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APPENDICES

Appendix A

UV-VIS absorption spectra of PVA films containing various metal salts with various contents.

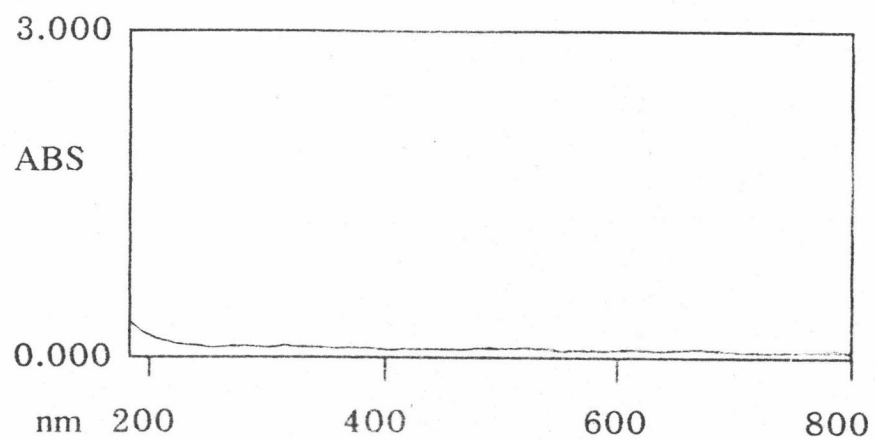


Figure A-1 : UV-VIS absorption spectra of standard PVA film.

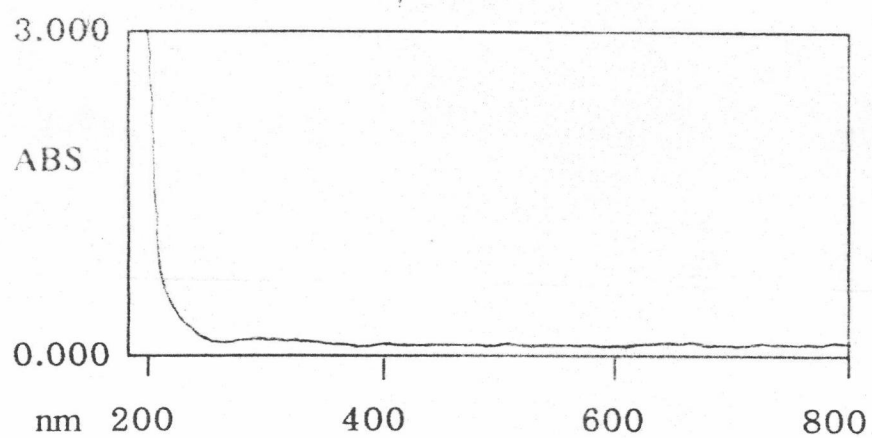


Figure A-2 : UV-VIS absorption spectra of LiCl aqueous solution.

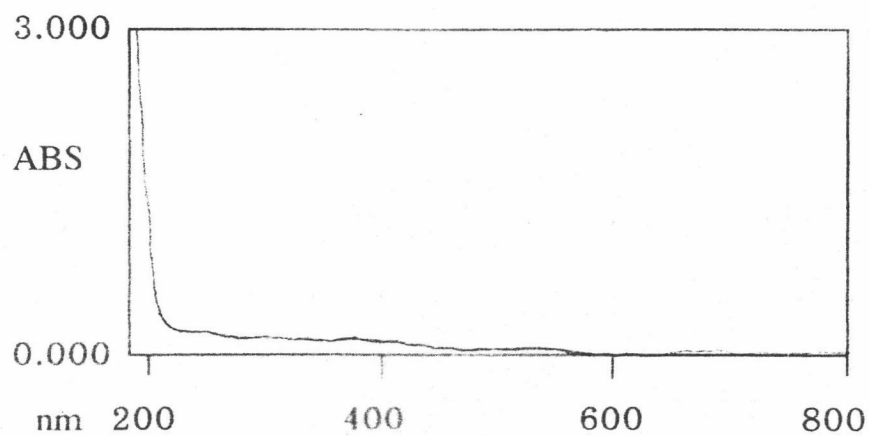


Figure A-3 : UV-VIS absorption spectra of NaCl aqueous solution.

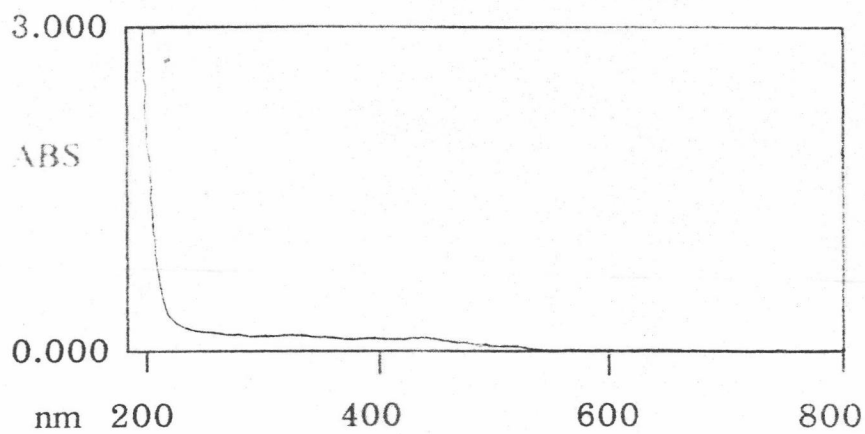


Figure A-4 : UV-VIS absorption spectra of KCl aqueous solution.

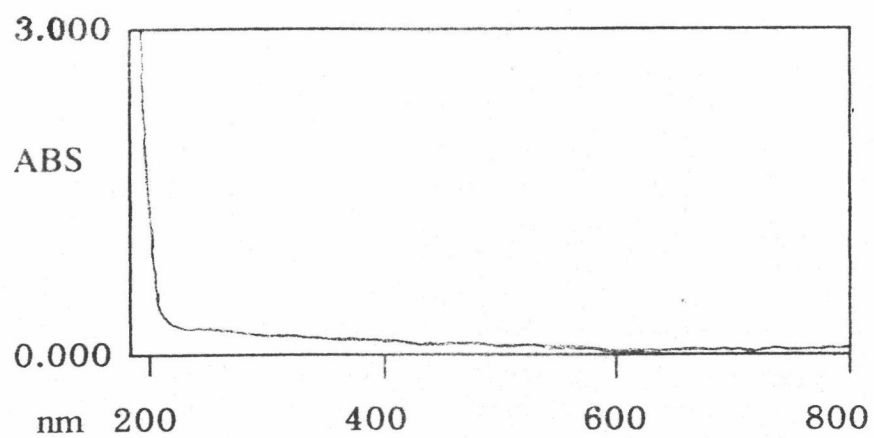


Figure A-5 : UV-VIS absorption spectra of CaCl_2 aqueous solution.

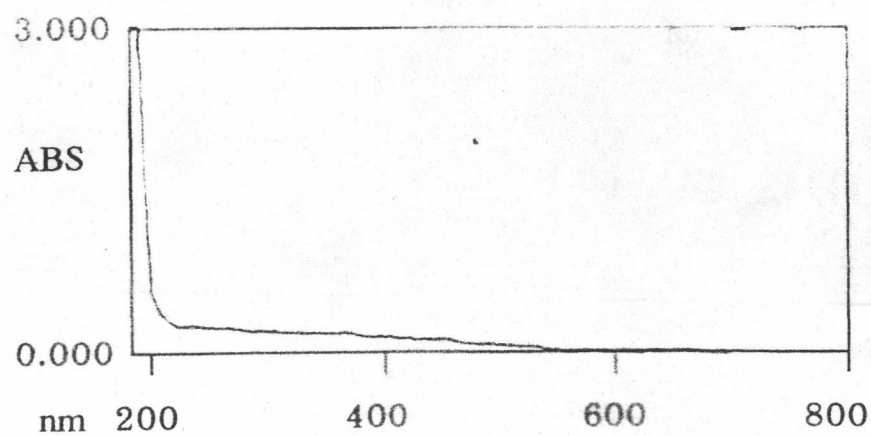


Figure A-6 : UV-VIS absorption spectra of BaCl_2 aqueous solution.

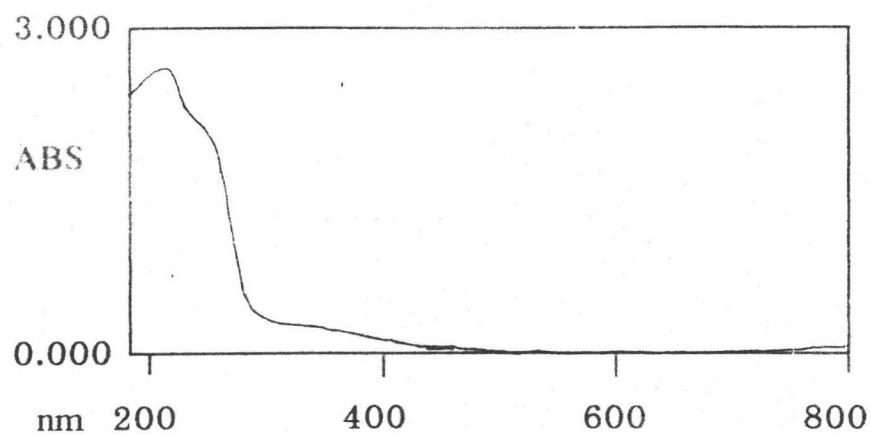


Figure A-7 : UV-VIS absorption spectra of FeCl₂ aqueous solution.

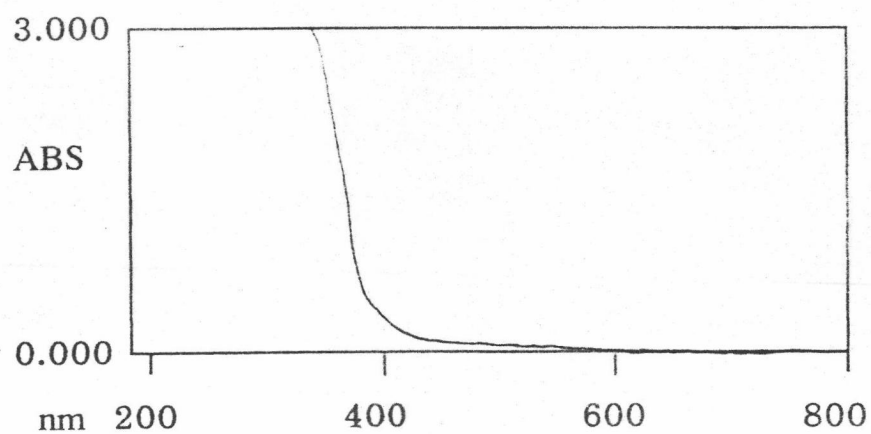


Figure A-8 : UV-VIS absorption spectra of FeCl₃ aqueous solution.

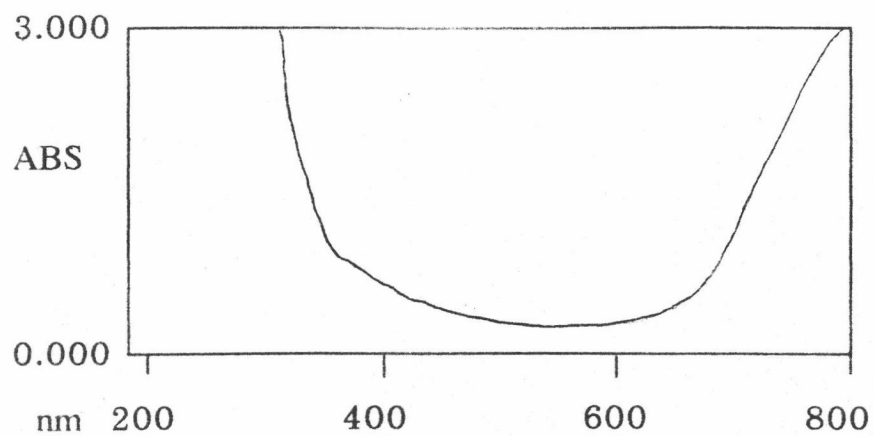


Figure A-9 : UV-VIS absorption spectra of CuCl_2 aqueous solution.

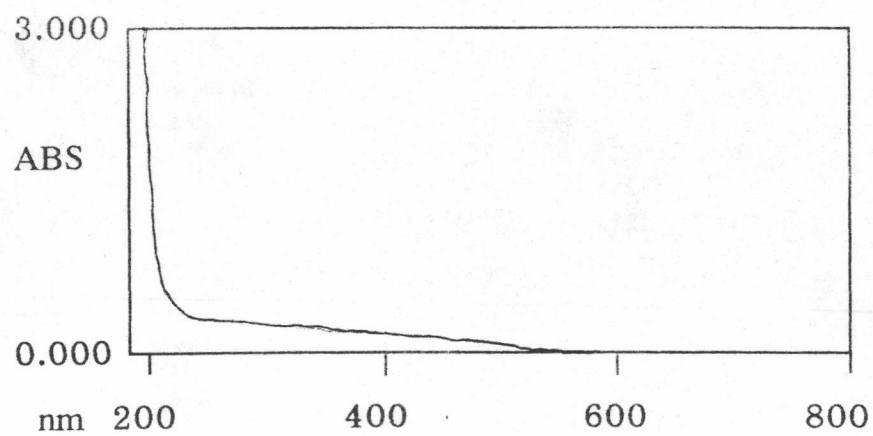


Figure A-10 : UV-VIS absorption spectra of ZnCl_2 aqueous solution.

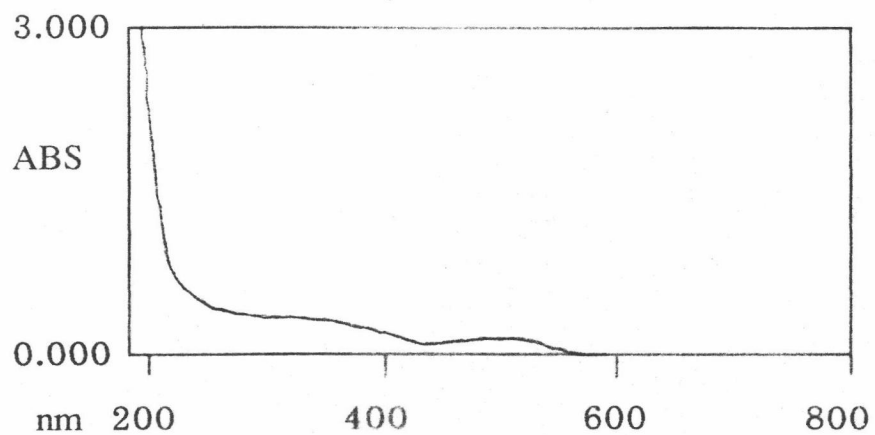


Figure A-11 : UV-VIS absorption spectra of CoCl_2 aqueous solution.

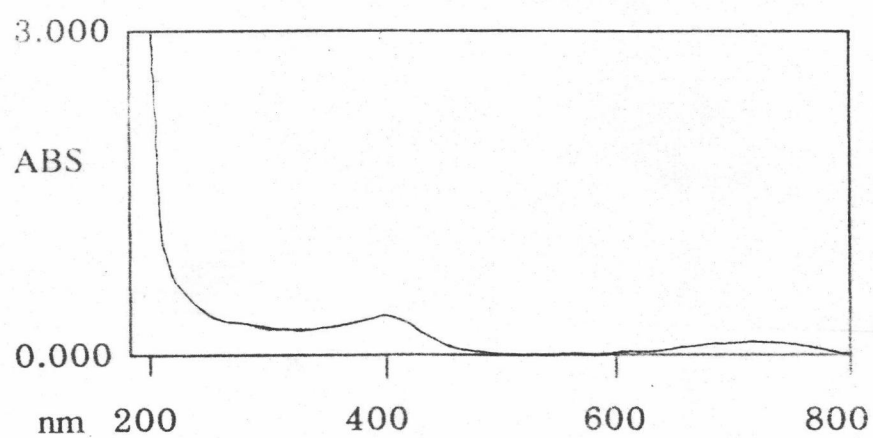
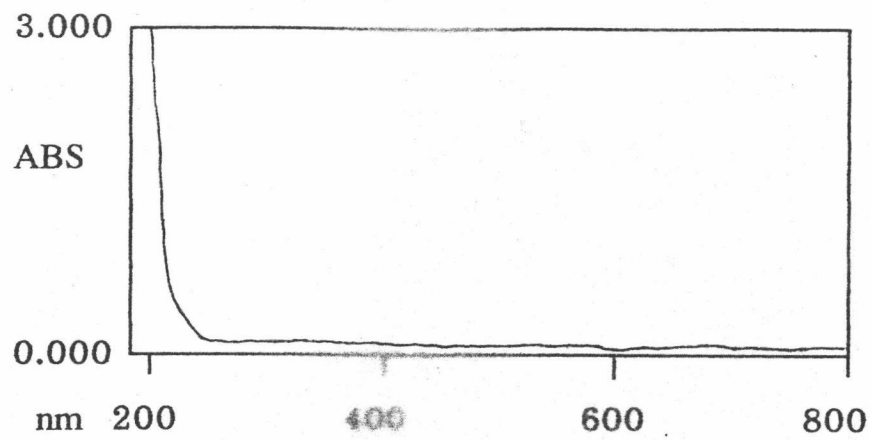
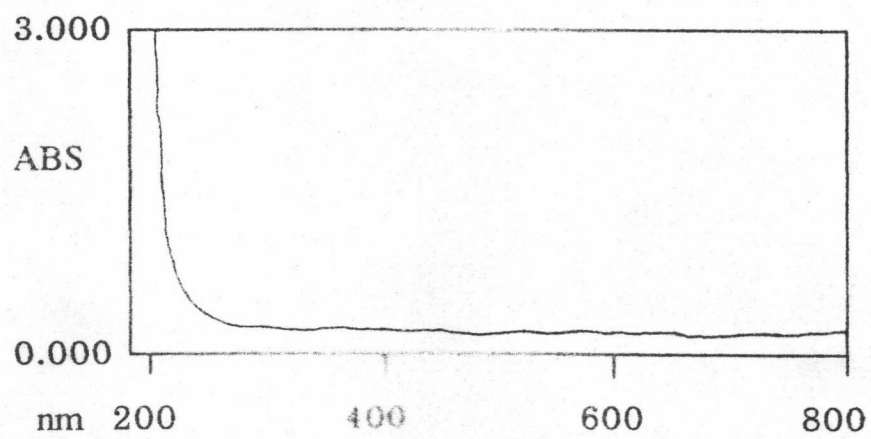


Figure A-12 : UV-VIS absorption spectra of NiCl_2 aqueous solution.

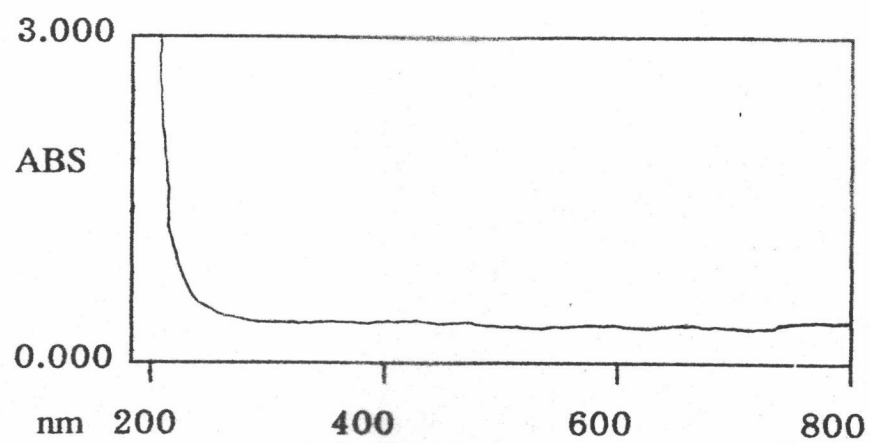


(a)

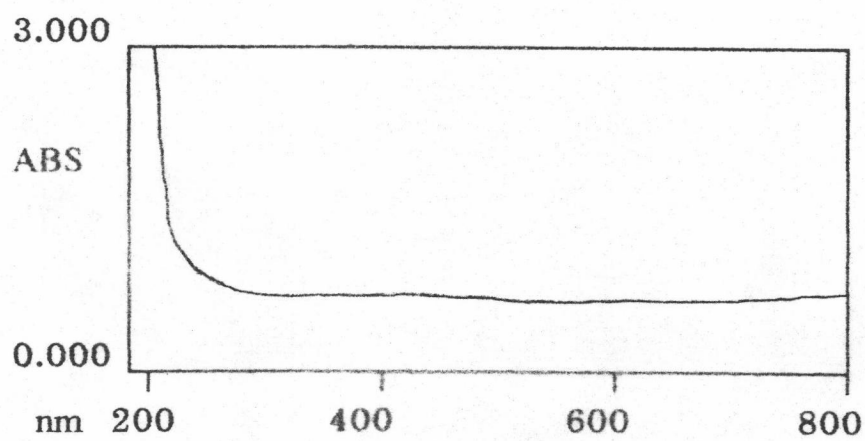


(b)

Figure A-13 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% LiCl.



(c)



(d)

Figure A-13 (continued)

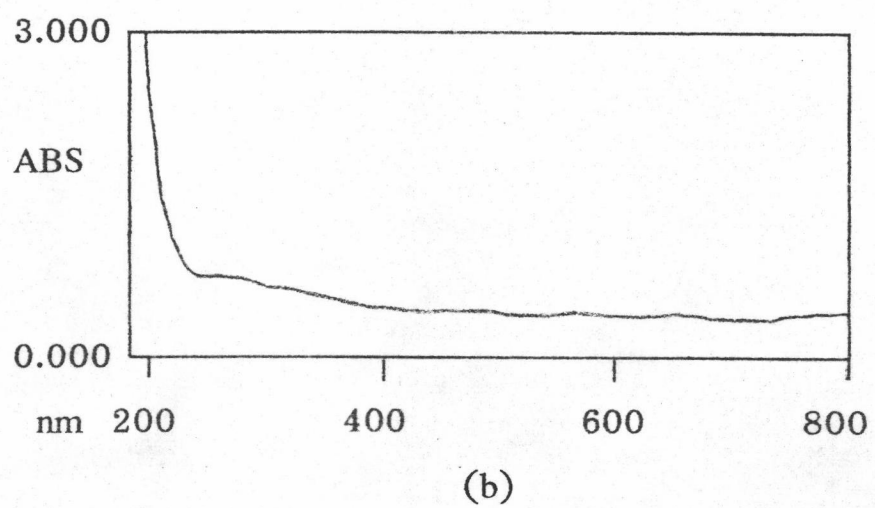
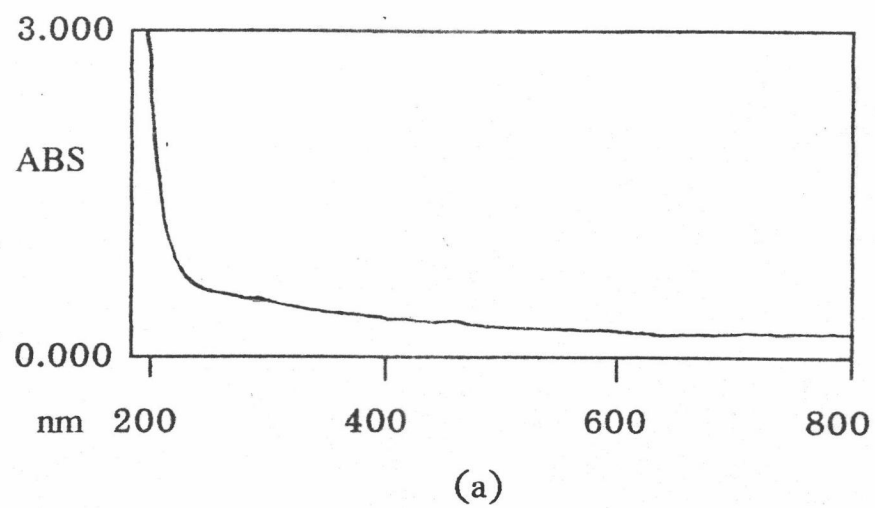
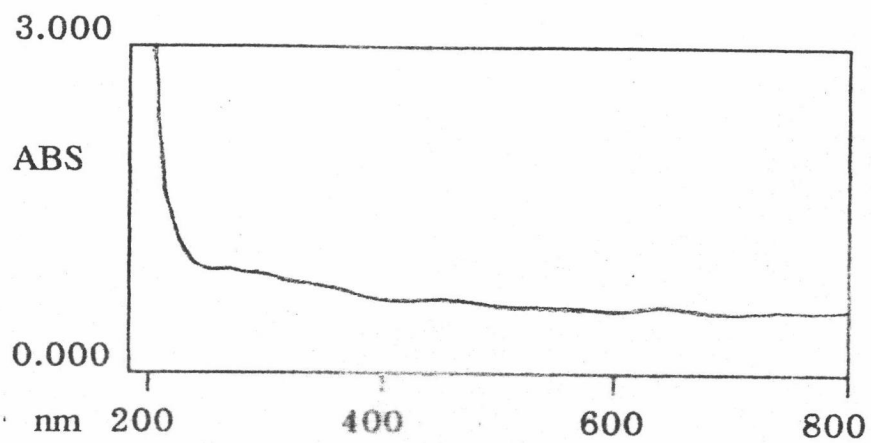
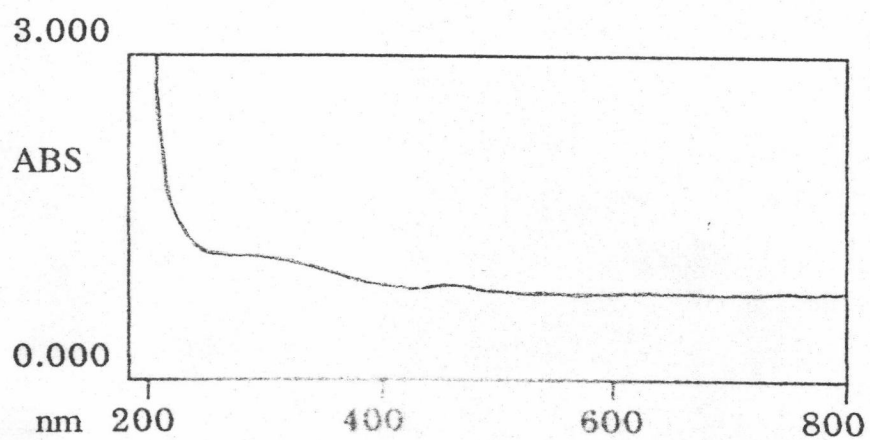


Figure A-14 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% NaCl.



(c)



(d)

Figure A-14 (continued)

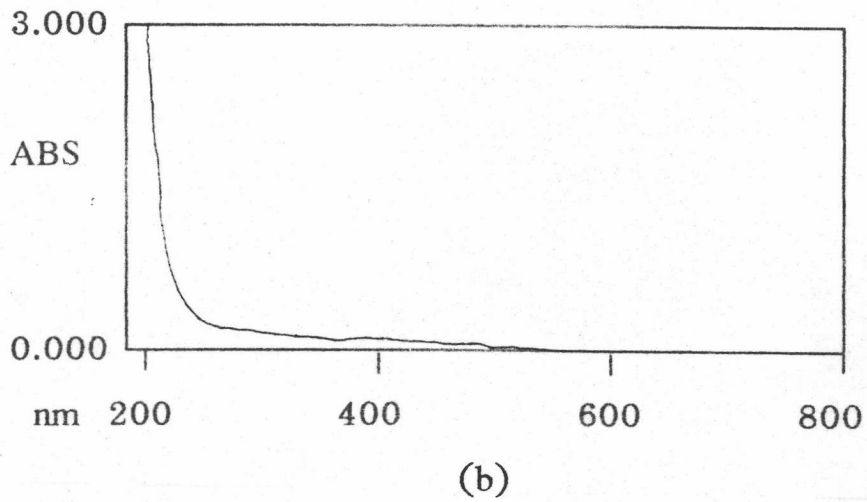
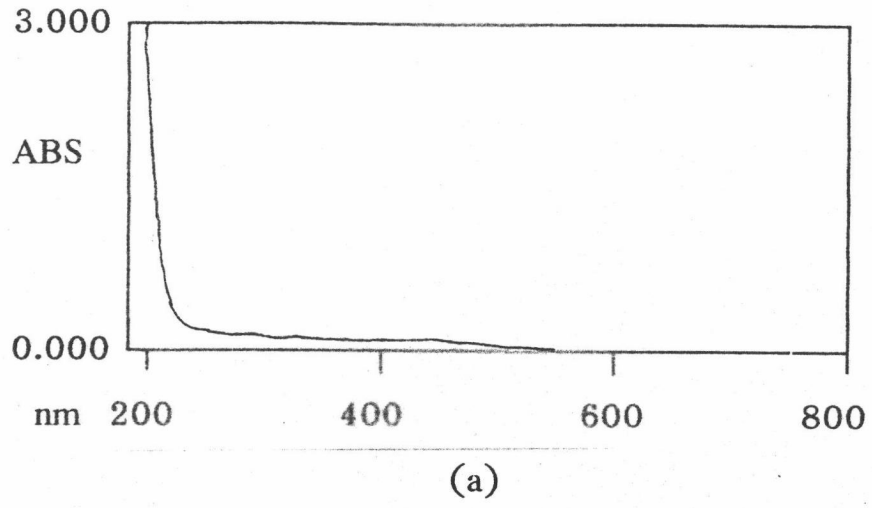
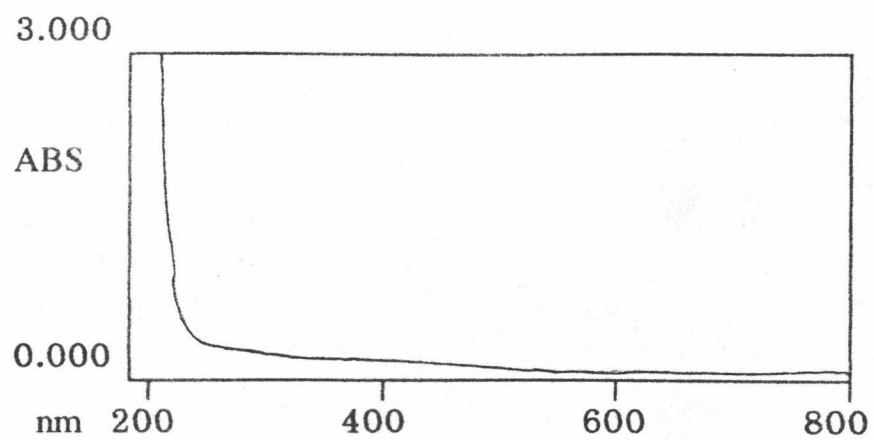
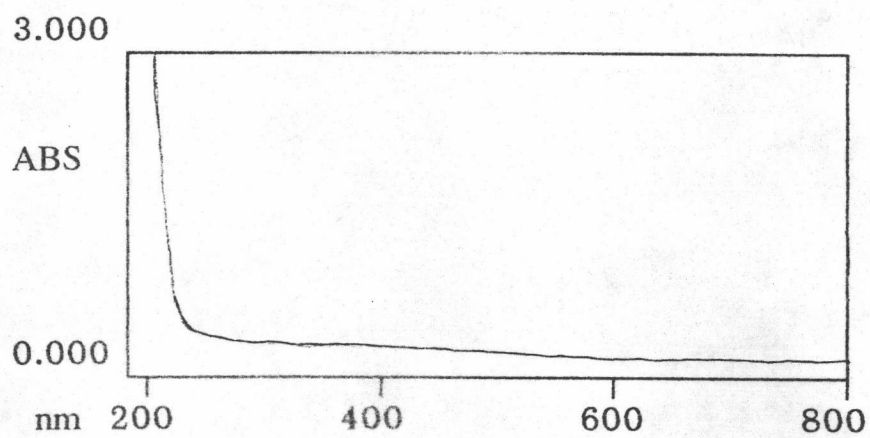


Figure A-15 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% KCl.

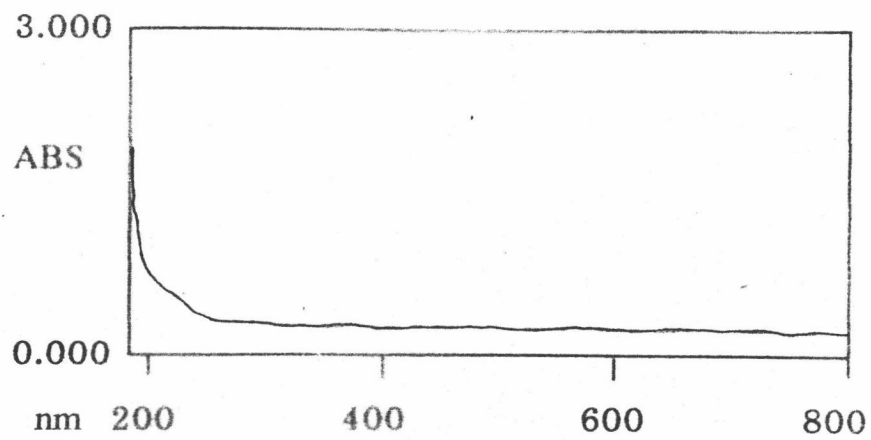


(c)

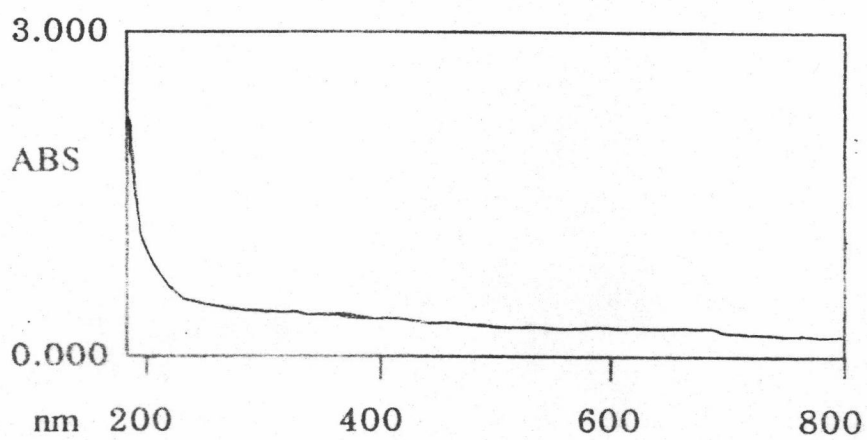


(d)

Figure A-15 (continued)

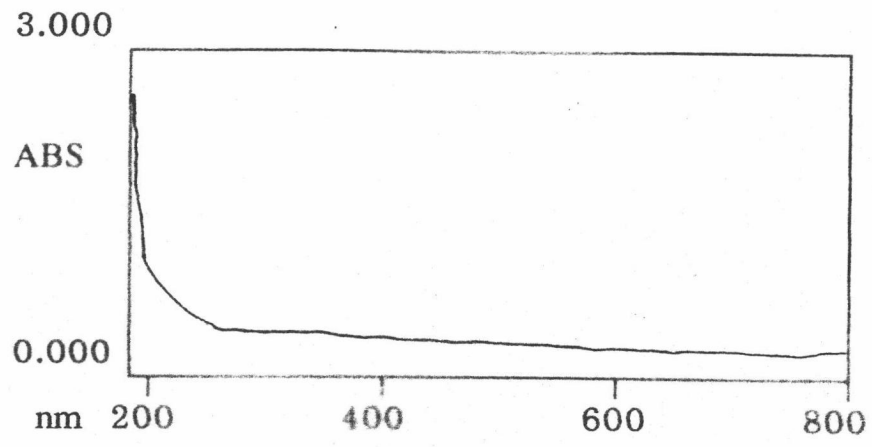


(a)

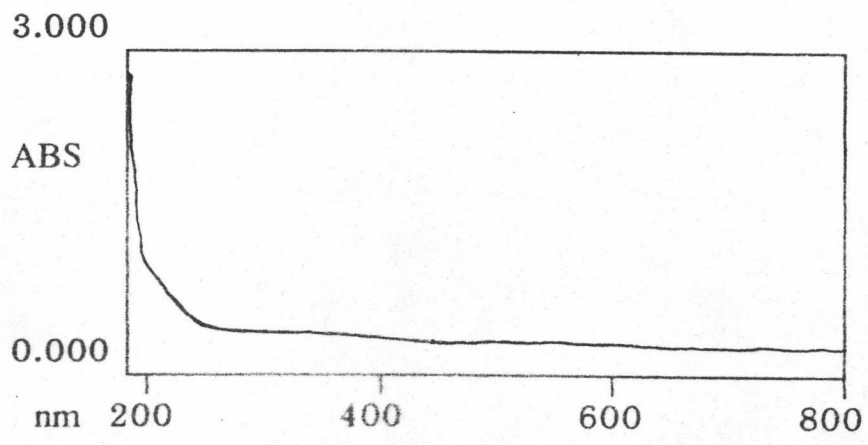


(b)

Figure A-16 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% CaCl₂.

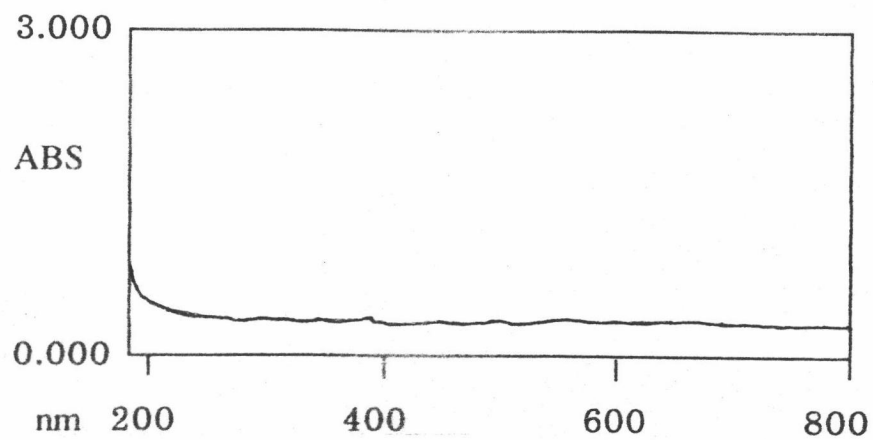


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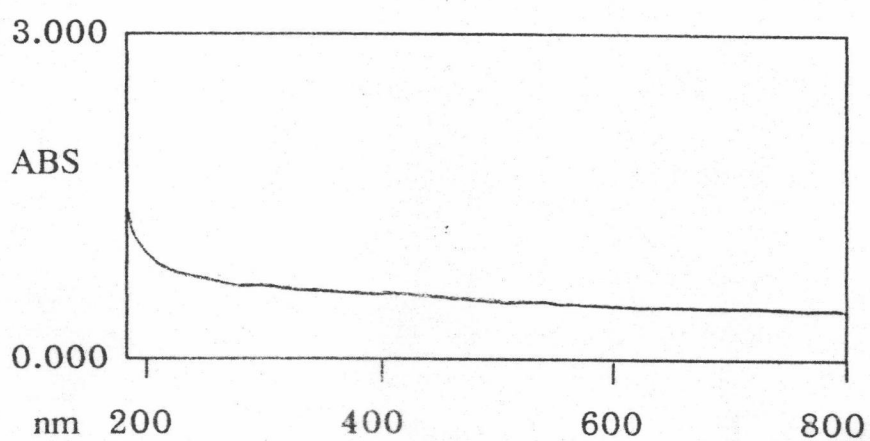


(d)

Figure A-16 (continued)

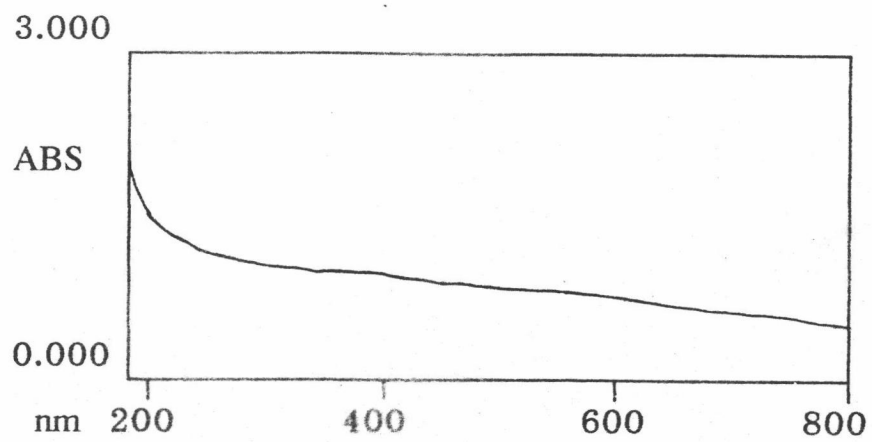


(a)

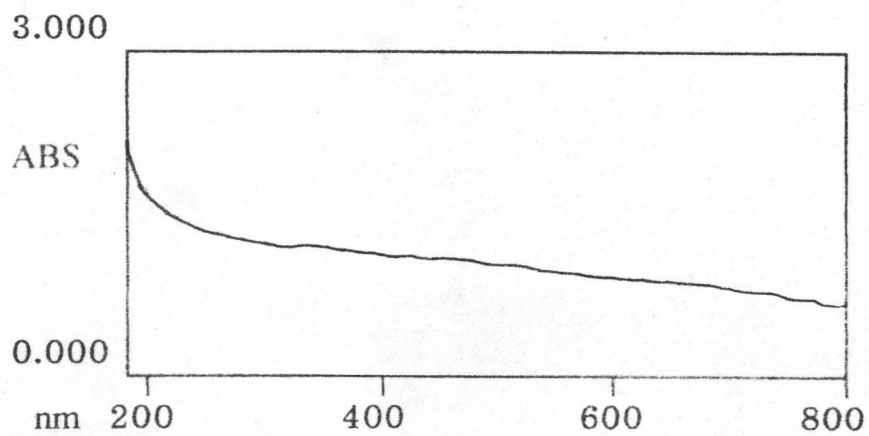


(b)

Figure A-17 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% BaCl₂.

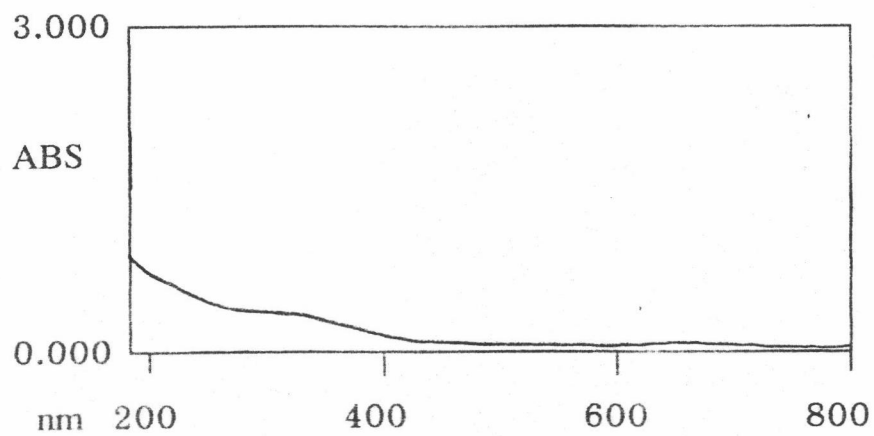


(c)

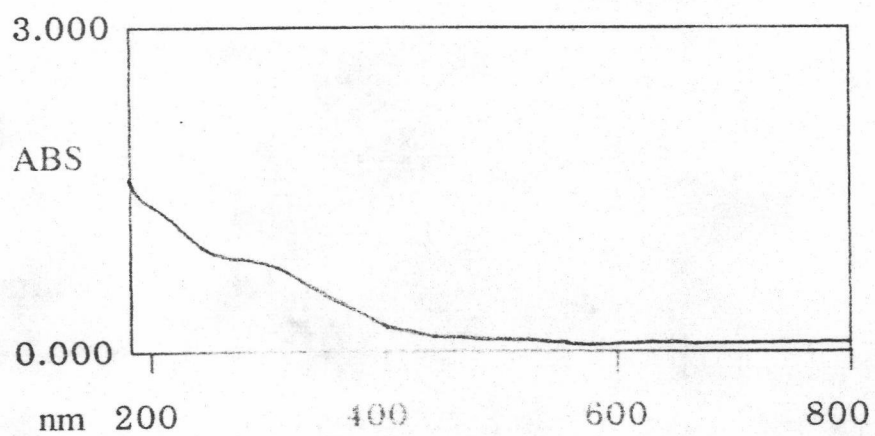


(d)

Figure A-17 (continued)



(a)



(b)

Figure A-18 : UV-VIS absorption spectra of PVA films containing

(a) 5% (b) 10% (c) 15% (d) 20% FeCl₂.

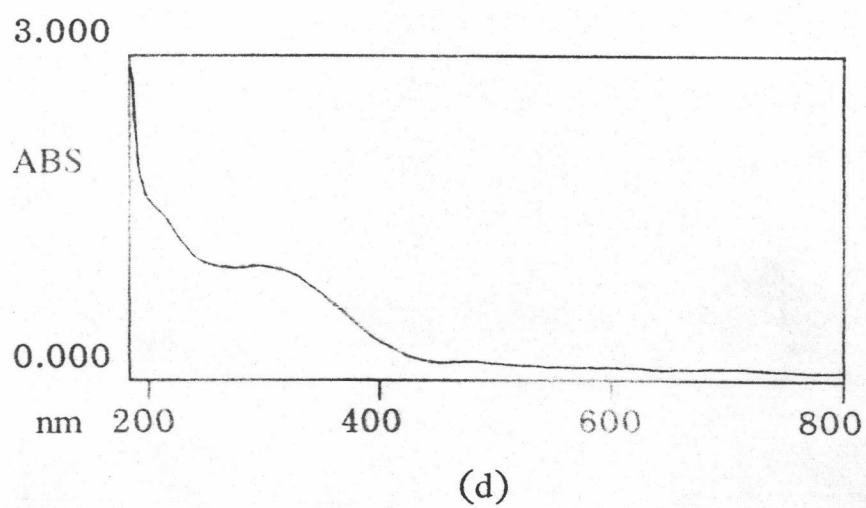
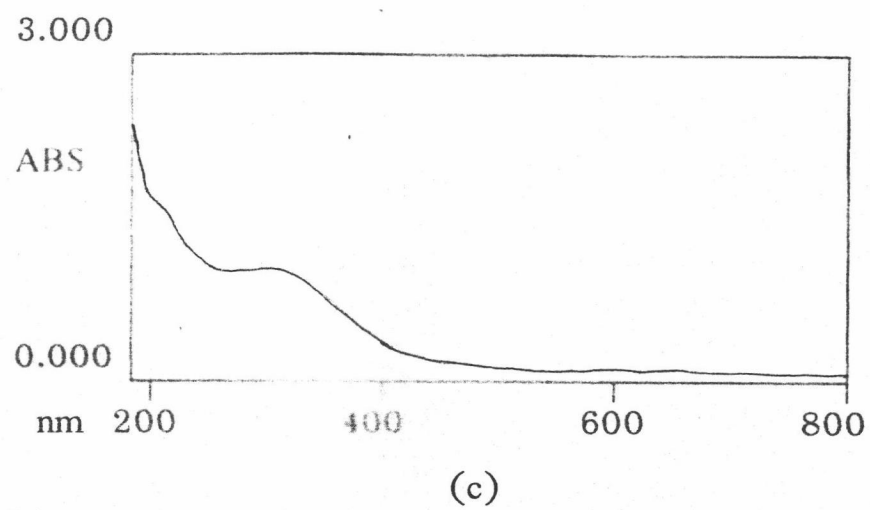


Figure A-18 (continued)

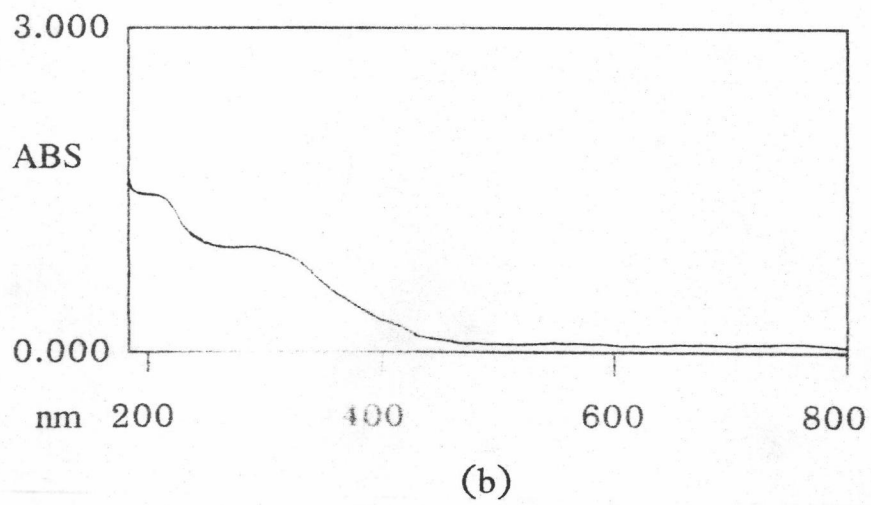
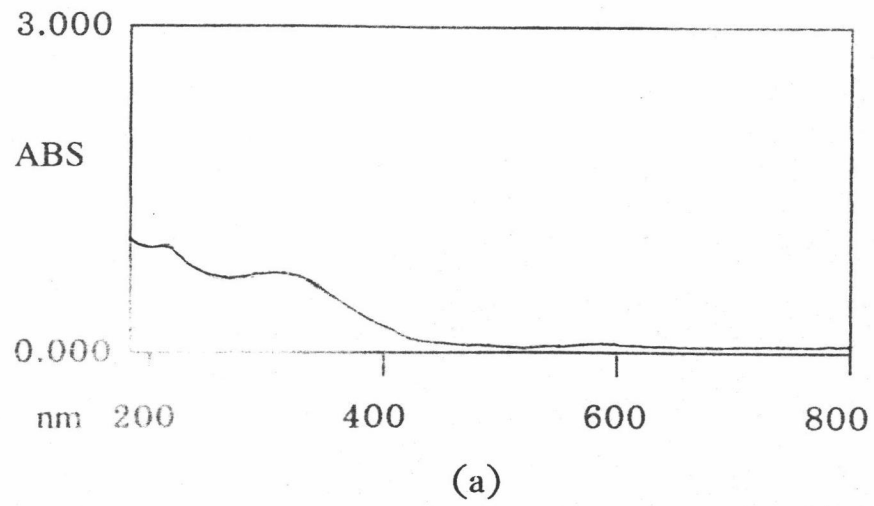


Figure A-19 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% FeCl_3 .

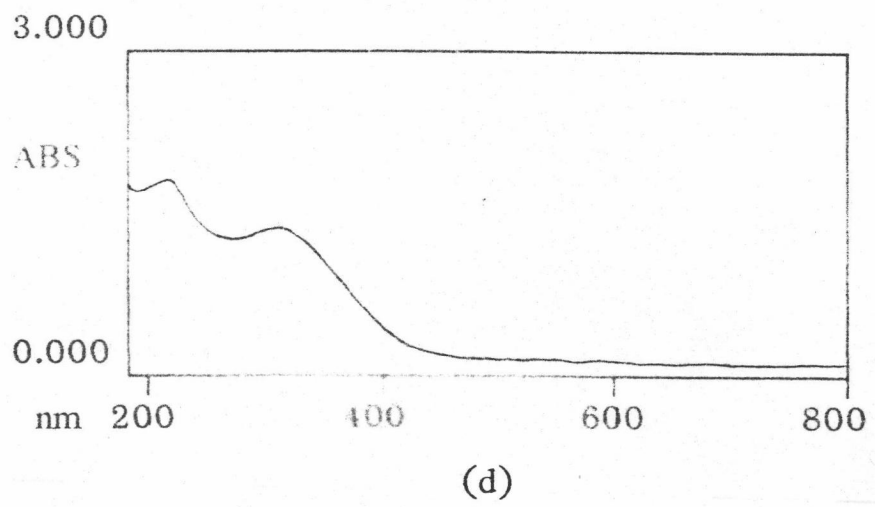
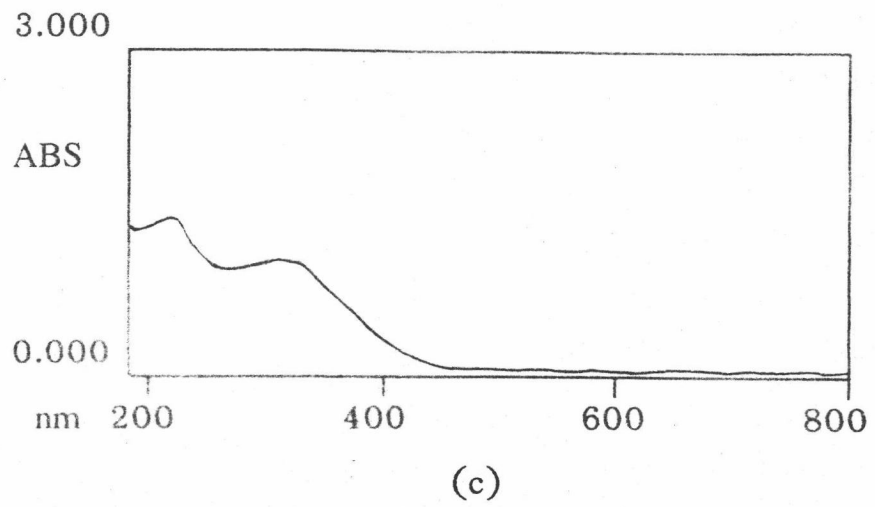
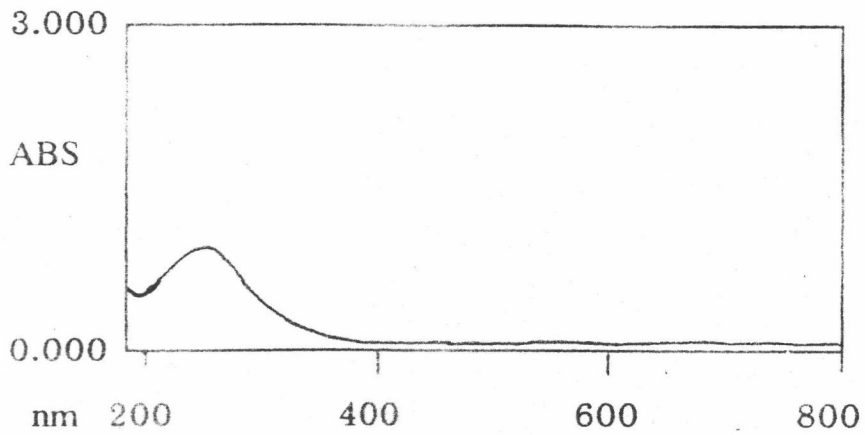
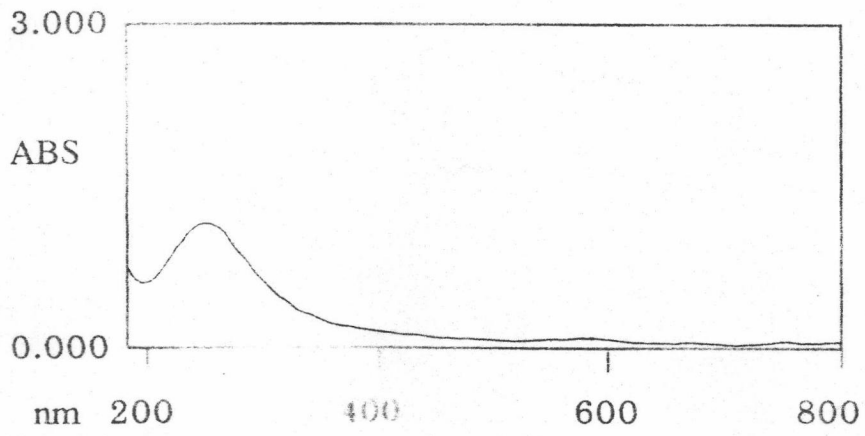


Figure A-19 (continued)



(a)



(b)

Figure A-20 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% CuCl_2 .

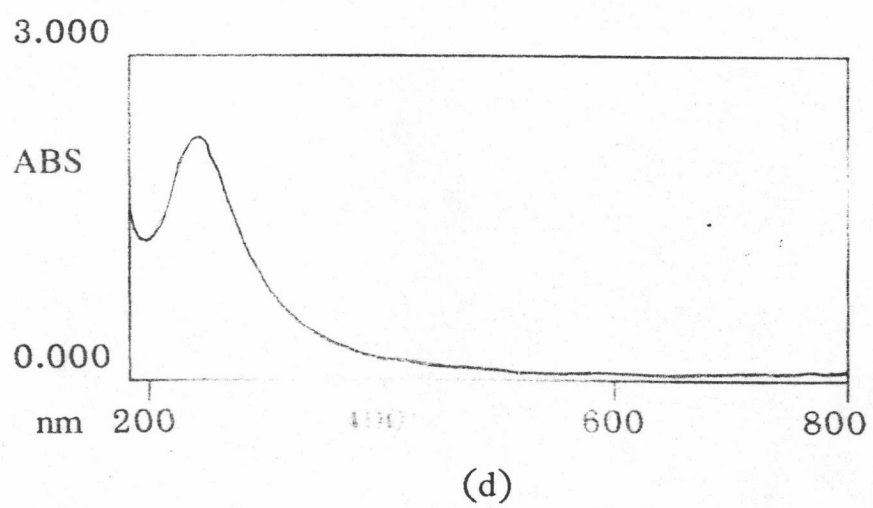
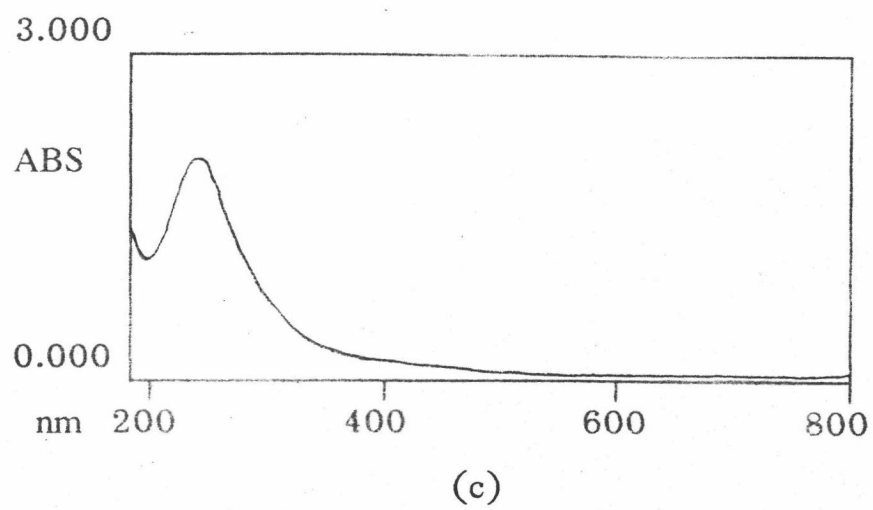
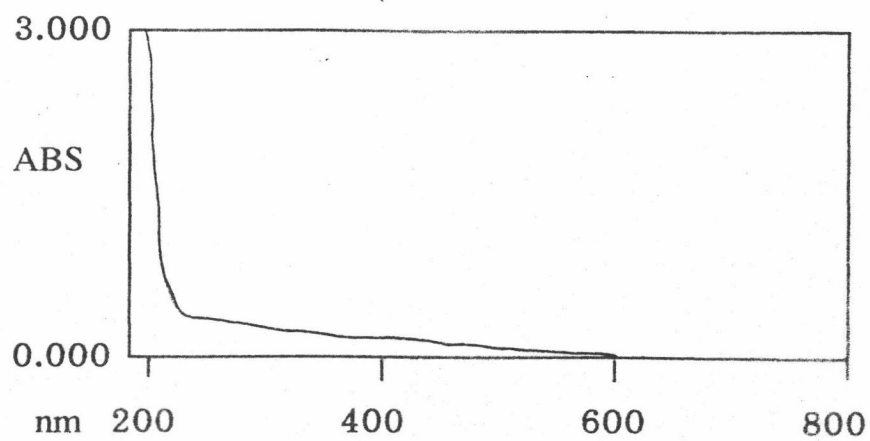
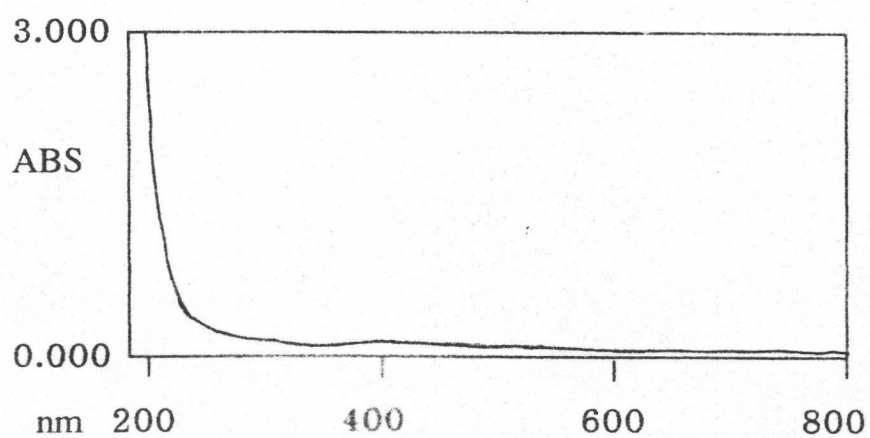


Figure A-20 (continued)

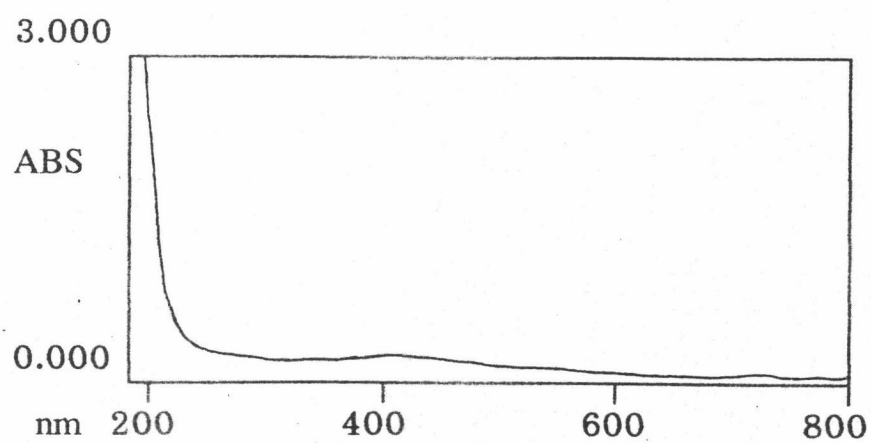


(a)

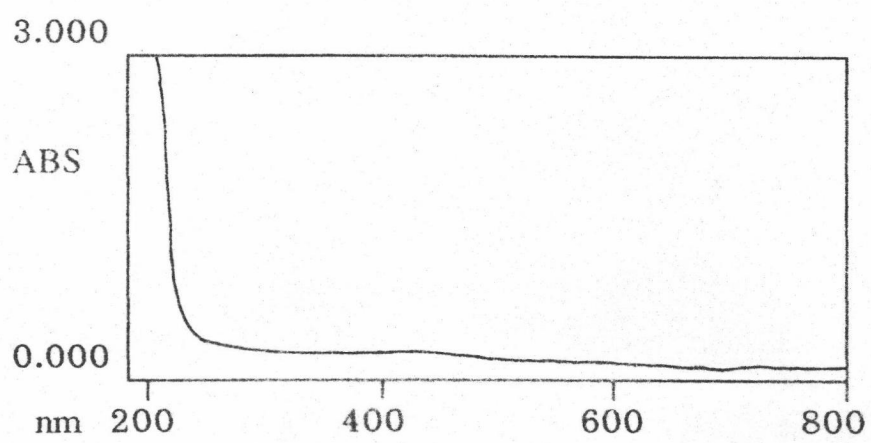


(b)

Figure A-21 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% ZnCl₂.



(c)



(d)

Figure A-21 (continued)

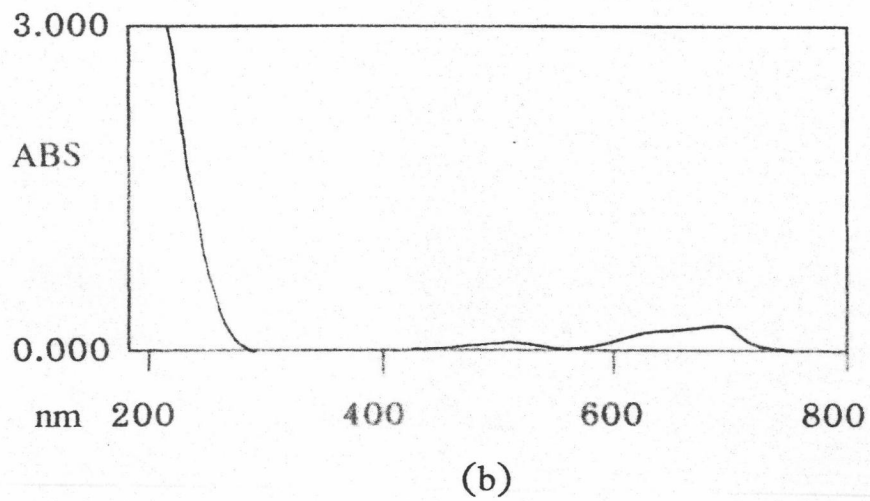
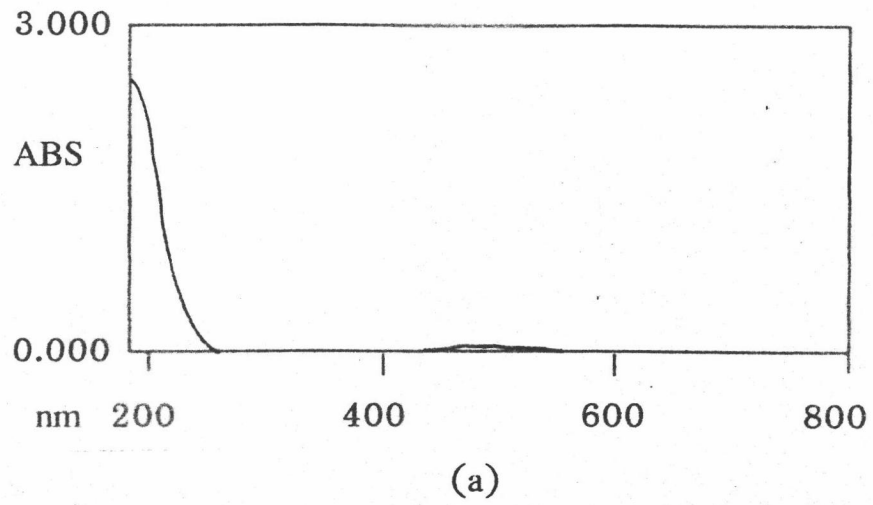


Figure A-22 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% CoCl_2 .

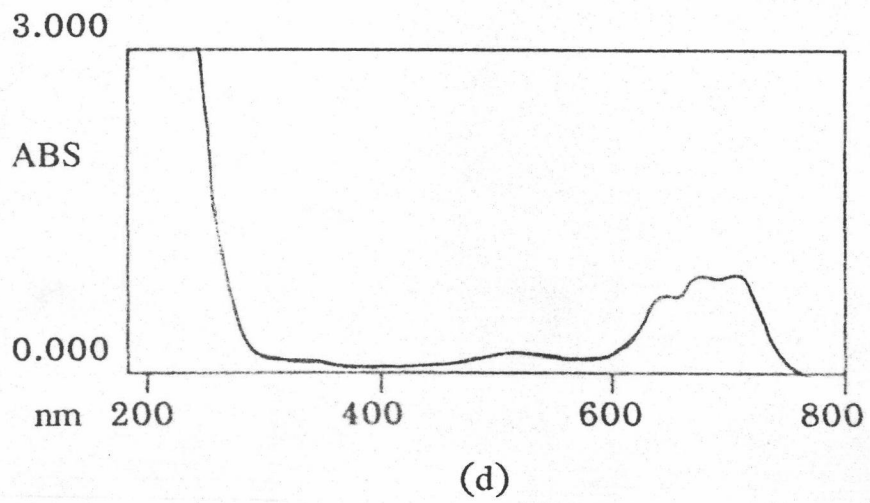
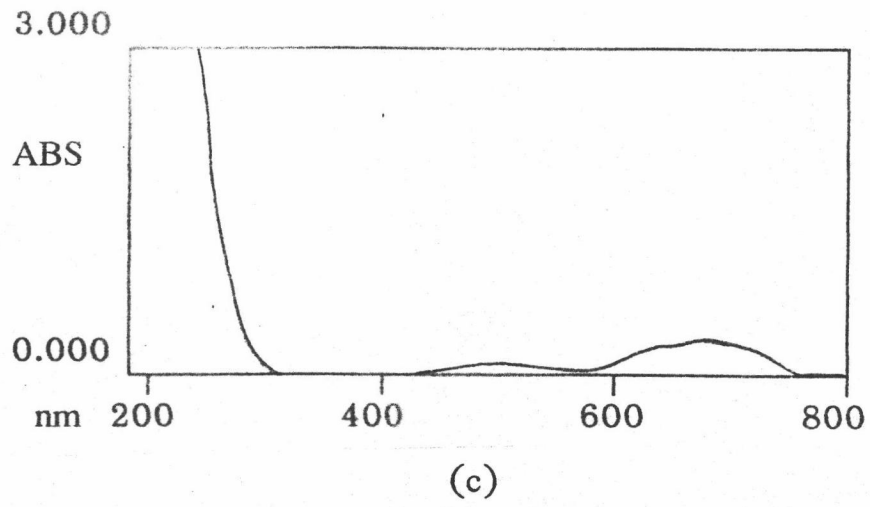


Figure A-22 (continued)

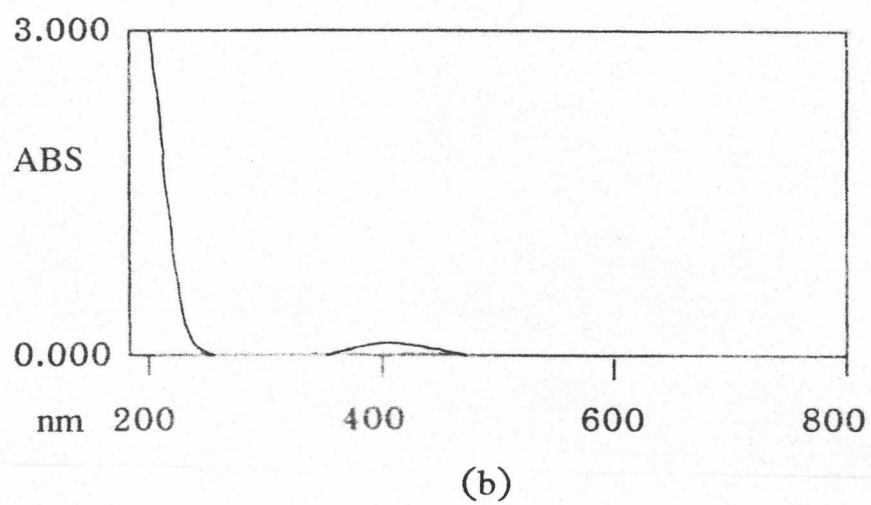
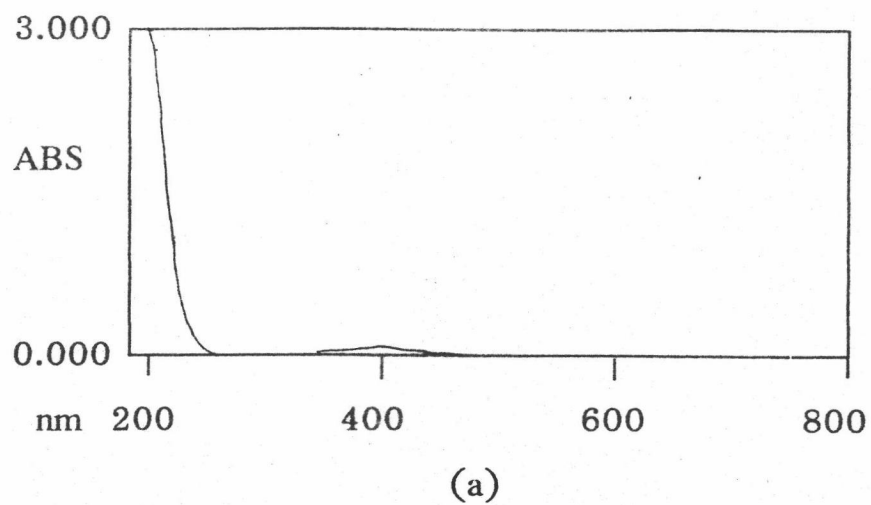


Figure A-23 : UV-VIS absorption spectra of PVA films containing
(a) 5% (b) 10% (c) 15% (d) 20% NiCl_2 .

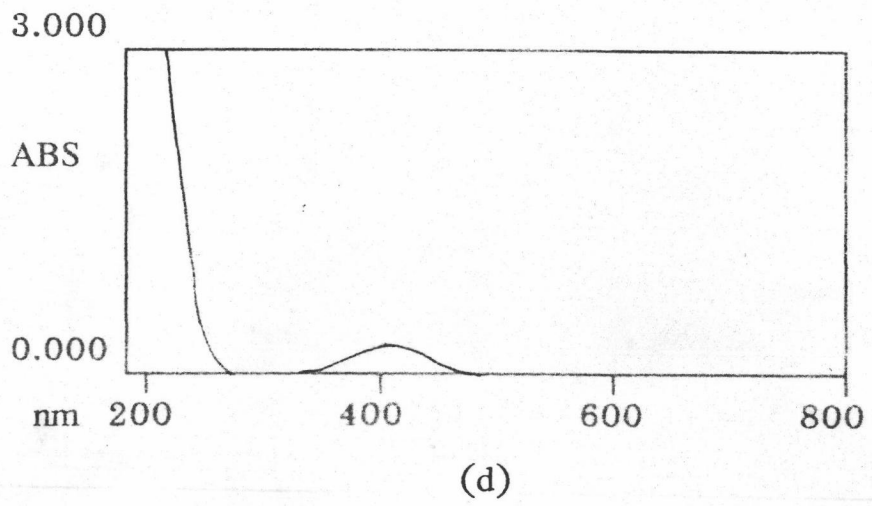
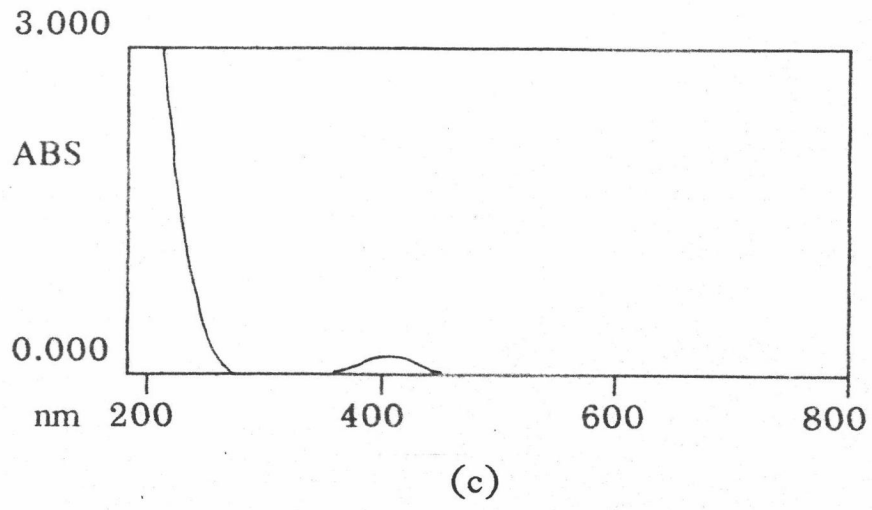


Figure A-23 (continued)

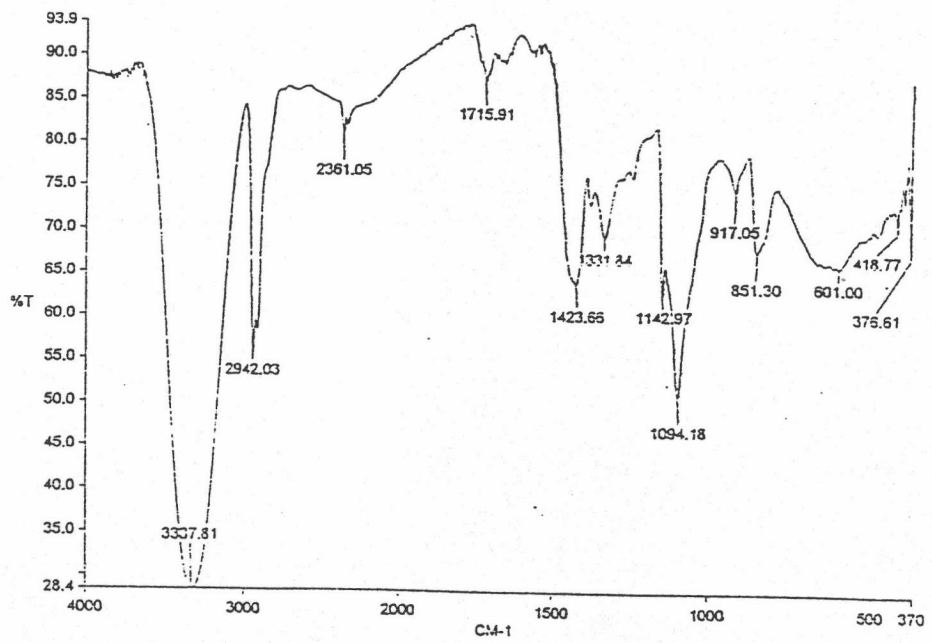
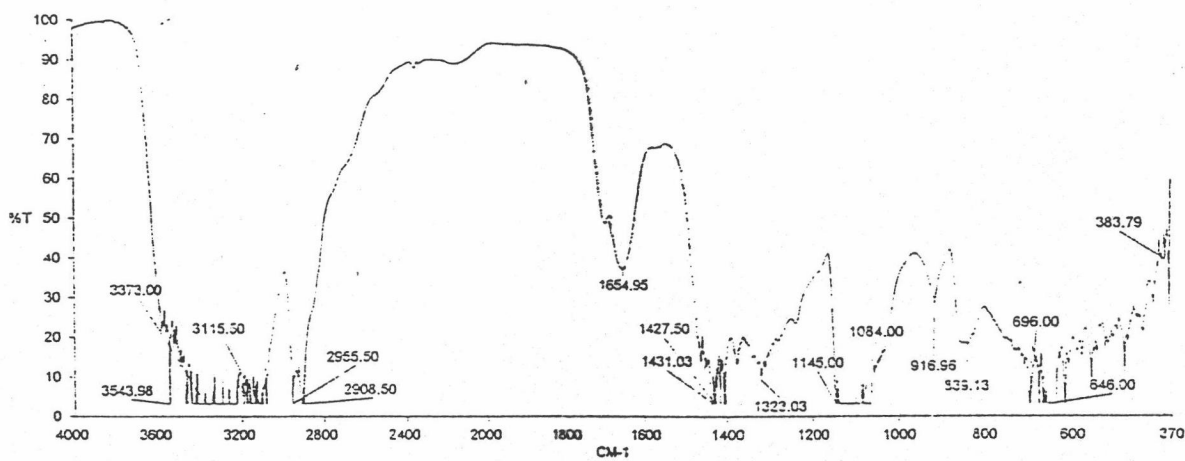


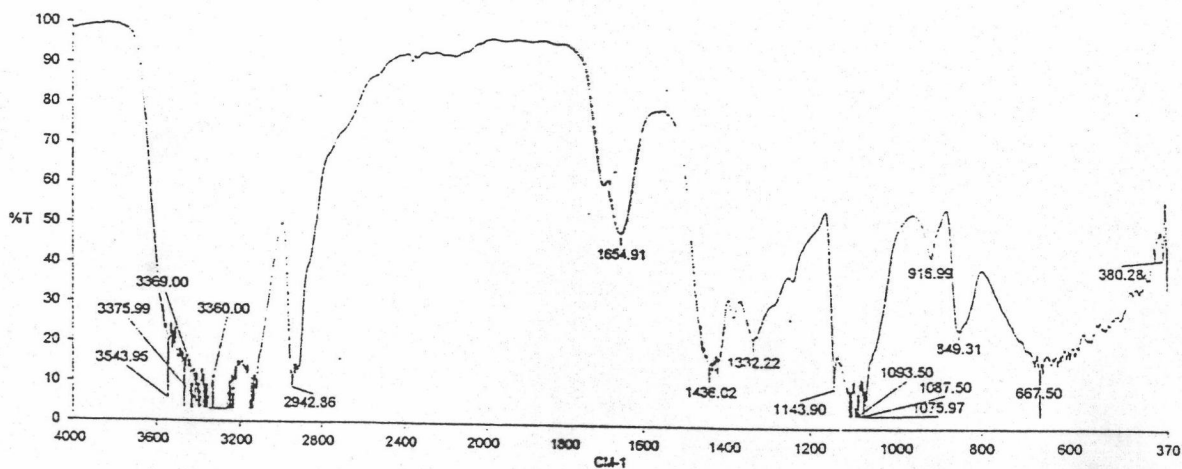
Figure B-1 : The infrared spectrum of standard PVA film.

Appendix B

The infrared absorption spectra of PVA film and PVA films containing 5, 10, 15, and 20% of LiCl, NaCl, KCl, CaCl₂, BaCl₂, FeCl₂, FeCl₃, CuCl₂, ZnCl₂, CoCl₂, and NiCl₂ obtained by infrared spectrophotometer of Perkin-Elmer system 2000 at a wavenumber of 360-4000 with FTIR technique under 60-120 times cycle and ambient condition i.e. room temperature and atmospheric pressure were shown in figures B-1 through B-12.



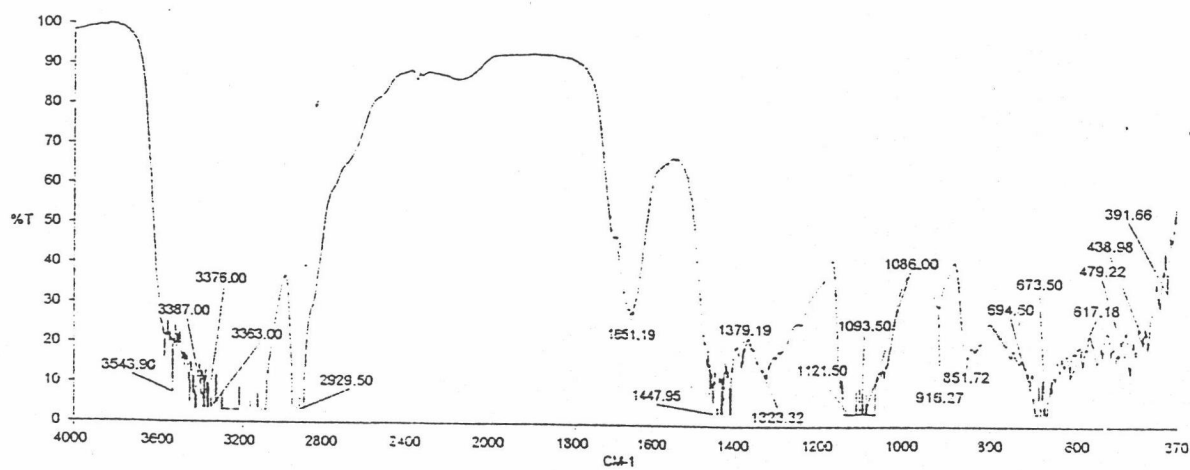
(a)



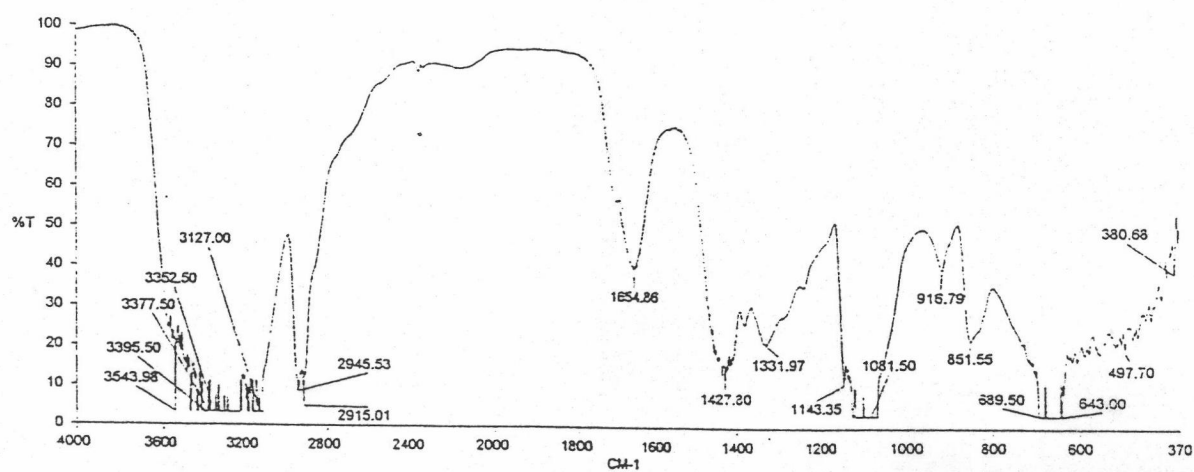
(b)

Figure B-2 : Effect of metal on the infrared spectra of PVA films containing LiCl

(a) 5% (b) 10% (c) 15% and (d) 20%

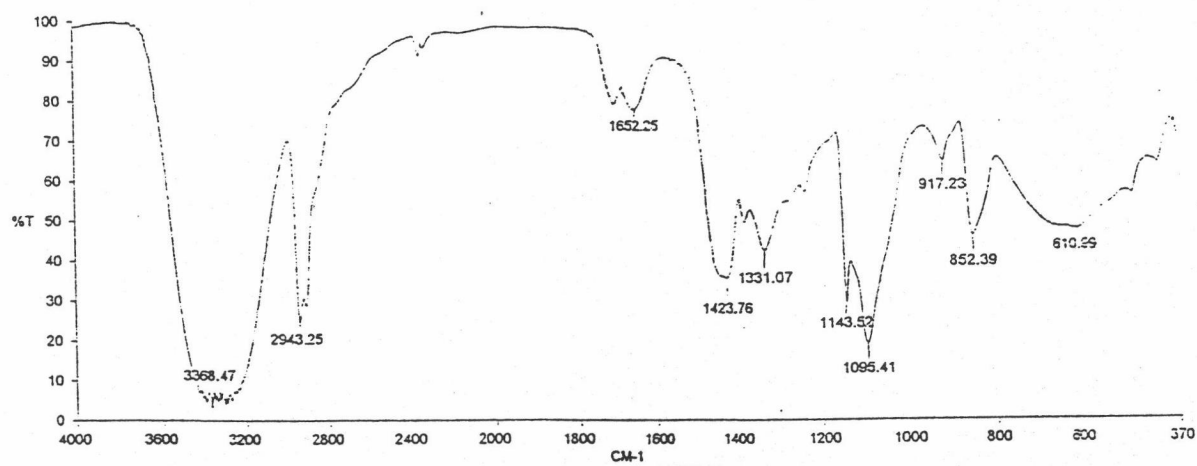


(c)

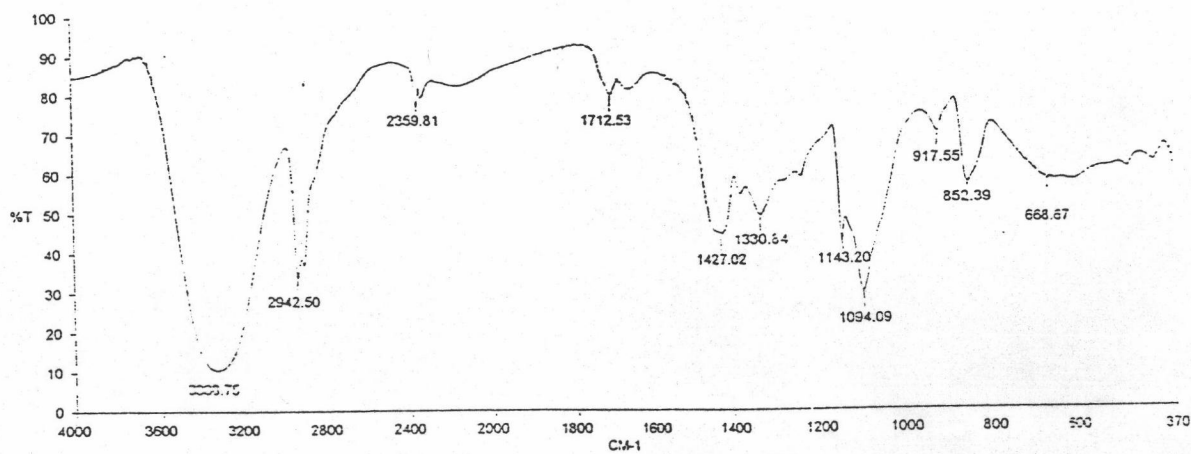


(d)

Figure B-2 (continued)



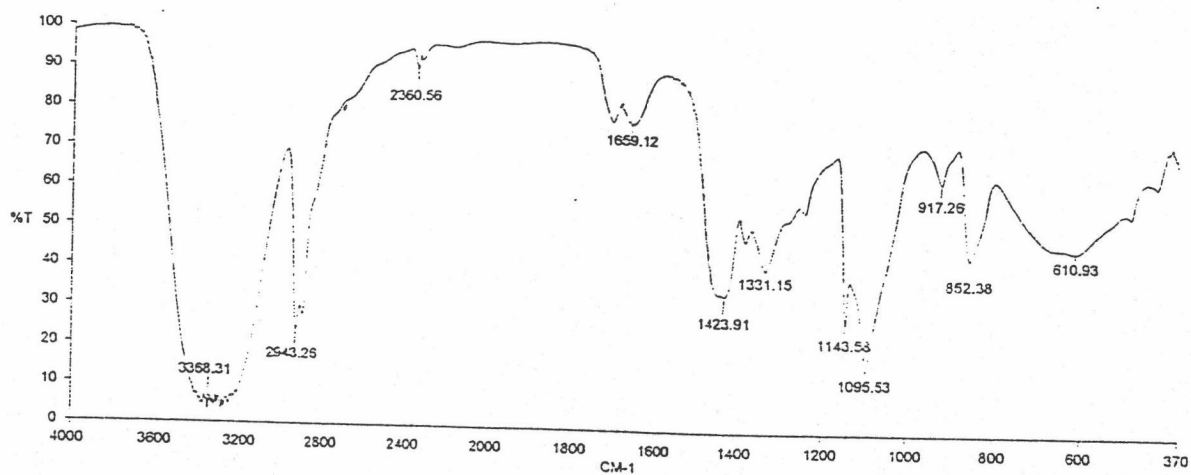
(a)



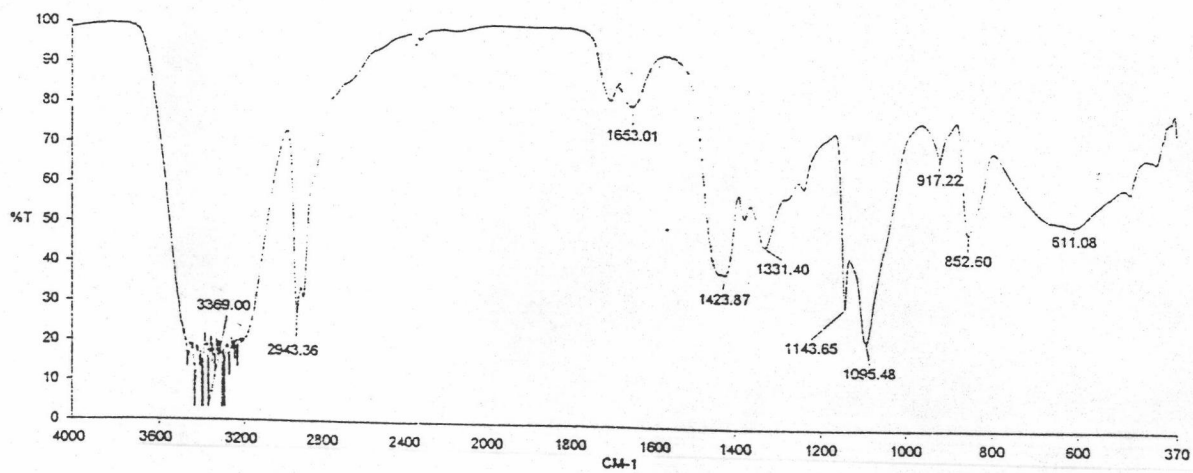
(b)

Figure B-3 : Effect of metal on the infrared spectra of PVA films containing NaCl

(a) 5% (b) 10% (c) 15% and (d) 20%

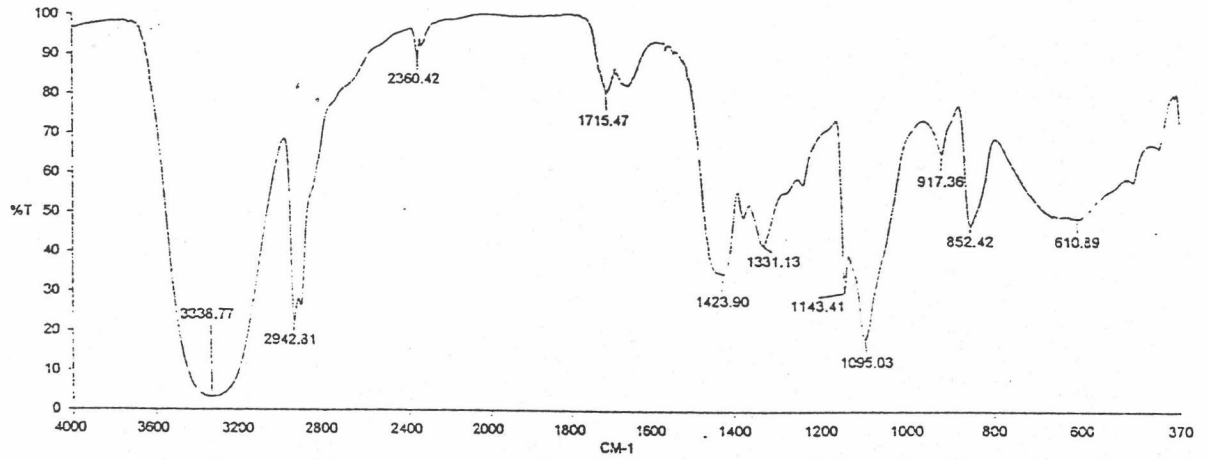


(c)

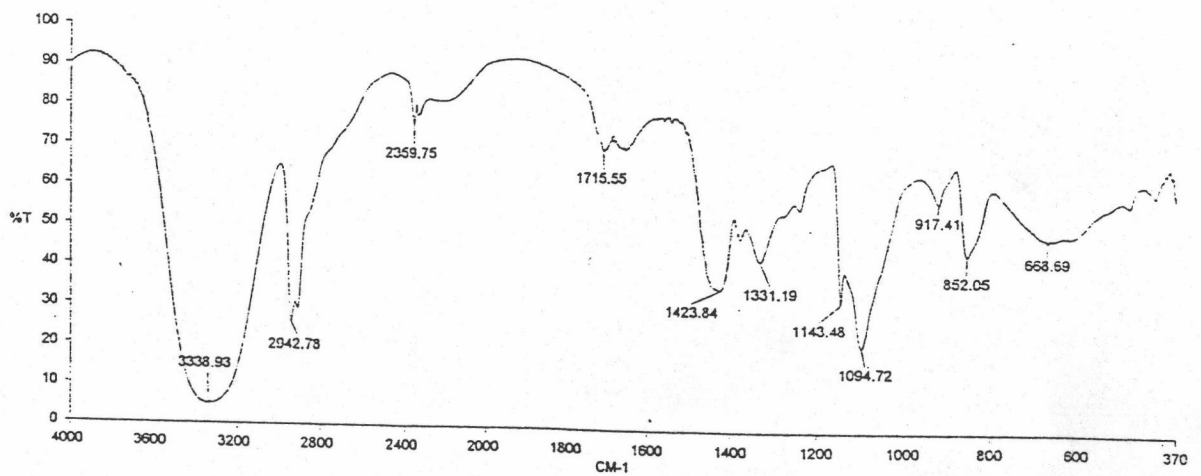


(d)

Figure B-3 (continued)



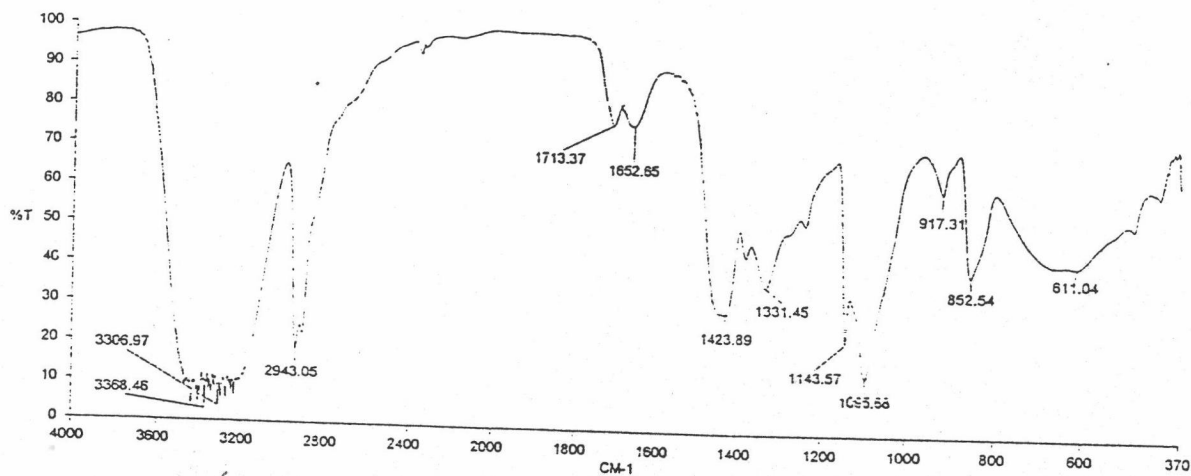
(a)



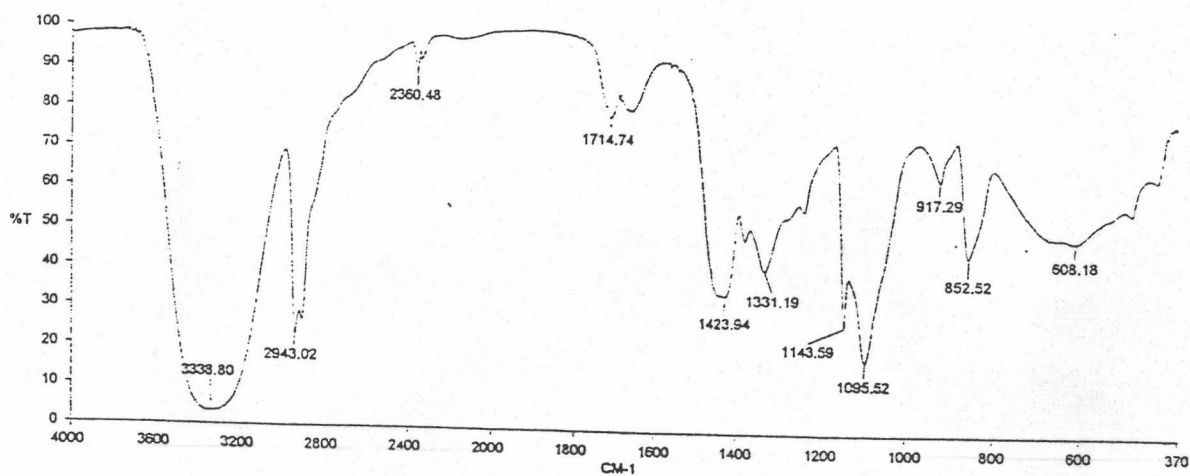
(b)

Figure B-4 : Effect of metal on the infrared spectra of PVA films containing KCl

(a) 5% (b) 10% (c) 15% and (d) 20%

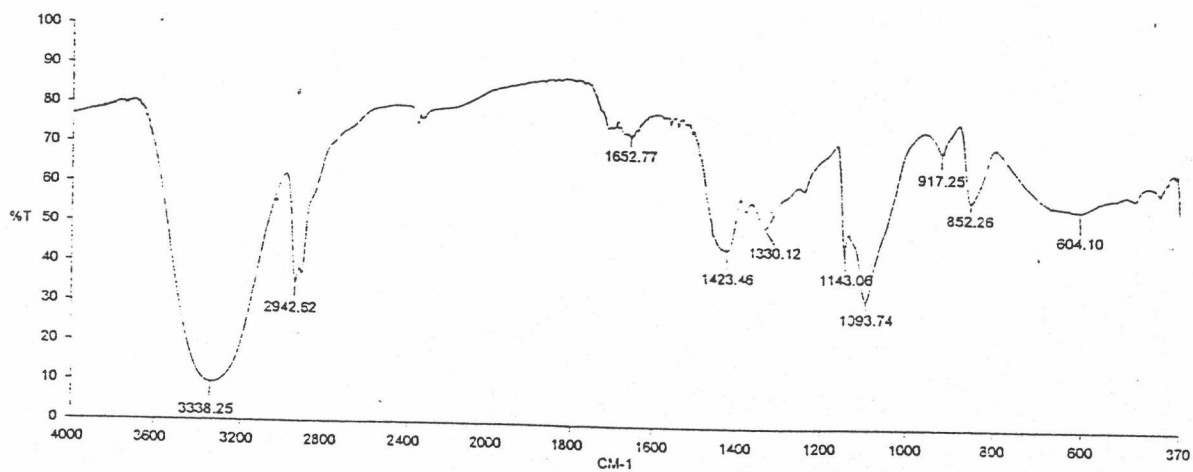


(c)

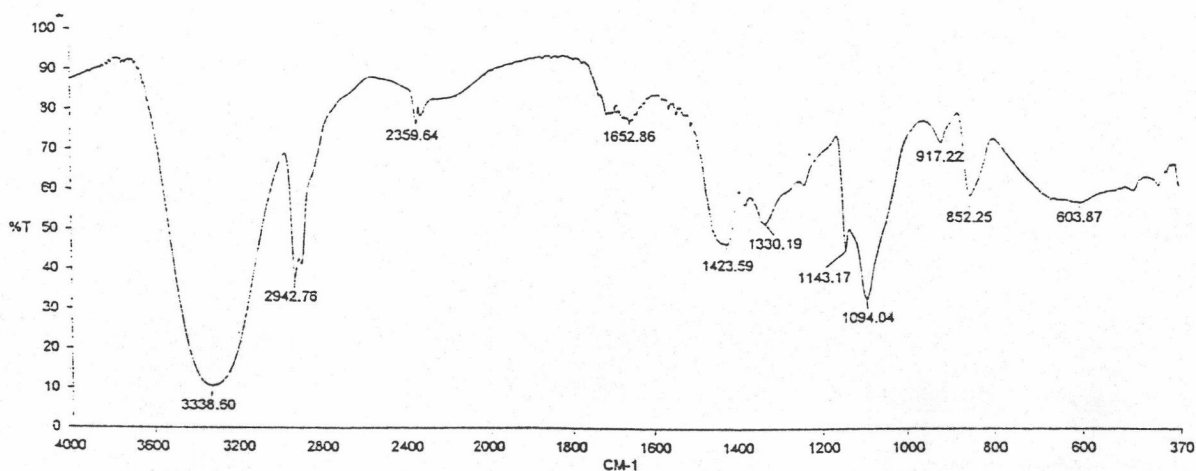


(d)

Figure B-4 (continued)



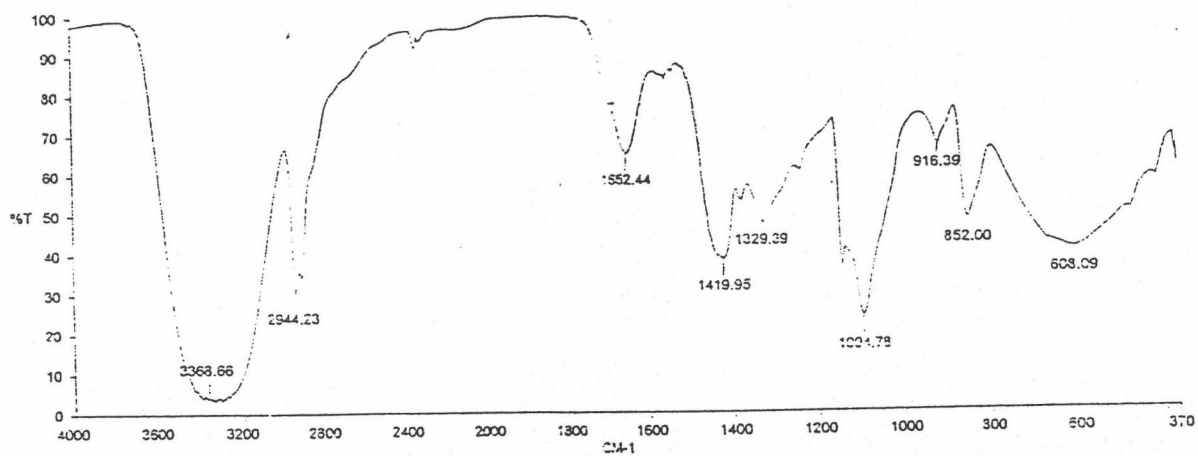
(a)



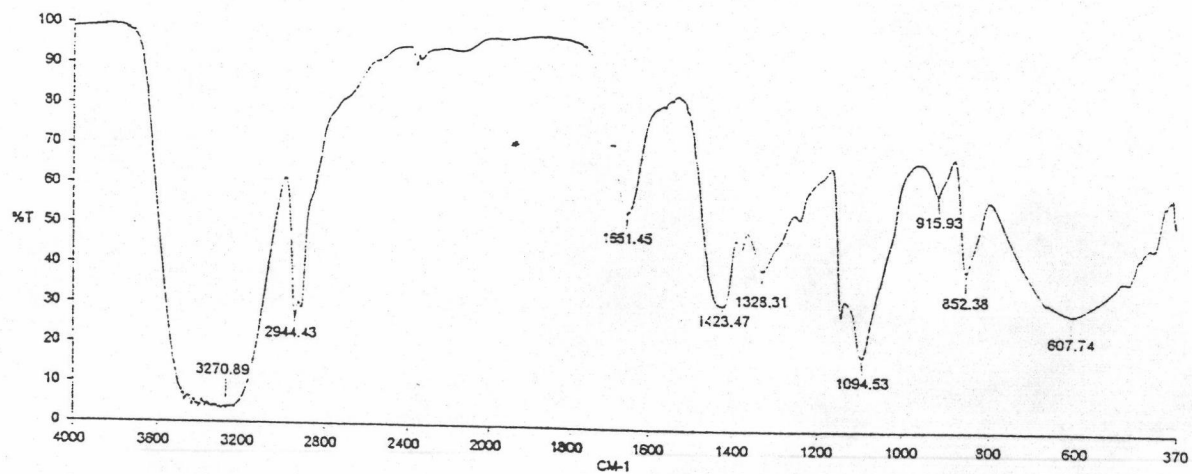
(b)

Figure B-5 : Effect of metal on the infrared spectra of PVA films containing CaCl_2

(a) 5% (b) 10% (c) 15% and (d) 20%

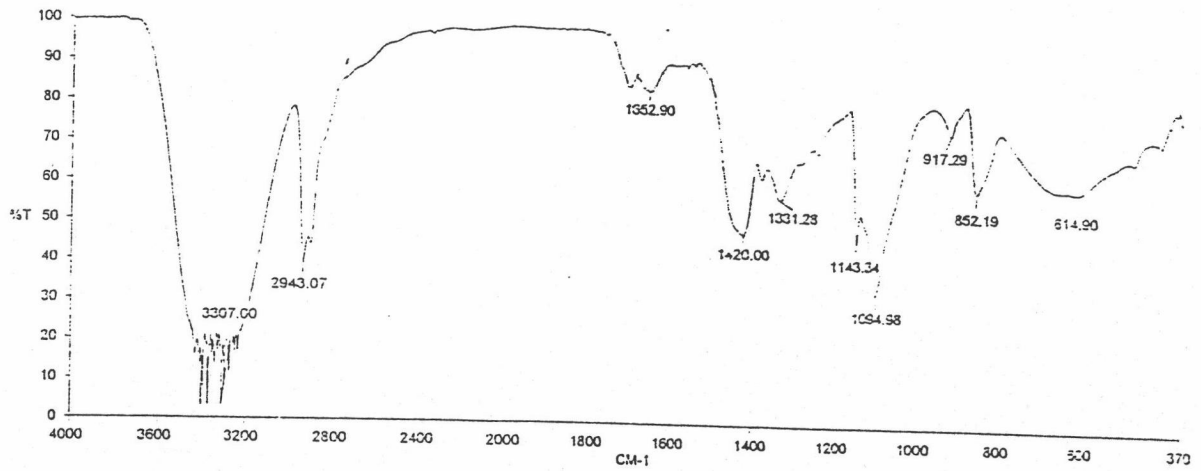


(c)

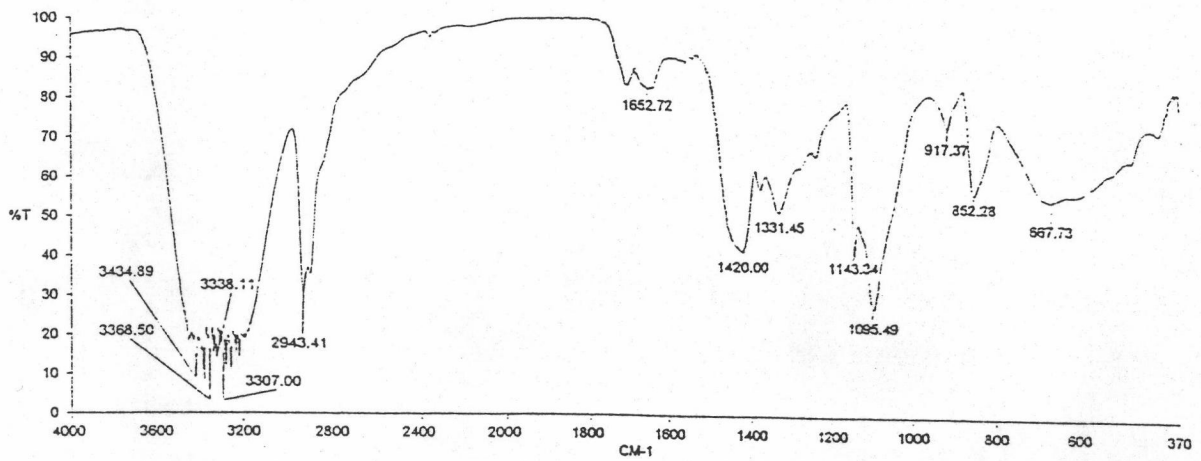


(d)

Figure B-5 (continued)



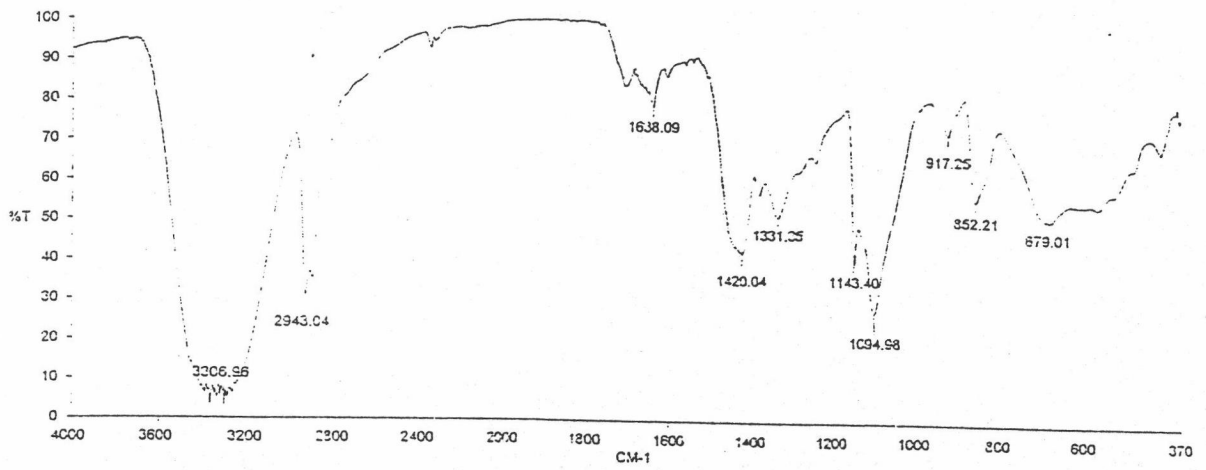
(a)



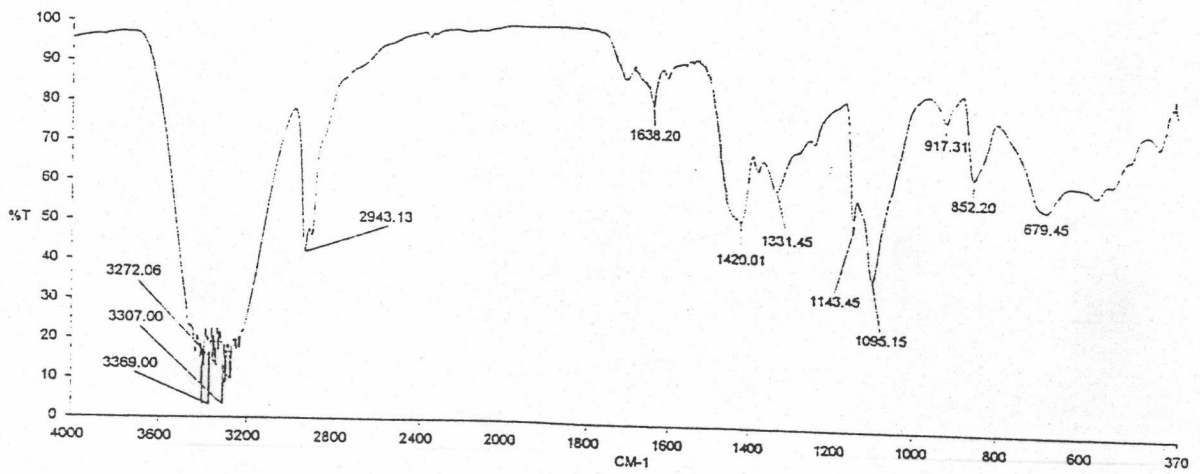
(b)

Figure B-6 : Effect of metal on the infrared spectra of PVA films containing BaCl₂.

(a) 5% (b) 10% (c) 15% and (d) 20%

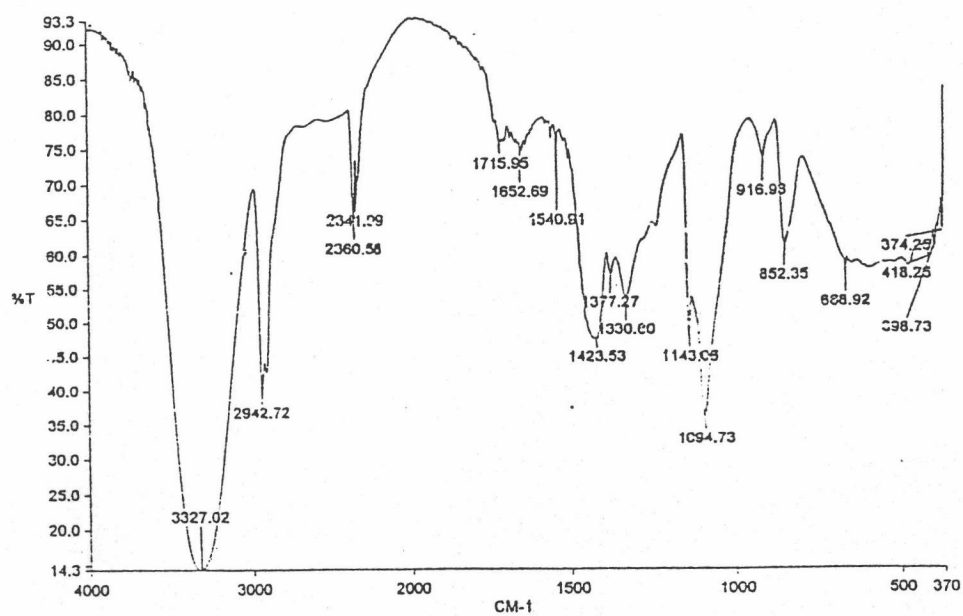


(c)

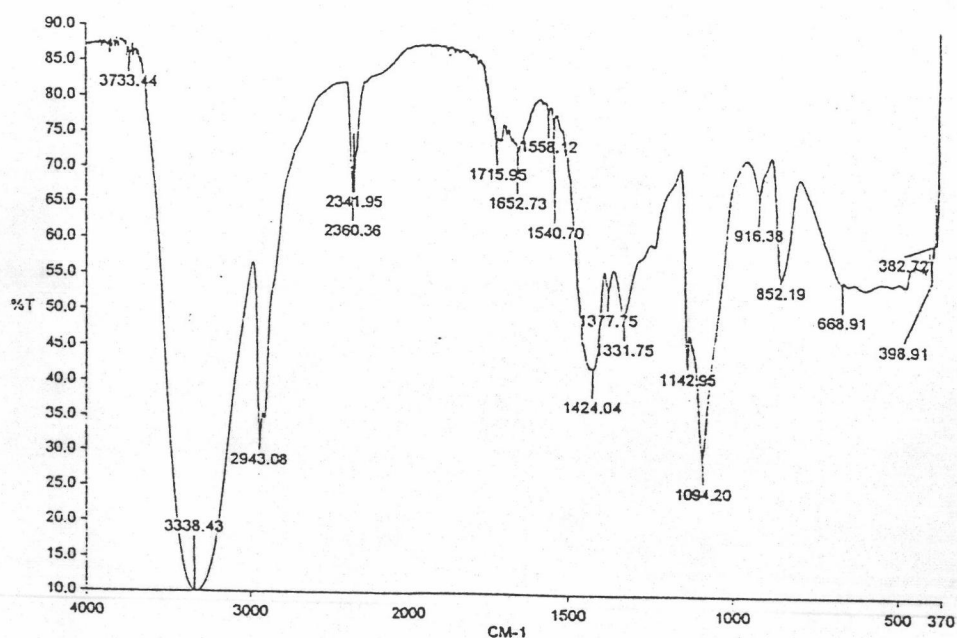


(d)

Figure B-6 (continued)



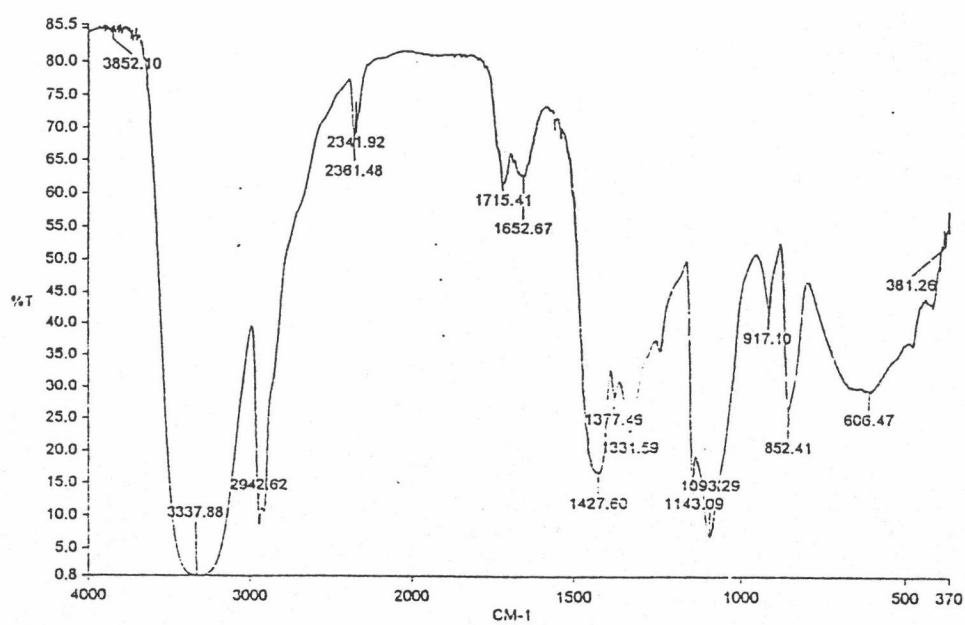
(a)



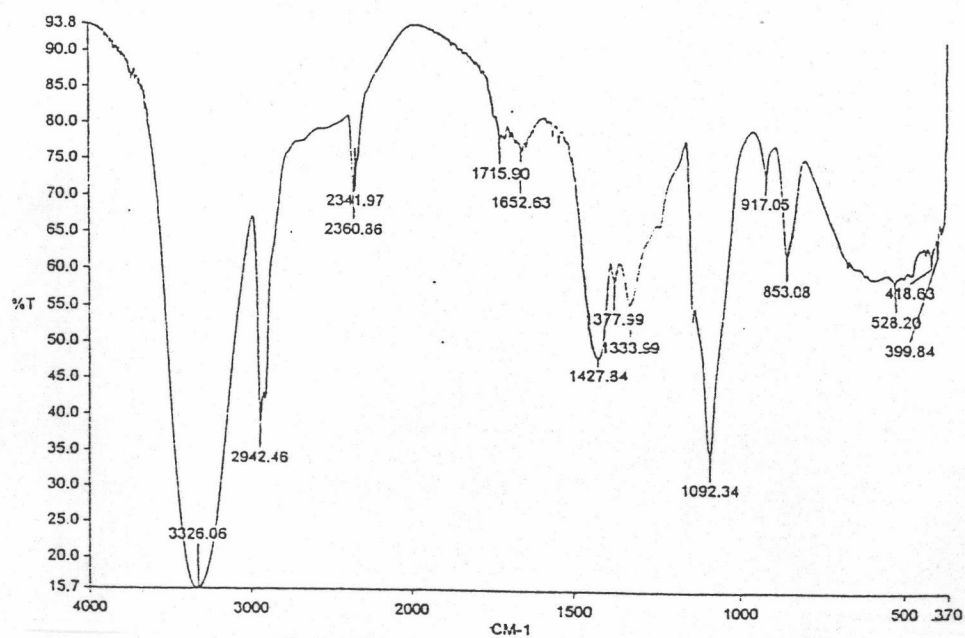
(b)

Figure B-7 : Effect of metal on the infrared spectra of PVA films containing FeCl_2

(a) 5% (b) 10% (c) 15% and (d) 20%



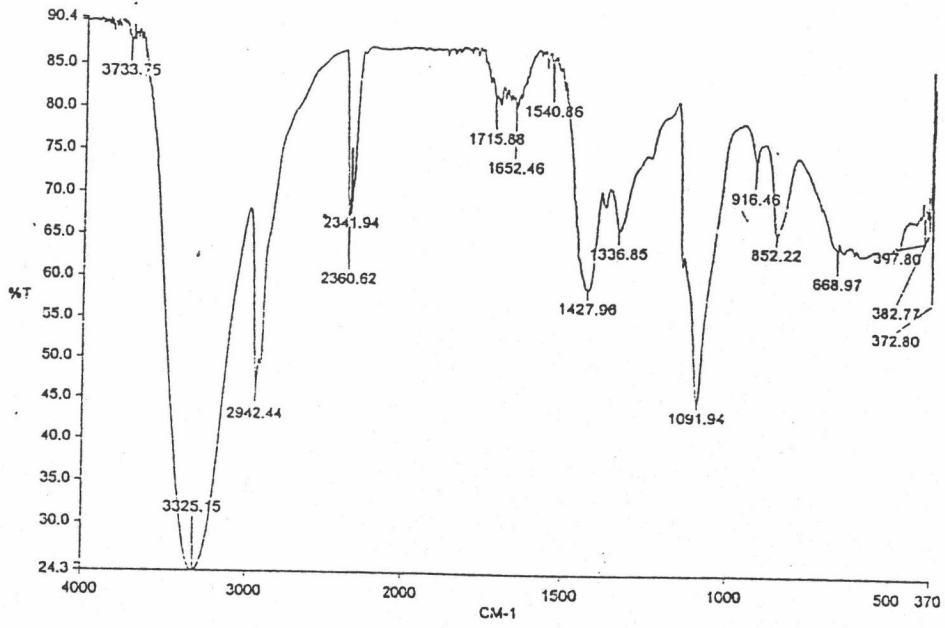
(a)



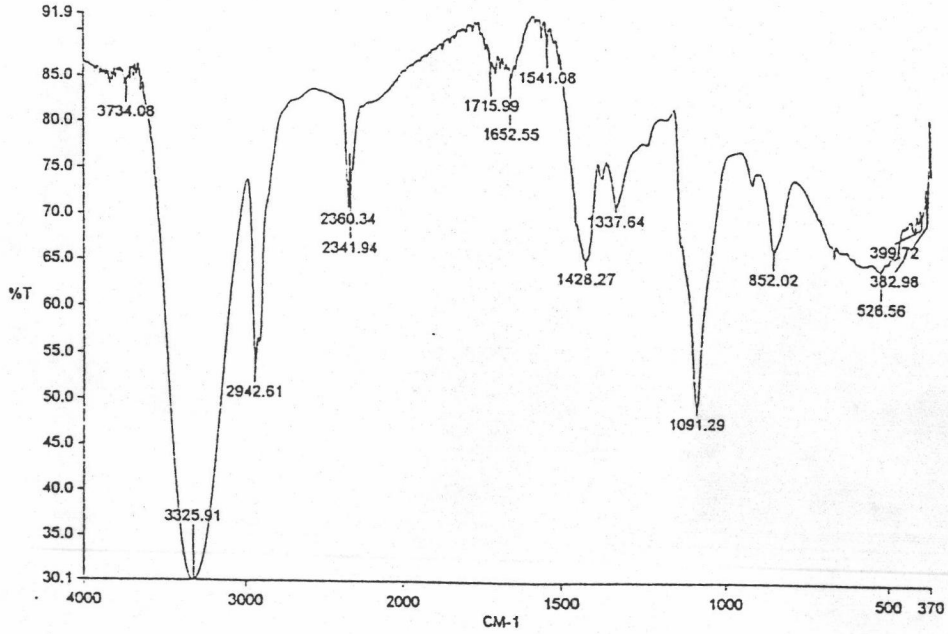
(b)

Figure B-8 : Effect of metal on the infrared spectra of PVA films containing FeCl₃

(a) 5% (b) 10% (c) 15% and (d) 20%

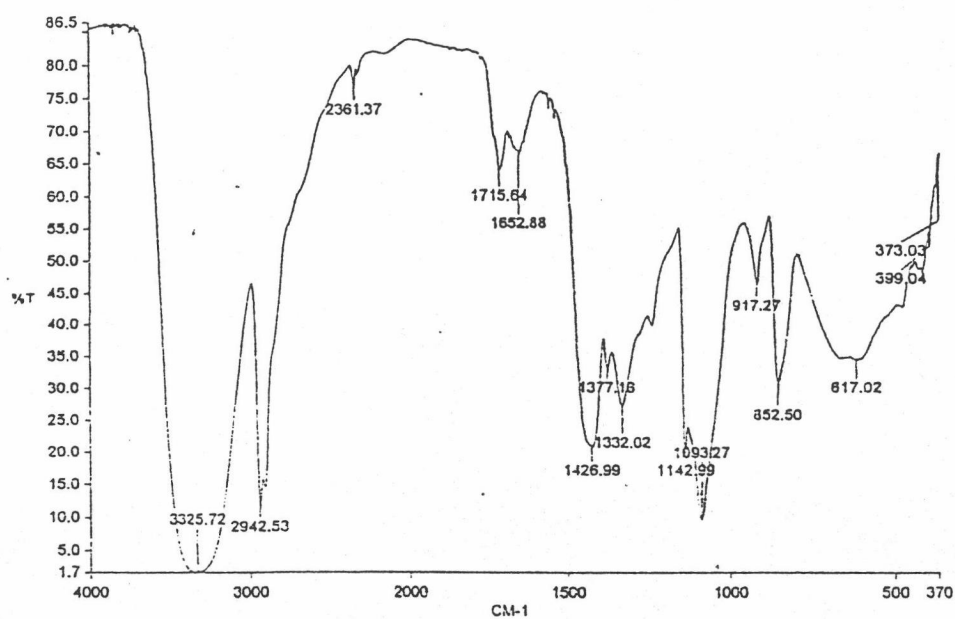


(c)

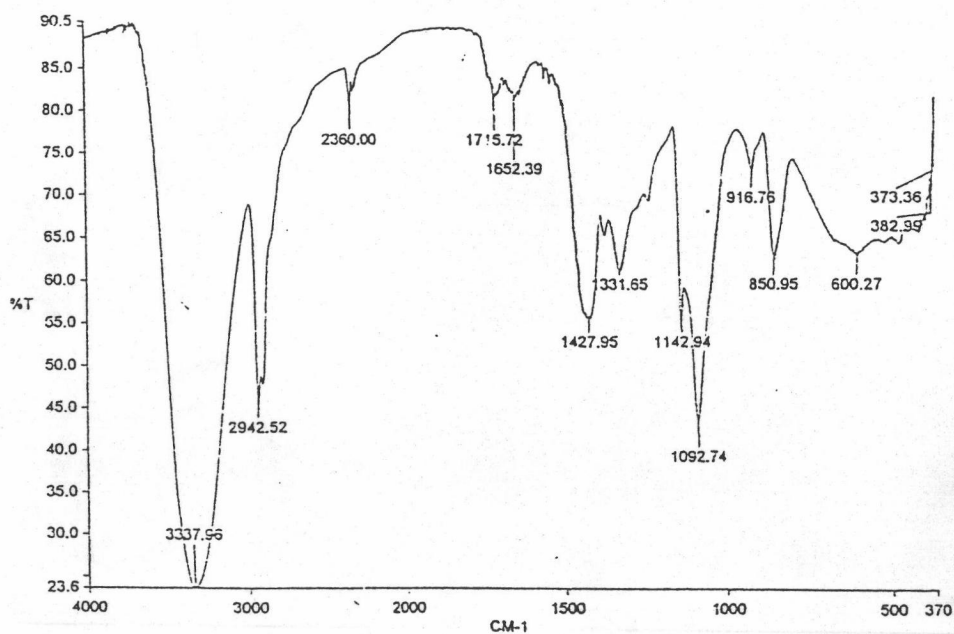


(d)

Figure B-8 (continued)



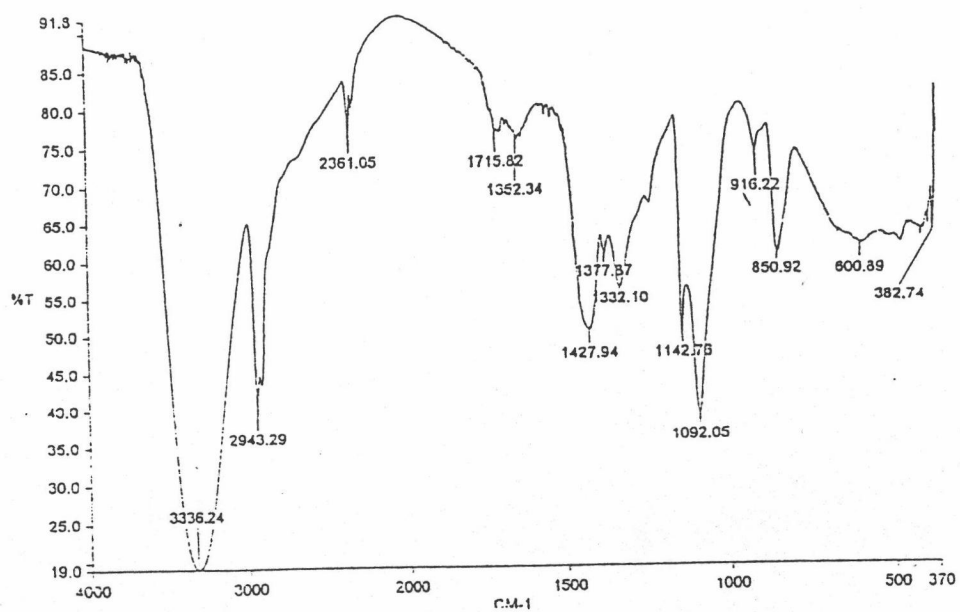
(a)



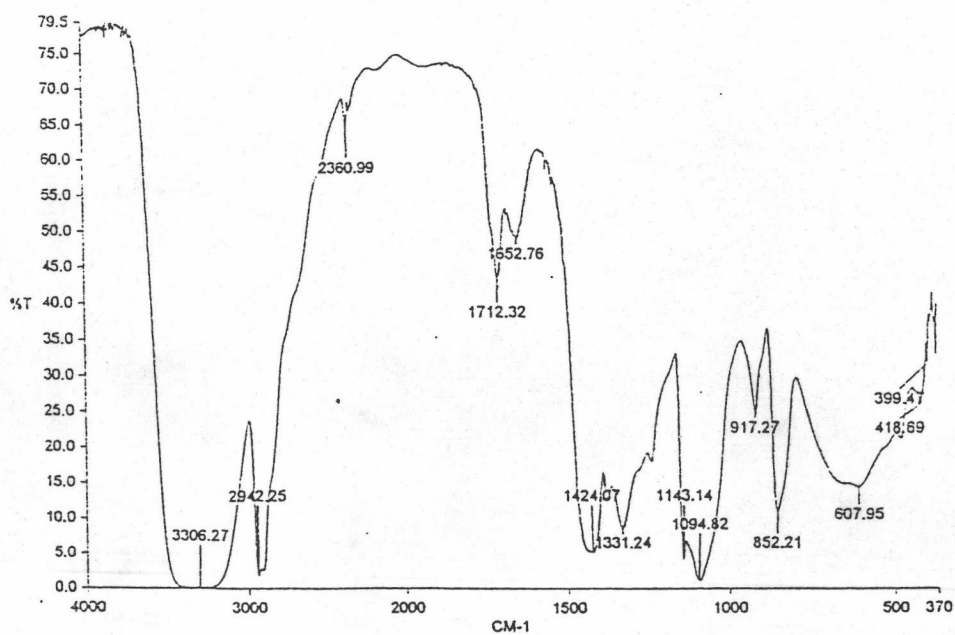
(b)

Figure B-9 : Effect of metal on the infrared spectra of PVA films containing CuCl₂

(a) 5% (b) 10% (c) 15% and (d) 20%

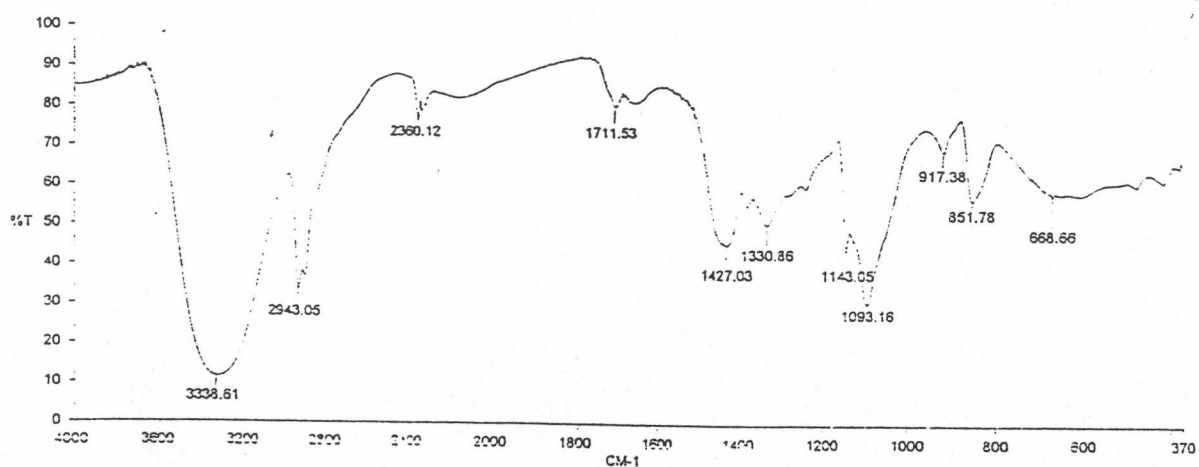


(c)

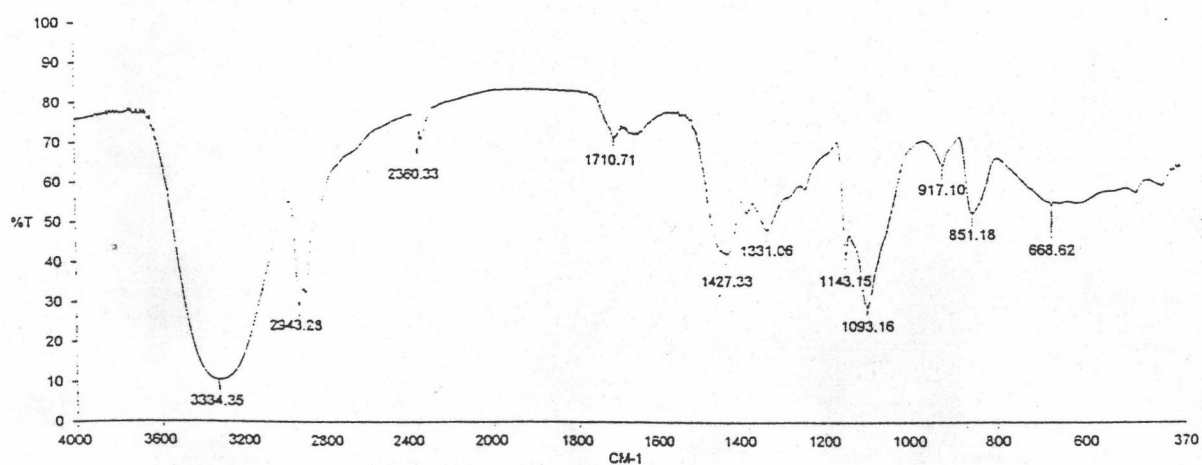


(d)

Figure B-9 (continued)



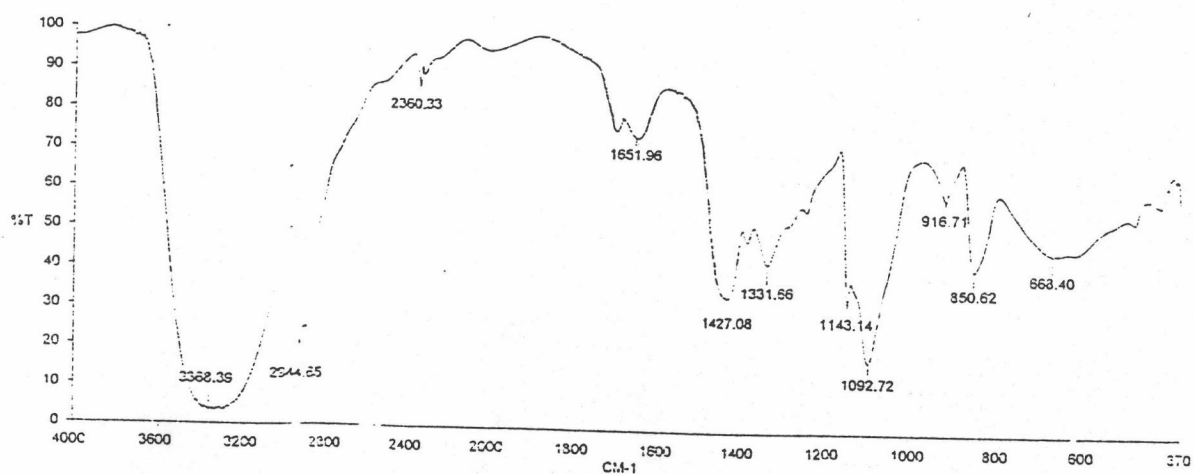
(a)



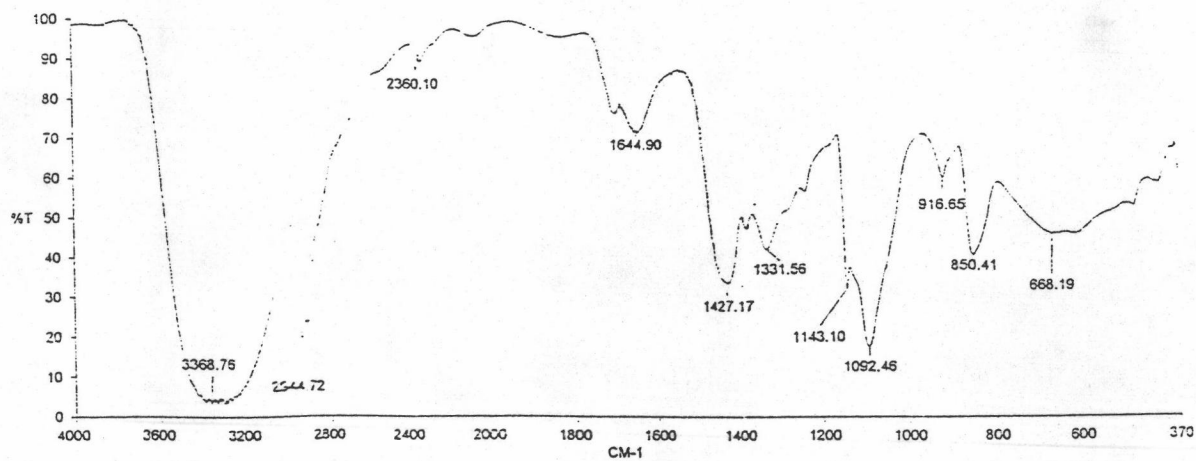
(b)

Figure B-10 : Effect of metal on the infrared spectra of PVA films containing $ZnCl_2$

(a) 5% (b) 10% (c) 15% and (d) 20%

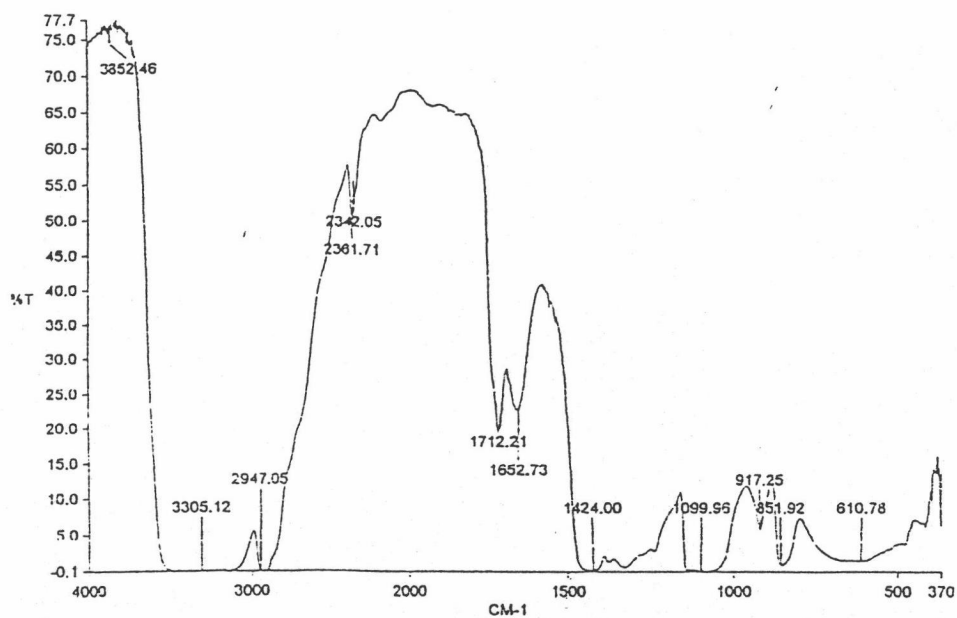


(c)

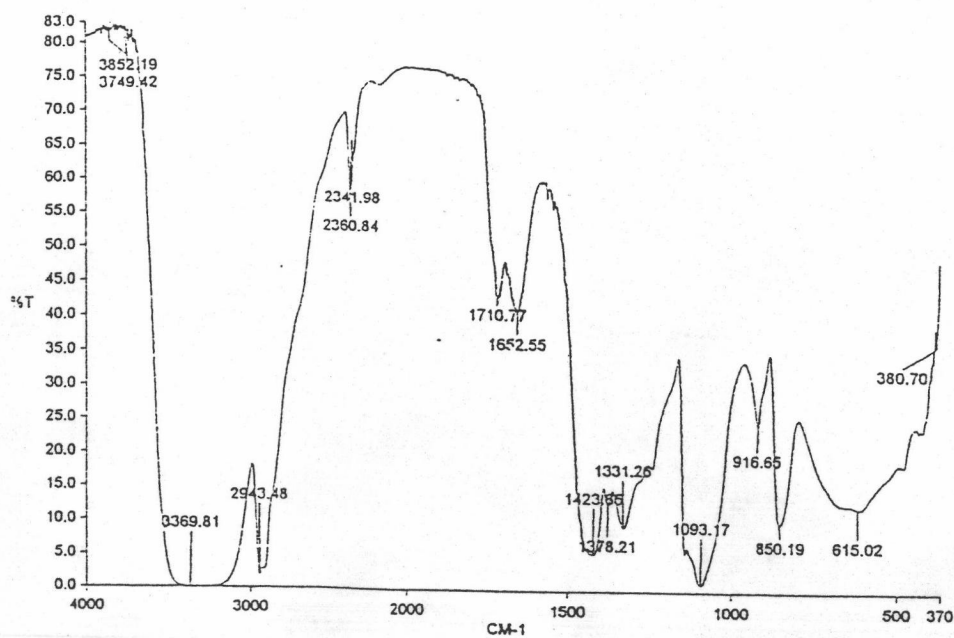


(d)

Figure B-10 (continued)



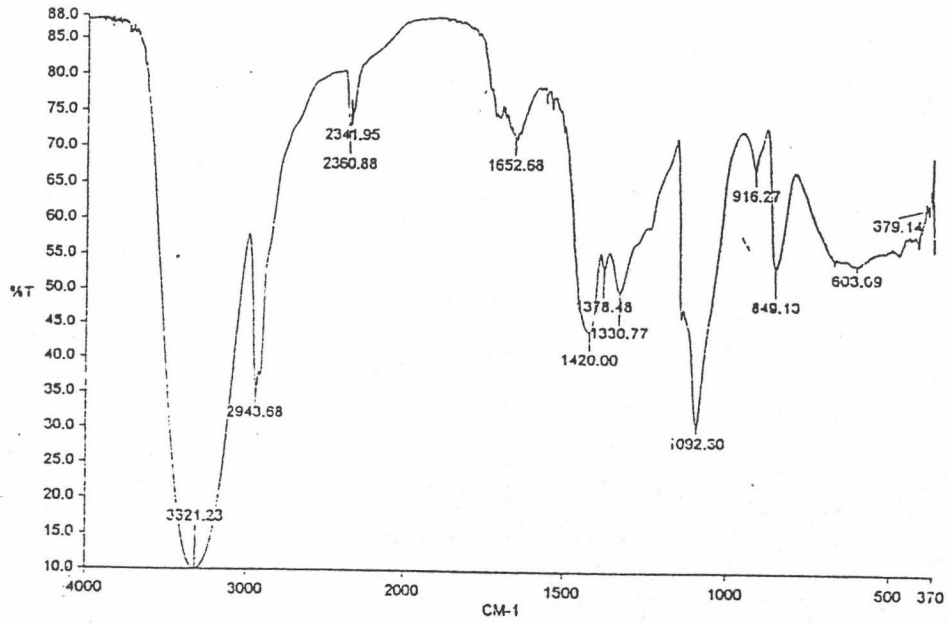
(a)



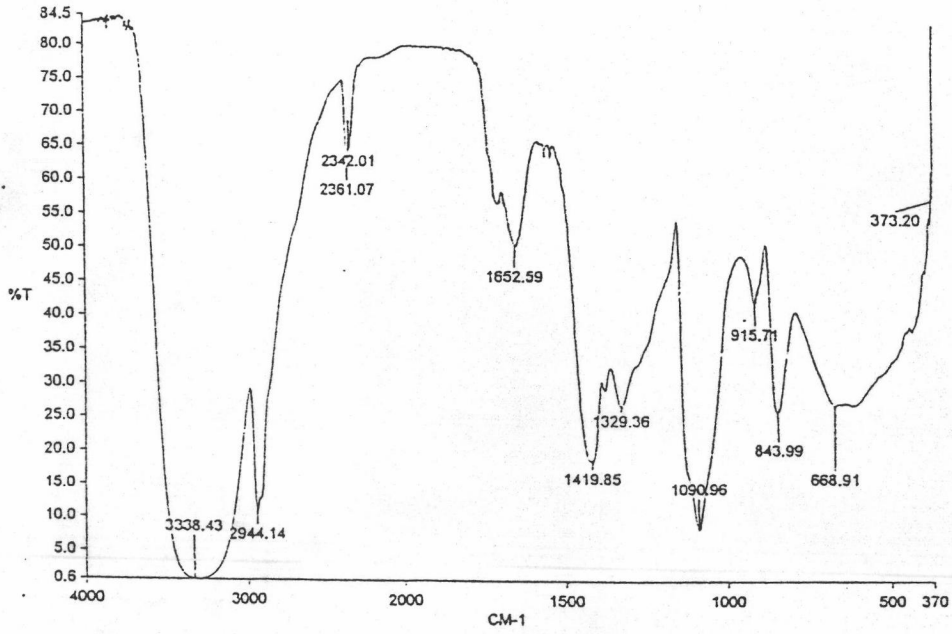
(b)

Figure B-11 : Effect of metal on the infrared spectra of PVA films containing CoCl_2

(a) 5% (b) 10% (c) 15% and (d) 20%

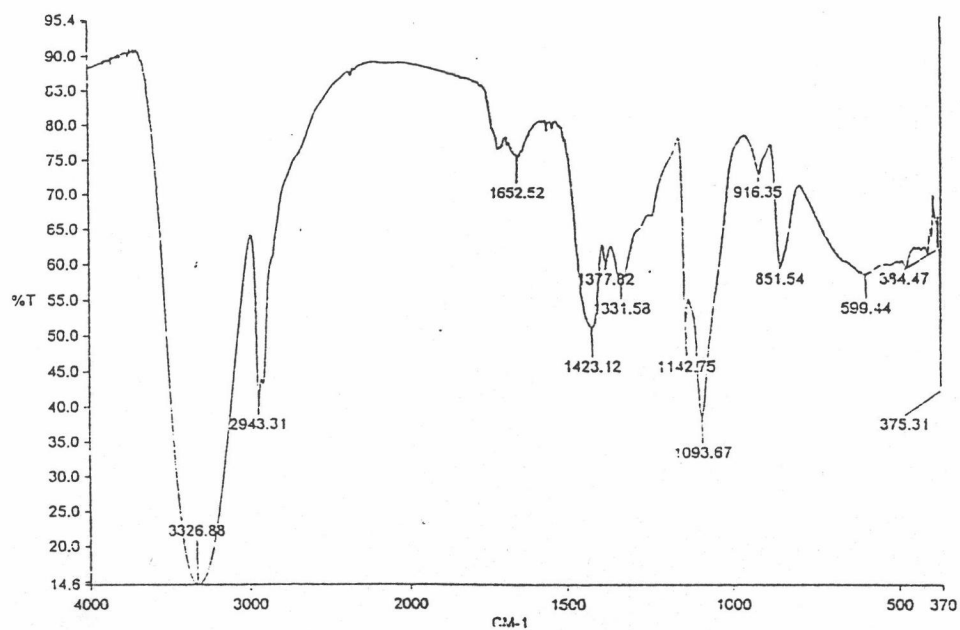


(c)

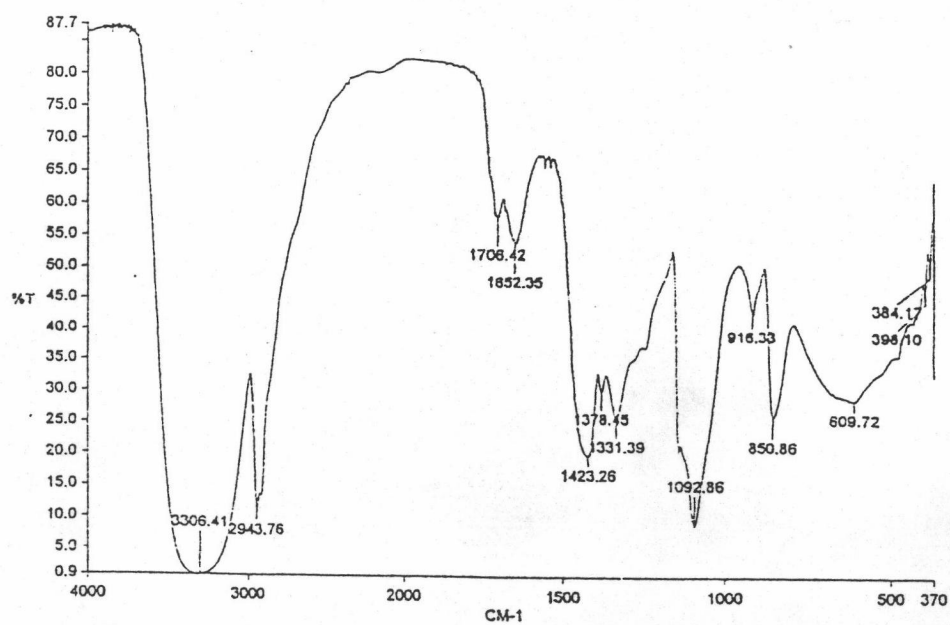


(d)

Figure B-11 (continued)



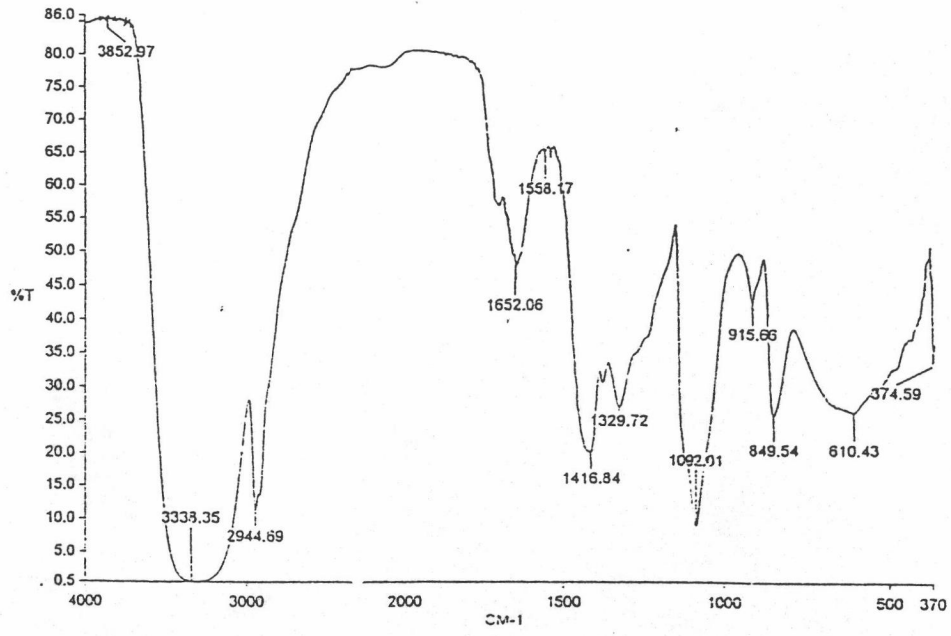
(a)



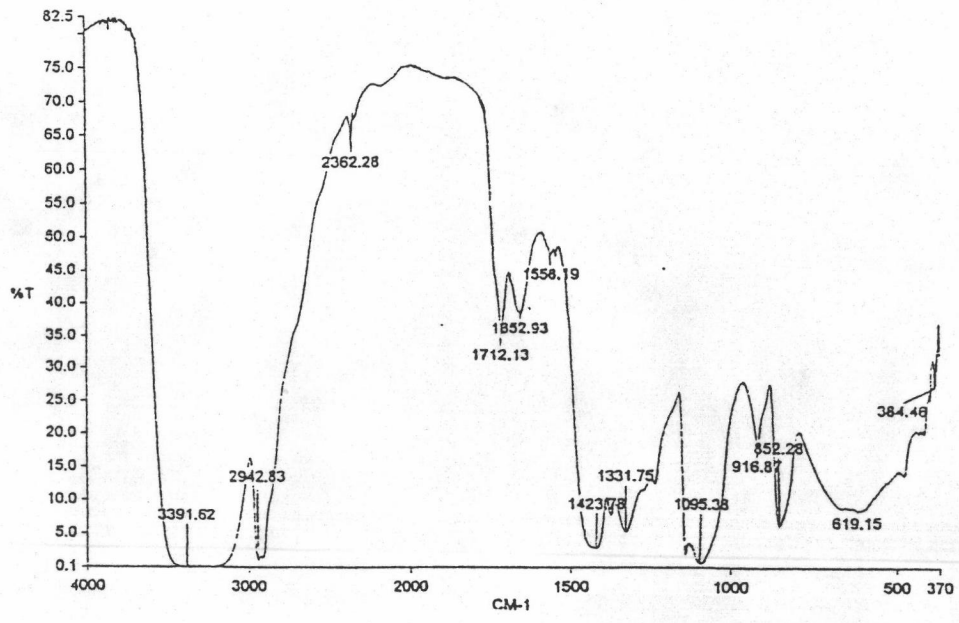
(b)

Figure B-12 : Effect of metal on the infrared spectra of PVA films containing NiCl₂

(a) 5% (b) 10% (c) 15% and (d) 20%



(c)



(d)

Figure B-12 (continued)

Appendix C

The infrared absorption spectra with ATR-FTIR techniques by using Perkin-Elmer system 2000 at a wavenumber of $700\text{--}4000\text{ cm}^{-1}$ under the ambient condition and 60 cycle times with zinc cyanide holders of PVA film and PVA films containing 5, 10, 15, and 20% of FeCl_2 , FeCl_3 , CuCl_2 , CoCl_2 and NiCl_2 were given in figures C-1 through C-6, whereas, in this method, the ATR-FTIR has been applied to PVA films containing LiCl , NaCl , KCl , CaCl_2 , BaCl_2 and ZnCl_2 showed the problems in spectra.

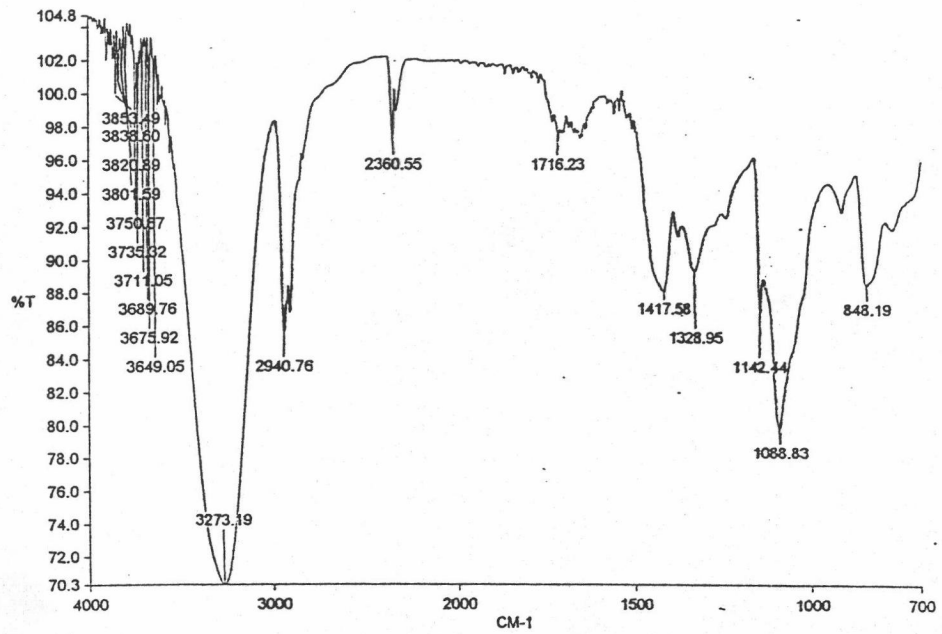
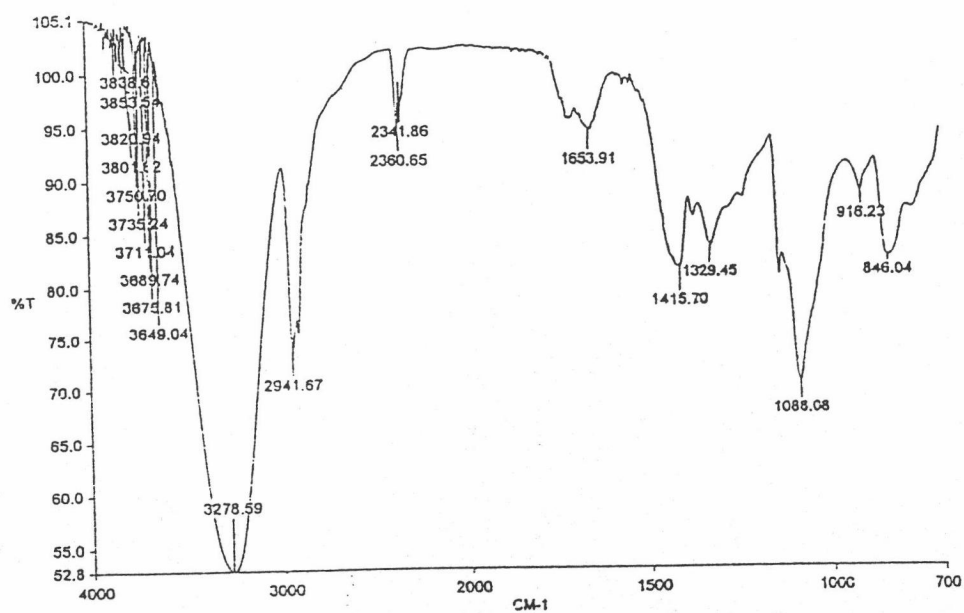
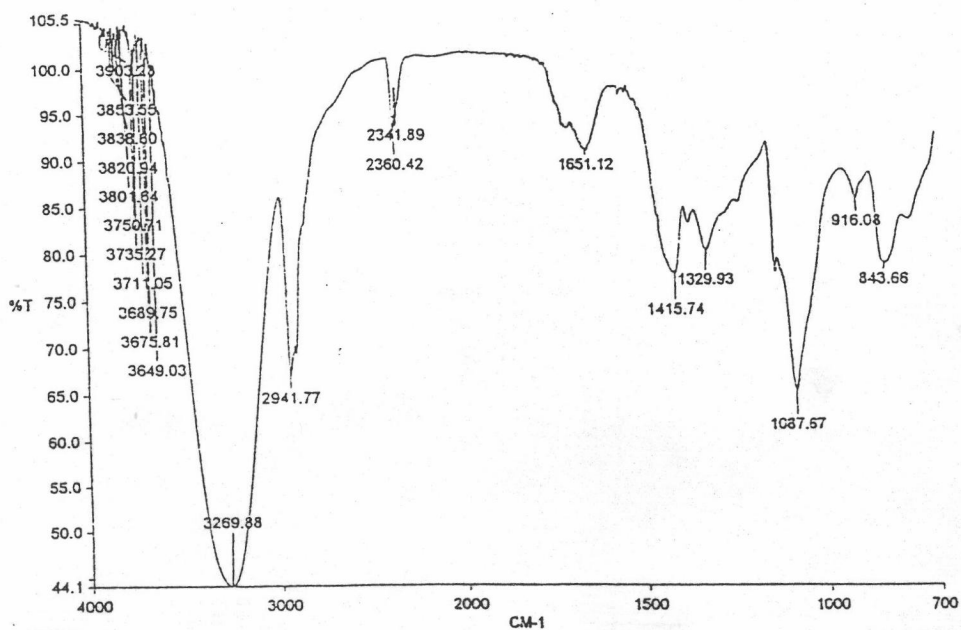


Figure C-1 : Infrared absorption spectra from ATR-FTIR of PVA films

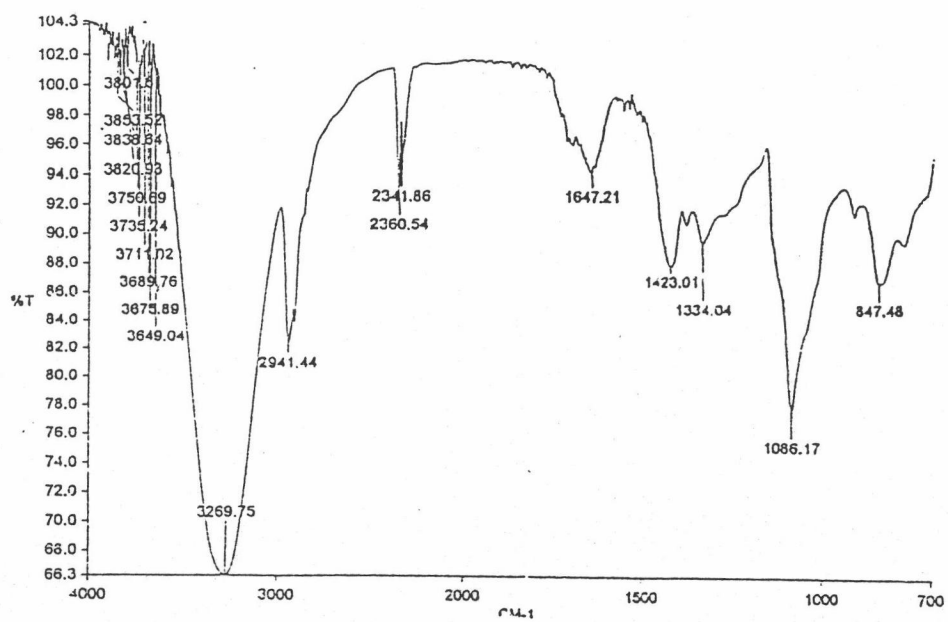


(a)

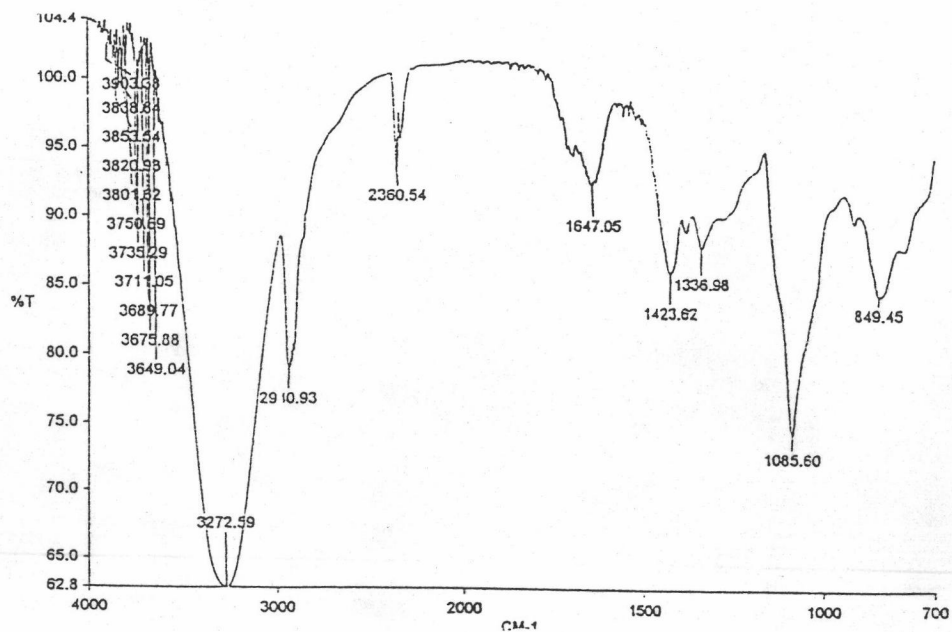


(b)

Figure C-2 : Infrared absorption spectra from ATR-FTIR of PVA films containing (a) 5% (b) 10% (c) 15% and (d) 20% of FeCl₂

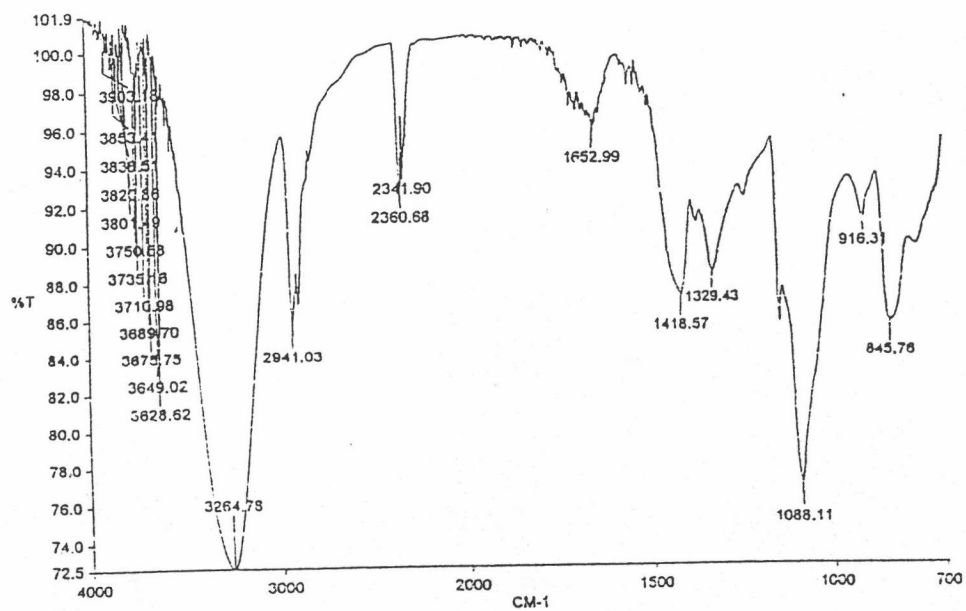


(c)

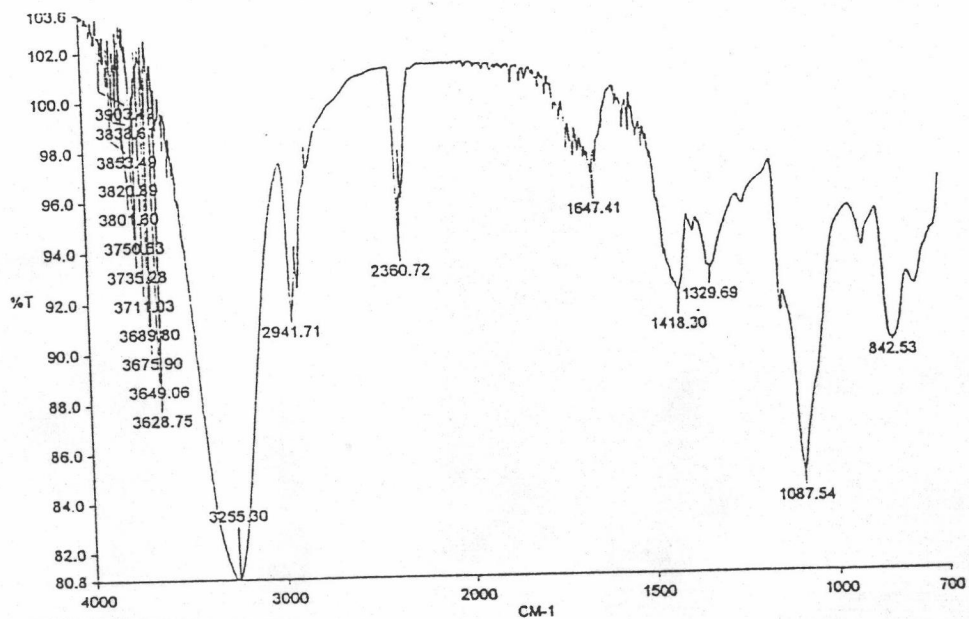


(d)

Figure C-2 (continued)

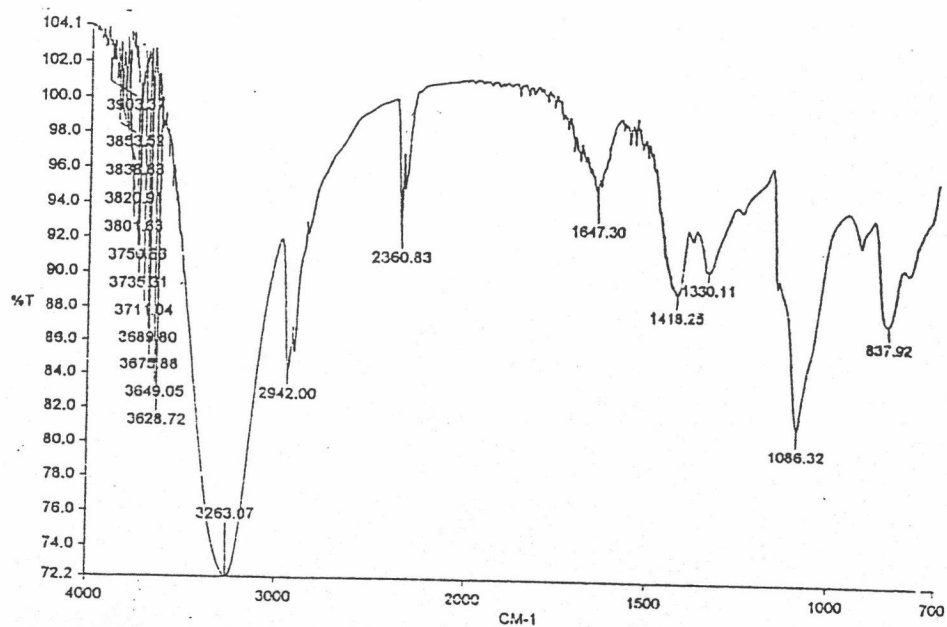


(a)

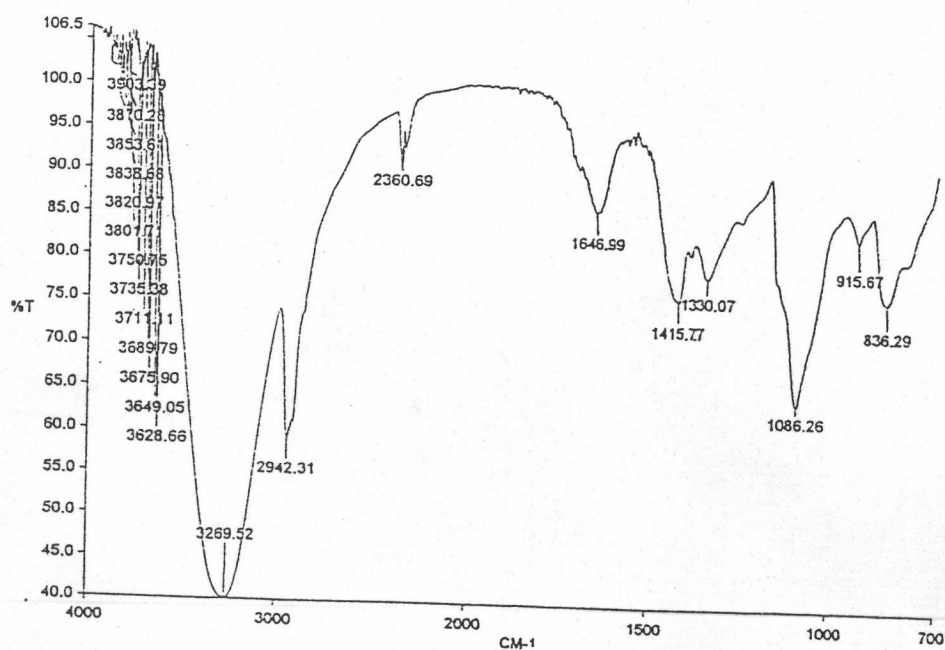


(b)

Figure C-3 : Infrared absorption spectra from ATR-FTIR of PVA films containing (a) 5% (b) 10% (c) 15% and (d) 20% of FeCl₃

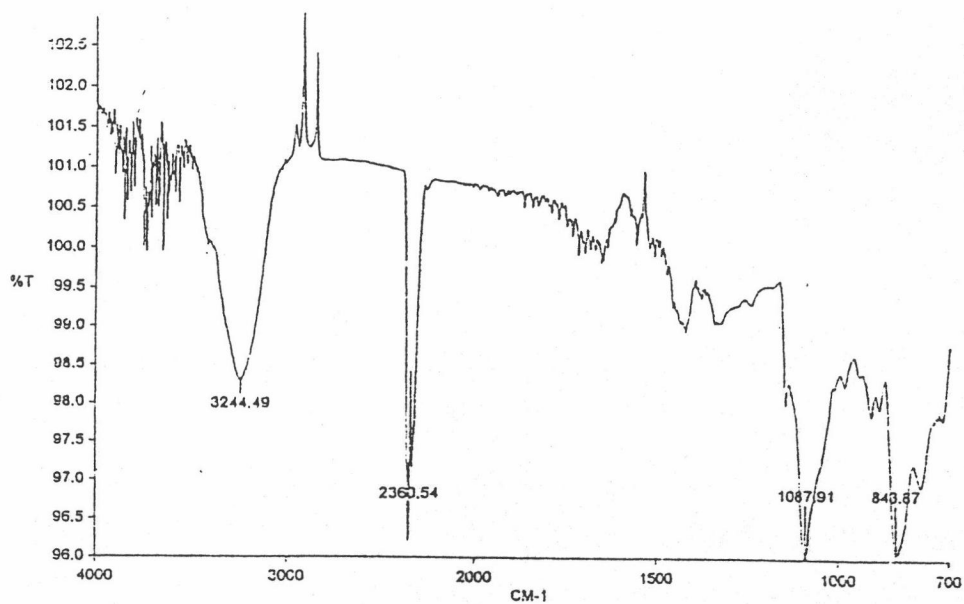


(c)

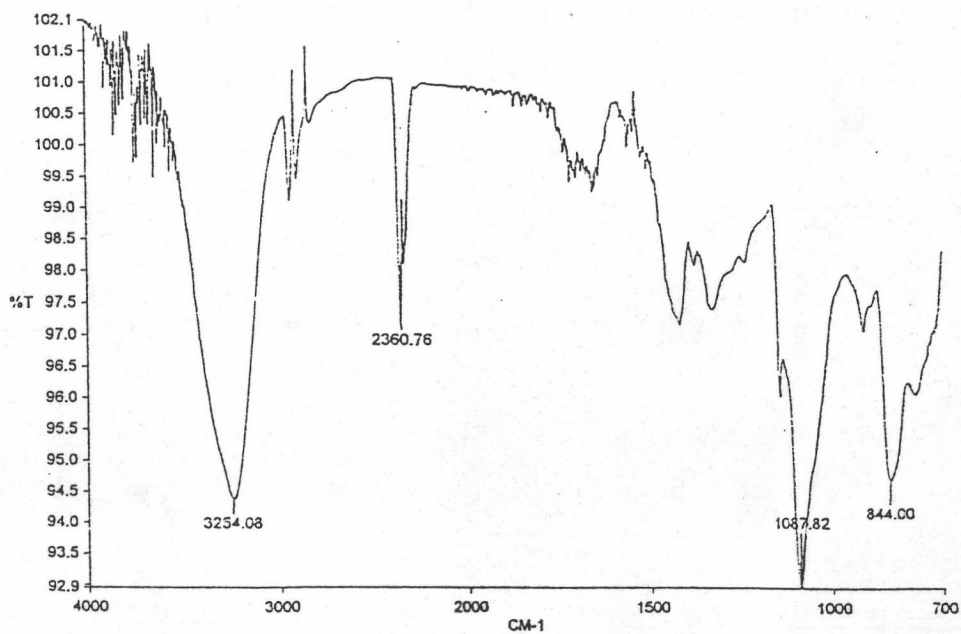


(d)

Figure C-3 (continued)

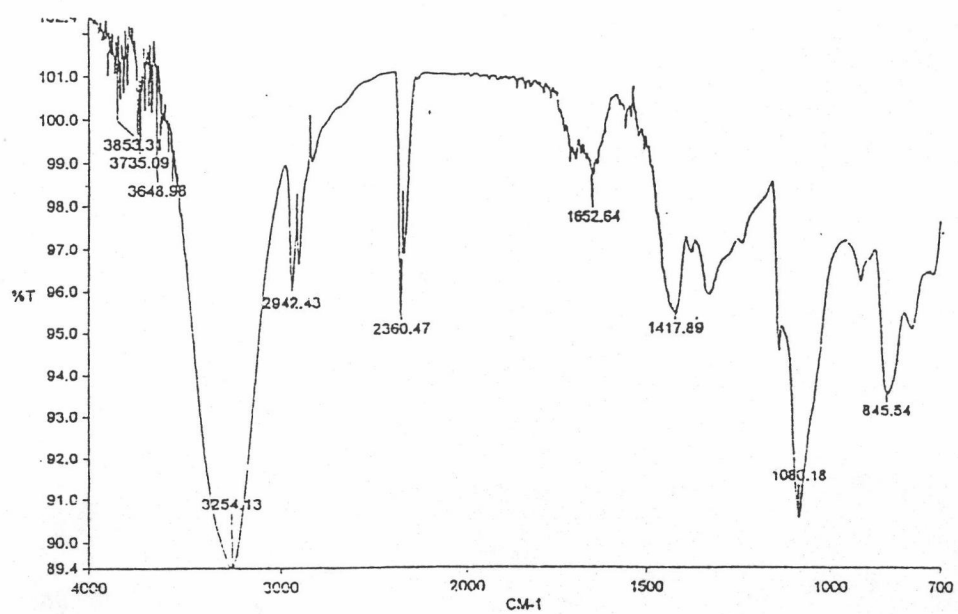


(a)

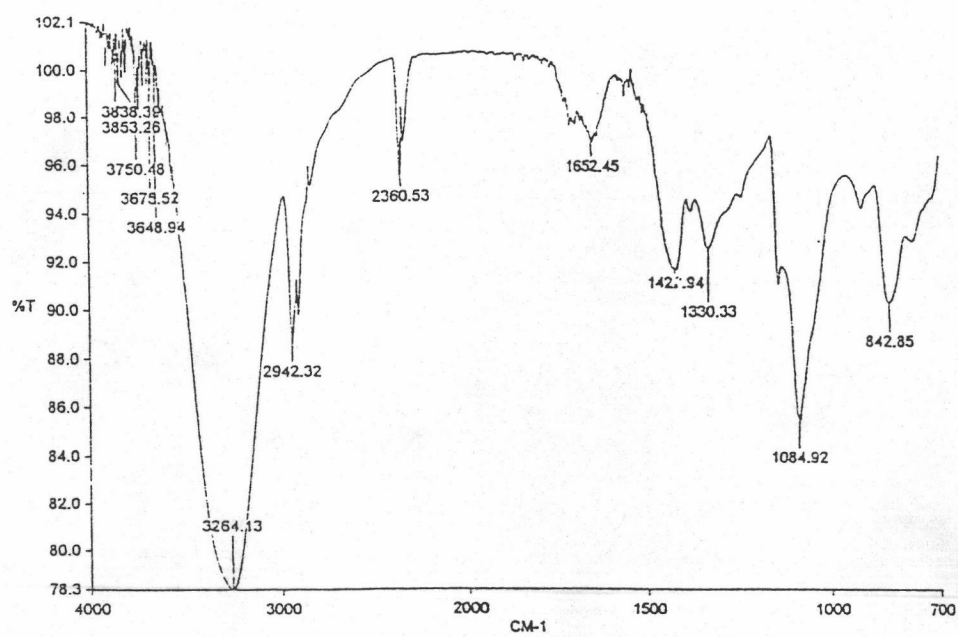


(b)

Figure C- 4 : Infrared absorption spectra from ATR-FTIR of PVA films containing (a) 5% (b) 10% (c) 15% and (d) 20% of CuCl_2

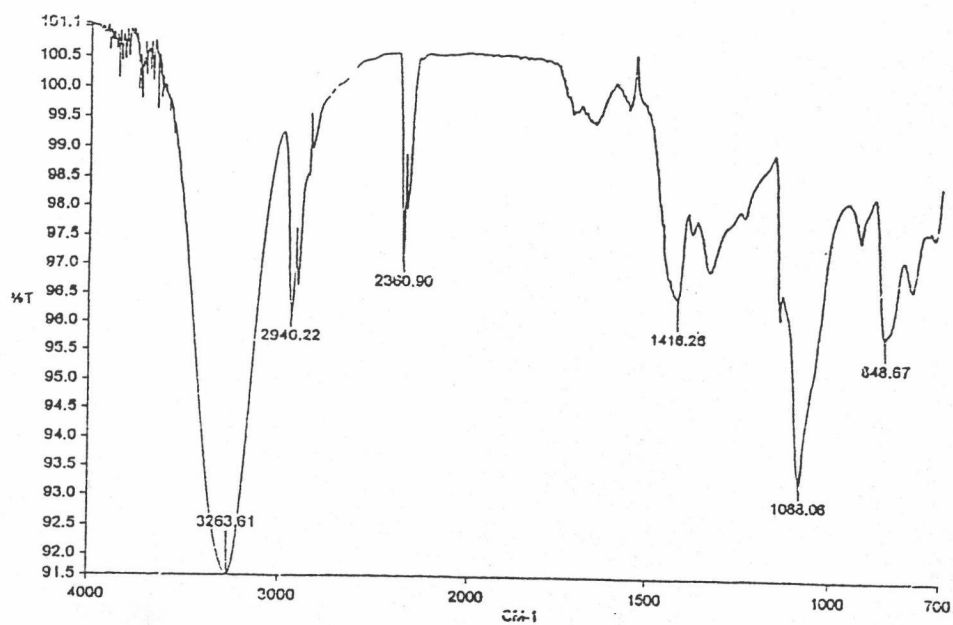


(c)

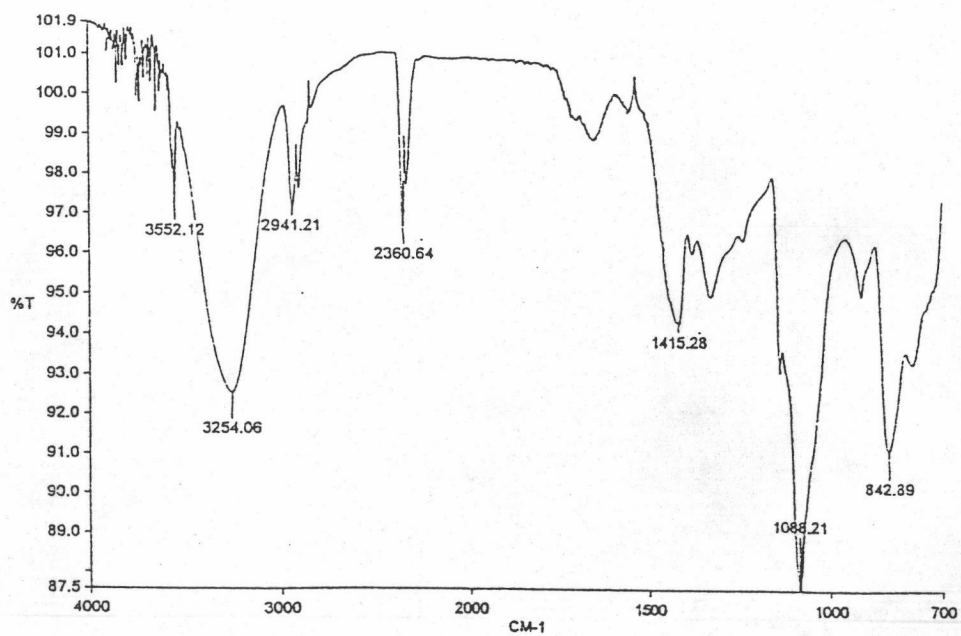


(d)

Figure C-4 (continued)

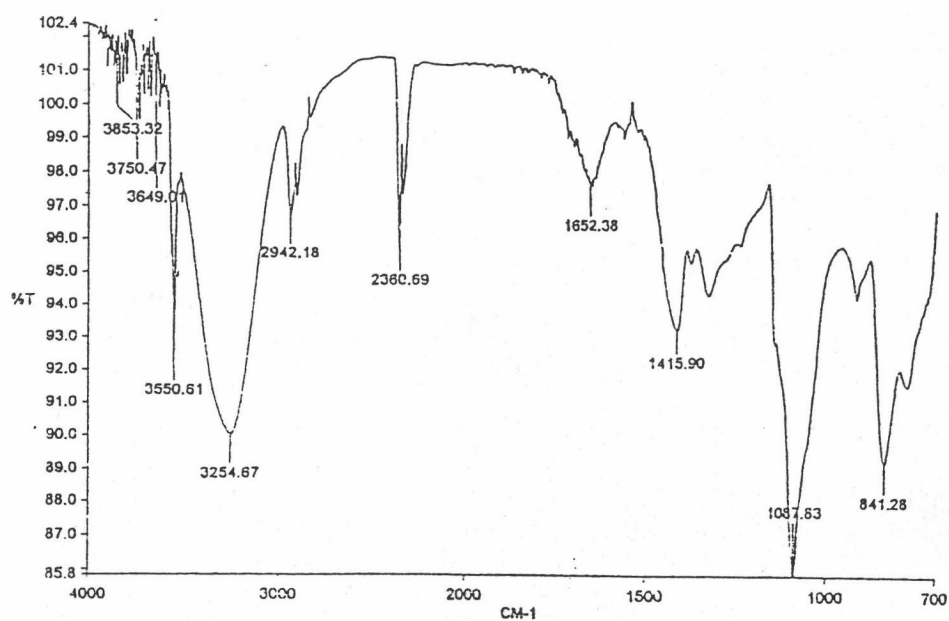


(a)

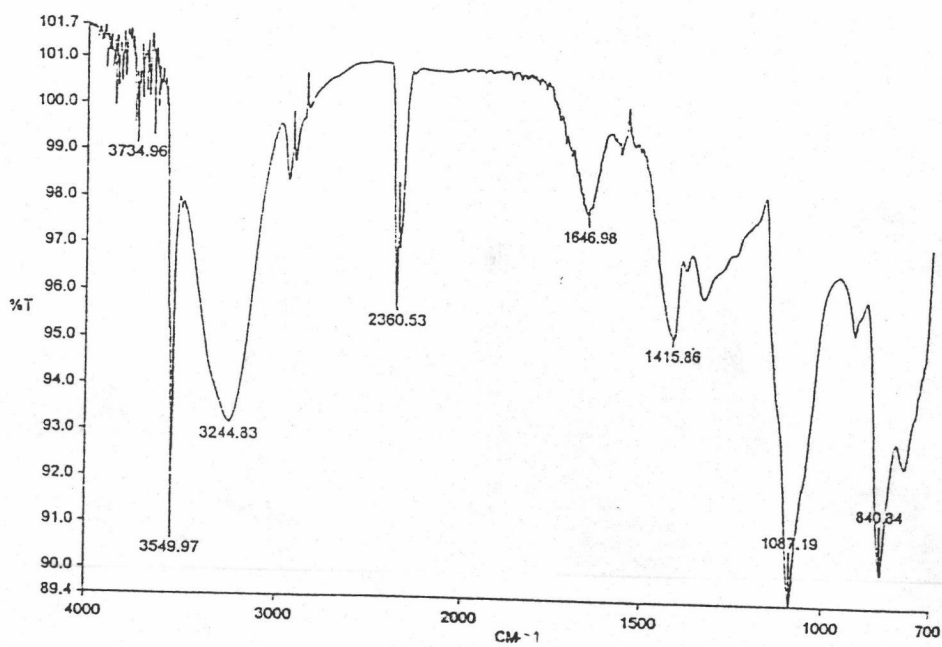


(b)

Figure C-5 : Infrared absorption spectra from ATR-FTIR of PVA films containing (a) 5% (b) 10% (c) 15% and (d) 20% of CoCl_2

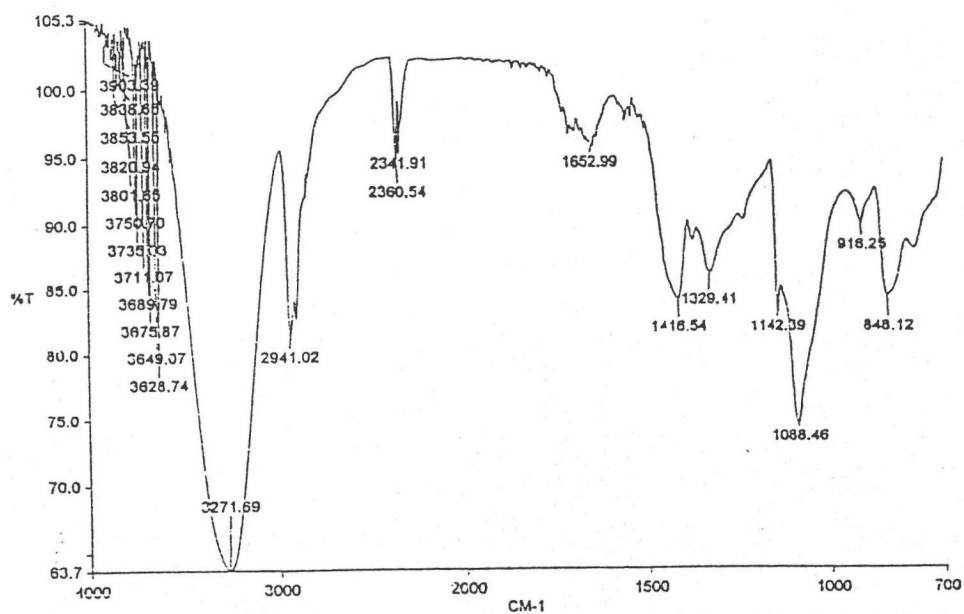


(c)

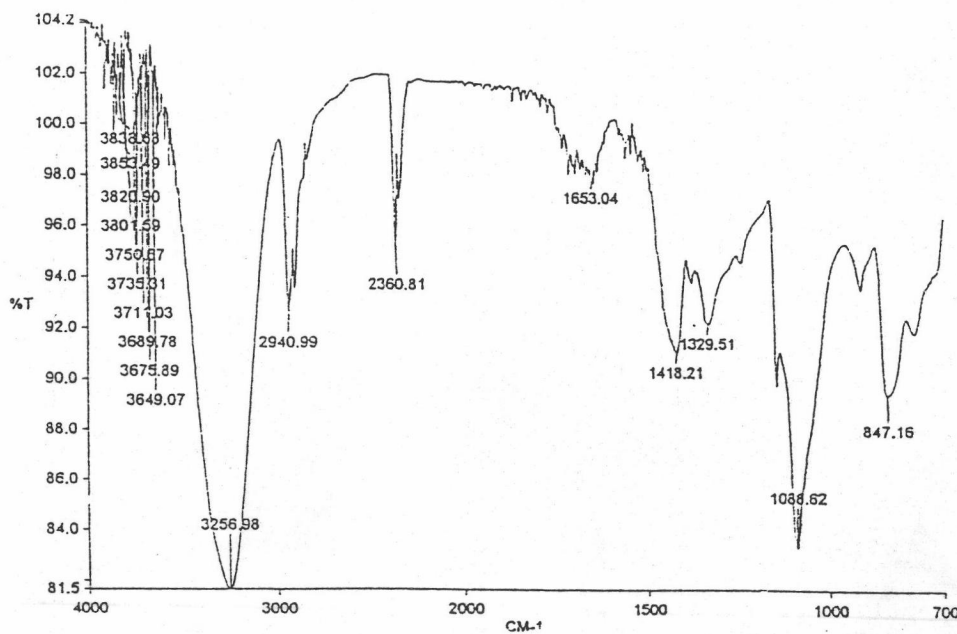


(d)

Figure C-5 (continued)

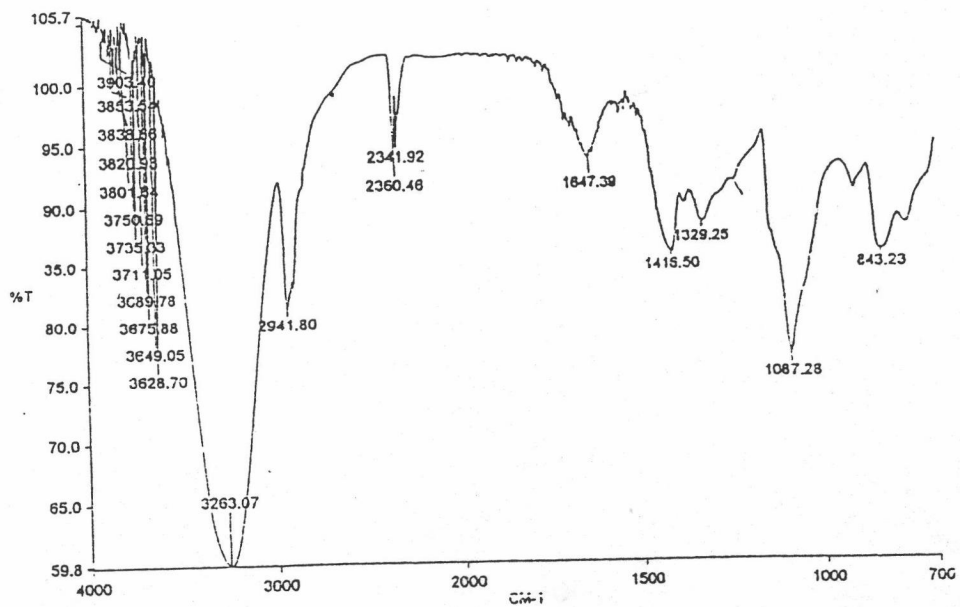


(a)

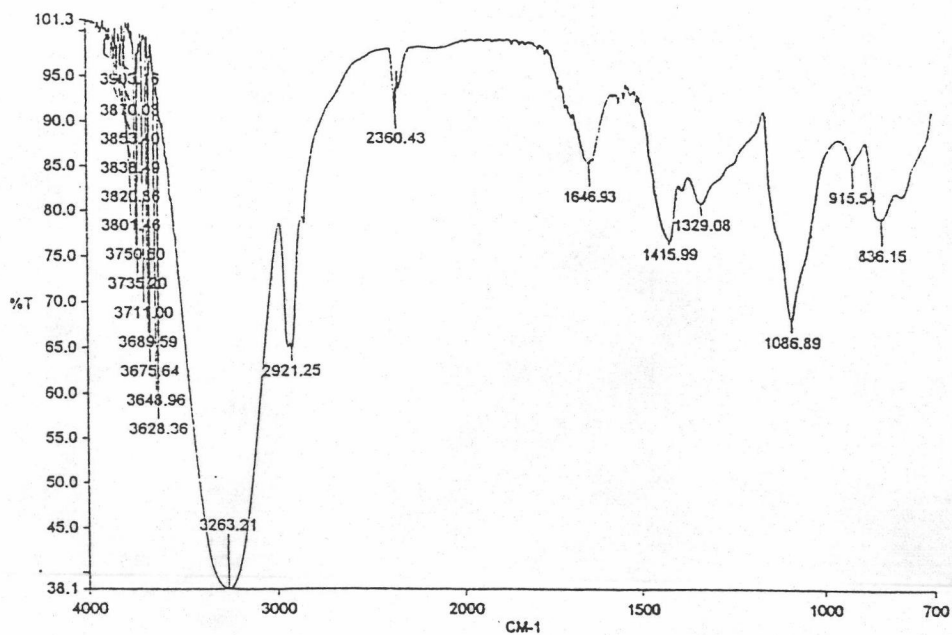


(b)

Figure C-6 : Infrared absorption spectra from ATR-FTIR of PVA films containing (a) 5% (b) 10% (c) 15% and (d) 20% of NiCl_2



(c)



(d)

Figure C-6 (continued)

Appendix D

The Raman spectra obtained from Perkin-Elmer system 2000 of Raman technique with a wavenumber of 200-3600 nm. at ambient condition and 200-400 powers of x-ray of PVA film and PVA films containing LiCl, NaCl, KCl, CaCl₂, BaCl₂, FeCl₂, FeCl₃, CuCl₂, ZnCl₂, CoCl₂ and NiCl₂ were expressed in figures D-1 through D-17.

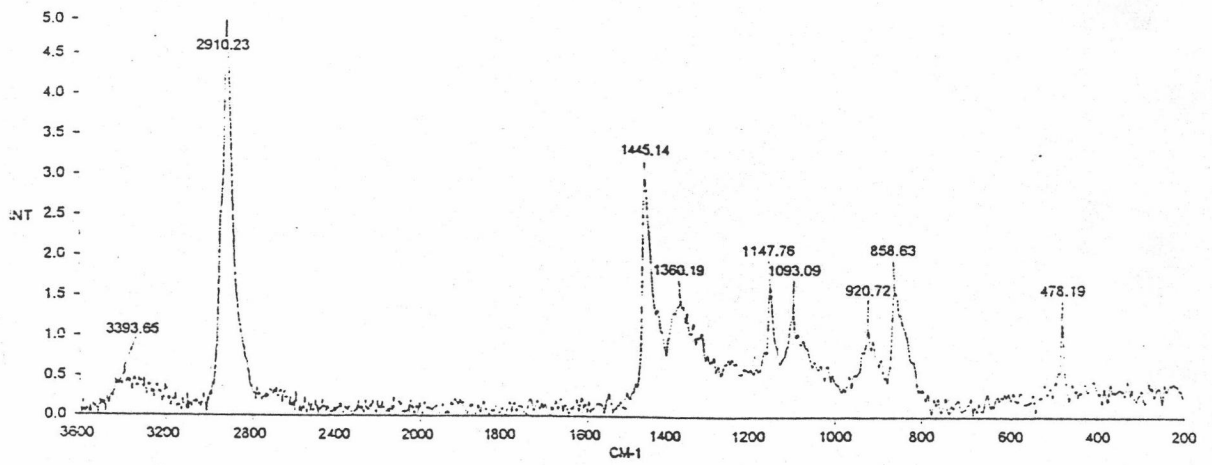


Figure D-1 : Raman spectra of PVA film as a standard reference.

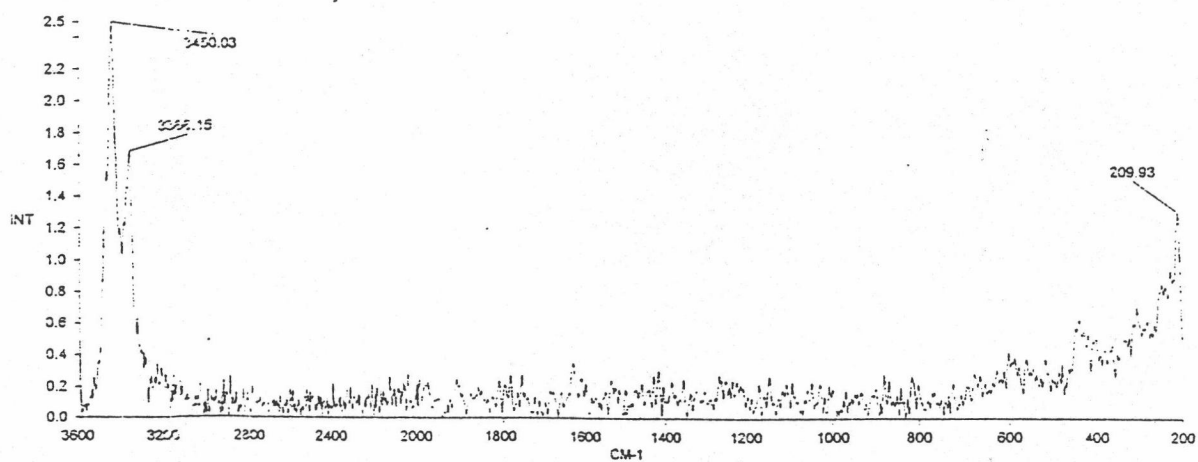


Figure D-2 : Raman spectra of metal salt powders of calcium chloride

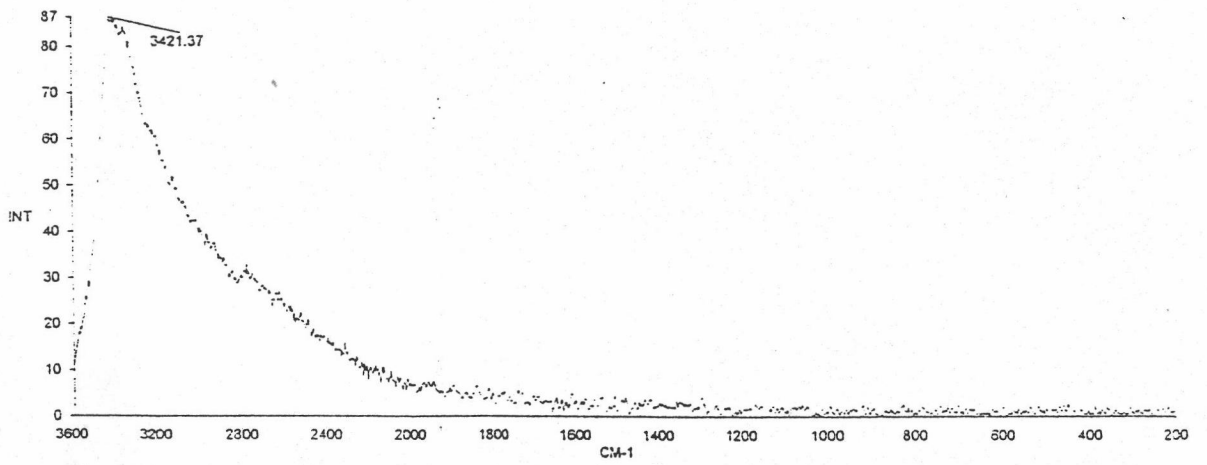


Figure D-3 : Raman spectra of metal salt powders of ferrous chloride

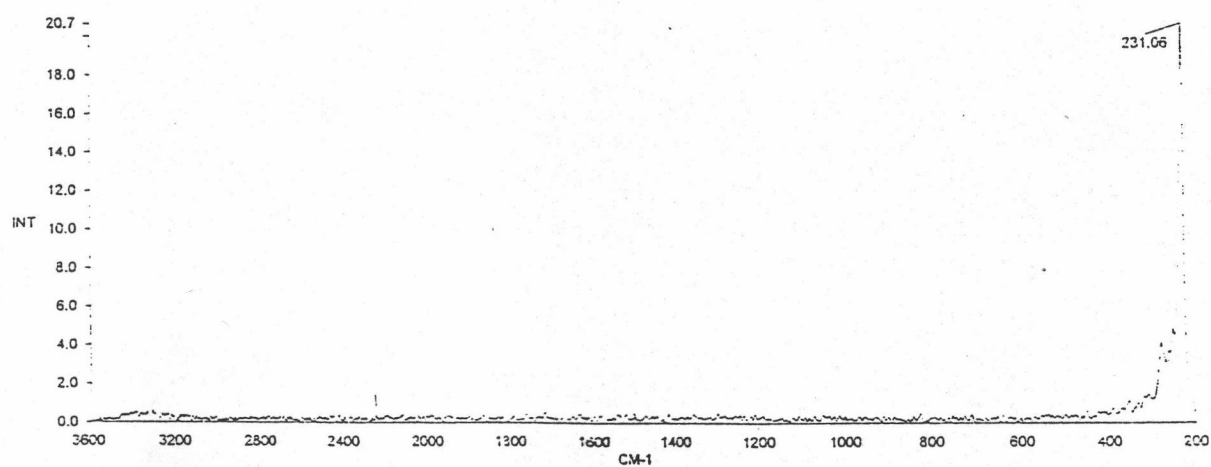


Figure D-4 : Raman spectra of metal salt powders of Zinc chloride

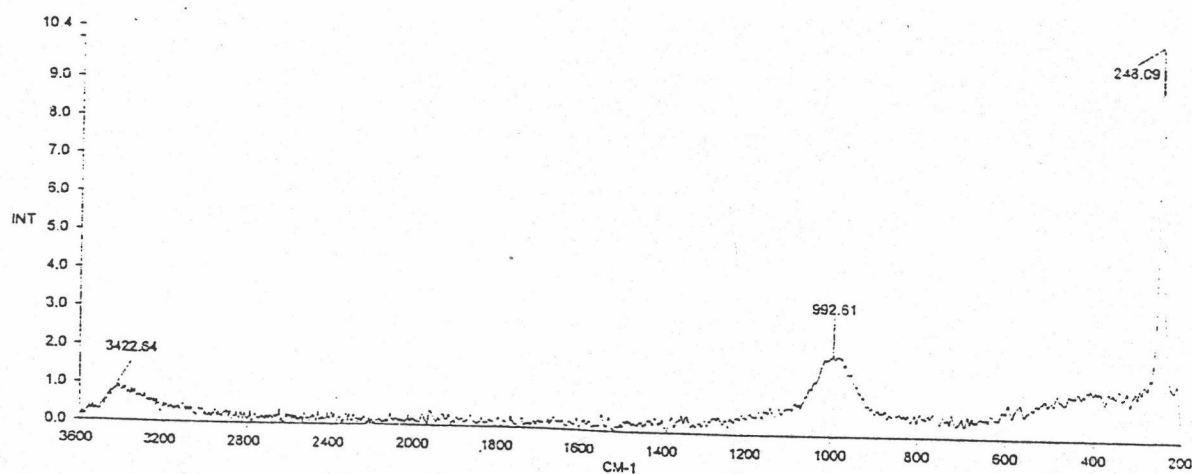


Figure D-5 : Raman spectra of metal salt powders of cobalt chloride

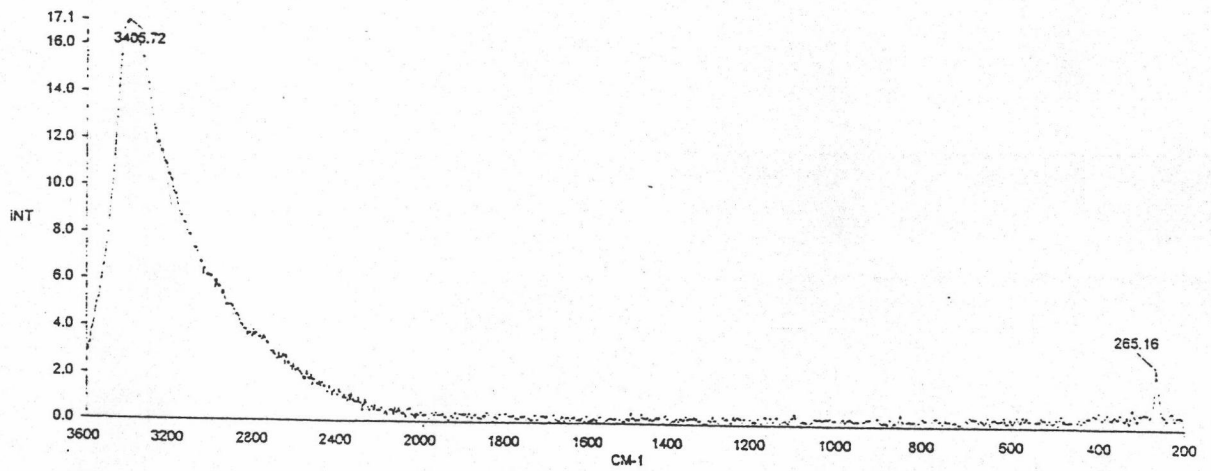


Figure D-6 : Raman spectra of metal salt powders of nickel chloride

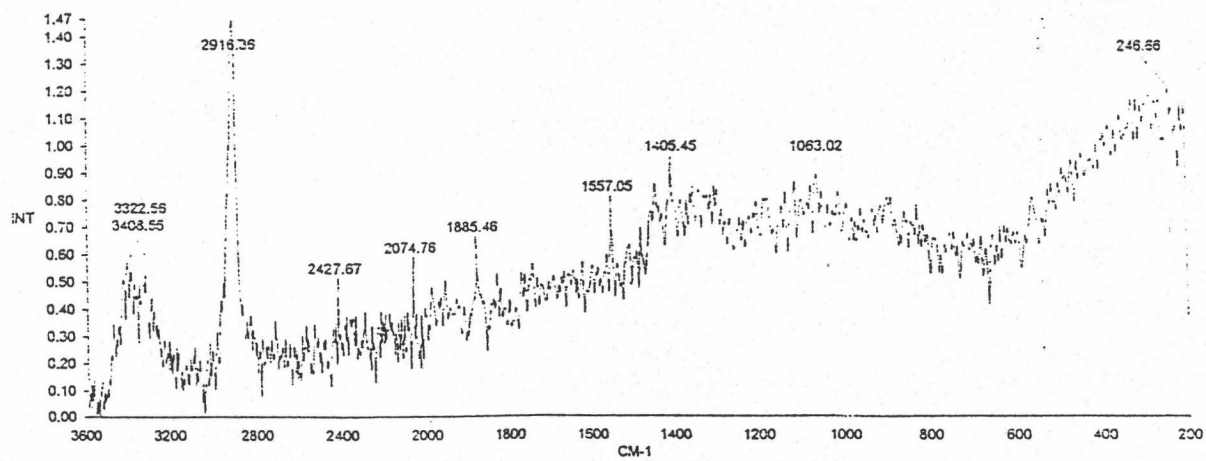


Figure D-7 : Raman spectra of PVA films containing 15%
LiCl

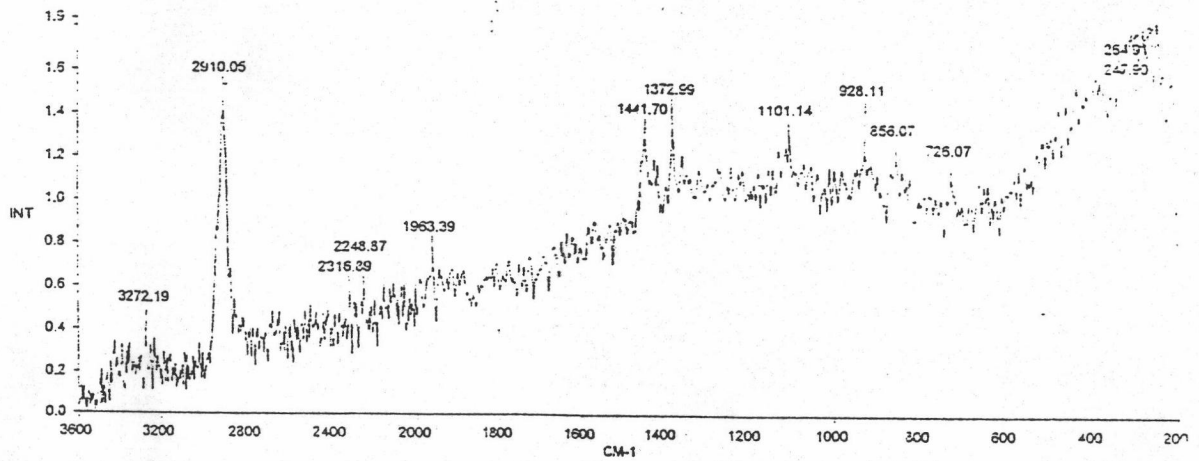


Figure D-8 : Raman spectra of PVA films containing 15%
NaCl

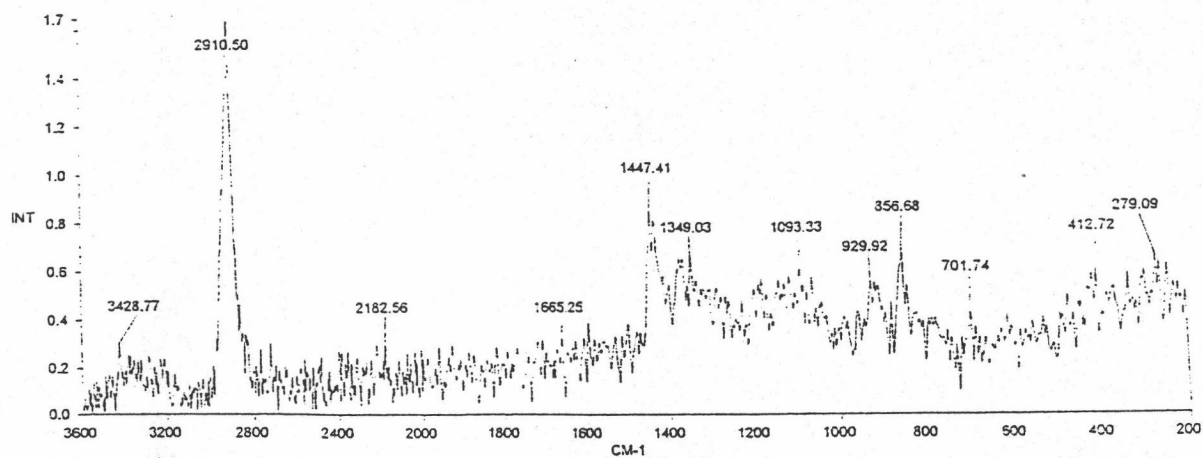


Figure D-9 : Raman spectra of PVA films containing 15%
KCl

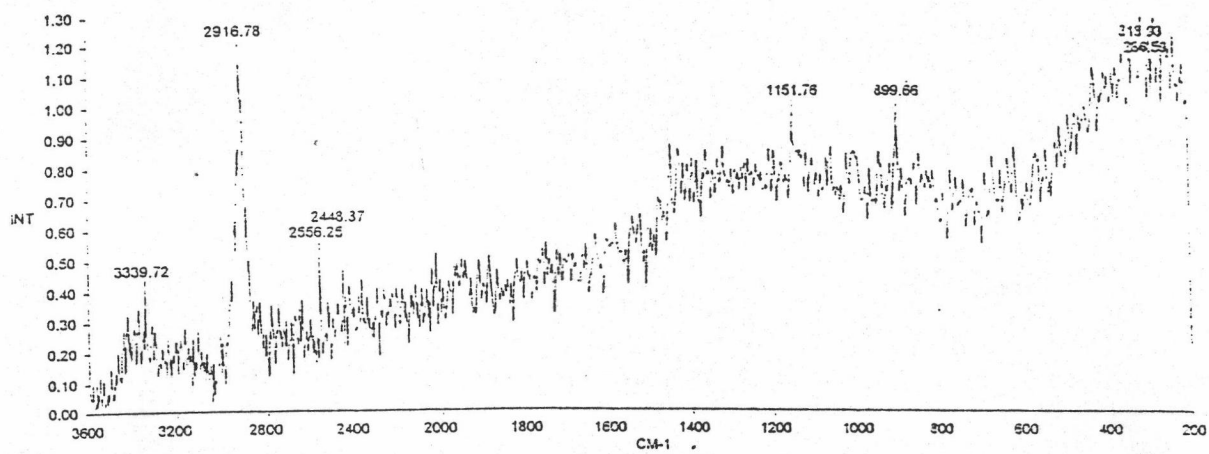


Figure D-10 : Raman spectra of PVA films containing 15%
 CaCl_2

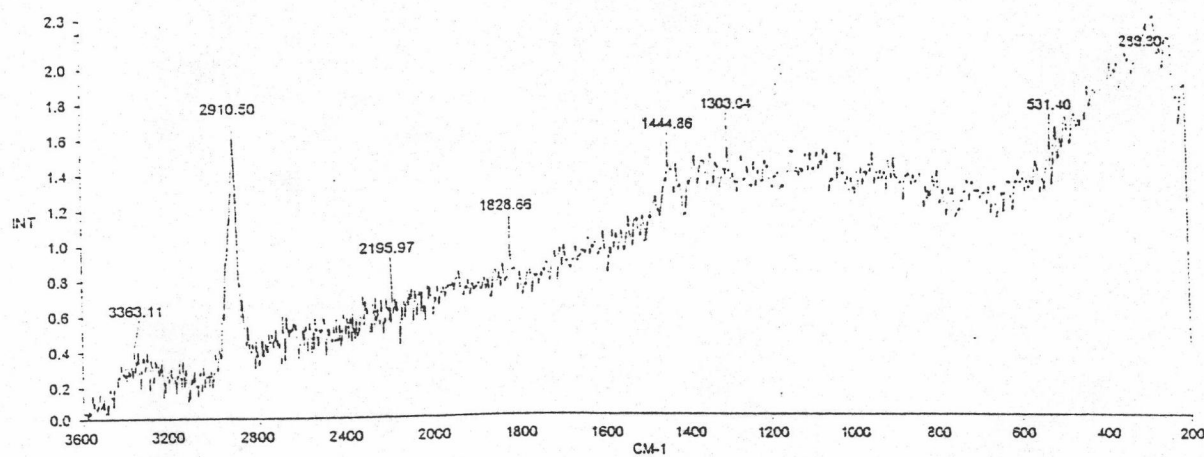


Figure D-11 : Raman spectra of PVA films containing 15%
 BaCl_2

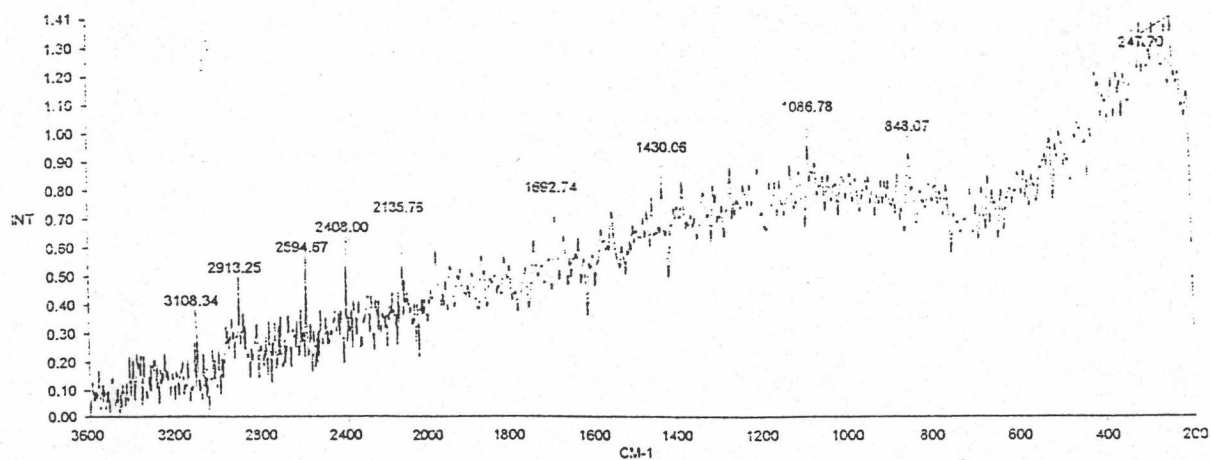


Figure D-12 : Raman spectra of PVA films containing 15%
 FeCl_2

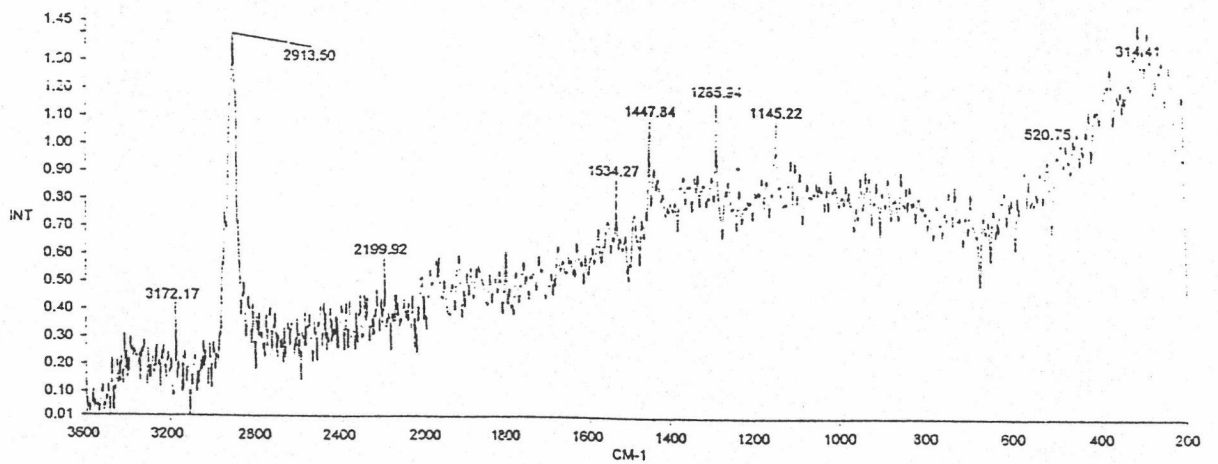


Figure D-13 : Raman spectra of PVA films containing 15%
 FeCl_3

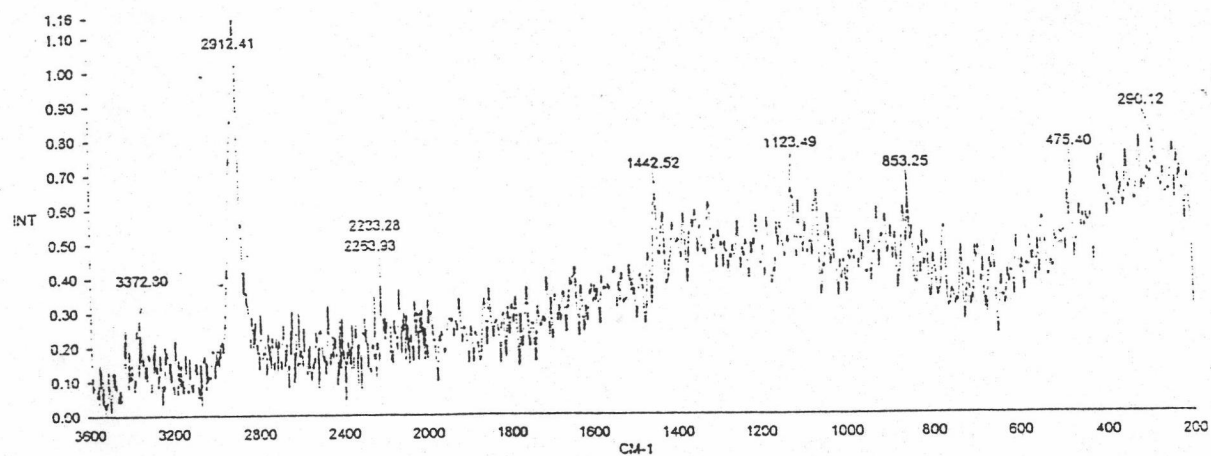


Figure D-14 : Raman spectra of PVA films containing 15%
 CuCl_2

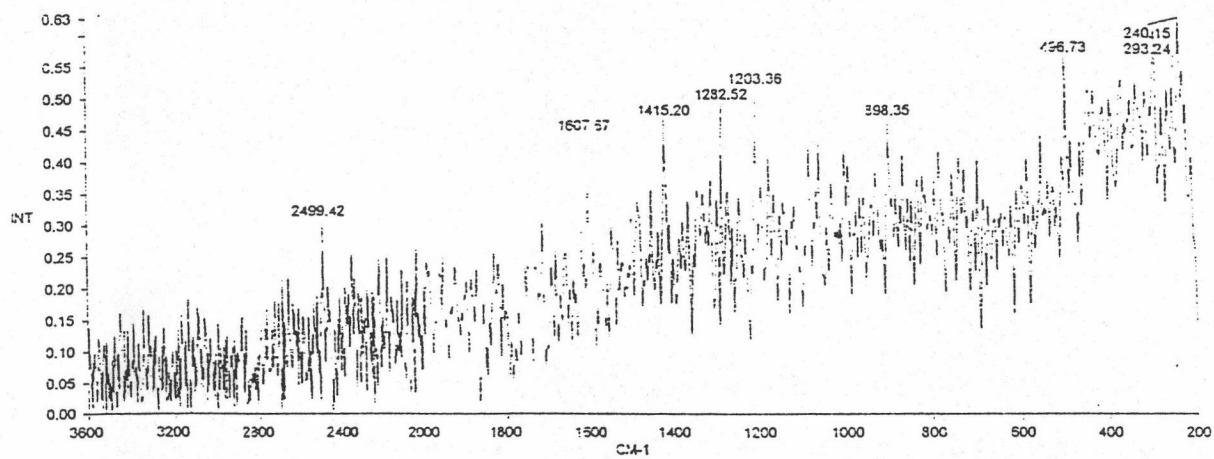


Figure D-15 : Raman spectra of PVA films containing 15%



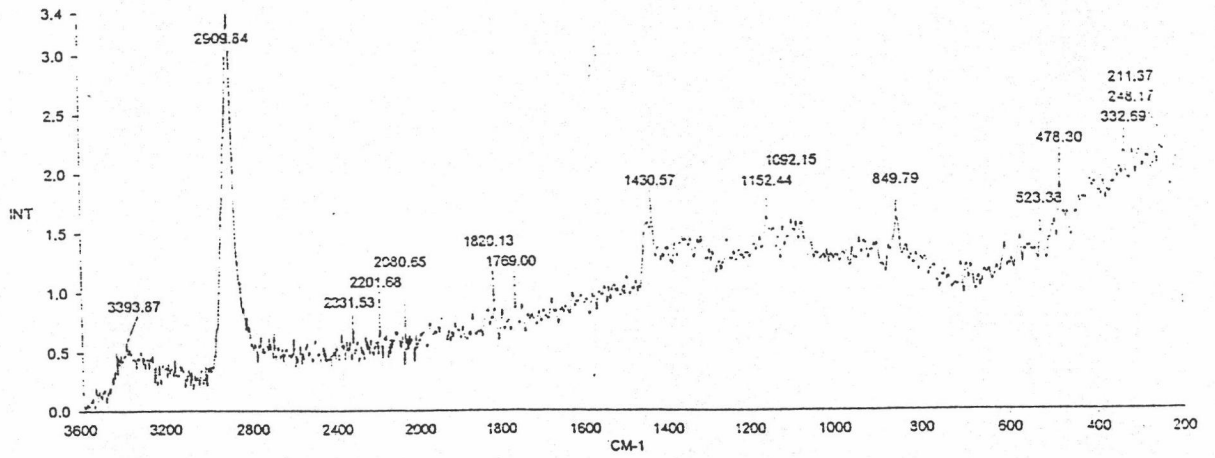


Figure D-16 : Raman spectra of PVA films containing 15%
 CoCl_2

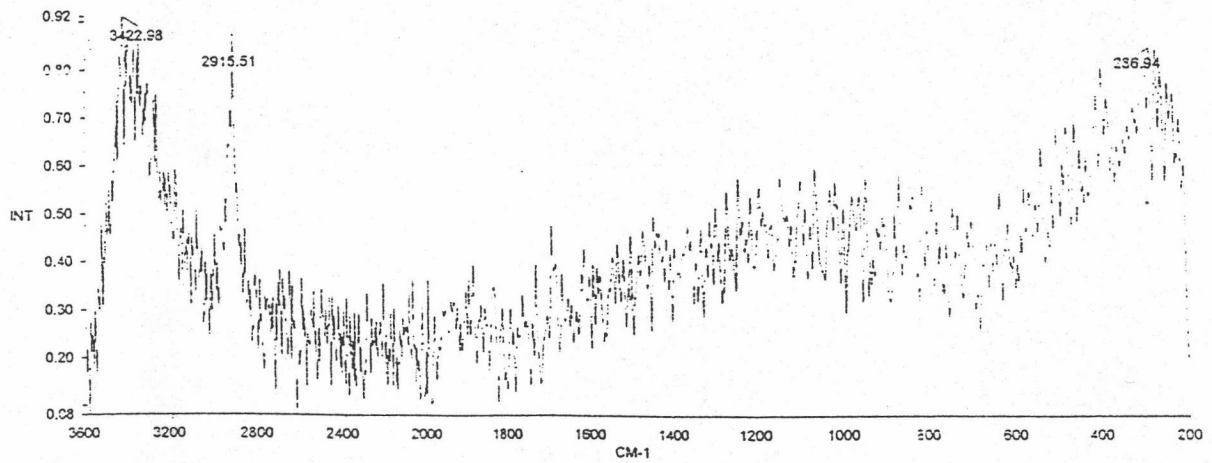


Figure D-17 : Raman spectra of PVA films containing 15%
 NiCl_2

Appendix E

The thermal properties associated with mechanical behavior of PVA film and PVA films containing LiCl, NaCl, KCl, CaCl₂, BaCl₂, FeCl₂, FeCl₃, CuCl₂, ZnCl₂, CoCl₂ and NiCl₂ as a modulus (MPa) versus temperature (°C) from Dynamic mechanical spectroscopy of Polymer Laboratory system DMTA MkII with mode of bending at temperature ranging -20 upto 100 °C were shown in figures E-1 through E-12.

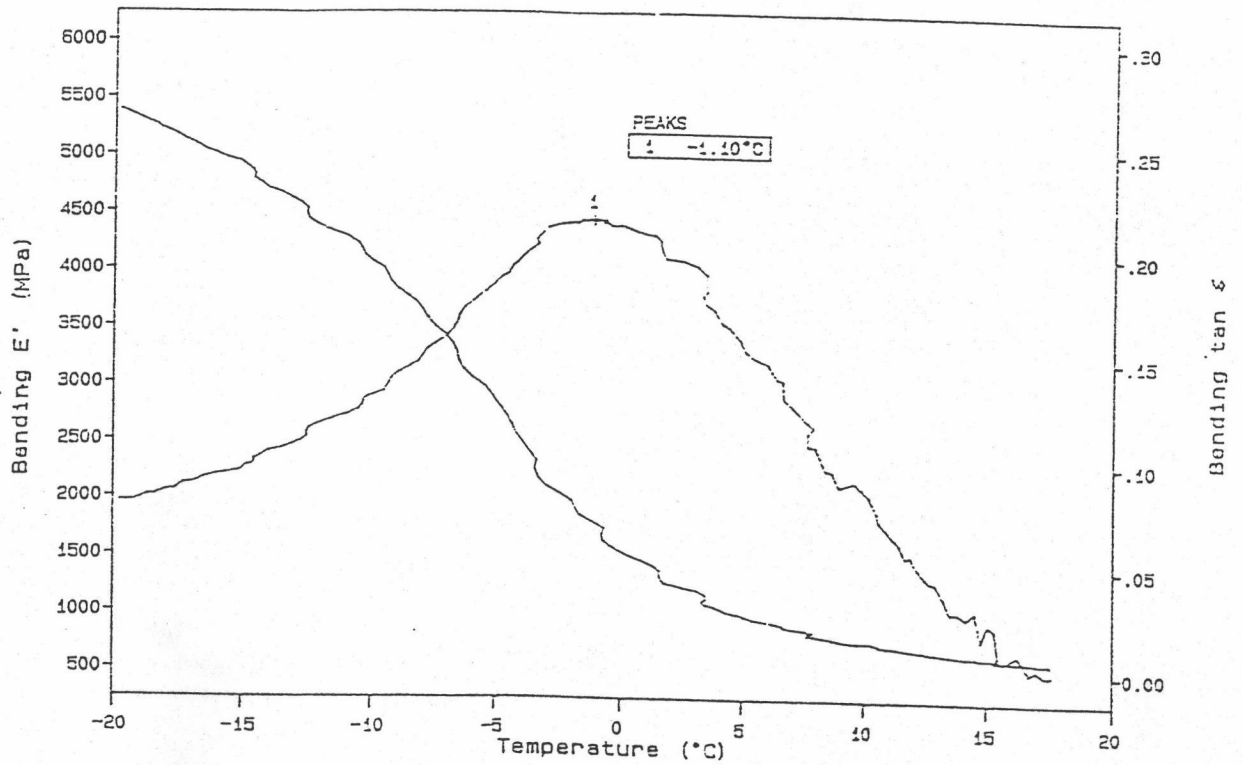


Figure E-2 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 5% LiCl.

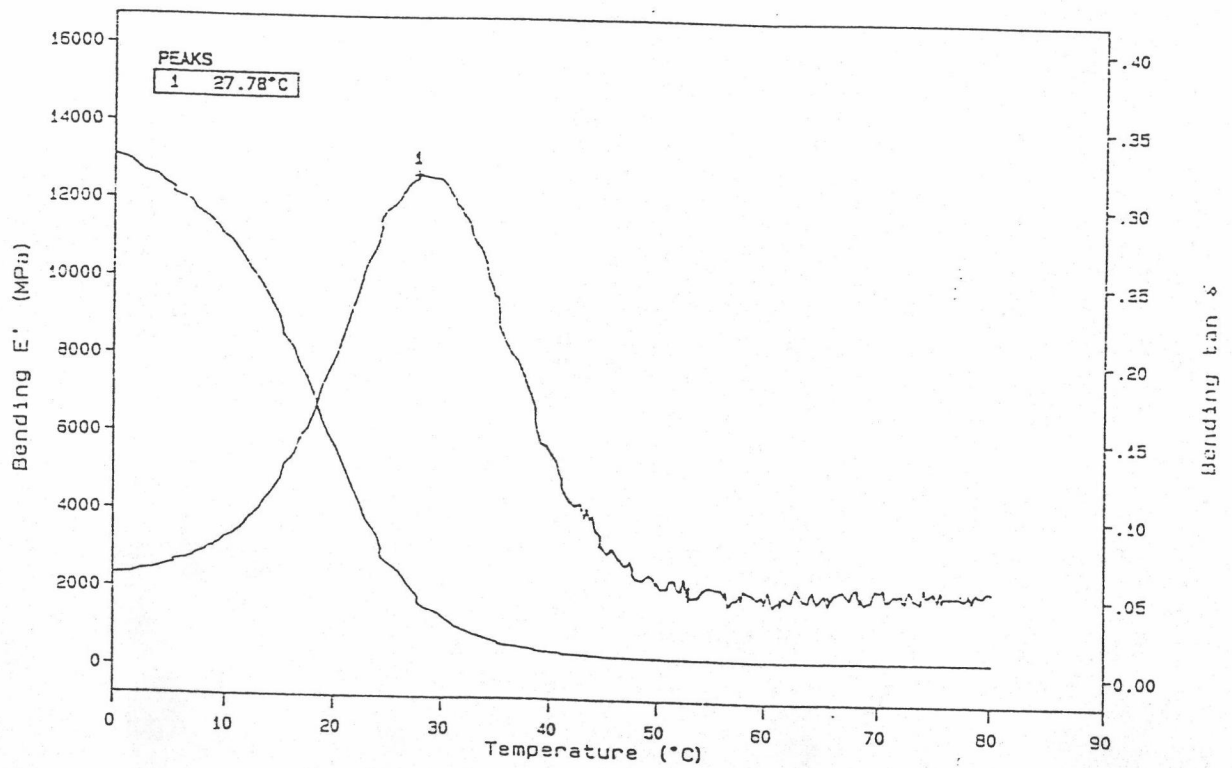


Figure E-1 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA film.

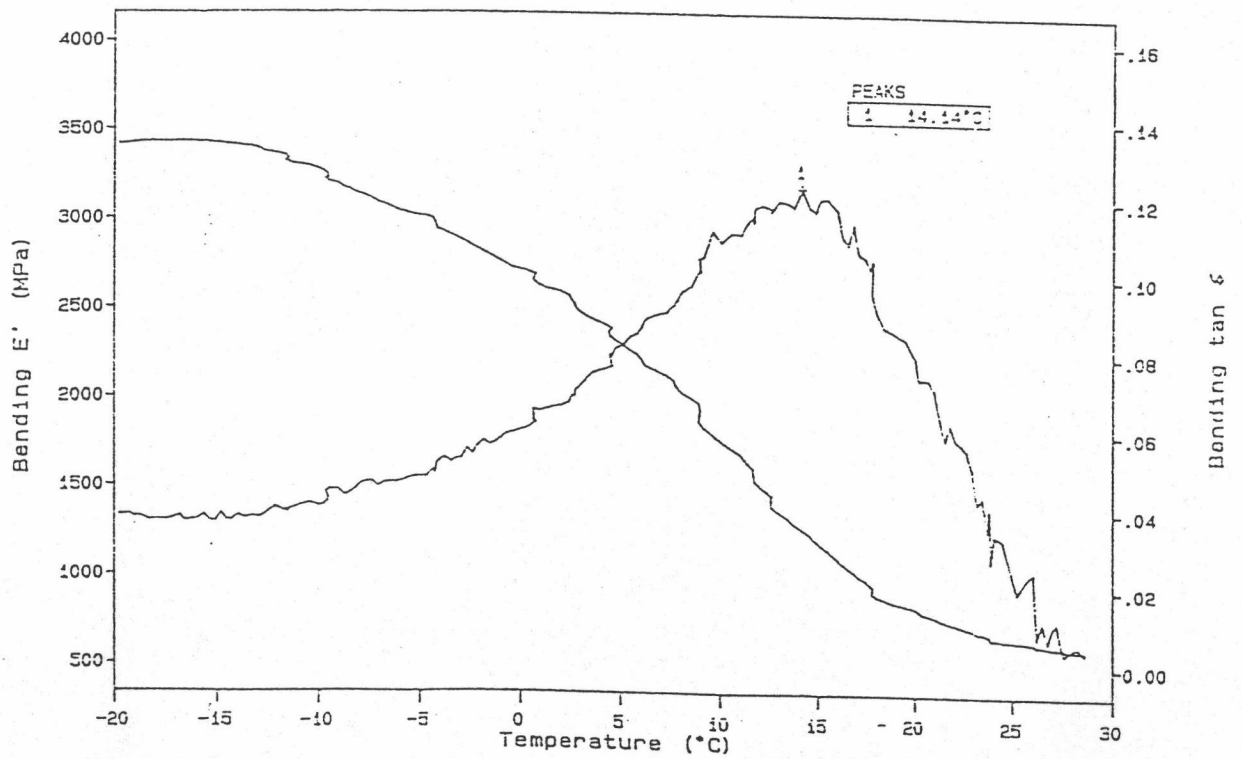


Figure E-3 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% NaCl.

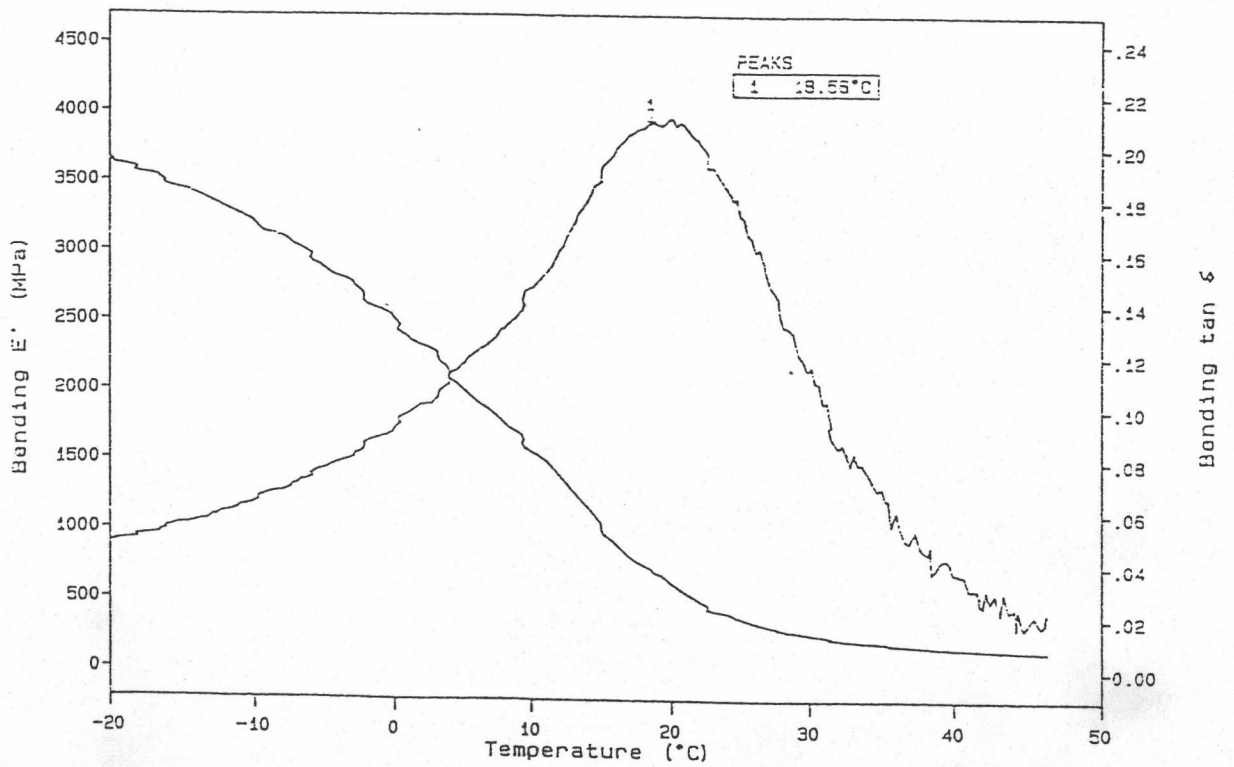


Figure E-4 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% KCl.

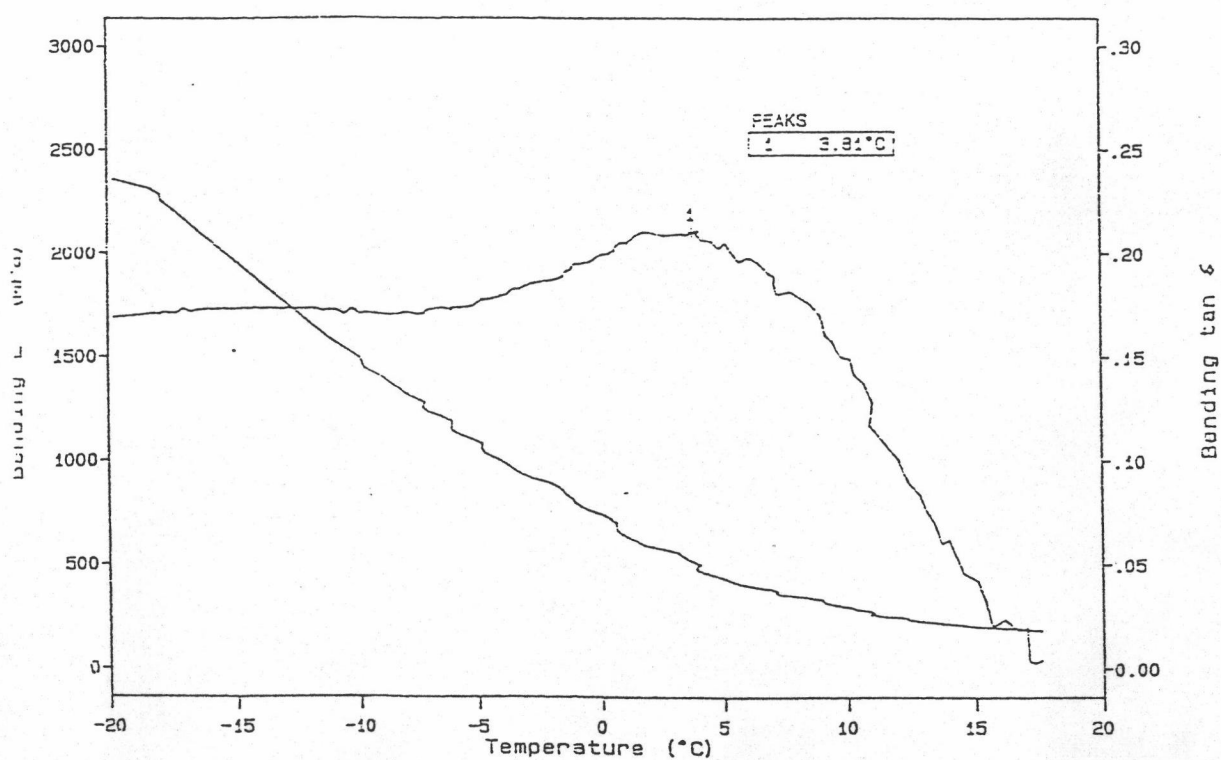


Figure E-5 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% CaCl_2 .

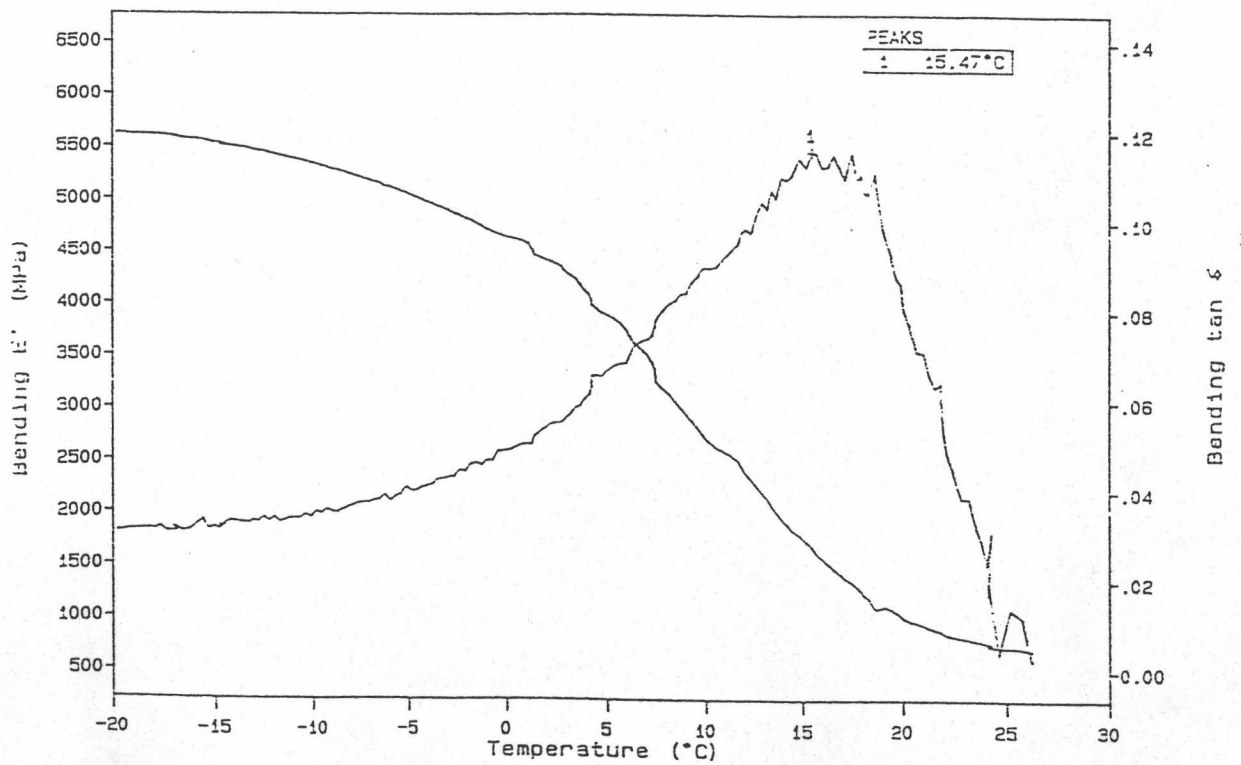


Figure E-6 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 5% BaCl_2 .

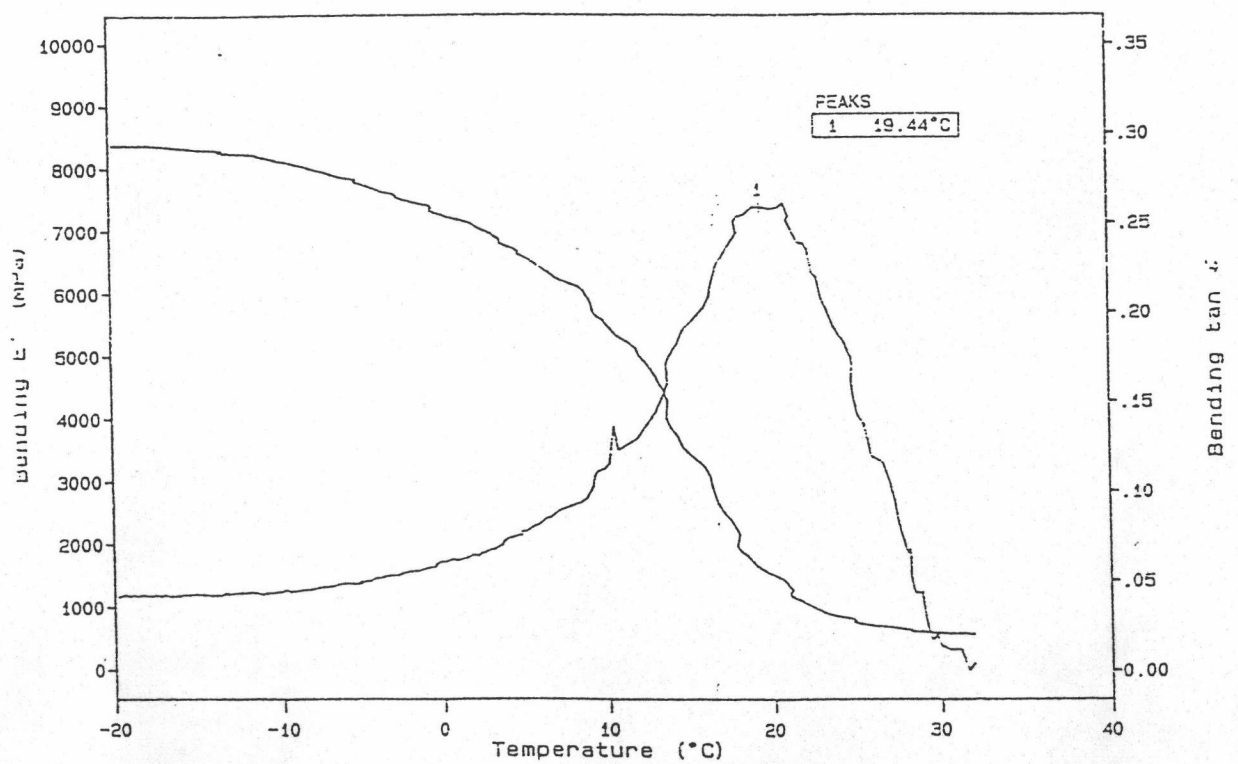


Figure E-7 : The modulus and $\tan \delta$ plotted against temperature from -20 through 100°C corresponding to the PVA films containing 15% FeCl_2 .

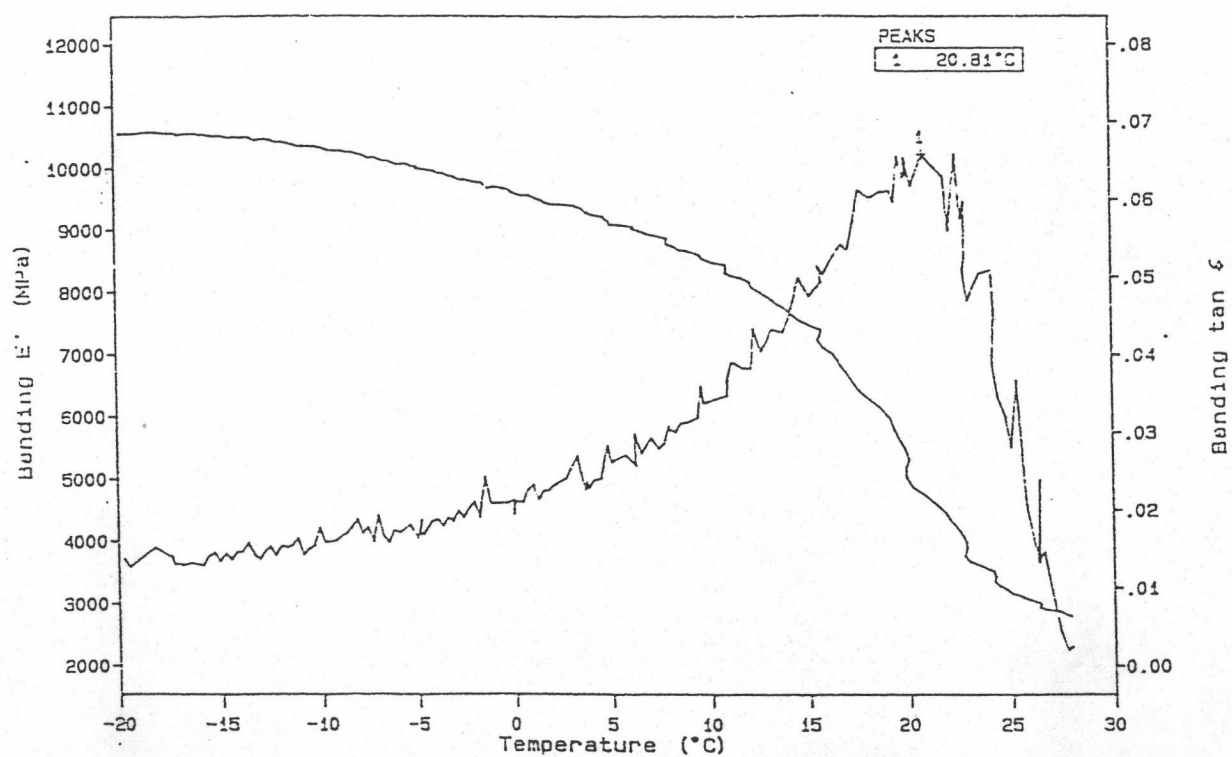


Figure E-8 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% FeCl_3 .

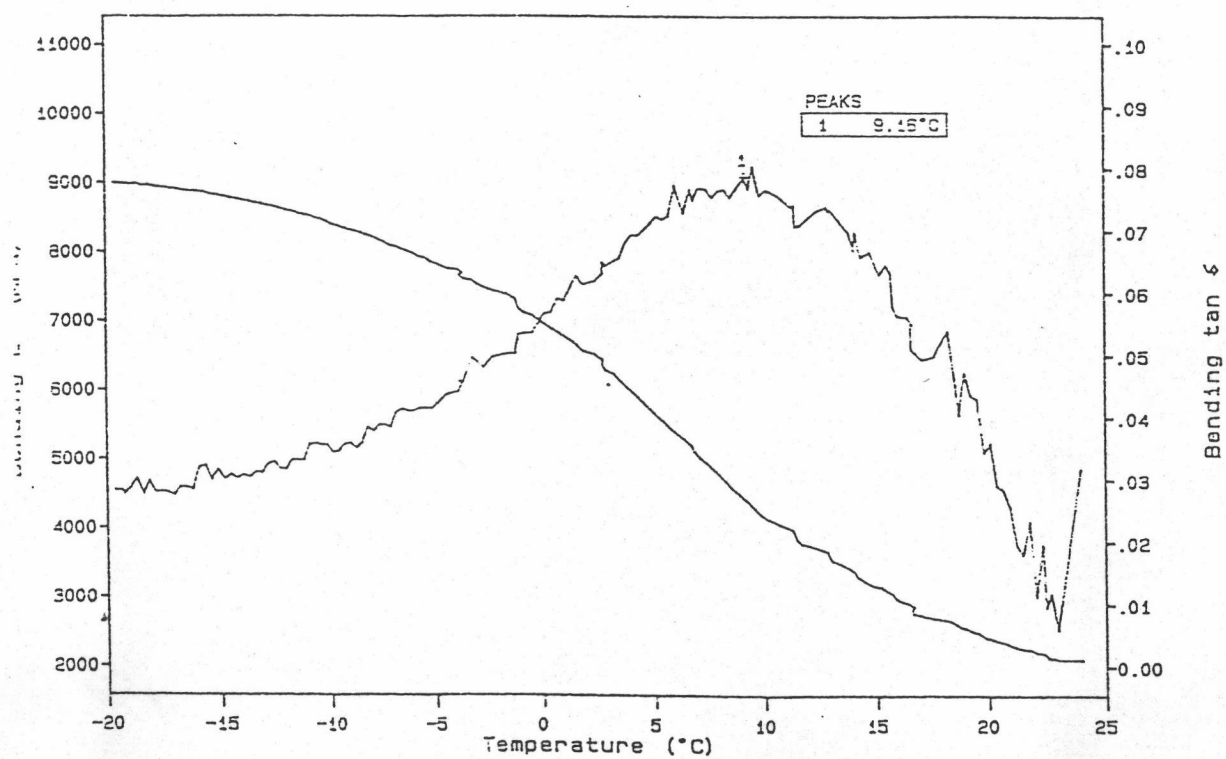


Figure E-9 : The modulus and $\tan \delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% CuCl_2 .

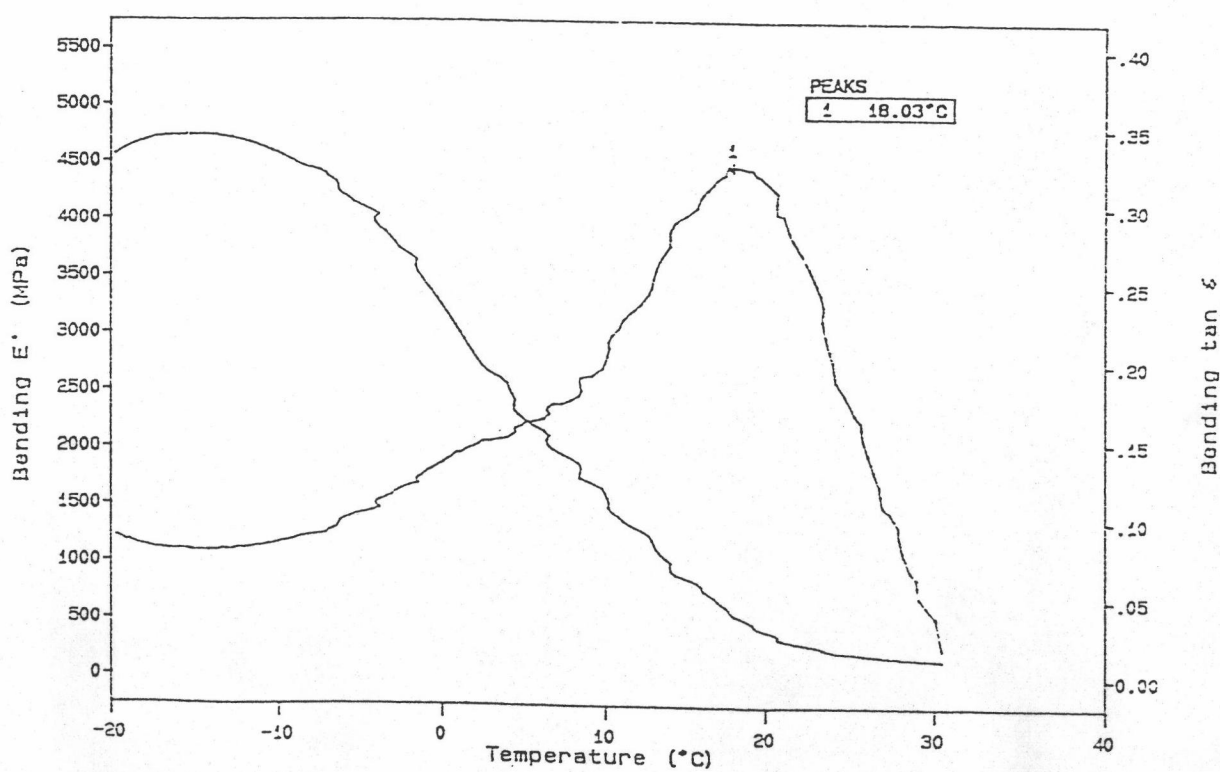


Figure E-10 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 20% ZnCl_2 .

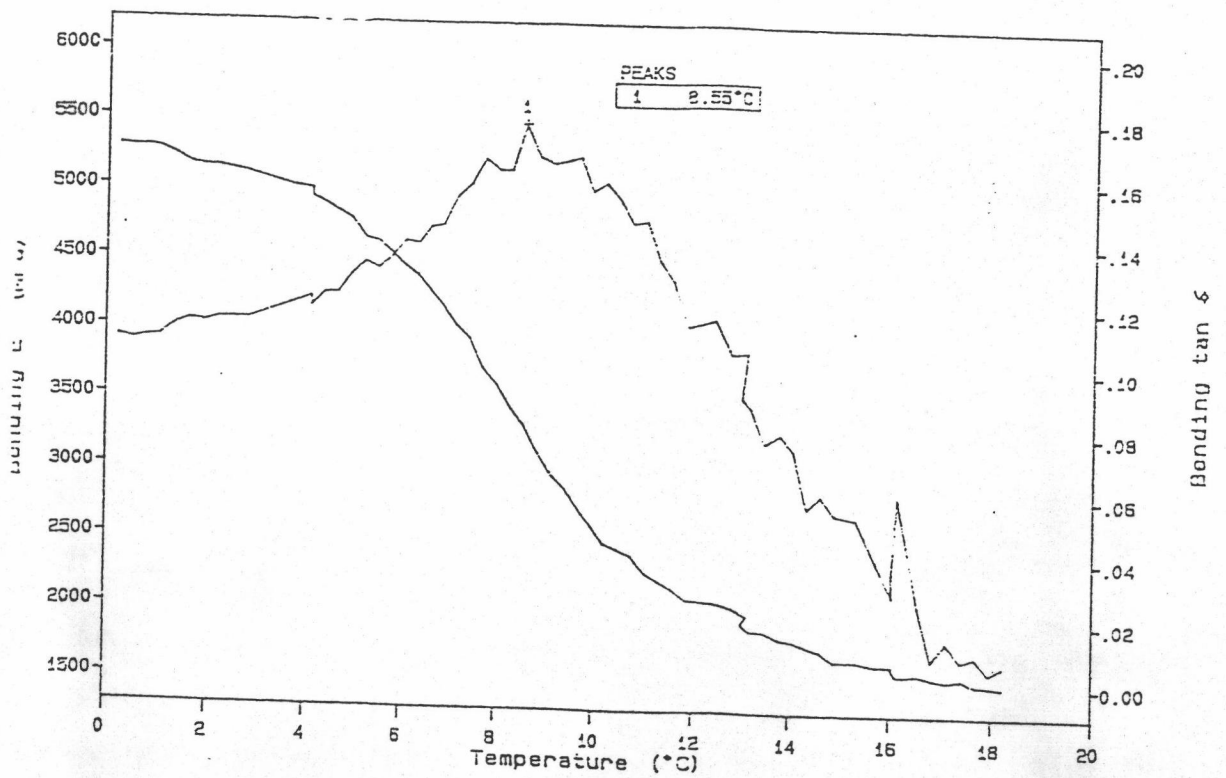


Figure E-11 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% CoCl_2 .

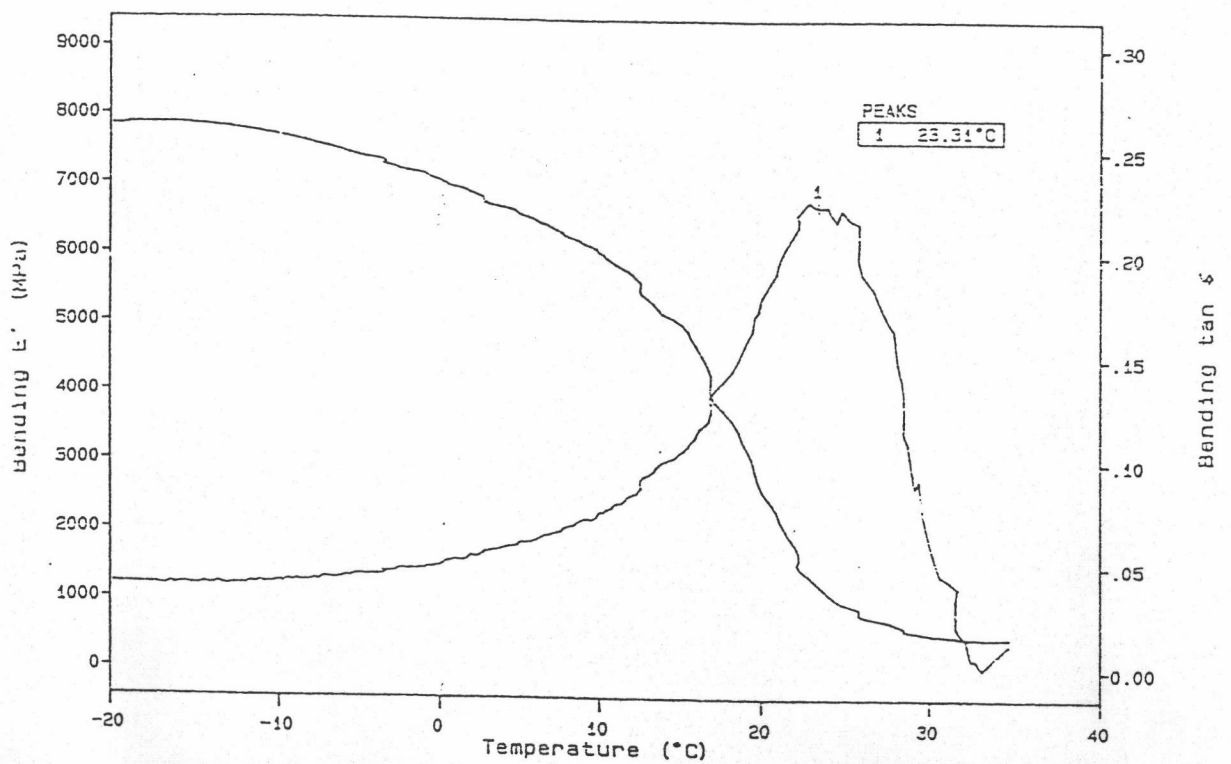


Figure E-12 : The modulus and $\tan\delta$ plotted against temperature from -20 through 100 °C corresponding to the PVA films containing 15% NiCl_2 .

Appendix F

The evidences in testing PVA film and PVA films containing 1, 5, 10,15, and 20% of LiCl, NaCl, KCl, CaCl₂, BaCl₂, FeCl₂, FeCl₃, CuCl₂, ZnCl₂, CoCl₂ and NiCl₂ with Lloyd tensile tester, load cell of 100 N. at ambient condition according to standard test method of ASTM D-638 and ASTM D-882 were found and shown in figures F-1 through F-11.

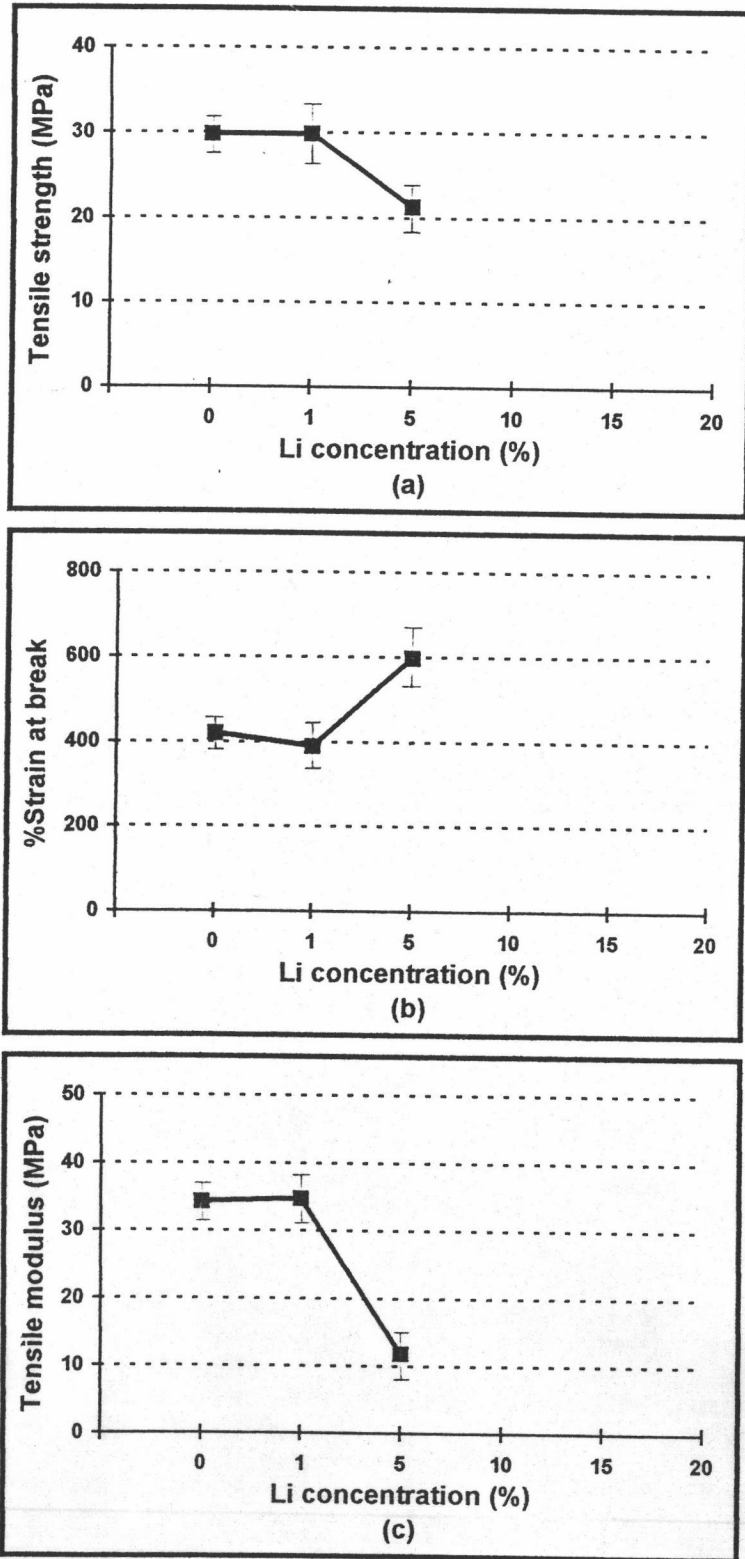


Figure F-1 : Effect of lithium salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% LiCl.

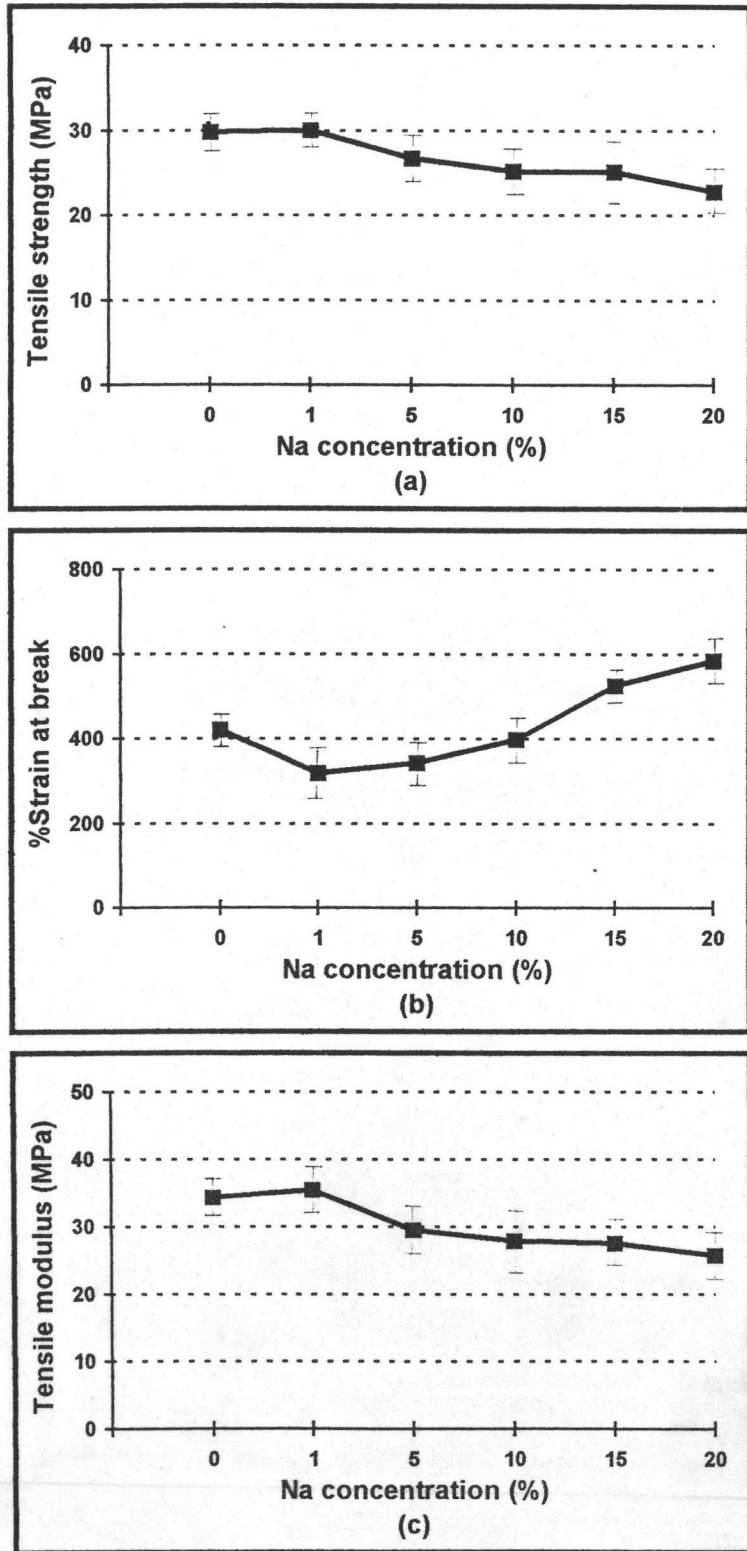


Figure F-2 : Effect of sodium salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% NaCl.

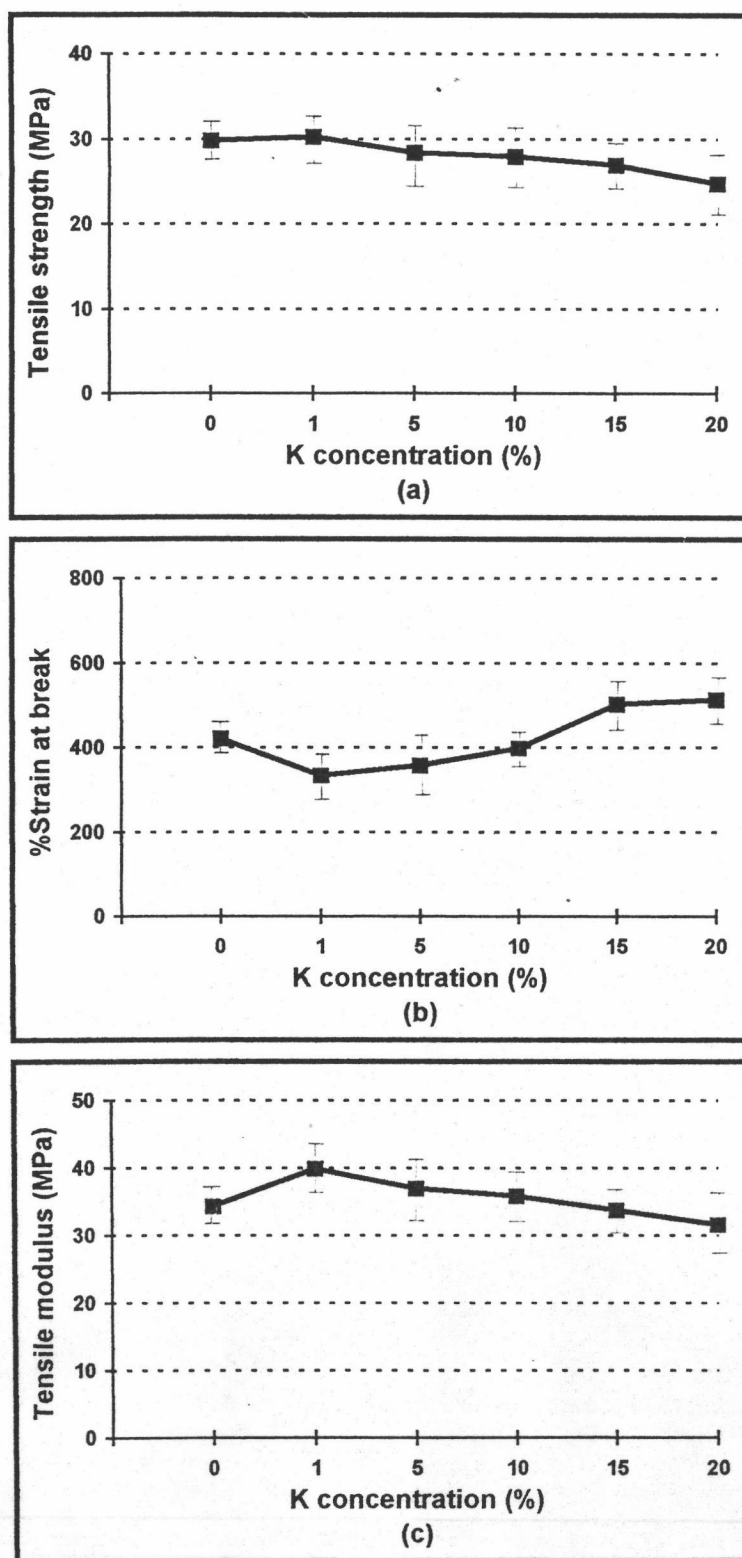


Figure F-3 : Effect of potassium salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% KCl.

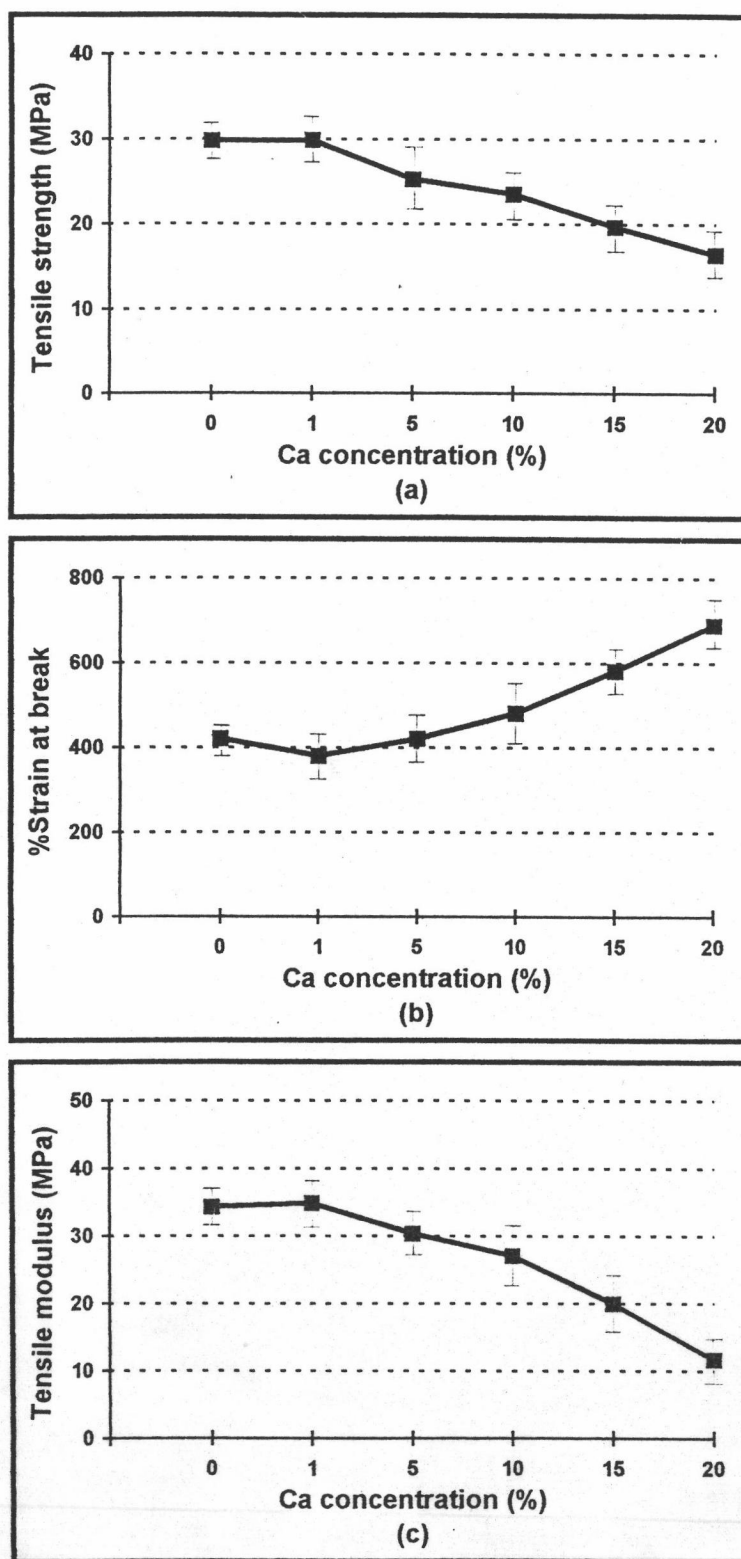


Figure F-4 : Effect of calcium salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% CaCl_2 .

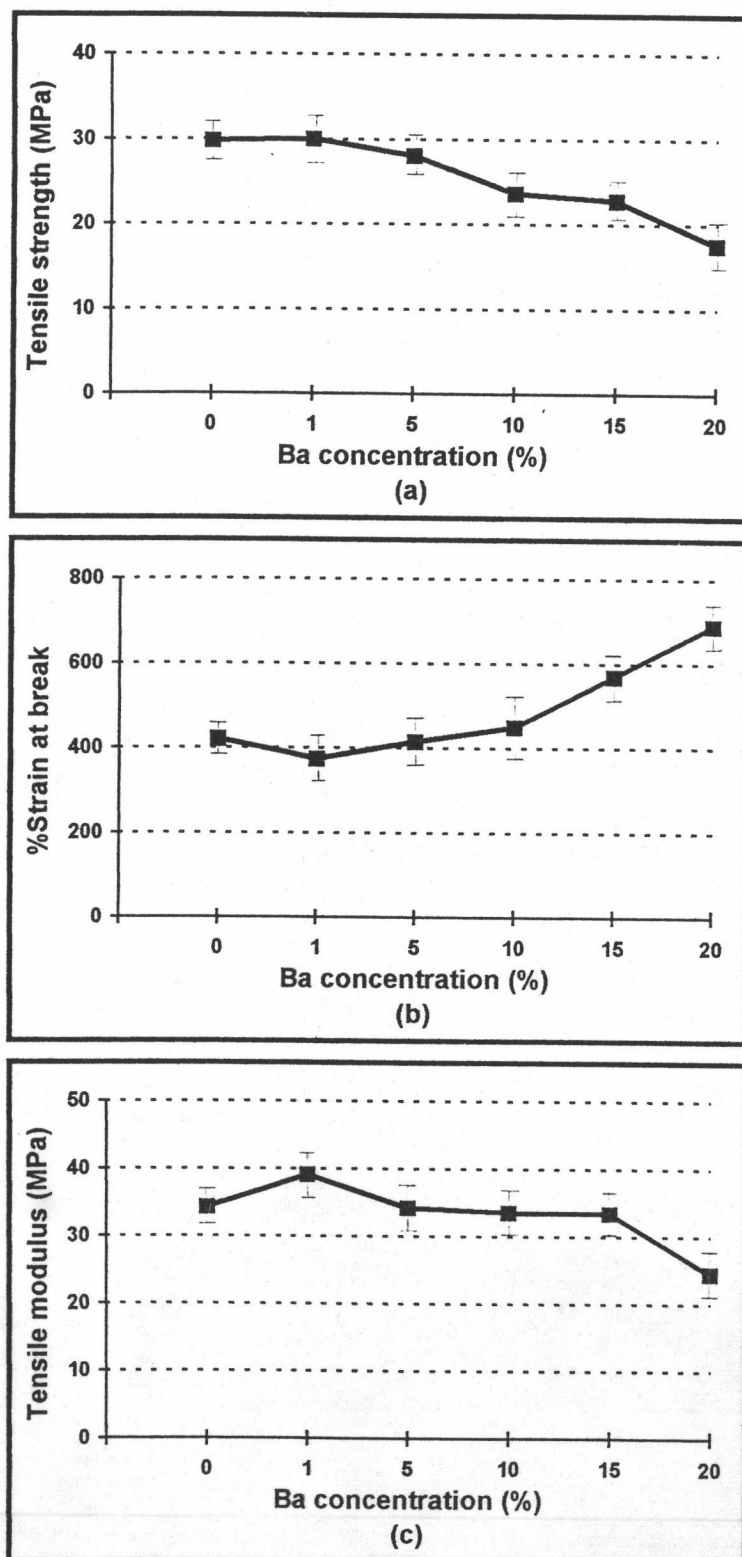


Figure F-5 : Effect of barium salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% BaCl_2 .

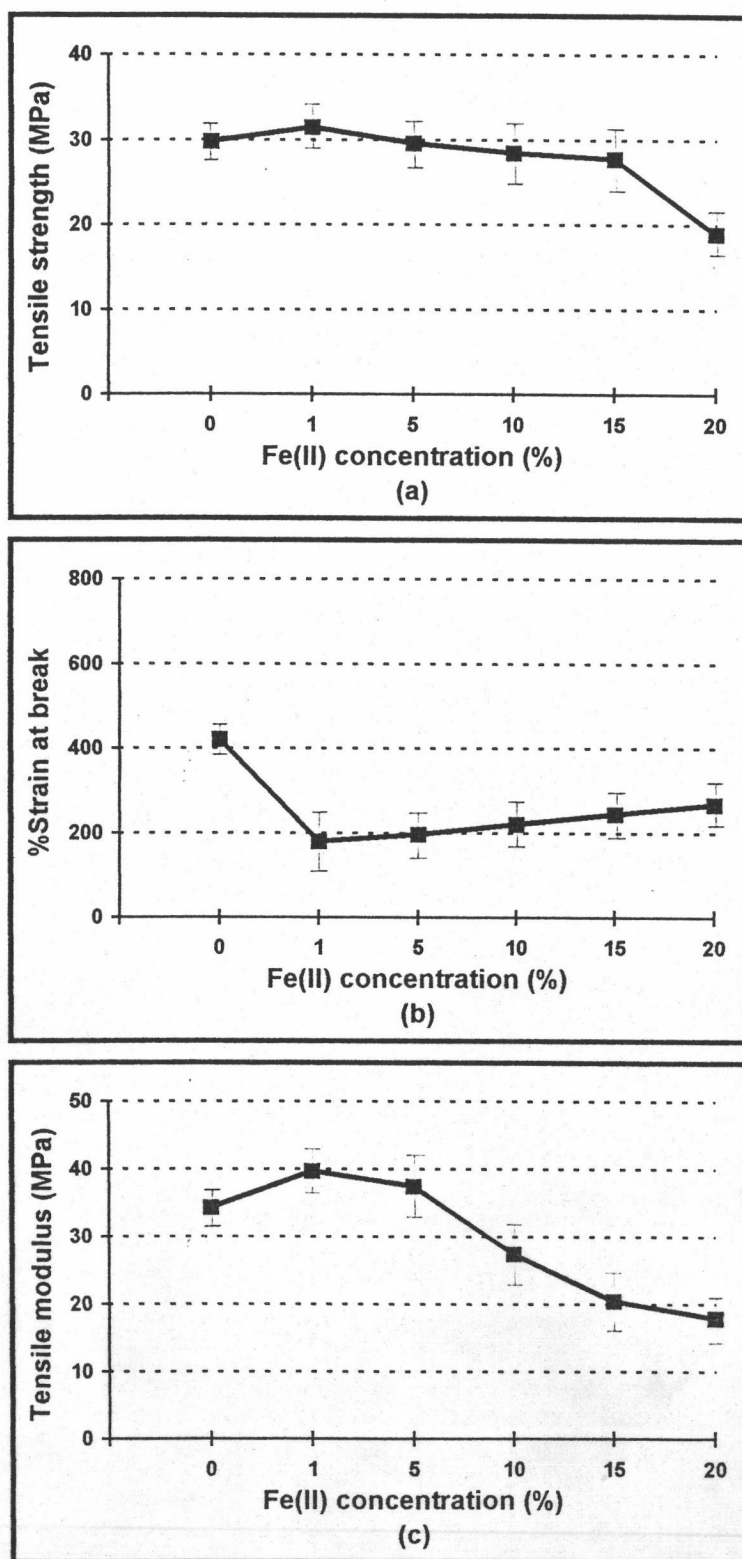


Figure F-6 : Effect of iron(II) salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% FeCl_2 .

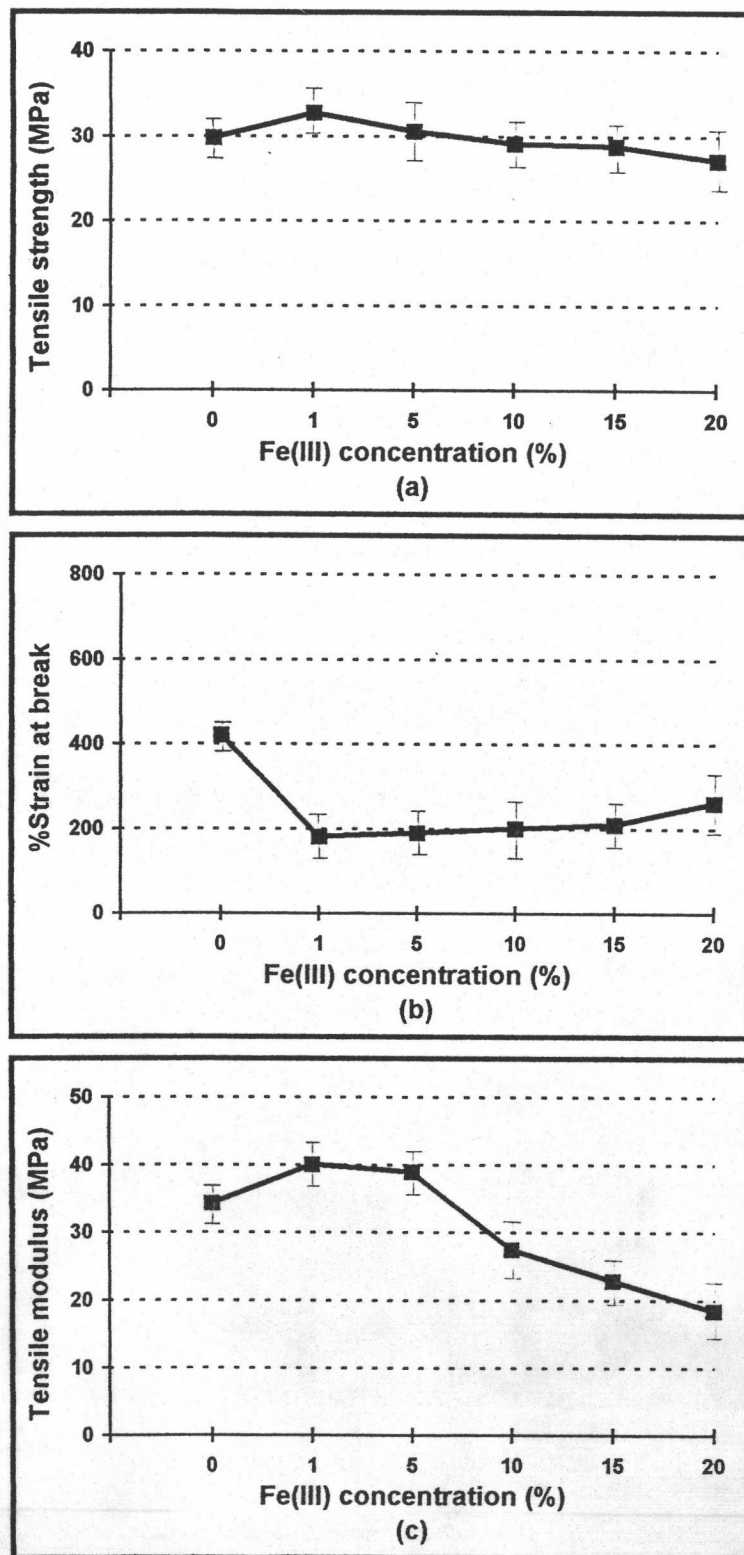


Figure F-7 : Effect of iron(III) salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% FeCl_2 .

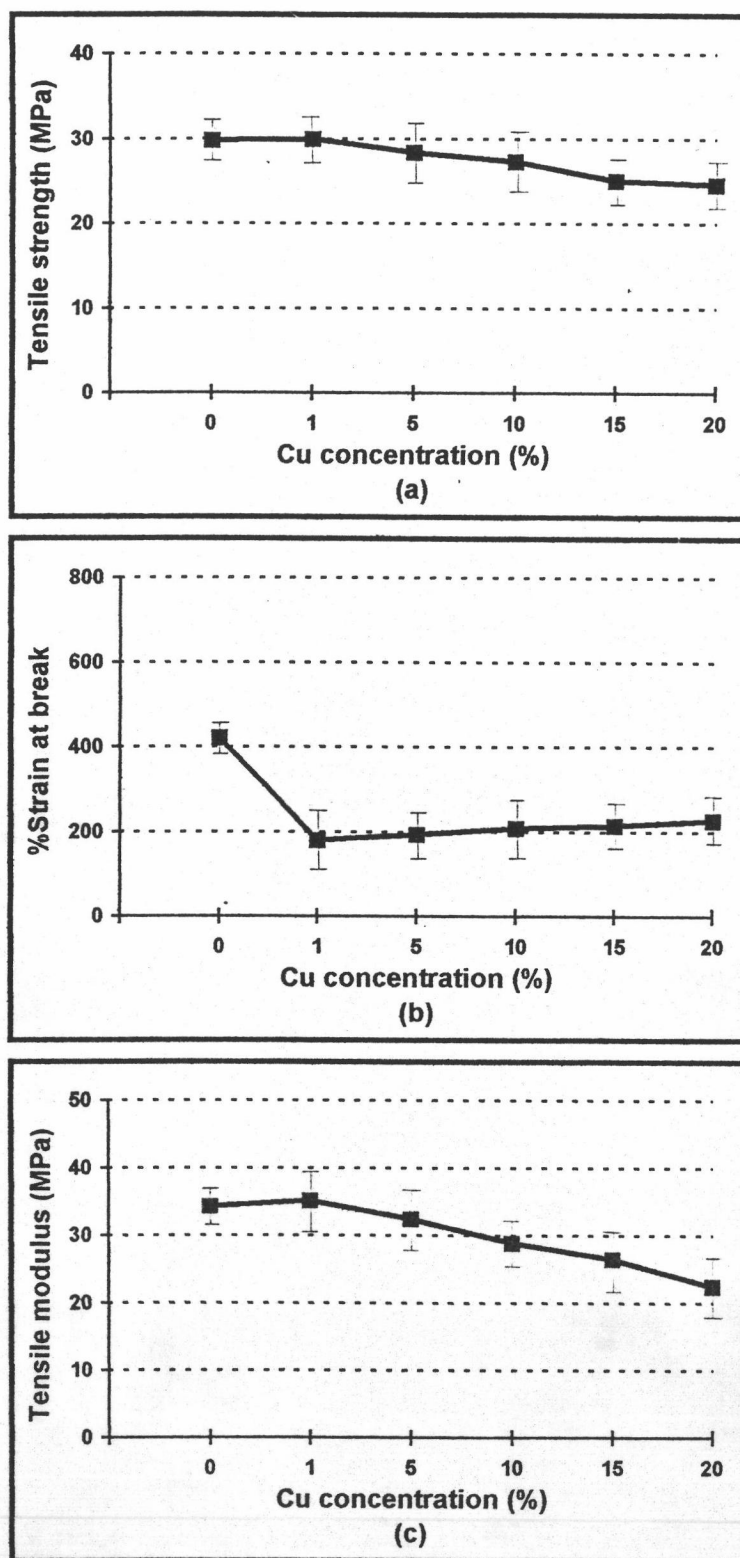


Figure F-8 : Effect of copper salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% CuCl_2 .

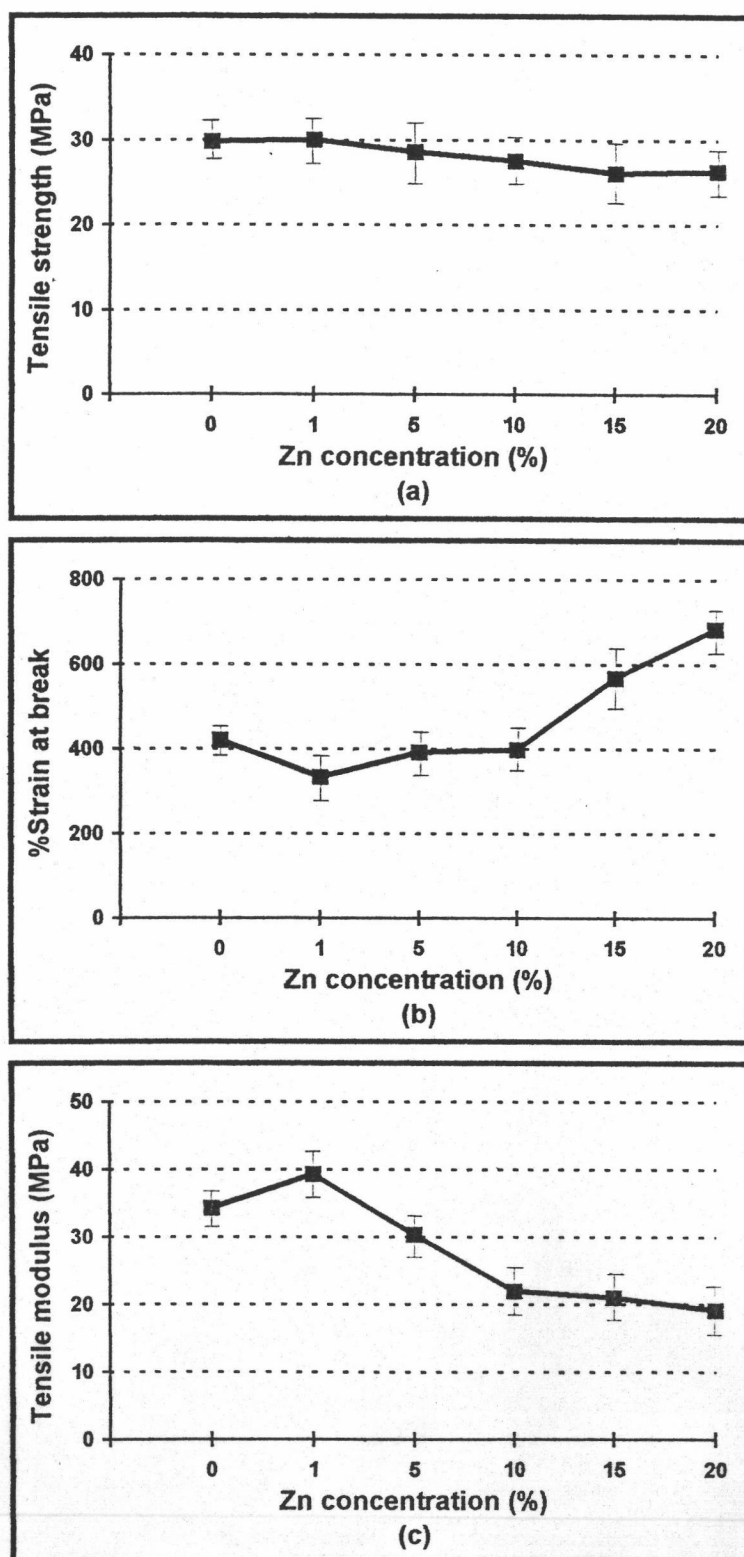


Figure F-9 : Effect of zinc salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% ZnCl_2 .

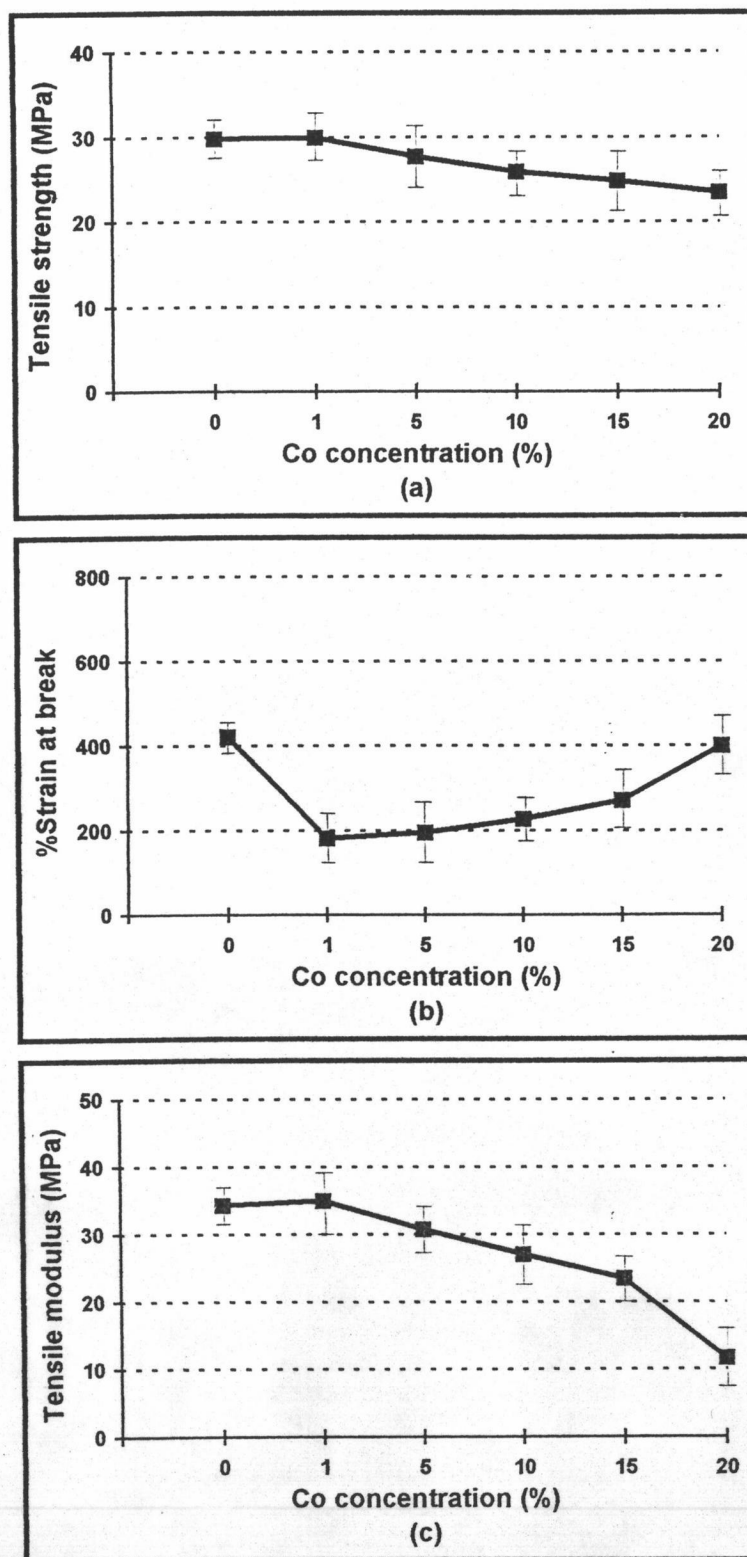


Figure F-10 : Effect of cobalt salt on mechanical properties

(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

of PVA films containing 1, 5, 10, 15 and 20% CoCl_2 .

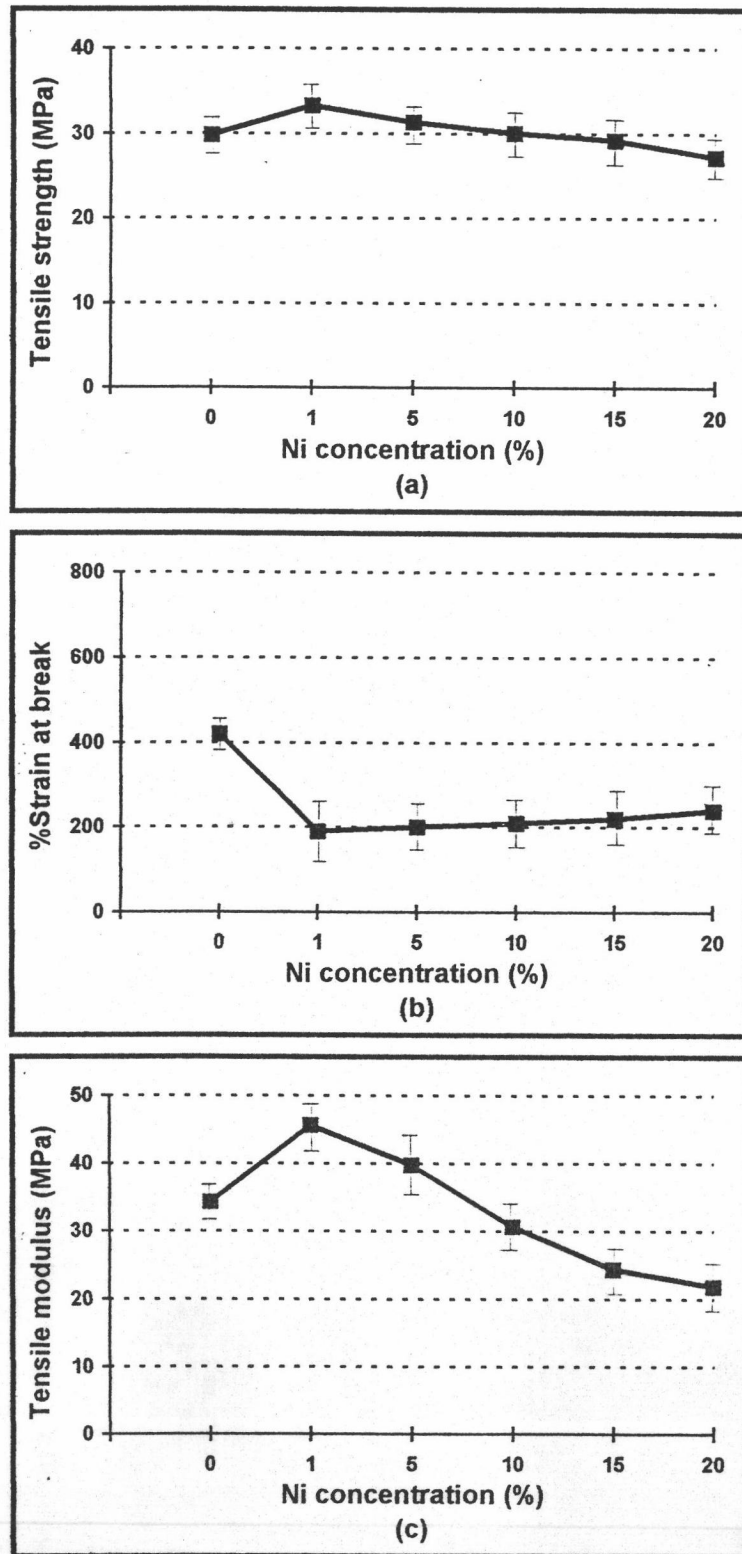


Figure F-11 : Effect of calcium salt on mechanical properties

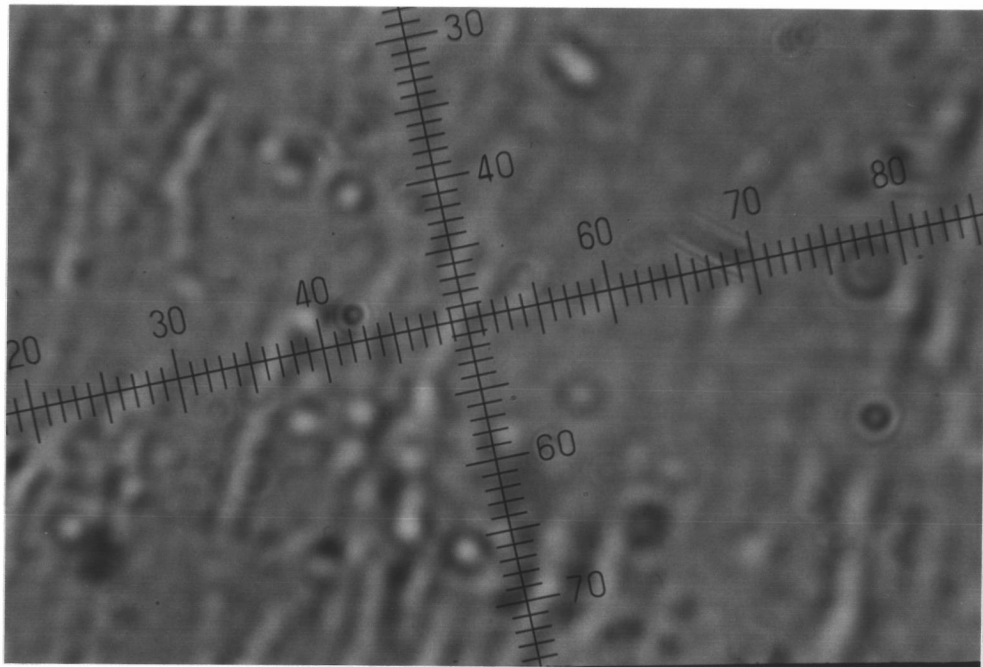
(a) Tensile strength (MPa) (b) % Strain at break

(c) Tensile modulus (MPa)

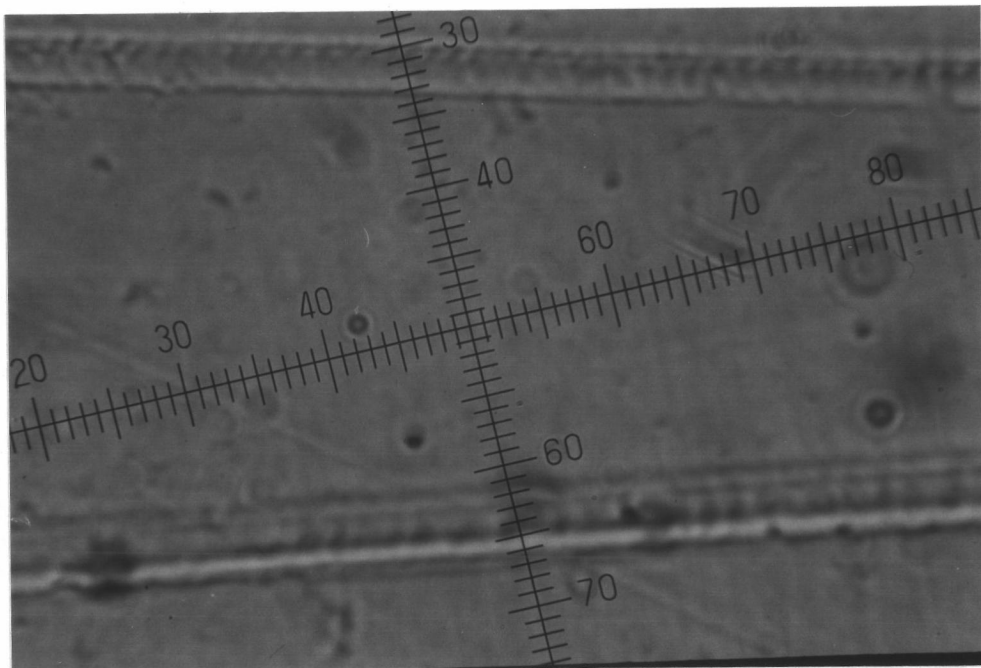
of PVA films containing 1, 5, 10, 15 and 20% NiCl_2 .

Appendix G

The optical micrographs of PVA film and PVA films containing 5% of LiCl, NaCl, KCl, CaCl₂, BaCl₂, FeCl₂, FeCl₃, CuCl₂, ZnCl₂, CoCl₂ and NiCl₂ either before or after deformation under tensile testing were found in figures G-1 through G-12.

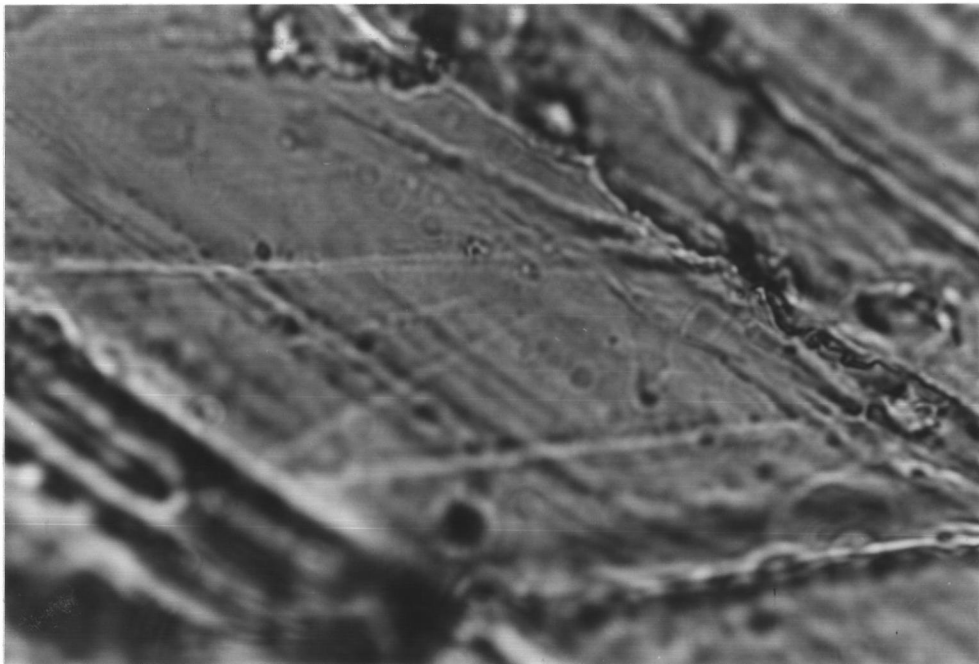


(a)

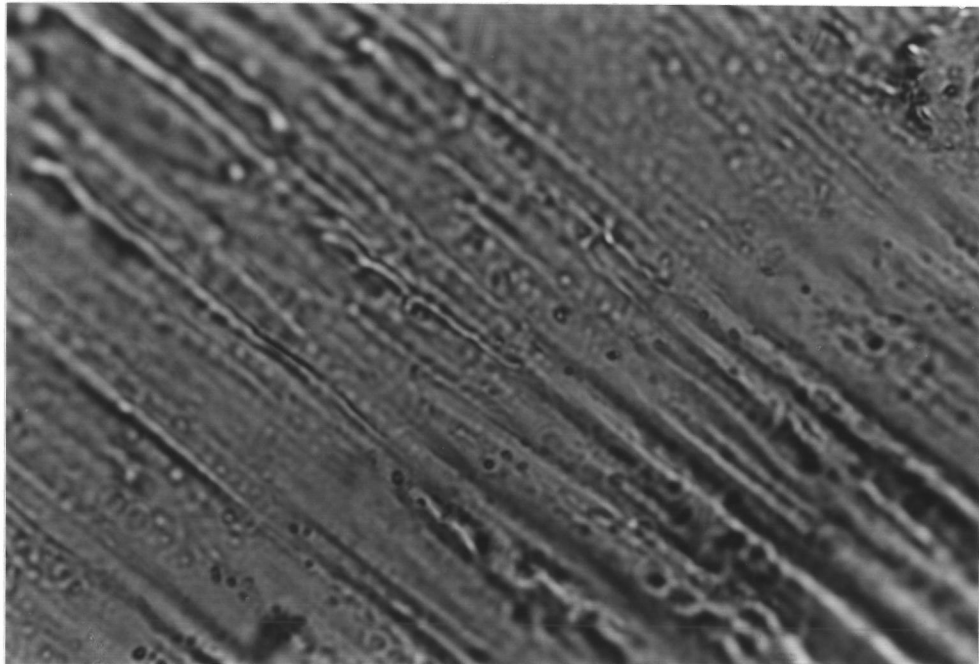


(b)

Figure G-1 : Optical micrograph of standard PVA film
(a) before (b) after
deformation under tensile testing.

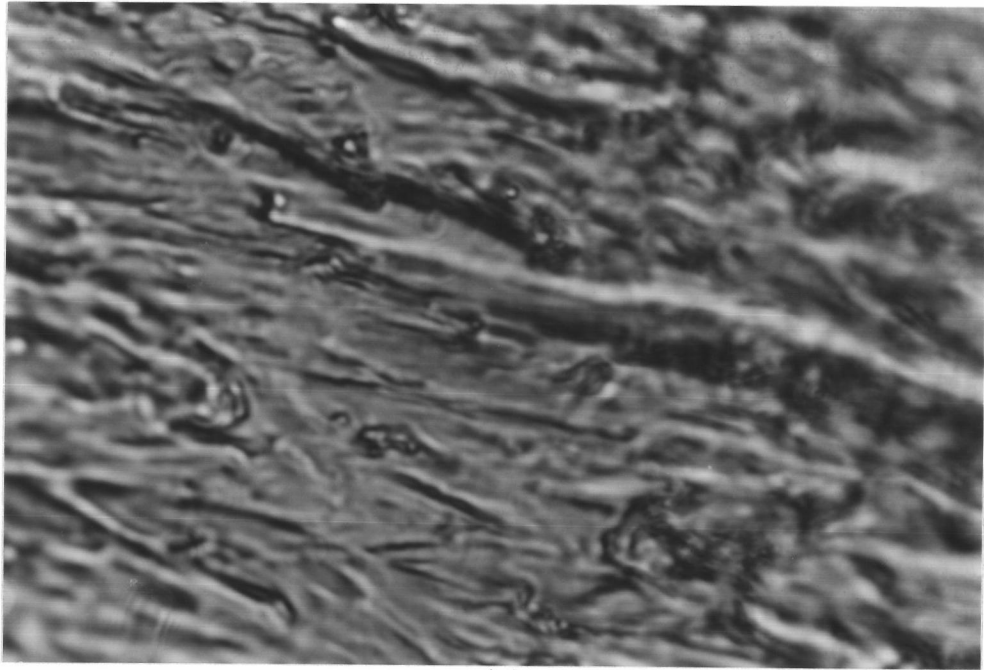


(a)

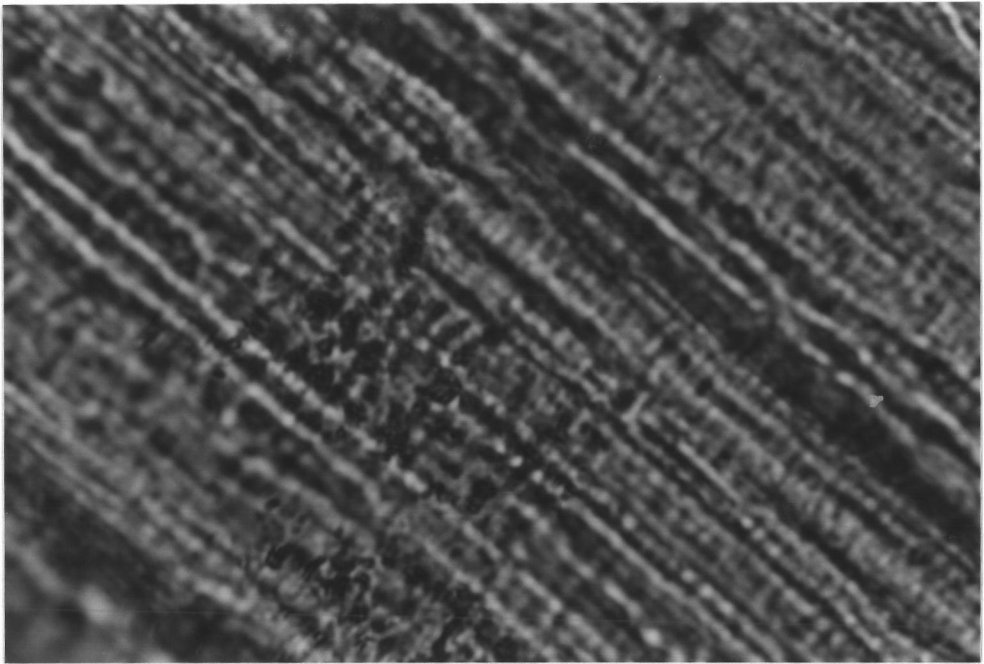


(b)

Figure G-2 : Optical micrograph of PVA films containing
5% LiCl
(a) before (b) after
deformation under tensile testing.

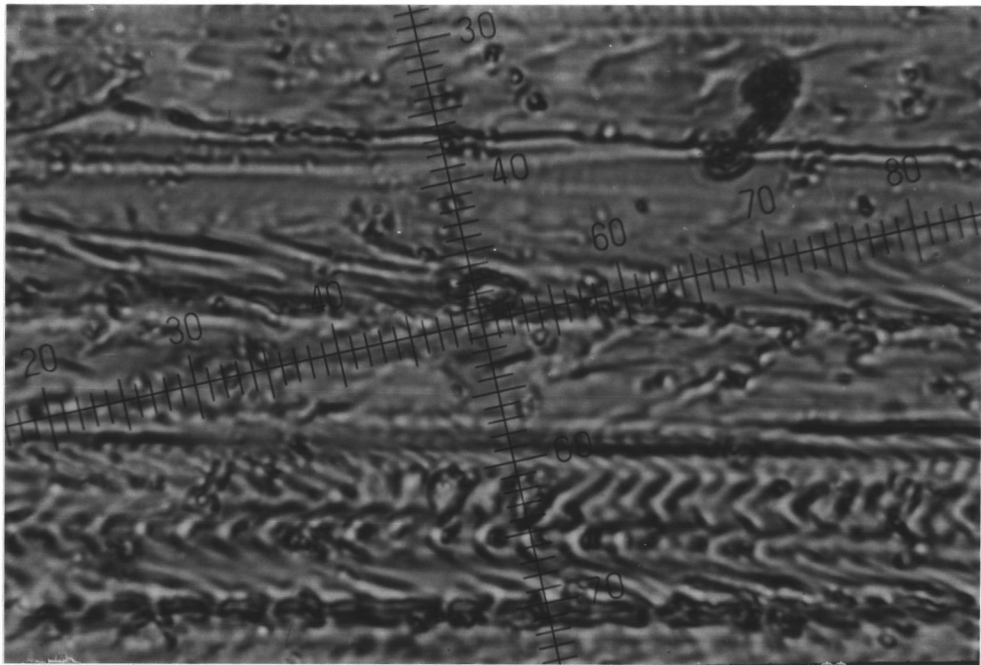


(a)

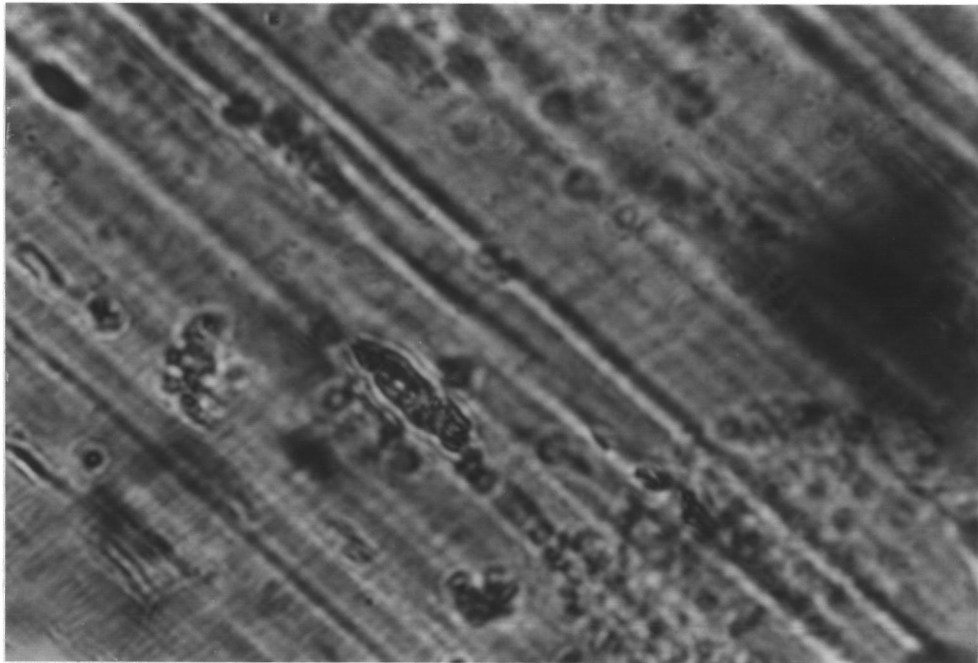


(b)

Figure G-3 : Optical micrograph of PVA films containing
5% NaCl
(a) before (b) after
deformation under tensile testing.

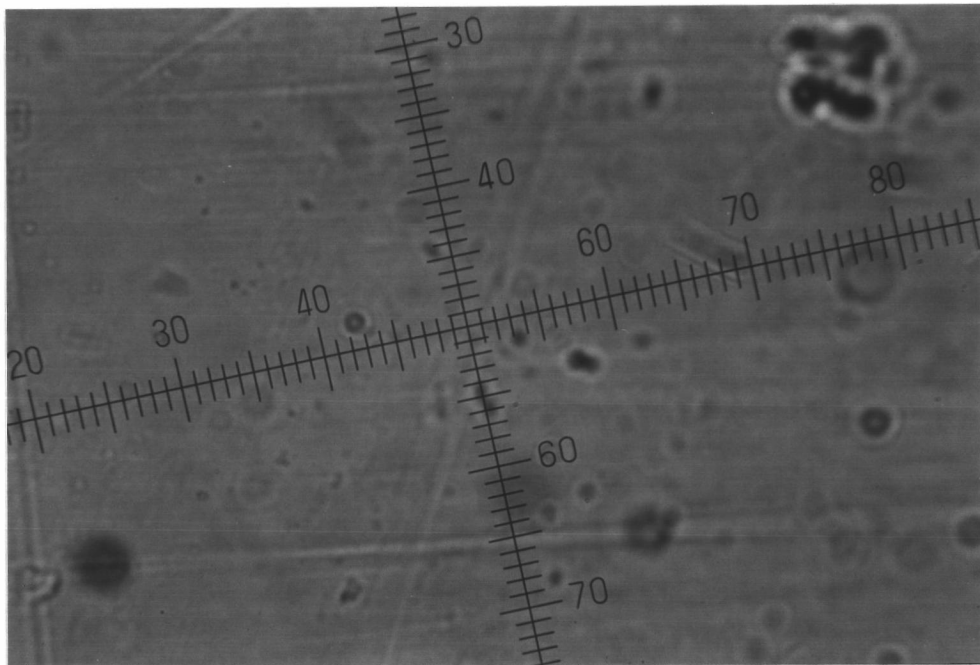


(a)

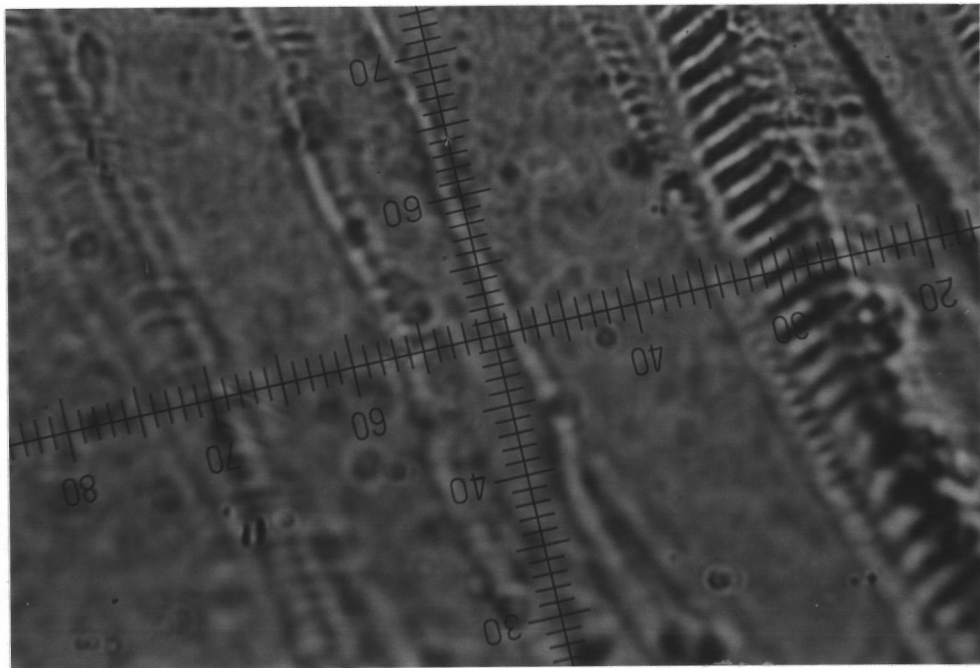


(b)

Figure G-4 : Optical micrograph of PVA films containing 5% KCl
(a) before (b) after deformation under tensile testing.

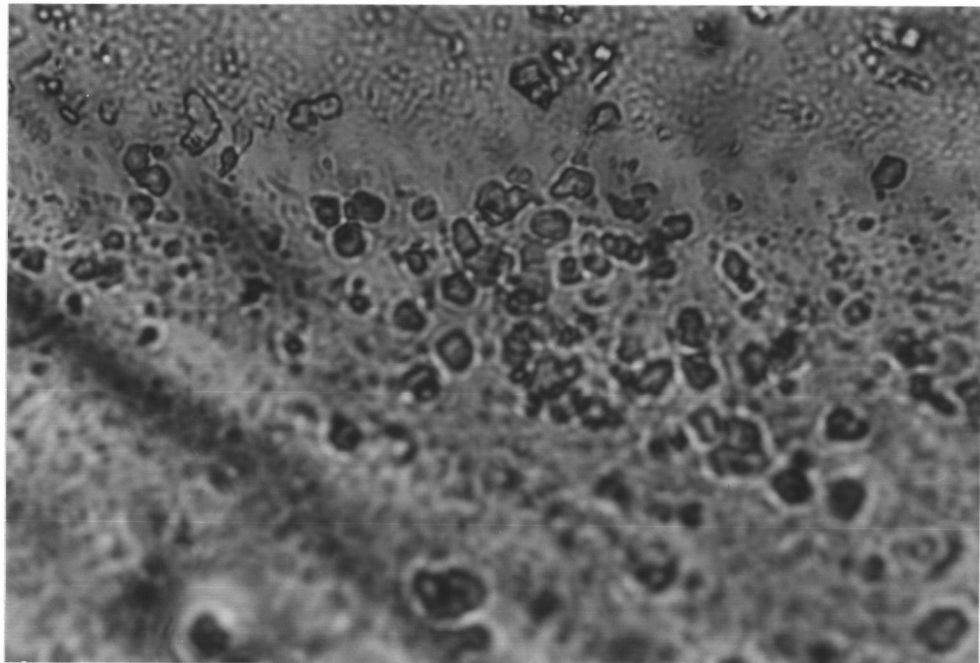


(a)

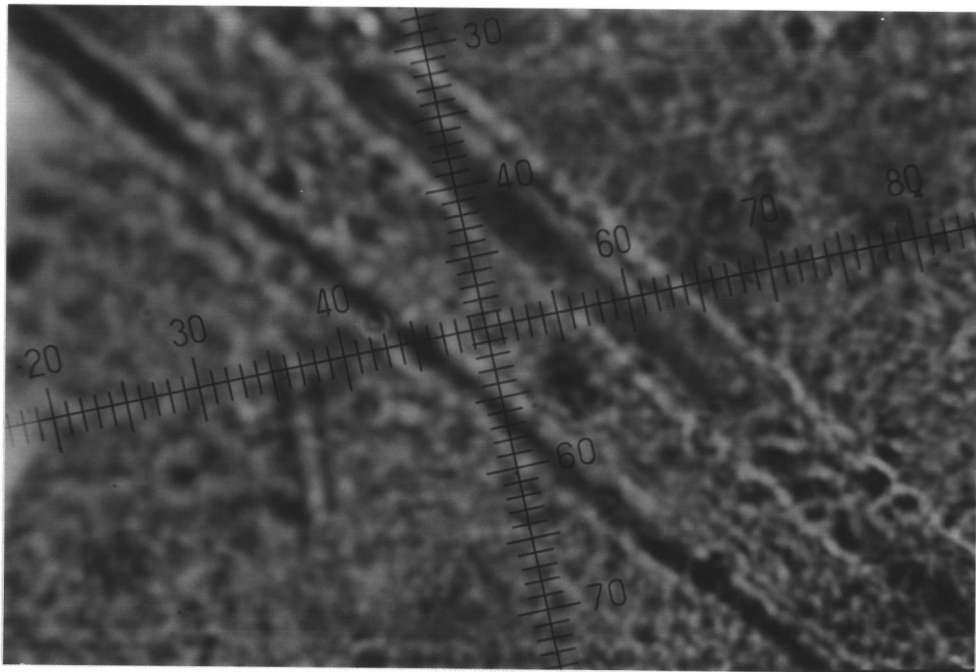


(b)

Figure G-5 : Optical micrograph of PVA films containing
5% CaCl₂
(a) before (b) after
deformation under tensile testing.

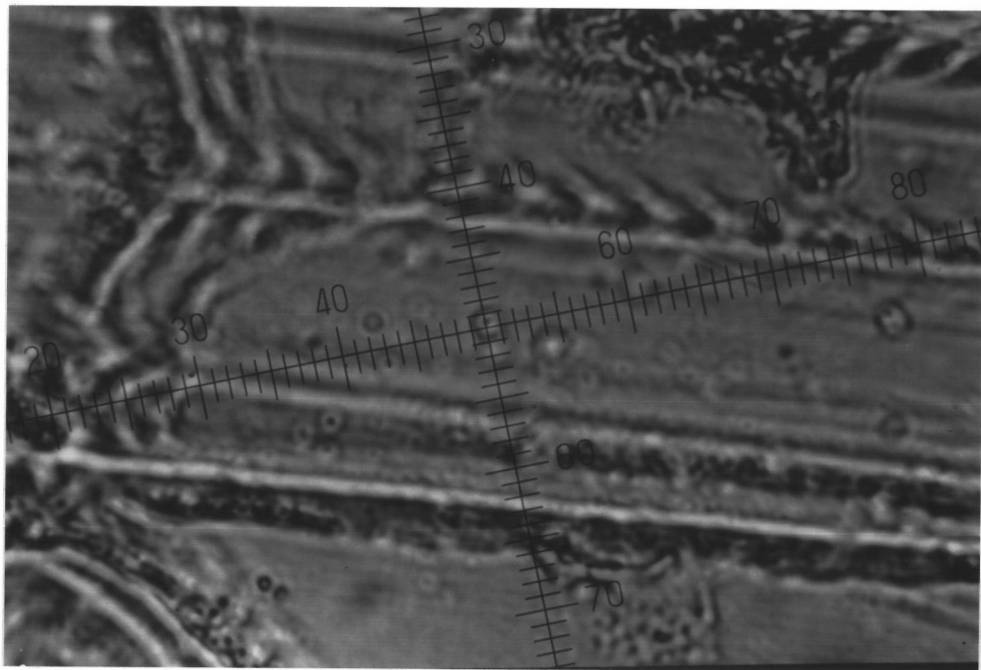


(a)

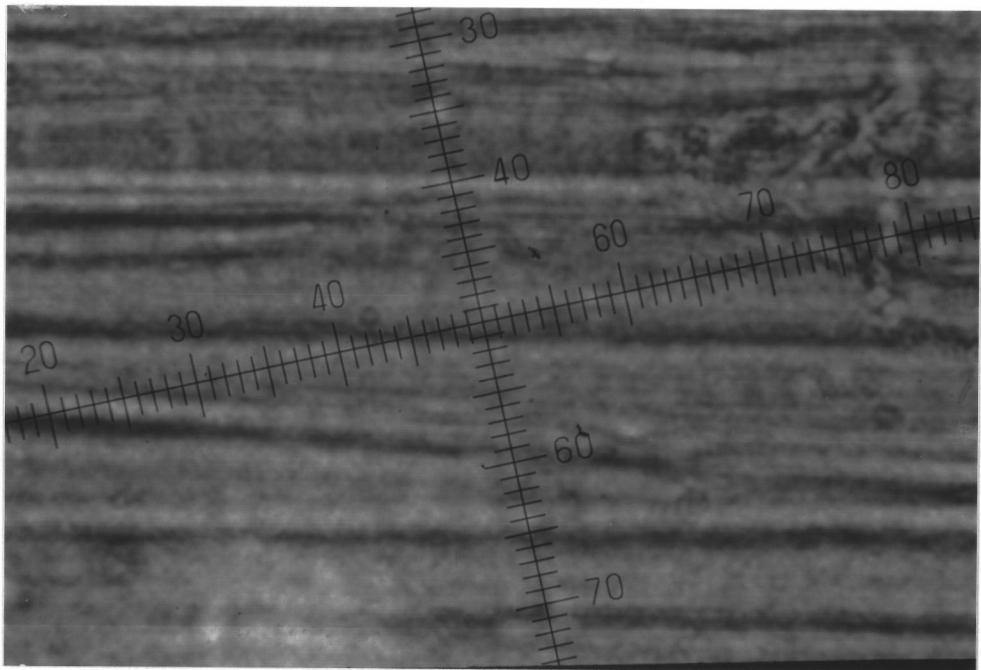


(b)

Figure G-6 : Optical micrograph of PVA films containing 5% BaCl_2
(a) before (b) after deformation under tensile testing.

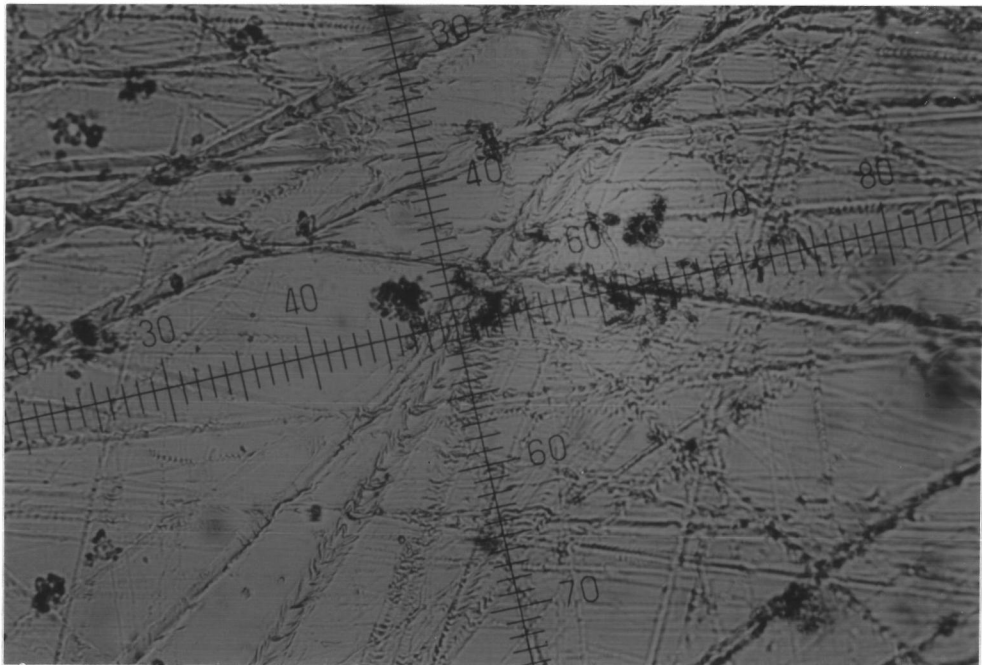


(a)

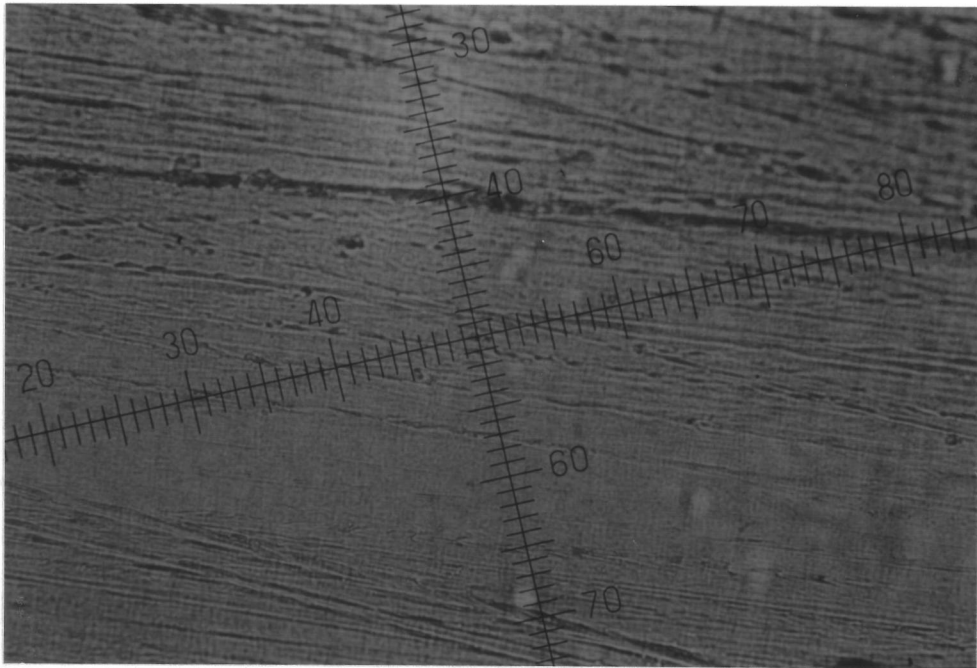


(b)

Figure G-7 : Optical micrograph of PVA films containing
5% FeCl₂
(a) before (b) after
deformation under tensile testing.

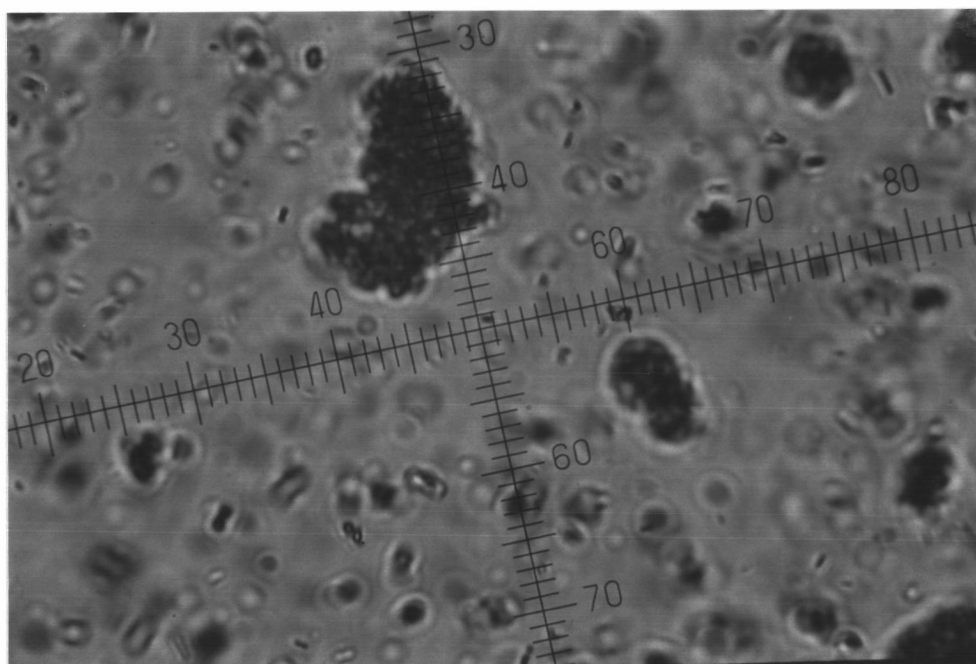


(a)

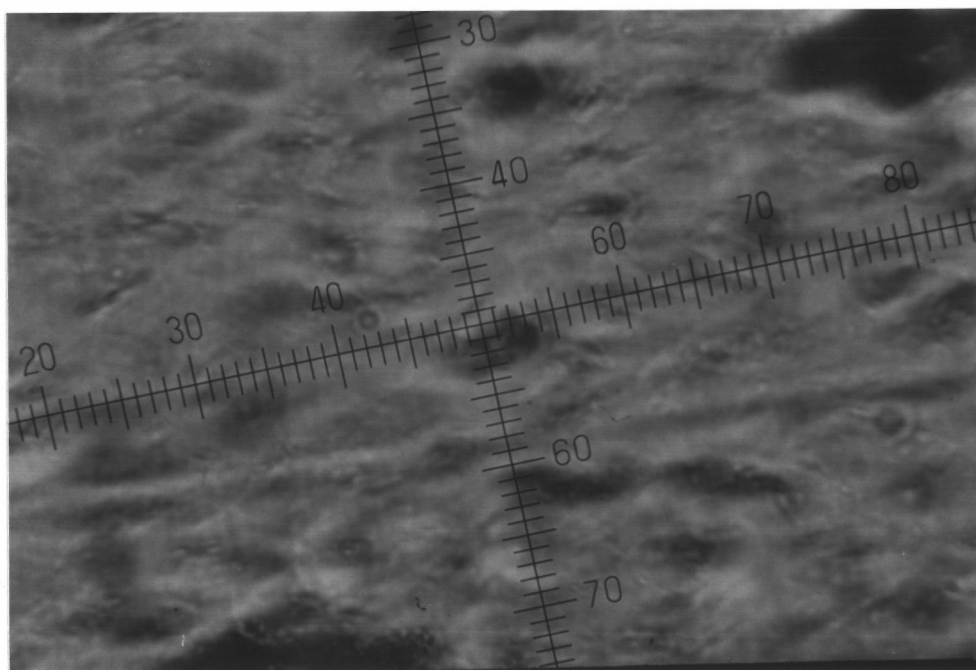


(b)

Figure G-8 : Optical micrograph of PVA films containing
5% FeCl₃
(a) before (b) after
deformation under tensile testing.



(a)

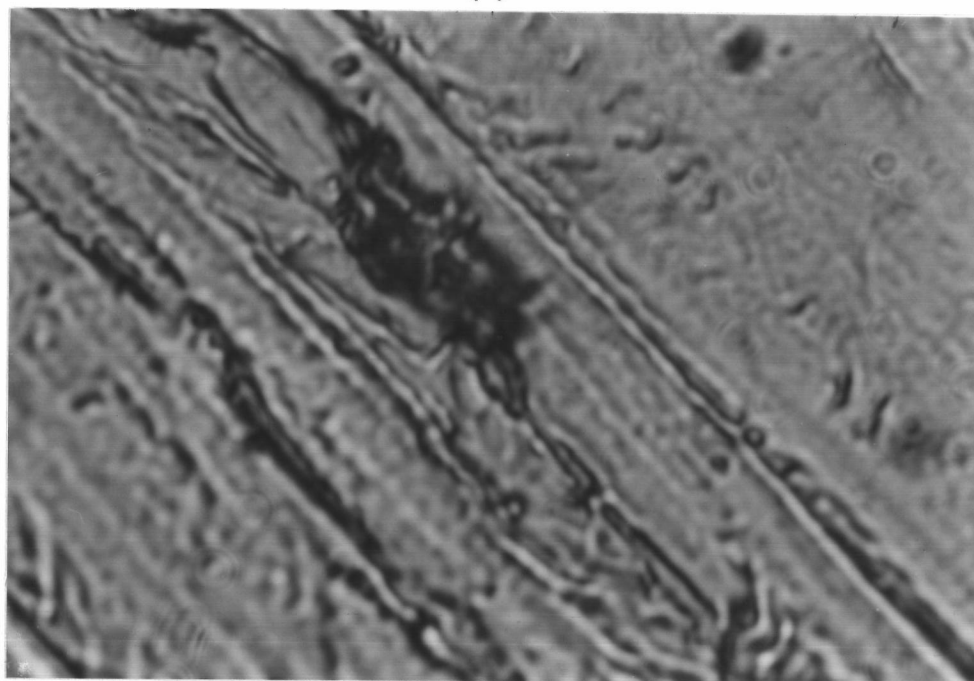


(b)

Figure G-9 : Optical micrograph of PVA films containing 5% CuCl₂
(a) before (b) after deformation under tensile testing.



(a)

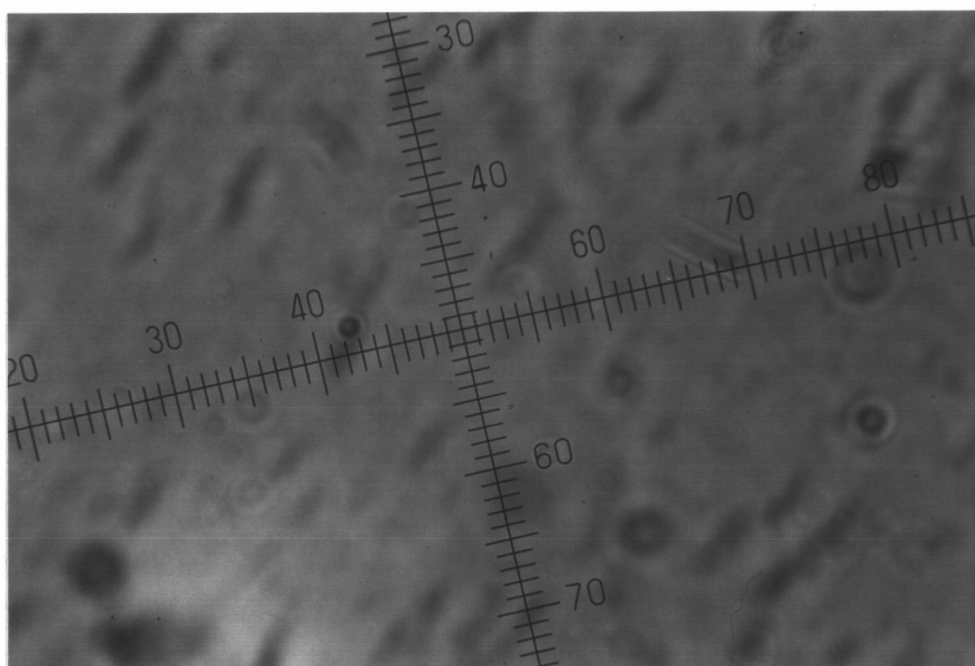


(b)

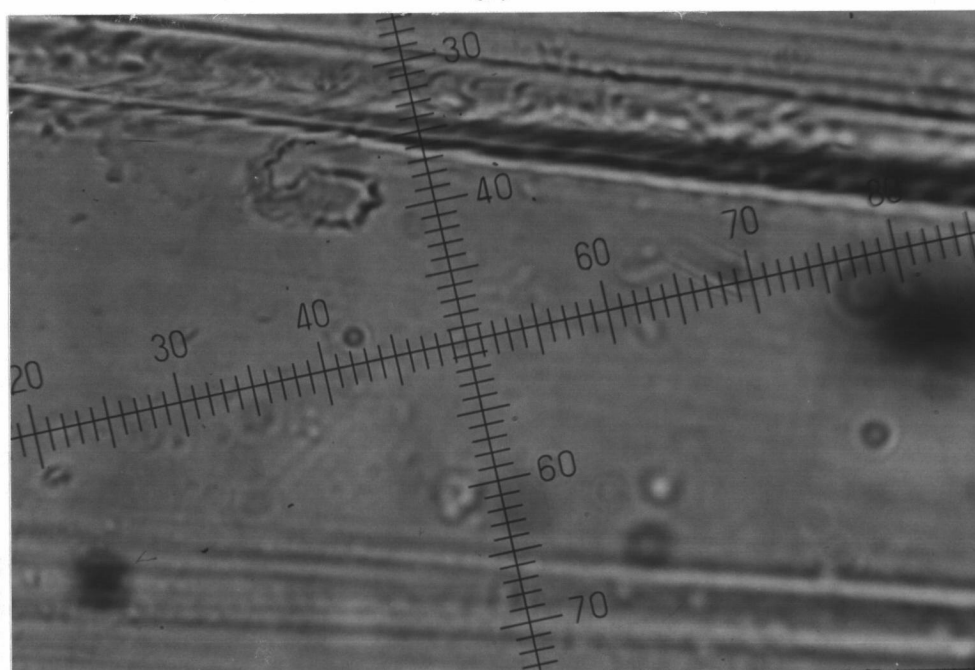
Figure G-10 : Optical micrograph of PVA films containing
5% ZnCl_2

(a) before (b) after

deformation under tensile testing.

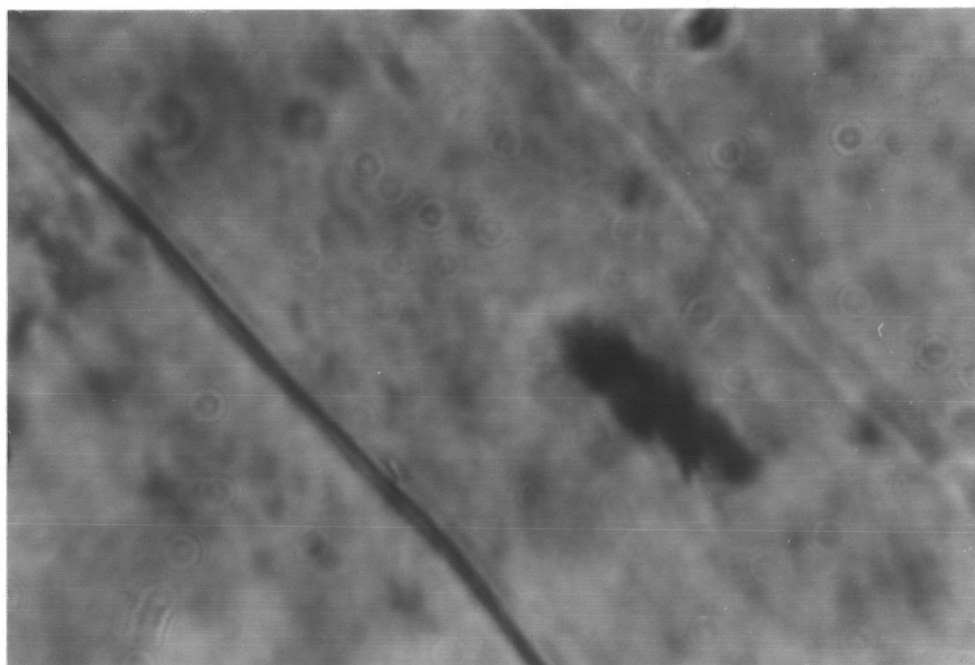


(a)

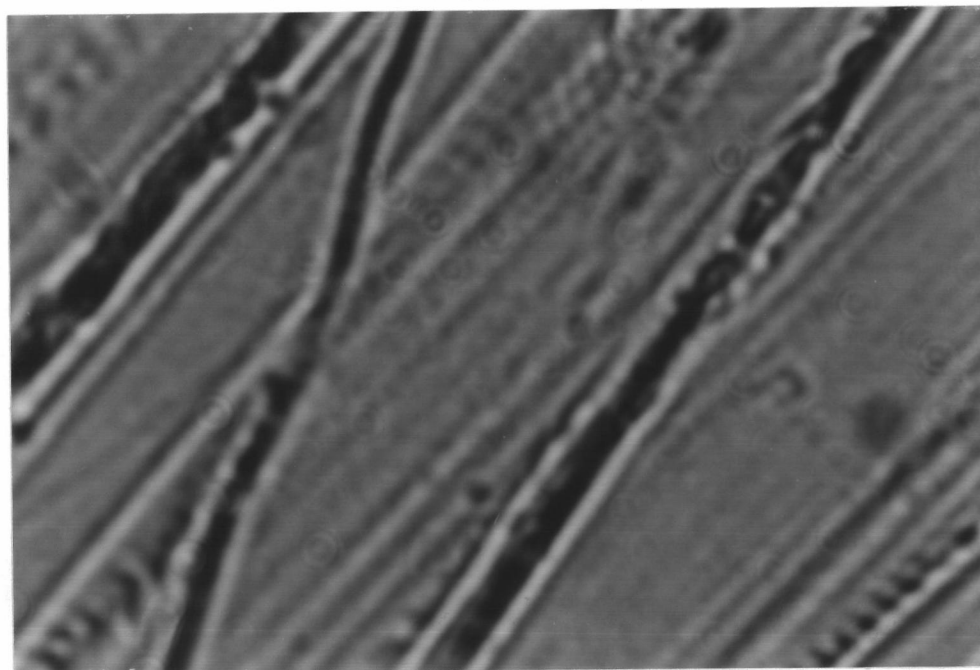


(b)

Figure G-11 : Optical micrograph of PVA films containing 5% CoCl₂
(a) before (b) after deformation under tensile testing.



(a)



(b)

Figure G-12 : Optical micrograph of PVA films containing
5% NiCl₂
(a) before (b) after
deformation under tensile testing.



BIOGRAPHY

Miss Suphanee Pongkitwitoon was born in Nakornrajchaisima, Thailand, on July 31, 1970. She graduated a Bachelor degree of Science in Chemistry with honour from Khon Kaen University in 1992. She has been started as a graduate student in Department of Materials Science with a major in Applied Polymer Science and Textile Technology, Chulalongkorn University in June 1992 and completely graduated the programme in March 1995.