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APPENDIX A

CALCULATION METHOD

Program for Calculation of Conductivity by Van Der Pauw Method.

```
OK
LIST
10    CLS
15    d1=0 : d2=0 : d3=0 : d4=0 : R1=0.001 : R2=0.001 : R3=0.001 :
      R4=0.001
20    INPUT "d1= "; d1
30    INPUT "d2= "; d2
40    INPUT "d3= "; d3
50    INPUT "d4= "; d4
60    D=(d1+d2+d3+d4)/4
80    PRINT "R1234[1]= "; : INPUT R1
81    PRINT "R1234[2]= "; : INPUT R2
82    PRINT "R1234[3]= "; : INPUT R3
83    PRINT "R1234[4]= "; : INPUT R4
150   FOR 0=1 TO 4
160   IF 0=1 THAN W1=R1 : W2=R2
165   IF 0=2 THAN W1=R2 : W2=R3
170   IF 0=3 THAN W1=R3 : W2=R4
```

```
175    IF 0=4 THAN W1=R4 : W2=R1

200    M=PI*D

210    A=M*W1 : B=M*W2

220    F=(A+B)*0.5

230    X=0.693147/F

240    P=EXP(-A*X) + EXP(-B*X)

250    IF P <= 1.00001 THEN 280

260    X=X*P

270    GOTO 240

280    BEEP : PRINT "CONDUCTIVITY"; 0; "="; X

290    IF 0=1 THEN C1 = X

300    IF 0=2 THEN C2 = X

310    IF 0=3 THEN C3 = X

320    IF 0=4 THEN C4 = X

330    Cav=(C1+C2+C3+C4)/4

400    NEXT 0

401    BEEP : PRINT "AVERAGE CONDUCTIVITY= " ; Cav

405    PRINT "THICHNESS= "; D

410    PRINT "RESISTANCE No 1= "; R1

420    PRINT "RESISTANCE No 2= "; R2

430    PRINT "RESISTANCE No 3= "; R3

440    PRINT "RESISTANCE No 4= "; R4

500    END
```
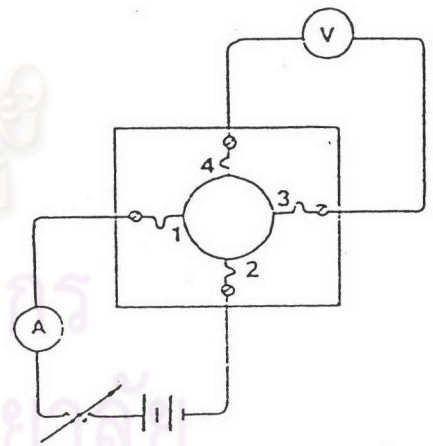
Calculation Conductivity of polypyrrole.

CNR was prepared by electrochemical and chemical solution method. The thickness was measured by vernier caliber. After that electrical conductivity of CNR was measured by Van Der Pauw method.
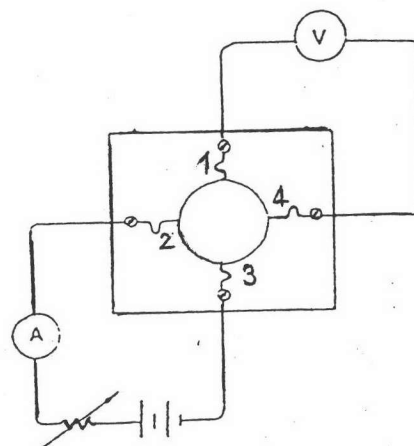
Sample 1

Four ohmic contacts at the edge of the disc sample are made for then measurement. First apply suitable current (I_{12}) though contacts 1 and 2 and measure potential different (V_{34}) between contact 3 and 4 and obtains ratio $R1 = |V_{34}| / I_{12}$.

I_{12} (mA)	$|V_{34}|$ (mV)	R_{1234} (Ω)
39×10^{-3}	25	589.743
56×10^{-3}	21	375.000
72×10^{-3}	22	305.555
100×10^{-3}	34	340.000
average R_{1234} (R_1)		402.574

Secondaly, I_{23} is applied through the contact 2 and 3 and measure the potential difference, V_{41} which will give the ratio $R_2 = |V_{41}| / I_{23}$

I_{23} (mA)	$|V_{41}|$ (mV)	R_{2341} (Ω)
62×10^{-3}	44	709.6774
28×10^{-3}	37	1321.428
23×10^{-3}	33	1434.782
18×10^{-3}	31	1722.222
average R_{2341} (R_2)		1297.222

Then calculate for the conductivity ($\sigma 1$) of the disc sample by equation $\sigma = (\sigma 1 + \sigma 2 + \sigma 3 + \sigma 4) / 4$.

The above program will give the following information (in principle, $\sigma 1$, $\sigma 2$, $\sigma 3$, $\sigma 4$, can be calculated by changing the position of electrodes around).

RUN

THICKNESS   d1   = 0.073

d2   = 0.072

d3   = 0.069

d4   = 0.064

RESISTANCE No.1 = 402.5747

RESISTANCE No.2 = 1297.0270

RESISTANCE No.3 = 174.1231

RESISTANCE No.4 = 230.3266

CONDUCTIVITY $\sigma 1 = 4.170 \times 10^{-3}$

$\sigma 2 = 5.748 \times 10^{-3}$

$\sigma 3 = 1.580 \times 10^{-2}$

$\sigma 4 = 1.030 \times 10^{-2}$

$\sigma avr = 9.006 \times 10^{-3}$

OK

Sample 2

RUN

THIKNESS $d1 = 0.068$

$d2 = 0.067$

$d3 = 0.065$

$d4 = 0.064$

RESISTANCE No.1 = 313.031

RESISTANCE No.2 = 1192.713

RESISTANCE No.3 = 750.555

RESISTANCE No.4 = 268.137

CONDUCTIVITY $\sigma 1 = 5.112 \times 10^{-3}$

$\sigma 2 = 3.504 \times 10^{-3}$

$\sigma 3 = 7.157 \times 10^{-3}$

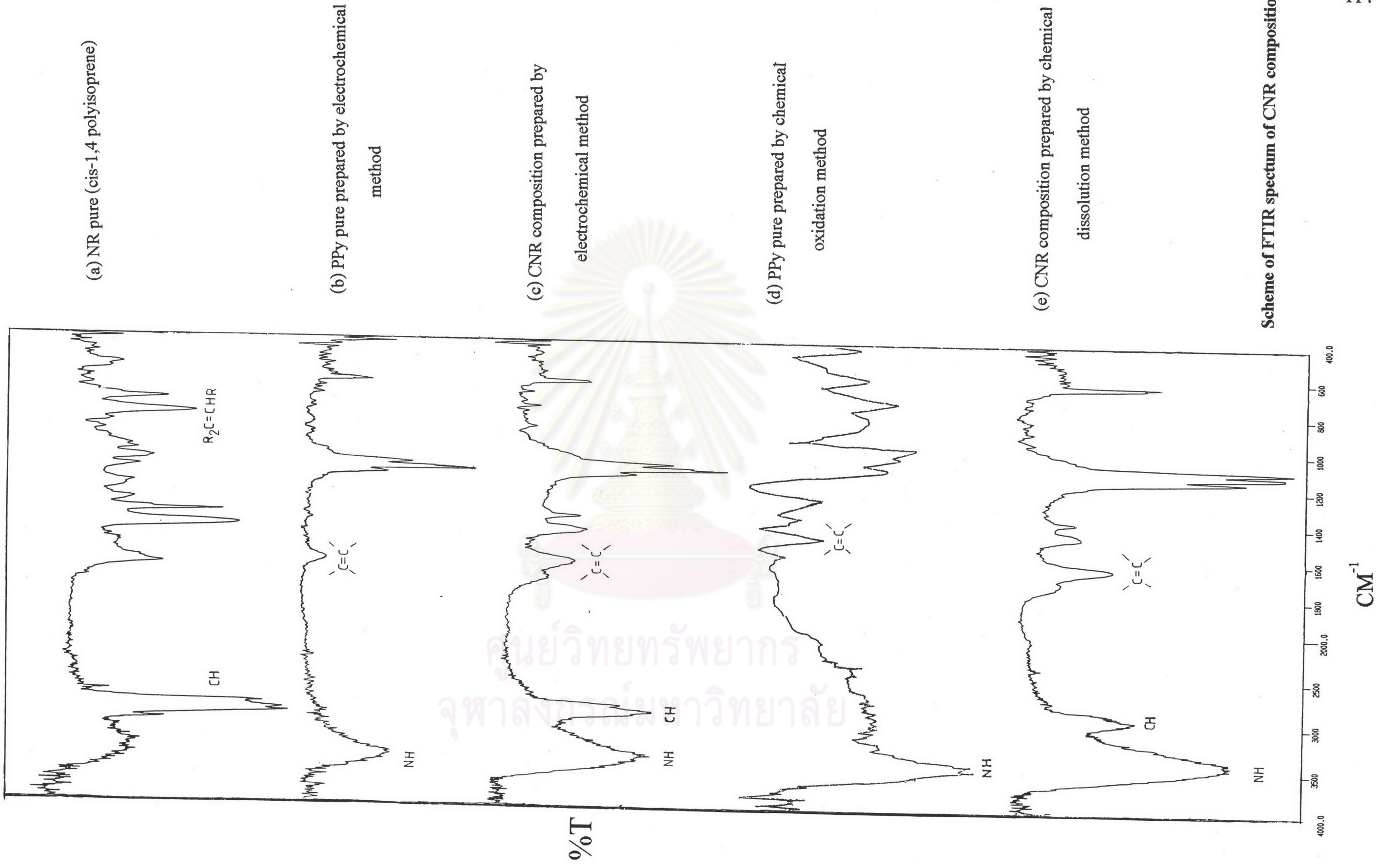$\sigma 4 = 1.152 \times 10^{-3}$

$\sigma avr = 6.825 \times 10^{-3}$

OK

Finally, the average conductivity of CNR sheet can be calculated by Van Der Pauw method to be 7.9×10^{-3} S/cm.

APPENDIX B

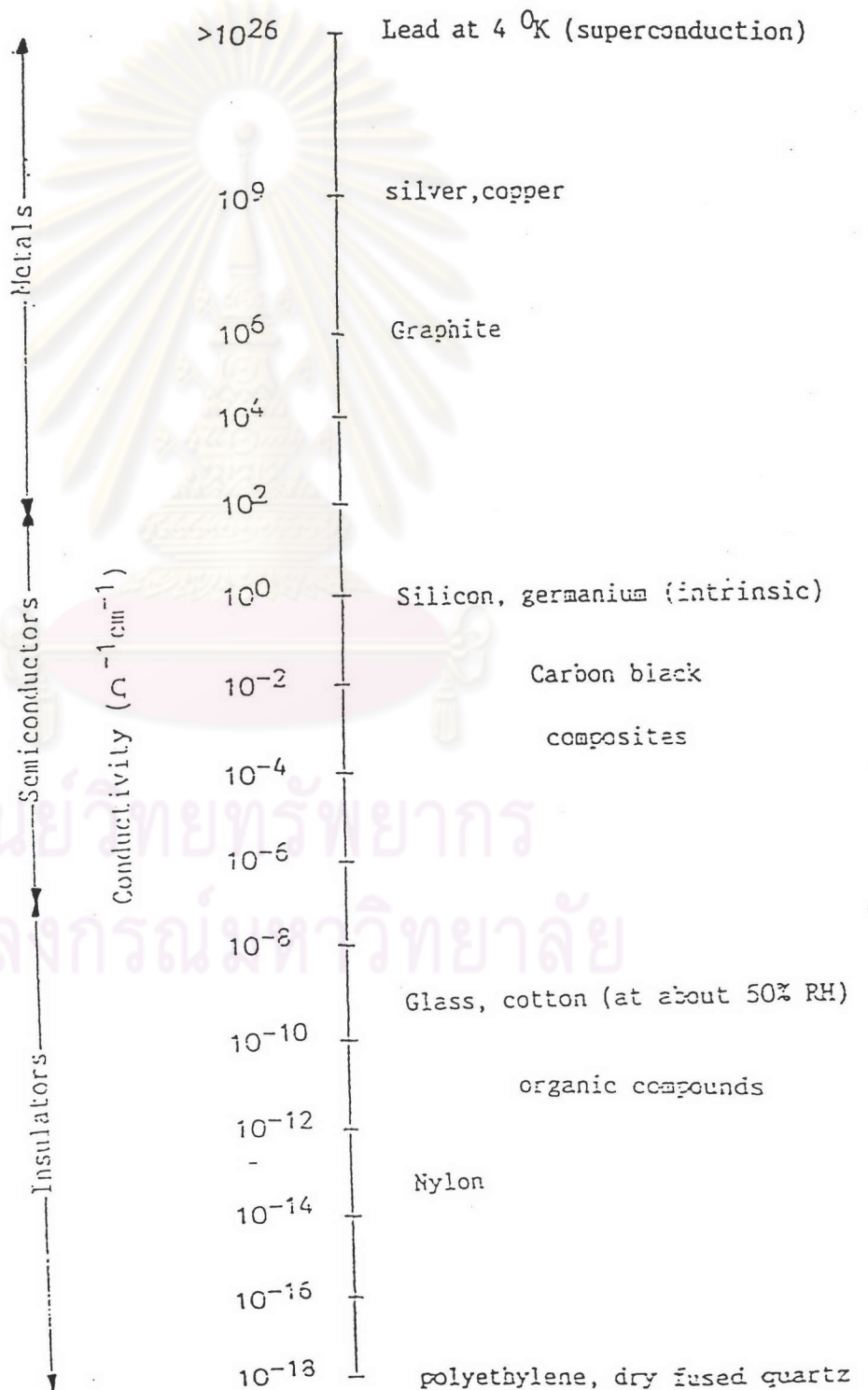**The assignment for the FTIR spectrum of CNR composite.**

Wavenumber ν (cm^{-1})	Assignment
3450	NH stretching (PPy)
2950	CH stretching (NR)
1710	C=C stretching (NR+PPy)
1660	and ring stretching (PPy)
1600	
1490	CH in-plane bending (NH)
1350	
1220	
1180	doping-induced mode (PPy)
1160	
1100	
660	aromatic ring (PPy)
620	and CH out of plane (NH+PPy)
600	

(a) NR pure (cis-1,4 polyisoprene)

(b) PPy pure prepared by electrochemical method

(c) CNR composition prepared by electrochemical method

(d) PPy pure prepared by chemical oxidation method

(e) CNR composition prepared by chemical dissolution method

Scheme of FTIR spectum of CNR composition.

THE CONDUCTIVITY OF REFERENCE MATERIAL[29]

VITA

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