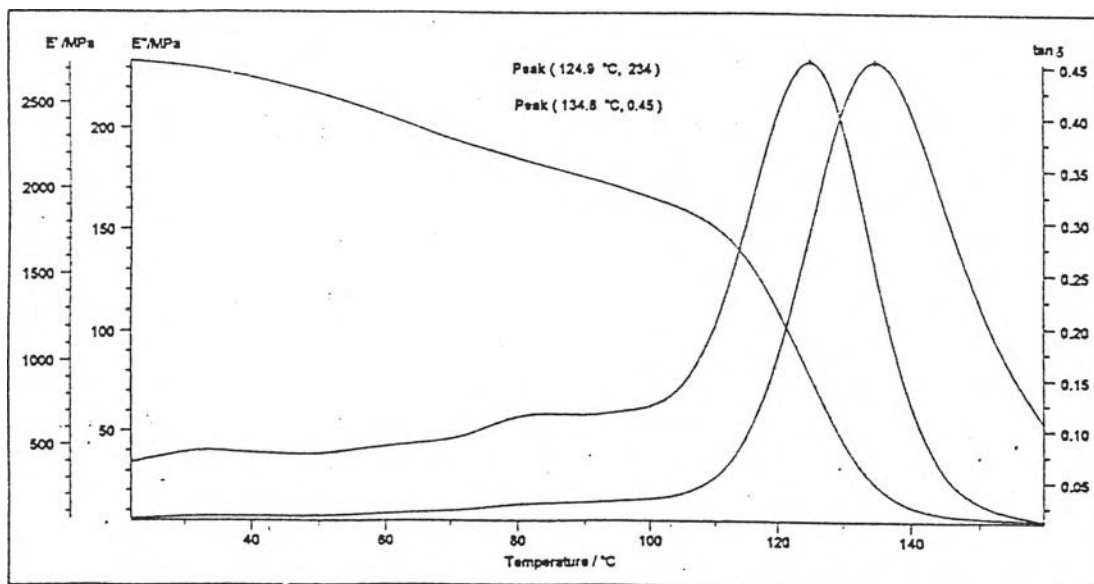


Figure A. 3.32 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.1 : 0.1 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

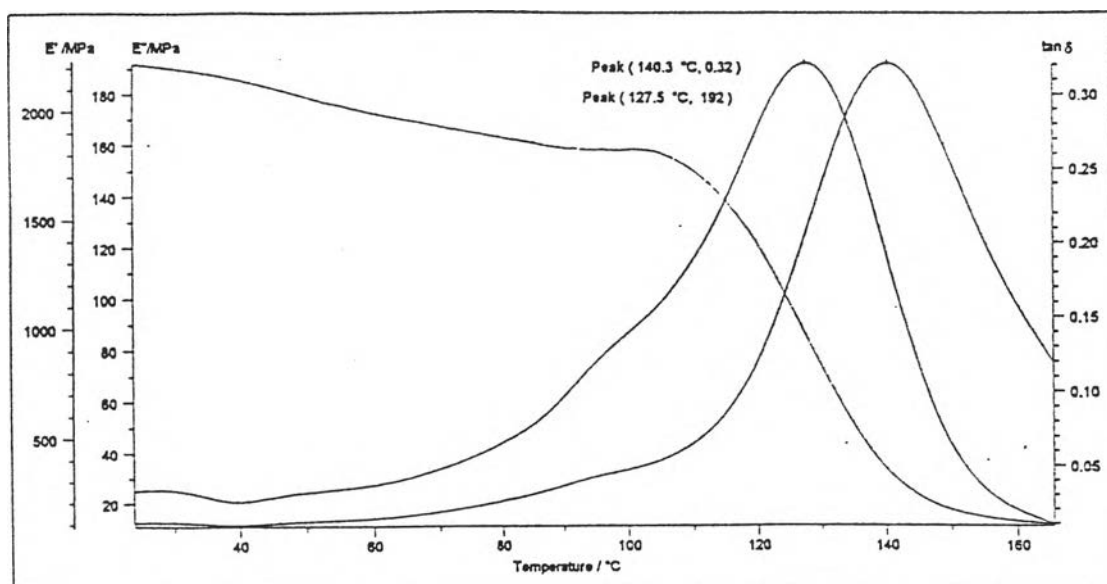


Figure A. 3.33 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

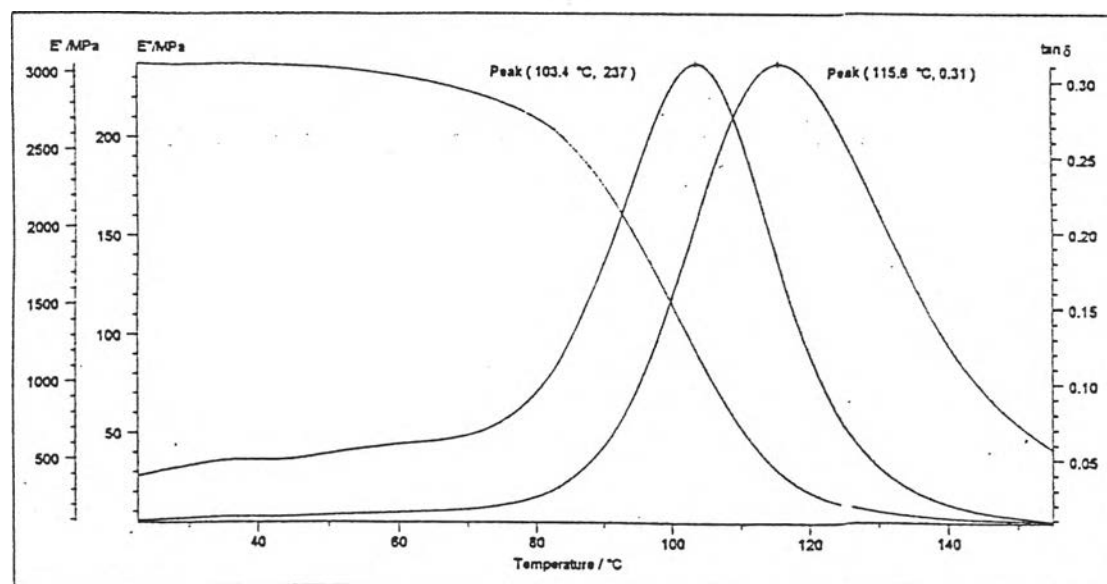


Figure A. 3.34 DMA thermogram of Co-containing epoxy polymer at the mole ratio of CoL : MA : DGEBA 0.3 : 0.3 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

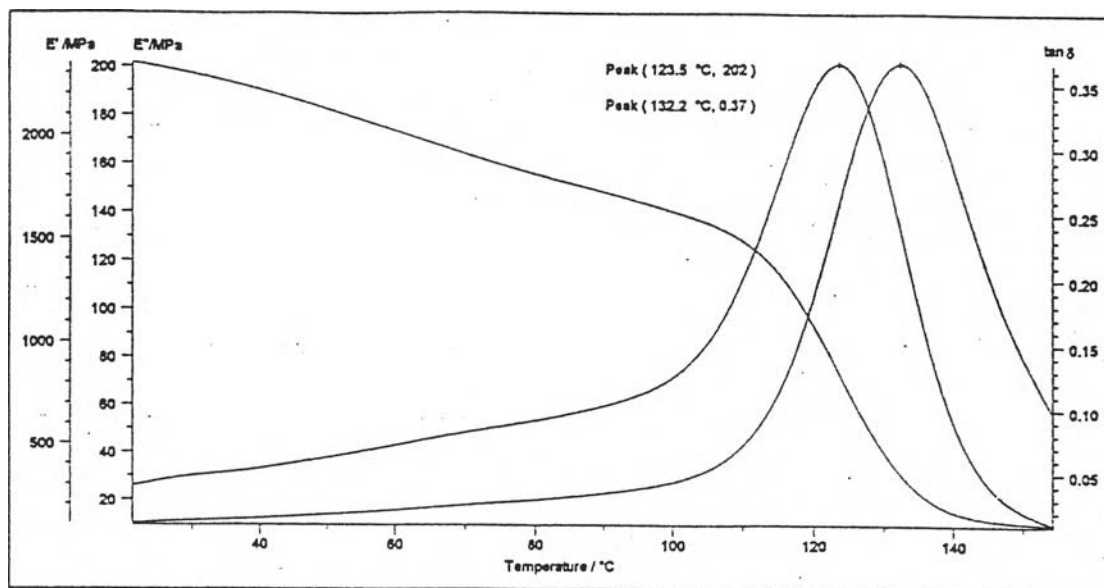


Figure A. 3.35 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.1 : 0.1 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

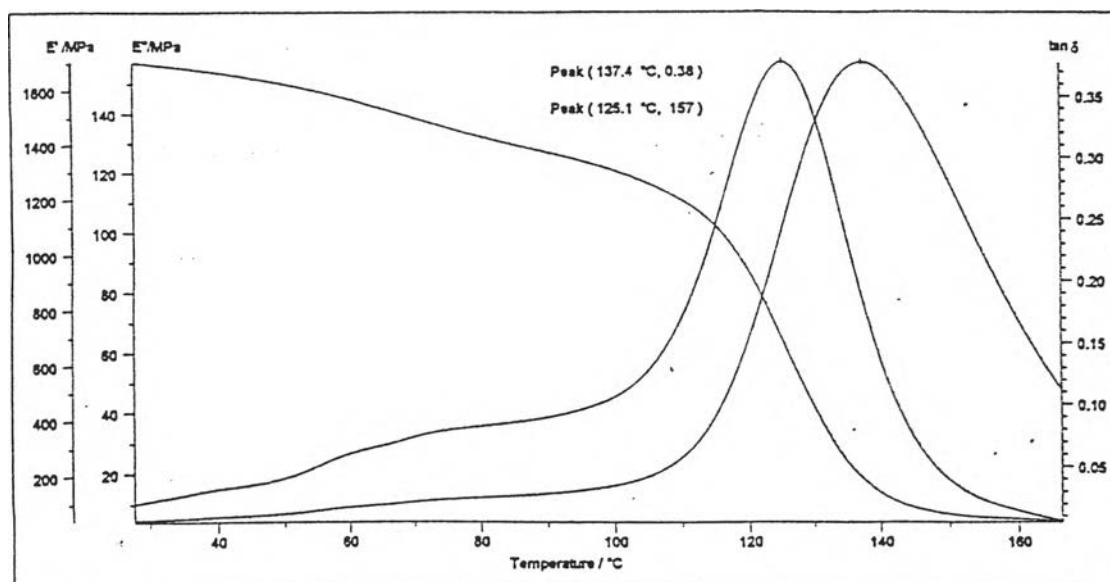


Figure A. 3.36 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

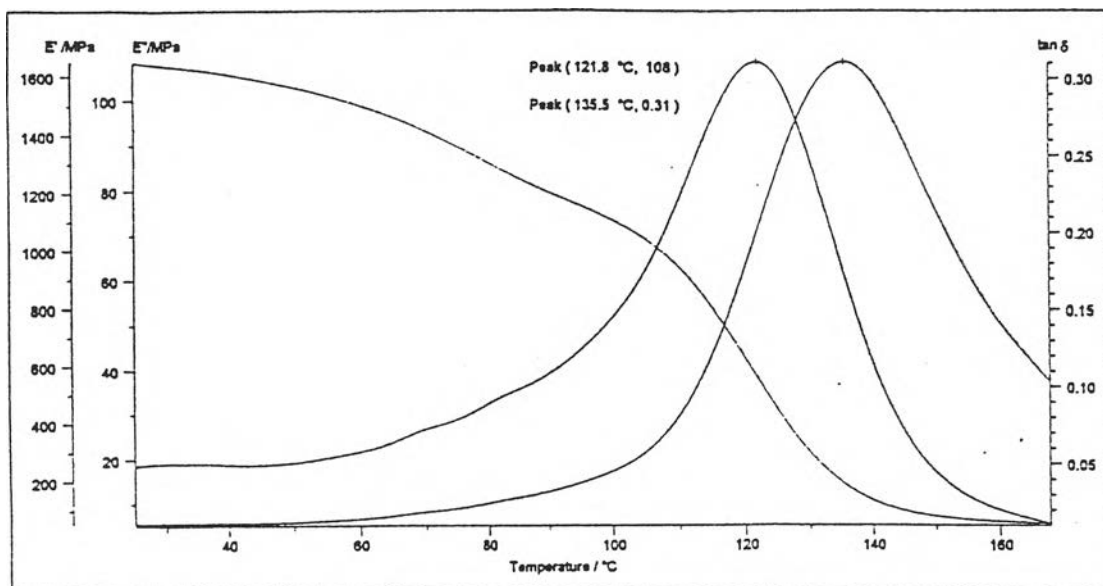


Figure A. 3.37 DMA thermogram of Ni-containing epoxy polymer at the mole ratio of NiL : MA : DGEBA 0.3 : 0.3 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

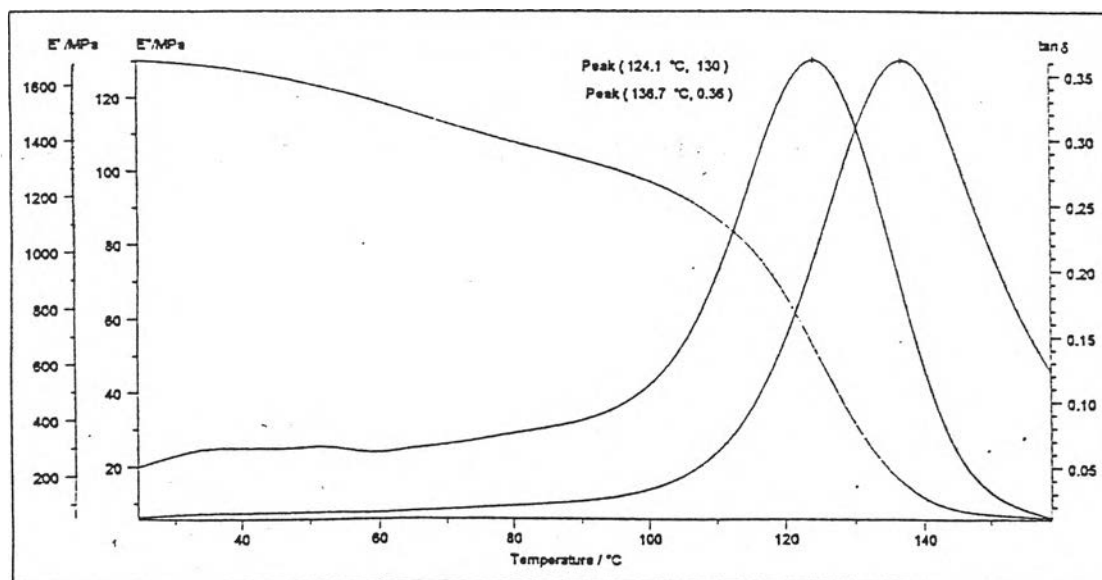


Figure A. 3.38 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.1 : 0.1 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

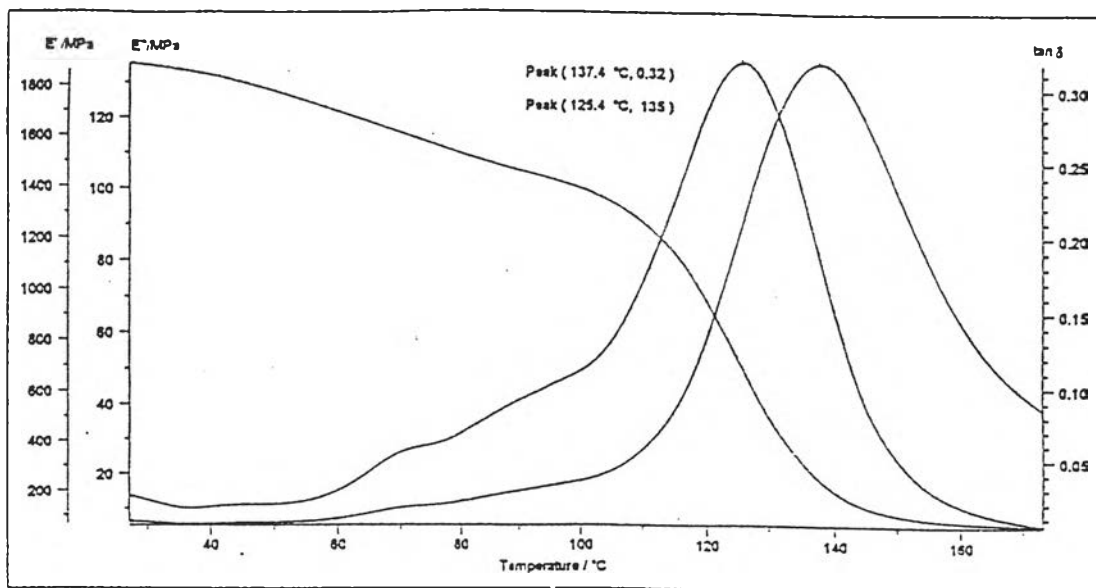


Figure A. 3.39 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.2 : 0.2 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst

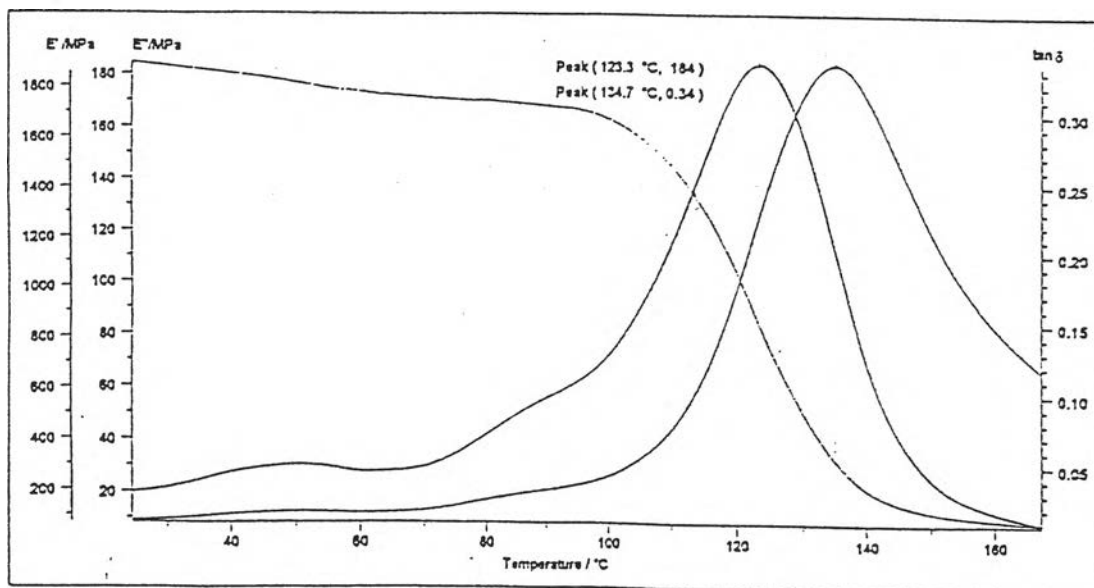


Figure A. 3.40 DMA thermogram of Zn-containing epoxy polymer at the mole ratio of ZnL : MA : DGEBA 0.3 : 0.3 : 1 and  $\text{Bu}_4\text{NOH}$  was employed as a catalyst



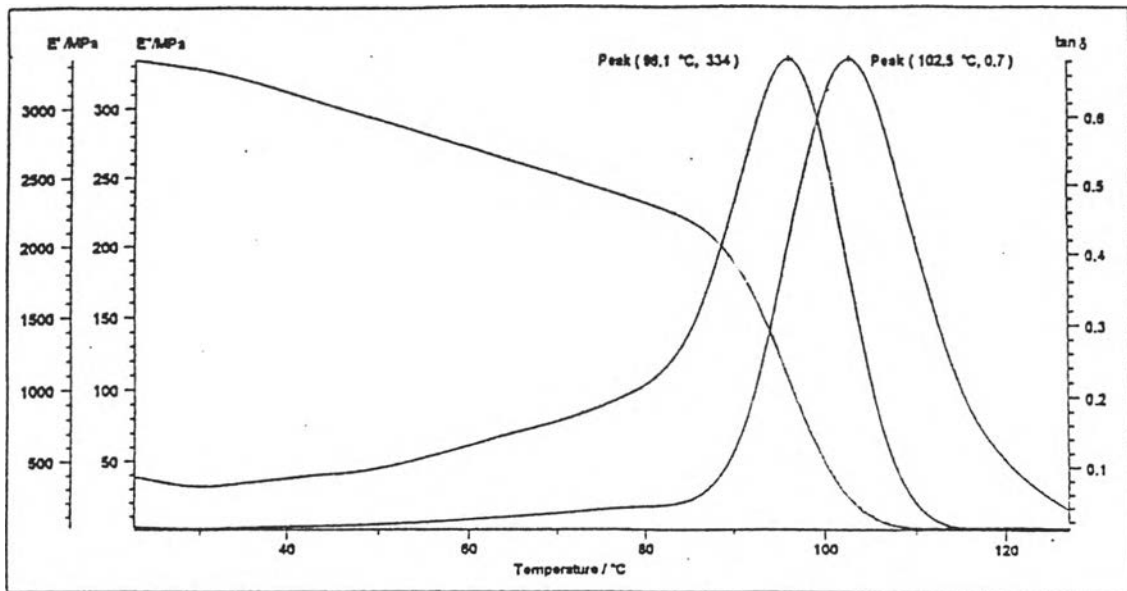


Figure A. 3.41 DMA thermogram of DGEBA-MA system at DGEBA : MA ratio of 1 : 2.8 and BDMA was employed as a catalyst

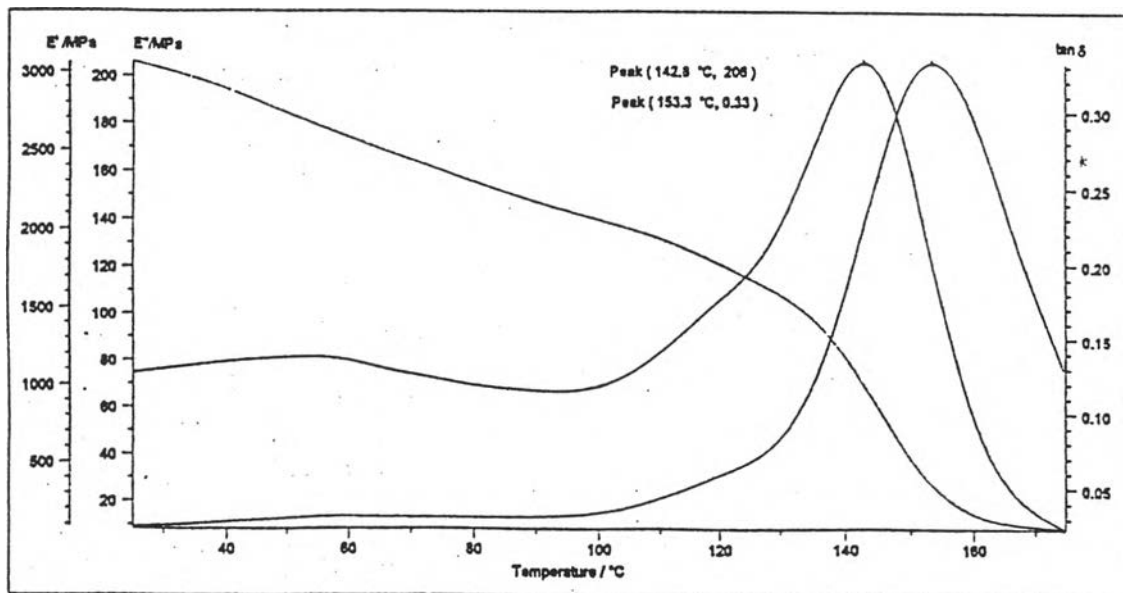


Figure A. 3.42 DMA thermogram of DGEBA-DETA system at DGEBA : DETA ratio of 1 : 1

## VITA

Nongnuch Sutivisedsak was born on February 21, 1975 in Bangkok, Thailand. She received Bachelor Degree of Science in Chemistry, Chulalongkorn University, in 1996. In the same year, she was a student in graduate school at Chulalongkorn University studying in Chemistry and has been studying science since then. She graduated with Master Degree of Science in 1999.

