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APPENDICES

Appendix A Determination of PANI and PI molecular structure from elemental analysis

The molecular compositions for polyaniline and polyimide from EA (C, H, N mode) were calculated from equations A.1 and A.2 as follows:

$$\%O = 100 - \%C - \%H - \%N \quad (A.1)$$

$$[X] = \%X / M_x \quad (A.2)$$

where %C, %H and %N = % weights from elemental analyzer of C, H and N

%X = % weight of element (C, H, N, O)

[X] = amount of X element in mole

M_x = molecular weight of X element (g/mol)

The empirical formula of polyaniline; emeraldine base form and polyimide are $(C_6H_{4.5}N_1)_4$ and $(C_{11}H_5O_{2.5}N_1)_2$, respectively. The calculated data were normalized with respect to [N].

Table A.1 Average numbers of mole in the molecular structures of PANI and PI from elemental analyses

Sample	Synthesis date	[C]	[H]	[N]	[O]
EB batch 1	24/5/2001	5.99	4.74	1	-
EB batch 2	16/9/2001	5.97	4.37	1	-
EB batch 3	4/2/2001	6.00	4.67	1	-
PI batch 1	4/2/2002	10.39	5.68	1	2.87
PI batch 2	25/12/2002	10.55	5.88	1	3.10
PI batch 3	8/9/2002	10.36	5.63	1	3.01

Appendix B Calculation of doping level (%) from elemental analysis of the doped polyaniline

The % doping levels of the doped polyaniline films at various ratios of N_A/N_{EB} were calculated from the amount of carbon (C), hydrogen (H), and nitrogen (N) atoms obtained from elemental analysis. The thermogram from TGA at the 1st step weight loss around 40-120 °C was considered as the amount of water at various doping ratios. Then the $\%S_{CSA}$ at various doping ratios was calculated by subtracting out the amount of water, then the percentage doping ratio of camphorsulfonic acid doped polyaniline were calculated as in equation B.2:

$$\%S_{CSA} = 100 - \%O_{H2O} - \%C - \%H - \%N \quad \text{(B.1)}$$

$$\text{\% doping level of PANI-CSA} = \frac{\%S_{CSA}}{\%N} \times \frac{M_N}{M_{SO4}^{2-}} \times 100 \quad \text{(B.2)}$$

For HNO_3 doped PANI, The molar ratio of nitrogen was used to calculate the amount of excess N from $H^+NO_3^-$ by equations B.3-B.5 for various doping ratios whereas the symbol of [ ] means the amount of element in molar ratio. Then, the amounts of excess nitrogen from $H^+NO_3^-$ at various doping ratios were used to calculate the percentage doping ratio of nitric acid doped polyaniline as in equation B.6.

$$[N] = \frac{\%C}{M_C} \times \frac{\text{mol. of N } (=1)}{\text{mol. of C } (=6)} \quad \text{(B.3)}$$

$$\%N_{PANI} = [N] \times M_N \quad \text{(B.4)}$$

$$\%N_{Dopant} = \%N - \%N_{PANI} \quad \text{(B.5)}$$

$$\text{\% doping level of PANI-HNO}_3 = \frac{\%N_{Dopant}}{\%N_{PANI}} \quad \text{(B.6)}$$

Table B.1 Raw data from elemental analyses and the calculated doping levels of HNO_3 doped polyaniline

N_A/N_{EB}	EA Data			Calculated Data			% Doping level
	% C	% H	% N	[N]	$\%N_{PANI}$	$\%N_{Dopant}$	
EB	74.68	4.85	14.52	0.89	12.45	0.00	0.00
0.20	71.09	3.64	14.59	0.99	13.82	0.77	11.14
0.50	66.95	3.75	14.58	0.93	13.02	1.56	24.03
1.00	60.48	3.43	14.69	0.84	11.76	2.93	49.88
2.00	55.51	3.69	15.04	0.77	10.79	4.25	78.74
5.00	54.37	4.28	15.03	0.76	10.57	4.46	84.28
10.00	54.01	3.53	15.40	0.75	10.50	4.90	93.28
20.00	53.60	3.50	15.47	0.74	10.42	5.05	96.85

Table B.2 Raw data from elemental analyses and the calculated doping levels of CSA doped polyaniline

N_A/N_{EB}	EA Data			Calculated Data		% Doping level
	% C	% H	% N	$\% O_{H2O}$	$\% S_{dopant}$	
EB	74.64	4.85	14.52	5.99	0.00	0.00
0.20	71.30	5.34	12.84	5.15	5.37	11.28
0.50	68.78	5.57	11.12	4.36	10.17	24.69
1.00	64.29	5.88	9.24	5.99	14.60	42.68
2.00	61.75	5.98	7.44	5.99	18.83	68.34
5.00	60.73	6.19	6.72	5.08	21.28	85.45
10.00	60.40	6.19	6.03	5.02	22.35	100.00
20.00	60.17	6.06	5.90	6.46	21.42	98.06

Table B.3 Calculated doping level and the electrical conductivity of CSA and HNO_3 doped polyanilines

N_A/N_{EB}	% Doping level		Conductivity (S/cm)	
	HNO_3	CSA	HNO_3	CSA
0.20	11.14	11.28	1.63E-05	1.35E-04
0.50	24.03	24.69	3.11E-04	1.21E-03
1.00	49.88	42.68	1.96E-02	1.26E-02
2.00	78.74	68.34	1.52E+00	1.80E+00
5.00	84.28	85.45	2.15E+00	3.79E+00
10.00	93.28	100.00	2.54E+00	3.94E+00
20.00	96.85	98.06	2.38E+00	7.99E+00

Appendix C Identification of characteristic FT-IR peaks of synthesized polyaniline and polyimide

The FT-IR spectrum of the undoped, doped polyaniline are shown in Table C.1. The values in the [ ] represent the data taken from references.

Table C.1 Assignment peaks for FT-IR absorption bands of undoped and doped polyanilines

Wavenumber (cm^{-1})			Assignments	References
PANI	PANI-HNO_3	PANI-CSA		
3242 ± 3	3247± 3 [3100-3500]	3234 ± 2	N-H stretching	Kang *et al.*(1998)
		1732 ± 3 [1741]	Stretching of C=O group of acid	The Aldrich library of FT-IR Spectra
	1530 ± 8 [1530 - 1540]		N-O asymmetric stretching	Wade *et al.*, (1995)
1584 ± 2	1576 ± 1	1557 ± 6	C=N stretching of quinoid ring	Milton and Monkman *et al.*, (1993)
1493 ± 2	1537 ± 2	1480 ± 1	C=C Stretching of benzenoid ring	Zeng and Ko.,(1998)
	1344 ± 2 [1360-1430]		Vibrational mode of NO_3^-	Wade *et al.*, (1995)

Wavenumber (cm^{-1})			Assignments	References
PANI	PANI-HNO_3	PANI-CSA		
1297 ± 4	1317 ± 1	1300 ± 2	C-N stretching of benzenoid ring	Show-An Chen *et al.*, (1995)
	1228 ± 3 [1230]		C-N stretching through C-N-C angle	Levon *et al.*, (1995)
1155 ± 5	1175 ± 4 [1165]		Broken symmetry mode of quinoid structure	Chan *et al.*, (1994)
		1145 ± 7	A mode of Q=N^+H-B or B-NH-B	Morales *et al.*, (1977)
		1035 ± 6 [1059]	Sulfonic acid salt group	The Aldrich library of FT-IR Spectra
	917 ± 1 [800-860]		Vibrational mode of NO_3^-	Wade *et al.*, (1995)
824 ± 3	836 ± 1 [825]		Out of plane bending of 1,4-ring	Milton and Monkman (1993)
	764 ± 4 [740]	779 ± 5	C-H out of plane bending of 1,2-ring	Kang *et al.*(1998)

The FT-IR spectrum of the synthesized polyimide are shown in Table C.2

Table C.2 Assignment of peaks for FT-IR absorption bands of synthesized polyimide

Wavenumber (cm^{-1})	Assignments	References
1770-1790 [1778]	C=O symmetric stretching.	Han *et al.*(1999)
1726 ± 10 [1730]	C=O asymmetric stretching.	Han *et al.*(1999)
1664 ± 10 [1670]	Amide carbonyl stretching.	Han *et al.*(1999)
1597	C=C in phase of PI.	Han *et al.*(1999)
1500	C-C band of p-substituted.	Han *et al.*(1999)
1380 [1380]	C-N stretching	Asawaknajana, N. (1997)
725 [730]	C=O bending	Asawaknajana, N. (1997)

Appendix D Calculation of doping level from FT-IR

According to Beer's law (Campbell and White, 1989),

$$A_i = \varepsilon_i b_i c_i \qquad (D.1)$$

where A_i = area of i peak

ε_i = absorptivity (cm^2/g)

b_i = path length (cm)

c_i = concentration of i functional group (mol/cm^3)

The area ratio of undoped, CSA and HNO_3 doped polyanilines can be calculated as follows:

$$\text{Area ratio} = A_{1480} / A_{1557} \qquad (D.2)$$

where A_{1480} = Area of peak at 1480 cm^{-1} (C=C aromatic stretching)

A_{1557} = Area of peak at 1557 cm^{-1} (-N= stretching)

Equation D.1 and D.2 can be rewritten as shown in equation D.3

$$A_{1480} / A_{1557} = r \times (c_{1480} / c_{1557}) \qquad (D.3)$$

where $r = \varepsilon_{1480} / \varepsilon_{1557} . b_{1480}/b_{1557}$

Consider the structures of the emeraldine base and the fully doped polyaniline, the values of c_{1480} / c_{1557} are 5.5 and 12, respectively. The values of r can be calculated or calibrated from equation D.3 when we consider the case of the emeraldine salts where we know both area and concentration ratios (the average of last three data points). The r values were found to be 0.0919 and 0.115 for CSA and HNO_3 doped polyanilines, respectively. The % doping level was calculated following the equation D.4.

$$\text{doping level (\%)} = [(A_{1480} / A_{1557}/r) - 5.5]/[(12 - 5.5)] \quad \times 100$$

(D.4)

Table D.1 Doping level of CSA doped polyaniline from FT-IR

Doping ratio (N_A/N_{EB})	A_{1480}	A_{1557}	A_{1480} / A_{1557}	% Doping level
EB	35.56	64.44	0.55	4.85
0.2	41.73	58.27	0.72	31.50
0.5	43.75	56.25	0.78	41.47
1.0	45.26	54.74	0.83	49.43
2.0	47.04	52.96	0.89	59.38
5.0	51.76	48.24	1.07	89.35
10.0	53.24	46.76	1.14	99.97
20.0	51.71	48.29	1.07	89.01

Table D.2 Doping level of HNO_3 doped polyaniline from FT-IR

Doping ratio (N_A/N_{EB})	A_{1480}	A_{1557}	A_{1480} / A_{1557}	% Doping level
EB	35.56	64.44	0.55	33.62
0.2	46.92	53.08	0.88	53.21
0.5	50.74	49.26	1.03	83.59
1.0	55.70	44.30	1.26	33.62
5.0	57.98	42.02	1.38	99.99
10.0	52.91	47.09	1.12	65.69
20.0	53.16	46.84	1.13	67.21

Appendix E Calculation of doping level from EDX

The % doping levels of the doped polyaniline films at various ratios of N_A/N_{EB} were calculated from the amounts of carbon (C), nitrogen (N), oxygen (O) and sulfur (S) mole percents obtained from EDX. For CSA doped polyaniline, the % doping level was calculated from the amounts S as shown in the equation E.1 where the undoped and saturated doping levels correspond to % moles of S equal to 0.00 and 1.00, respectively.

$$\text{Doping level of CSA (\%)} = \%S \times 100 \quad \text{(E.1)}$$

For HNO_3 doped PANI, the percent mole of oxygen was used to calculate the % doping level whereas the undoped and saturated doping levels have the % moles of O equal to 4.07 and 24.80, respectively.

$$\text{Doping level of } HNO_3 \text{ (\%)} = (\%N - 4.07)/(24.80 - 4.07) \times 100 \quad \text{(E.2)}$$

Table E.1 Doping level of CSA doped polyaniline from EDX

Doping ratio (N_A/N_{EB})	% mole of S	% Doping level
EB	0.00	0.00
0.2	0.21	21.00
0.5	0.33	33.33
1.0	0.62	62.33
2.0	0.65	65.00
5.0	0.77	77.67
10.0	0.90	90.67
20.0	1.00	100.33

Table E.2 Doping level of HNO_3 doped polyaniline from EDX

Doping ratio (N_A/N_{EB})	% mole of O	% Doping level
EB	4.07	0.00
0.2	12.22	24.18
0.5	15.41	43.07
1.0	17.94	58.07
2.0	21.79	80.87
5.0	25.02	99.98
10.0	25.35	101.92
20.0	24.05	94.20

Appendix F Identification of characteristic peaks of polyaniline from UV-visible spectroscopy

The UV-Visible spectra of undoped and doped polyanilines from the references are shown in Table F.1. The wavelength in [ ] refers to the results of the assignments cited from references.

Table F.1 Assignment peaks of UV-Visible peaks of undoped and doped polyanilines

Wavelength (nm)	Assignments	References
325 ± 5 [325]	π-π* transition of benzenoid segment	Stejskal *et al.*, (1996)
635 ± 5 [630]	π-π* transition of quinoid segment	Stejskal *et al.*, (1996)
440 ± 10 [440]	transition of quinoid segment to bipolaron state	Zeng *et al.*, (1992)
800 ± 40 [830]	localized of polaron state	Olinga *et al.*, (2000)

The data from UV-Visible spectra are summarized in Table F.2 whereas N/A means not detectable.

Table F.2 Summarized data from UV-Visible spectra of undoped and doped polyanilines

Doping ratio	Acid type	Absorbance			
		Wavelength (cm^{-1})			
		320-340	630-640	430-450	760-840
EB	-	0.47	0.39	N/A	N/A
0.20	CSA	0.47	0.40	N/A	N/A
0.50	CSA	0.47	0.40	N/A	N/A
1.00	CSA	0.37	0.22	N/A	N/A
2.00	CSA	0.40	0.26	N/A	N/A
5.00	CSA	0.36	N/A	N/A	0.30
10.00	CSA	0.55	N/A	0.17	0.31
20.00	CSA	0.70	N/A	0.15	0.29
0.20	HNO_3	0.48	0.40	N/A	N/A
0.50	HNO_3	0.46	0.39	N/A	N/A
1.00	HNO_3	0.47	0.40	N/A	N/A
2.00	HNO_3	0.45	0.27	N/A	N/A
5.00	HNO_3	0.40	N/A	0.12	0.22
10.00	HNO_3	0.41	N/A	0.13	0.23
20.00	HNO_3	0.43	N/A	0.13	0.23

Appendix G Raw data of percentage weight loss of PANI and PI and the composites by TGA

The raw data of percentage weight loss of undoped polyaniline, 10-CSA and 10-HNO_3 doped polyaniline are shown in Tables G.1 and G.2, respectively.

Table G.1 Raw data of percentage weight loss of undoped and 10-CSA doped polyanilines

Doping ratio	% weight loss			% Residue at 700 °C
	Temperature range (°C)			
	30 - 110	240 - 400	400 - 580	
EB #1	6.19	-	38.73	53.48
EB #2	6.10	-	32.66	57.37
0.20	5.15, 4.83	6.54, 7.42	16.10, 18.44	66.86, 70.21
0.50	4.36	15.48	25.30	54.86
5.0	5.08	20.25	13.29	52.85
10.0	5.02, 4.98	36.41, 35.50	21.34, 16.98	33.04, 35.76
20.0	6.46, 5.26	39.81, 42.29	17.55, 20.16	32.79, 30.06

Table G.2 Raw data of percentage weight loss of undoped and 10-HNO_3 doped polyanilines

Doping ratio	% weight loss			% Residue at 700 °C
	Temperature range (°C)			
	30 - 110	160 - 320	400 - 580	
EB #1	6.19	-	38.73	53.48
EB #2	6.10	-	32.66	57.37
0.20	8.97, 7.63	9.66, 10.61	11.07, 9.89	62.37, 60.94
0.50	8.15	10.47	12.72	60.21
5.0	8.51	14.36	13.62	61.32
10.0	7.15	15.68	6.74	62.12
20.0	6.84, 7.25	19.10, 18.79	11.14, 12.46	57.85, 55.60

The raw data of percentage weight loss of poly(amic acid), polyimide and 10-CSA and 10-HNO_3 doped polyaniline/polyimide composites are shown in Tables G.3, G.4 and G.5, respectively.

Table G.3 Raw data of percentage weight loss of poly(amic acid) and polyimide

Sample	% weight loss		% Residue at 700 °C
	Temperature range (°C)		
	100 - 270	540 - 640	
PAA batch 1	41.07	18.46	33.38
PAA batch 2	35.23	24.88	35.61
PI batch 1	12.20	30.00	49.88
PI batch 2	8.38, 9.98	40.38, 37.25	48.94, 45.90
PI batch 3	9.42	35.69	52.33

Table G.4 Raw data of percentage weight loss of PANI-10CSA/PI composite

% PI	% weight loss			% Residue at 700 °C
	Temperature range (°C)			
	30 - 110	240 - 400	400 - 650	
1	6.64	39.84	17.23	31.8
10	5.98	33.76	14.62	36.46
30	5.01	32.13	22.31	38.92
50	3.14	25.47	27.44	42.14
70	2.95	18.84	31.43	45.32
75	3.13	18.26	32.62	45.96
80	2.28	14.47	35.11	46.51
90	1.97	11.64	37.22	47.70

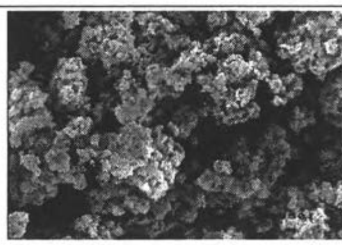
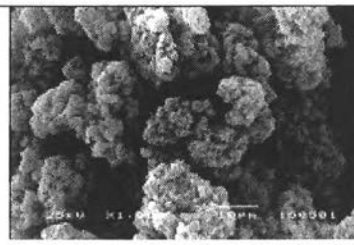
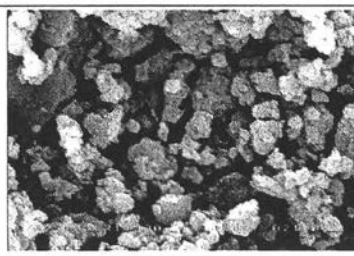
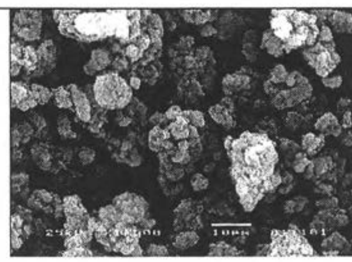
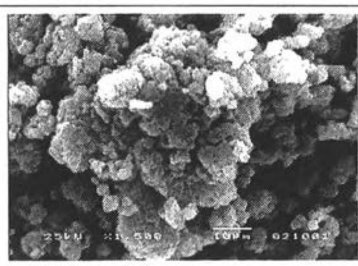
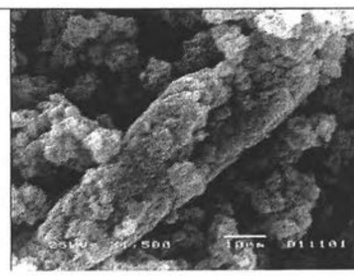
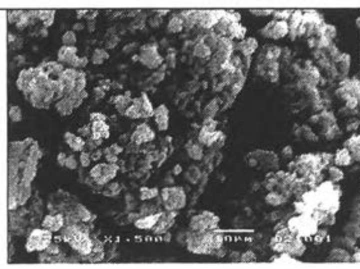
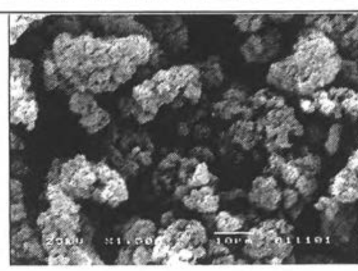
Table G.5 Raw data of percentage weight loss of PANI-10HNO_3/PI composite

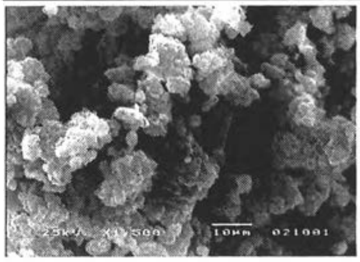
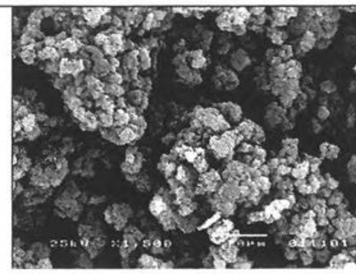
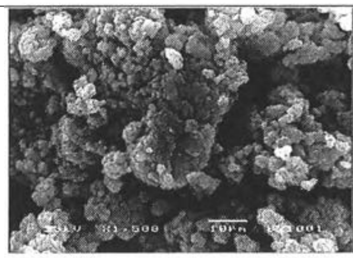
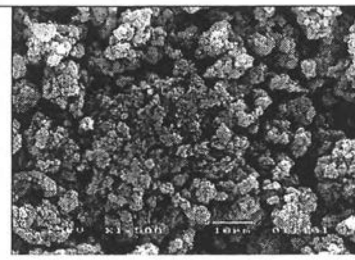
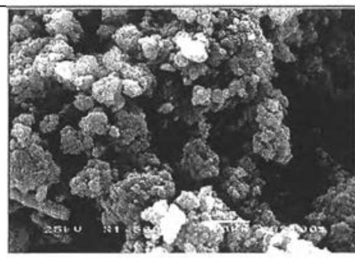
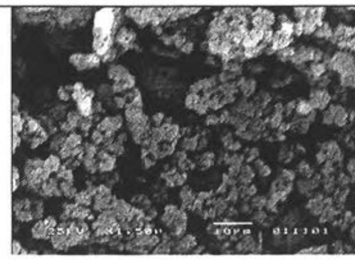
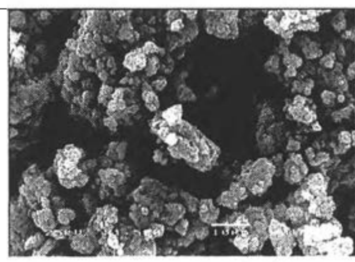
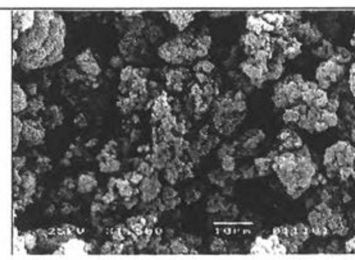
% PI	% weight loss			% Residue at 700 °C
	Temperature range (°C)			
	30 - 110	160 - 320	400 - 650	
1	8.23	23.75	8.40	54.08
10	6.54	22.74	13.00	54.10
30	5.32	19.79	19.84	52.37
50	3.65	16.33	26.13	51.59
70	3.31	12.85	30.71	50.31
75	1.71	12.72	33.41	51.05
80	2.72	11.97	34.09	50.04
90	2.45	10.02	36.46	50.00

Appendix H Scanning electron micrograph of PANI and PI and composites

The scanning electron micrograph of undoped polyaniline, CSA and HNO_3 doped polyaniline are shown in Table H.1.

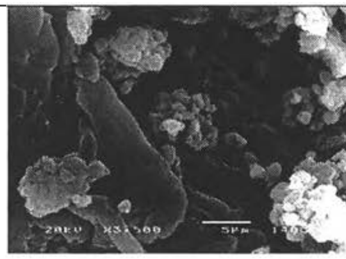
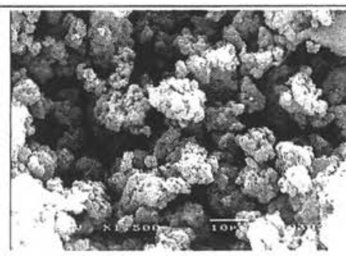
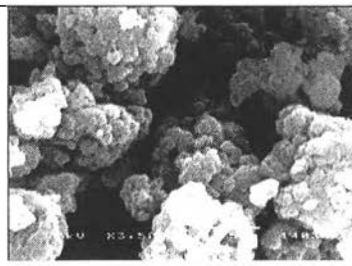
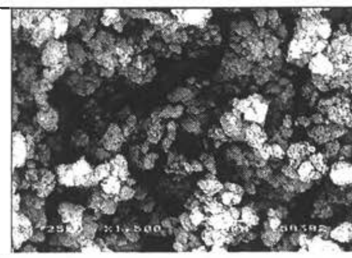
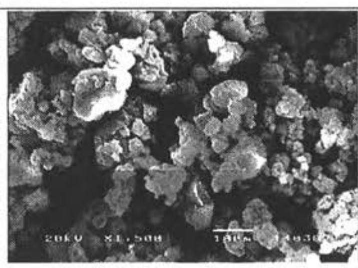
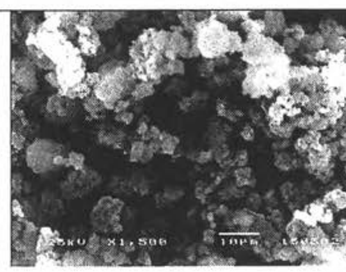
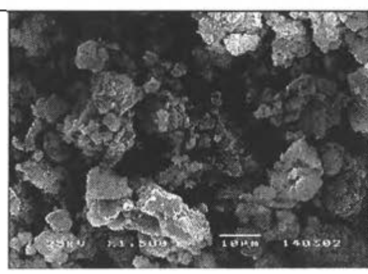
Table H.1 Scanning electron micrograph of undoped, CSA and HNO_3 doped polyaniline (powder form; x 1500).

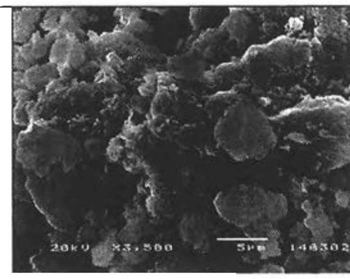
N_A/N_{EB}	CSA	HNO_3
EB		
0.2		
0.5		
1.0		

N_A/N_{EB}	CSA	HNO_3
2.0		
5.0		
10.0		
20.0		

The scanning electron micrograph of polyimide, 10-CSA and 10-HNO_3 doped polyaniline/polyimide composite at various blend ratios are shown in Table H.2.

Table H.2 Scanning electron micrograph of polyimide, 10-CSA and 10-HNO_3 doped polyaniline/polyimide composite at various blend ratios (powder form; x 1500).

Blend ratio (PI, % w/w)	CSA	HNO_3
1		
10		N/A
30	N/A	
50		
80		N/A

Blend ratio (PI, % w/w)	CSA	HNO_3
100 (PI pure)	N/A	 (x 3500)

Appendix I Determination of crystallinity percentage from XRD

The percentage of crystallinity was calculated from XRD data for undoped, CSA and HNO_3 doped polyanilines. The value of 2θ, d-spacing (Å) and Miller indices of emeraldine salt are shown in Table I.1, the values in [ ] are the results quoted in references (Winokur et al., 1998).

Table I.1 Values of 2θ, d-spacing (Å) and Miller indices of emeraldine hydrochloride

2θ	d-spacing (Å)	Miller indices
9.5 ± 0.5 [9.5]	9.57	0 0 1
14 ± 1 [14.52]	5.94	0 1 0
20.5 [20.62]	4.26	1 0 0
25.5 ± 2 [25.51]	3.51	1 1 0

The crystallinity percentage was calculated by a Gaussian's curve fitting method to find the amorphous and crystalline curve areas as shown in equation I.1.

$$\% \text{ Crystallinity} = \frac{A_{cryst}}{A_{cryst} + A_{amorphous}} \times 100 \qquad (I.1)$$

where A_{cryst} = The area of crystalline peak

$A_{amorphous}$ = The area of amorphous peak

Table I.2 Calculated crystallinity of CSA doped polyaniline

N_A/N_{EB}	% Amorphous	% Crystalline
EB	97.95	12.05
0.2	73.56	26.44
0.5	63.70	36.30
1.0	63.05	36.95
2.0	60.87	39.13
5.0	56.45	43.55
10.0	54.53	45.47
20.0	60.08	39.92

Table I.3 Calculated crystallinity of HNO_3 doped polyaniline

N_A/N_{EB}	% Amorphous	% Crystalline
EB	97.95	12.05
0.2	49.76	50.24
0.5	47.00	53.00
1.0	46.00	54.00
2.0	41.72	58.28
5.0	39.62	60.38
10.0	39.93	60.07
20.0	39.95	60.05

Appendix J Determination of Ohm's law regime

Ohmic regime or linear regime is the regime in which applied voltage is linearly dependent on current according to Ohm's law in equation J.1.

Due to the specific conductivity given by the equation J.1, the acceptable current, which was used in the experiments, should be in the Ohmic regime. Figures J.1 and J.2 are the plots of V_d and I by using a doped polyaniline and a silicon wafer as a standard material. These experiments were carried out under a pressure 1 atm, 46 - 52 % relative humidity, and 26 - 28°C.

$$V_d = IR \qquad (J.1)$$

where V_d = voltage drop (mV)

I = current (mA)

R = resistivity (Ω)

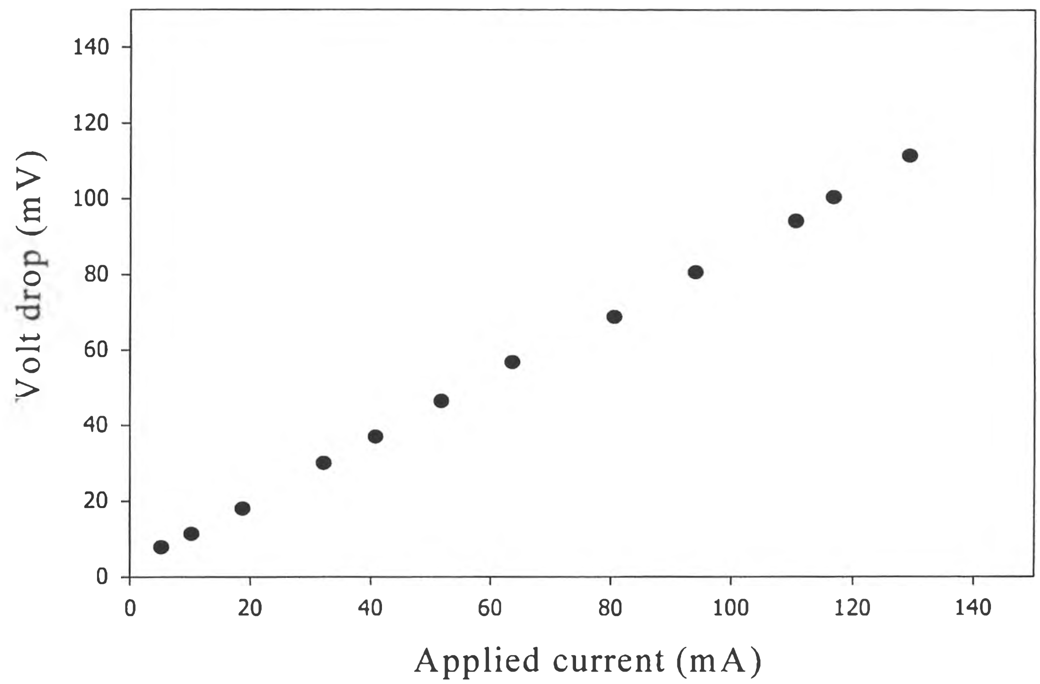


Figure J.1 Ohm's law region of the applied current and the volt drop by using the silicon wafer (Si8-3.5A) as a standard material.

The current range of silicon type Si10-28A is 0-15 mA (Swarngwong, J., 2000). The correlation for the silicon type Si8-3.5A (N) is shown in Figure J.1 which has a current range between 0-140 mA.

The Ohmic law regime of doped polyaniline is shown in Figure J.2, which shows a current range 0-65 and 0-80 mA for CSA and HNO_3 doped polyaniline, respectively.

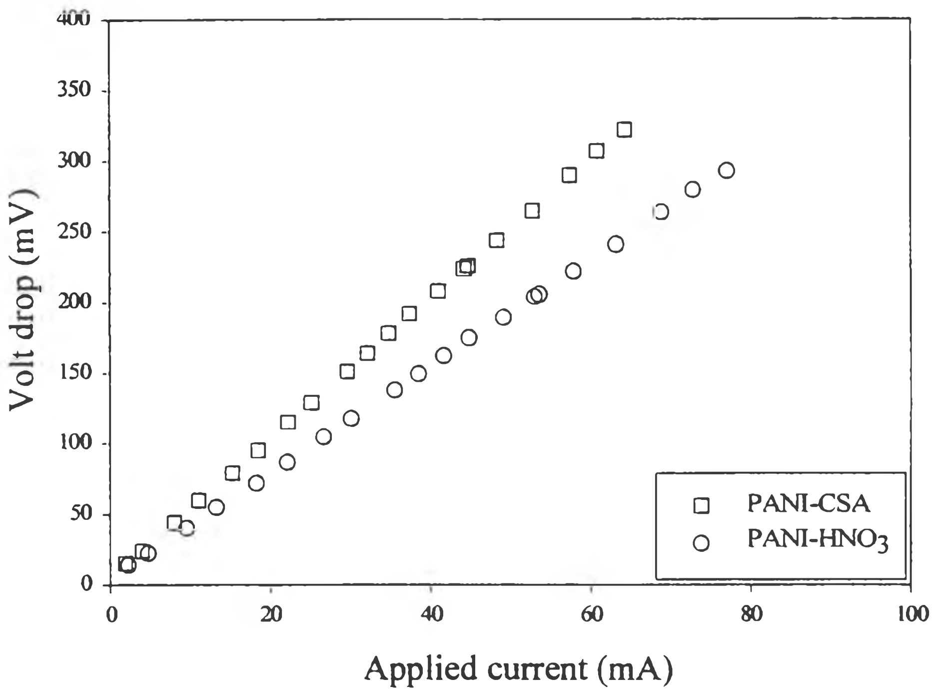
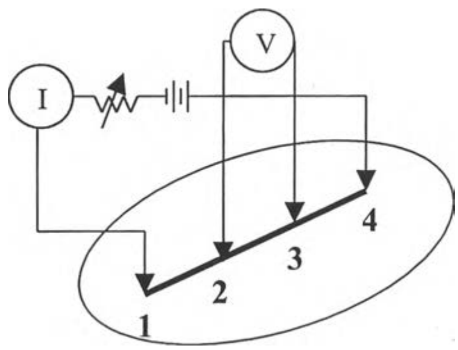


Figure J.2 Ohm's law regime: the voltage drop and the applied current of the camphorsulfonic acid doped polyaniline (PANI-CSA) and nitric acid doped polyaniline (PANI-HNO_3) pellets at doping ratio of N_A/N_{EB} =10.

Appendix K Determination of the geometric correction factor (K)

The electrical conductivity of polyaniline pellet was measured by a four-point probe meter. Probe head assemblies are available in two different arrangements of the probe pins; a linear array and a square array. For the linear array, a constant current (I) was applied to the two outer electrodes and the sample voltage (V) was measured between the two inner electrodes as shown in Scheme K.1.



Scheme K.1 Linear array four-point probe meter.

As in the case of microelectronic structures, four point probe sheet resistance measurements are susceptible to geometric error (K) which can be calculated by using Equation K.1.

$$K = \frac{w}{l} \qquad \text{(K.1)}$$

where	K	=	correction factor
	w	=	probe width (cm)
	l	=	probe length (cm).

In this measurement, the constant K value was determined by using a standard sheet with a known resistivity value; we used silicon wafer chips (SiO_2). K was calculated by using Equation K.2.

$$K = \frac{\rho}{R \times t} = \frac{I \times \rho}{V \times t} \qquad (K.2)$$

where K = geometric correction factor

ρ = resistivity of stand materials which were calibrated by using a four point probe at King Mongkut's Institute Technology of Lad Krabang (Ω.cm)

t = film thickness (cm)

R = film resistance (Ω)

I = current (A)

V = voltage drop (V).

The sheet resistivity (ρ) and thickness of silicon wafer chips are shown in Table K.1.

Table K.1 Sheet resistivity and thickness of standard sheet (SiO_2)

Standard No.	Material detail	Sheet Resistivity, ρ, (Ω.cm)	Thickness (cm)
1	Si 10-28A	4.58E+01	5.34E-02
2	Si8-35A	1.53	7.16E-02

Table K.2 Determination of K factor of the constructed four point probe meter (Probe CW1)

Condition: Temperature 26-28°C

Relative humidity 48-52%

Pressure 1 atm

Standard No.	I (mA)	V (mV)	K	Standard No.	I (mA)	V (mV)	K
Si 10-28A	9.8	4.9	1.89	Si8-35A	10.1	218	2.57
	190	61	2.94		16	384	2.31
	566	163.6	3.26		25	600	2.31
	626	180.8	3.27		42	991	2.35
	1023	268	3.60		81	1888	2.38
	1389	354	3.70		92	2105	2.42
Average			3.11	Average			2.39
SD			0.65	SD			0.09
				K value			2.75

Table K.3 Determination of K factor of the constructed four point probe meter (Probe P_AO)

Condition: Temperature 26-28°C

Relative humidity 48-52%

Pressure 1 atm

Standard No.	I (mA)	V (mV)	K	Standard No.	I (mA)	V (mV)	K
Si 10-28A	6.9	102.9	3.72	Si8-35A	2.29	57.5	4.99
	21	322	3.62		3.50	87.5	5.01
	26	391	3.69		4.86	122.5	4.97
	38	579	3.64		6.07	149.5	5.09
	45	696	3.59		7.10	180.5	4.93
	59	905	3.62				
Average			3.64	Average			4.16
SD			0.05	SD			0.058
				K value			3.74

Appendix L Conductivity measurement

The specific conductivity values of polyaniline pellets were measured by using the four point probe under the atmospheric pressure, 48-52 % relative humidity and 26-28 °C. The K value of the probe is 2.941. The thickness of pellets was measured by thickness gauge. The data of conductivity measurement are shown in Table L.1.

Table L.1 Raw data of conductivity measurement for CSA and HNO_3 doped polyanilines (N_A/N_{EB} = 10)

Acid	Doping ratio	Thickness (cm)	Applied voltage (mV)		Current (mA)		Voltage drop (mV)		σ (S/cm)	
			Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
CSA	0.20	0.01398	18.053	3.86E-02	0.008	2.84E-03	1132.000	4.24E+00	1.96E-04	9.34E-06
	0.20	0.01364	12.978	3.78E-02	0.006	2.31E-03	922.500	3.30E+00	1.79E-04	4.41E-06
	0.50	0.01561	8.593	3.30E-02	0.037	1.77E-02	618.500	3.01E+00	1.51E-03	5.33E-05
	0.50	0.01346	12.930	4.01E-02	0.056	2.08E-02	1237.500	4.61E+00	1.19E-03	4.88E-06
	1.00	0.01227	7.345	3.92E-02	0.718	5.08E-01	608.250	4.24E+00	0.032	6.33E-04
	1.00	0.01439	10.728	3.25E-02	1.382	5.30E-01	1172.250	4.51E+00	0.036	6.65E-05
	2.00	0.01450	3.173	1.05E-02	13.480	9.71E+00	168.667	1.15E+00	2.154	1.86E-01
	2.00	0.01147	3.025	1.12E-02	9.370	6.23E+00	112.000	6.91E-01	2.063	1.80E-01
	5.00	0.01248	2.188	6.97E-03	13.450	9.03E+00	77.750	4.84E-01	4.623	5.90E-01
	5.00	0.01212	2.503	1.11E-02	16.163	1.12E+01	100.500	6.55E-01	5.301	4.08E-01
	10.00	0.01181	3.628	1.20E-02	12.210	1.23E+01	118.500	9.16E-01	3.288	2.77E+00
	10.00	0.01269	2.595	1.08E-02	27.340	1.99E+01	143.250	1.02E+00	5.022	2.86E-01
	20.00	0.01245	2.430	9.96E-03	23.804	1.90E+01	96.400	7.19E-01	6.292	8.85E-01
	20.00	0.01253	2.952	1.03E-02	29.314	2.03E+01	159.000	1.05E+00	5.147	3.21E-01
HNO_3	0.20	0.01163	5.833	3.05E-02	0.620	4.01E-01	611.750	3.88E+00	0.022	8.12E-04
	0.20	0.01155	6.150	3.17E-02	0.527	3.47E-01	436.500	2.84E+00	0.030	7.79E-04
	0.50	0.01245	5.595	3.06E-02	1.266	8.62E-01	678.500	4.55E+00	0.051	8.50E-04

Acid	Doping ratio	Thickness (cm)	Applied voltage (mV)		Current (mA)		Voltage drop (mV)		σ (S/cm)	
			Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
	0.50	0.01150	5.595	1.05E-02	0.191	1.87E-01	80.000	7.28E-01	0.056	1.87E-02
	1.00	0.01197	5.595	2.84E-02	1.285	7.65E-01	485.750	2.88E+00	0.062	2.54E-04
	1.00	0.01116	5.595	2.64E-02	1.303	9.07E-01	581.750	4.05E+00	0.053	1.05E-04
	2.00	0.01130	5.595	1.27E-02	15.792	9.55E+00	391.000	2.31E+00	1.197	5.78E-02
	2.00	0.01168	5.595	1.55E-02	26.034	1.45E+01	403.400	2.17E+00	1.803	8.77E-02
	5.00	0.01198	5.595	1.75E-02	8.998	4.60E+00	371.500	1.85E+00	0.714	1.02E-02
	5.00	0.01200	5.595	1.87E-02	11.713	5.72E+00	435.250	2.11E+00	0.732	4.97E-03
	10.00	0.01164	5.595	2.28E-02	13.674	8.70E+00	617.000	3.89E+00	0.618	9.75E-03
	10.00	0.01125	5.595	2.14E-02	20.302	1.01E+01	602.000	2.95E+00	0.968	1.14E-02
	20.00	0.01134	5.595	2.35E-02	12.750	7.99E+00	454.000	2.83E+00	0.749	1.23E-02
	20.00	0.01220	5.595	2.36E-02	15.795	8.605721	571.500	3.08E+00	0.752	8.93E-03

Table L.2 Raw data of conductivity measurement for CSA and HNO_3 doped polyanilines (N_A/N_{EB} = 10) blend with PI at various blend ratios

Dopant	% PI	Thickness (cm)	Applied voltage (V)		Current (mA)		Voltage drop (mV)		σ (S/cm)	
			Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
CSA	1.00	0.01250	8.90	8.96E-02	15.00	1.58E-01	116.54	5.37E+00	3.50	8.00E-02
	1.00	0.01256	9.40	8.60E-02	15.00	2.36E-01	112.08	1.52E+01	3.62	4.19E-02
	5.00	0.01285	11.60	7.76E-02	14.60	1.60E-01	123.25	6.89E+00	3.13	6.14E-02
	5.00	0.01285	10.20	7.50E-02	14.60	1.59E-01	123.94	1.43E+01	3.12	2.94E-02
	10.00	0.01302	8.70	7.49E-02	15.20	1.40E-01	135.64	4.67E+00	2.93	7.83E-02
	10.00	0.01302	8.60	4.90E-02	15.20	2.15E-01	135.90	1.07E+01	2.92	5.25E-02
	20.00	0.01227	14.60	5.59E-02	14.90	1.10E-01	207.56	5.69E+00	1.99	5.36E-02
	20.00	0.01227	12.00	6.90E-02	14.90	2.87E-01	218.35	9.58E+00	1.89	8.30E-02
	30.00	0.01285	12.50	2.36E-02	10.60	2.50E-01	245.84	7.75E+00	1.14	8.54E-02
	30.00	0.01285	11.00	9.70E-02	10.60	3.69E-01	268.15	8.36E+00	1.05	1.17E-01
	50.00	0.01223	13.00	4.90E-02	6.50	2.10E-01	520.34	8.96E+00	0.35	6.52E-02
	50.00	0.01223	10.00	6.60E-02	6.50	6.35E-01	521.09	5.69E+00	0.35	3.10E-01
	70.00	0.01256	15.90	4.80E-02	5.50	2.40E-01	2053.71	1.04E+01	0.07	6.27E-02
	70.00	0.01256	12.20	9.80E-02	5.50	4.23E-01	2050.89	6.83E+00	0.07	1.68E-01
HNO_3	1.00	0.01267	14.30	5.50E-02	18.90	1.30E-01	161.97	6.39E+00	3.13	5.46E-02
	1.00	0.01267	10.36	8.50E-02	18.90	3.12E-01	160.56	7.69E+00	3.16	1.09E-01
	5.00	0.01228	15.60	9.60E-02	18.70	2.50E-01	218.32	5.63E+00	2.37	1.23E-01
	5.00	0.01228	12.50	8.10E-02	18.70	2.11E-01	212.55	4.59E+00	2.44	1.27E-01
	10.00	0.01233	19.30	9.50E-02	13.60	2.70E-01	173.05	4.92E+00	2.17	1.51E-01
	10.00	0.01233	10.60	9.20E-02	13.60	1.05E-01	175.58	9.16E+00	2.14	3.16E-02
	20.00	0.01205	12.60	9.70E-02	10.60	1.60E-01	168.59	8.99E+00	1.77	5.02E-02
	20.00	0.01205	9.60	9.90E-02	10.60	9.80E-02	170.04	1.06E+01	1.76	2.60E-02
	30.00	0.01242	14.40	6.30E-02	9.90	1.90E-01	421.84	9.65E+00	0.64	5.39E-02
	30.00	0.01242	8.70	1.60E-01	9.90	7.60E-02	420.72	1.27E+01	0.64	1.64E-02
	50.00	0.01401	18.00	8.60E-02	7.90	1.50E-01	353.23	5.69E+00	0.54	6.40E-02
	50.00	0.01401	6.90	4.80E-02	7.90	1.26E-01	344.28	1.64E+01	0.56	1.87E-02
	70.00	0.01226	19.00	7.60E-02	5.60	1.90E-01	1343.52	1.04E+01	0.12	5.09E-02
	70.00	0.01226	6.80	6.10E-02	5.60	1.59E-01	1229.70	2.07E+01	0.13	2.13E-02

Appendix M Conductivity measurement upon expose to CO

The specific conductivity values of polyaniline pellets upon exposure to CO were measured by using the four-point probe at pressure 1 atm., 65-69 % relative humidity and various temperatures. The K value of the probe is 2.941. The thickness of pellets was measured by thickness gauge. The data of conductivity measurement are shown in Table M.1, M.2 and M.3. The values of $\Delta\sigma$ and $\%\Delta\sigma$ are calculated from equation M.1 and M.2, respectively.

$$\Delta\sigma = \sigma_{CO} - \sigma_{N2,f} \quad \text{(M.1)}$$

$$\%\Delta\sigma = (\Delta\sigma/\sigma_{N2,f}) \times 100 \quad \text{(M.2)}$$

where σ_{CO} = the specific conductivity of CO (S/cm)

$\sigma_{N2,f}$ = the specific conductivity of N_2 at final (S/cm)

$\sigma_{N2,ini}$ = the specific conductivity of N_2 at initial (S/cm)

σ_{vac} = the specific conductivity of pellet after evacuated (S/cm)

σ_{air} = the specific conductivity of pellet in ambient at 1 atm (S/cm)

Table M.1 Raw data of conductivity measurement upon exposure to CO for CSA and HNO_3 doped polyanilines at 25 °C

Acid	Doping ratio	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	$\%\Delta\sigma$
CSA #1	1	1.56E-02	9.62E-03	8.41E-03	1000	9.00E-03	9.67E-03	1.26E-03	14.98
					500	8.88E-03	9.58E-03	1.17E-03	13.91
					250	9.16E-03	9.47E-03	1.06E-03	12.60
					125	8.81E-03	9.41E-03	1.00E-03	11.89
					62.5	8.74E-03	9.21E-03	8.00E-04	9.51
					31.25	8.38E-03	8.87E-03	4.60E-04	5.47
					15.63	8.61E-03	8.87E-03	4.60E-04	5.47
					7.81	-	-	-	-
CSA #2	1	1.91E-02	1.28E-02	1.14E-02	1000	1.21E-02	1.34E-02	2.00E-03	17.54
					500	1.19E-02	1.29E-02	1.50E-03	13.16
					250	1.20E-02	1.26E-02	1.20E-03	10.53
					125	1.16E-02	1.22E-02	8.00E-04	7.02
					62.5	1.18E-02	1.20E-02	6.00E-04	5.26
					31.25	1.18E-02	1.20E-02	6.00E-04	5.26
					15.62	1.16E-02	1.19E-02	5.00E-04	4.39
					7.81	1.14E-02	1.16E-02	2.00E-04	1.75
CSA #1	10	2.72	2.25	2.29	1000	2.94E+00	3.25E+00	9.60E-01	42.67
					500	2.21E+00	2.41E+00	1.20E-01	5.33
					250	2.34E+00	2.51E+00	2.20E-01	9.78
					125	2.32E+00	2.39E+00	1.00E-01	4.44
					62.5	2.24E+00	2.30E+00	1.00E-02	0.44
					31.25	-	-	-	-
					15.63	-	-	-	-
					7.81	-	-	-	-

Acid	Doping ratio	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
CSA #2	10	2.72	2.25	2.29	1000	1.32E+00	1.51E+00	6.50E-01	65.36
					500	1.25E+00	1.35E+00	4.90E-01	49.27
					250	1.02E+00	1.11E+00	2.50E-01	25.14
					125	-	-	-	-
					62.5	8.40E-01	9.30E-01	7.00E-02	7.04
					31.25	9.40E-01	9.90E-01	1.30E-01	13.07
					15.63	1.00E+00	1.23E+00	3.70E-01	37.20
					7.81	8.10E-01	1.24E+00	3.80E-01	38.21
CSA #3	10	4.84	0.62	0.46	1000	8.00E-01	9.10E-01	4.53E-01	73.32
					500	7.20E-01	7.80E-01	3.23E-01	52.28
					250	6.90E-01	7.20E-01	2.63E-01	42.57
					125	6.80E-01	6.80E-01	2.23E-01	36.10
					62.5	6.76E-01	6.30E-01	1.73E-01	28.01
					31.25	6.18E-01	5.89E-01	1.32E-01	21.38
					15.63	-	-	-	-
					7.81	-	-	-	-
CSA #4	10	2.86	1.35	1.27	1000	1.58E+00	1.86E+00	5.90E-01	46.46
					500	1.45E+00	1.61E+00	3.44E-01	27.09
					250	1.30E+00	1.42E+00	1.50E-01	11.81
					125	1.28E+00	1.36E+00	9.00E-02	7.09
					62.5	1.30E+00	1.33E+00	6.00E-02	4.72
					31.25	1.29E+00	1.30E+00	3.00E-02	2.36
					15.63	1.24E+00	1.29E+00	2.00E-02	1.57
					7.81	1.26E+00	1.28E+00	1.00E-02	0.79
HNO_3 #1	1	3.27E-02	2.03E-02	1.73E-02	1000	2.52E-02	2.75E-02	1.02E-02	58.96
					500	2.23E-02	2.45E-02	7.20E-03	41.62
					250	2.05E-02	2.22E-02	4.90E-03	28.32
					125	1.87E-02	2.13E-02	4.00E-03	23.12
					62.5	1.90E-02	1.96E-02	2.30E-03	13.29

Acid	Doping ratio	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	$\%\Delta\sigma$
					31.25	1.81E-02	1.87E-02	1.40E-03	8.09
					15.63	1.78E-02	1.81E-02	8.00E-04	4.62
					7.81	1.76E-02	1.77E-02	4.00E-04	2.31
HNO_3 #2	1	4.20E-02	5.35E-02	1.19E-03	1000	6.35E-03	1.16E-02	1.04E-02	874.87
					500	3.78E-03	7.27E-03	6.08E-03	508.79
					250	3.83E-03	5.26E-03	4.07E-03	340.54
					125	3.83E-03	9.50E-03	8.31E-03	695.56
					62.5	3.47E-03	4.35E-03	3.16E-03	264.66
					31.25	2.70E-03	2.99E-03	1.80E-03	150.42
					15.63	2.89E-03	2.60E-03	1.41E-03	117.67
					7.81	1.18E-03	1.83E-03	6.33E-04	53.02
HNO_3 #1	10	1.99	1.88	1.46	1000	1.78E+00	1.92E+00	4.60E-01	31.51
					500	1.75E+00	1.82E+00	3.57E-01	24.46
					250	1.75E+00	1.85E+00	3.90E-01	26.71
					125	1.76E+00	1.62E+00	1.57E-01	10.78
					62.5	1.50E+00	1.56E+00	1.01E-01	6.94
					31.25	1.43E+00	1.51E+00	5.46E-02	3.74
					15.63	1.42E+00	1.51E+00	4.75E-02	3.25
					7.81	-	-	-	-
HNO_3 #2	10	2.78	1.87	1.85	1000	1.58E+00	2.45E+00	6.00E-01	32.43
					500	1.55E+00	2.12E+00	2.70E-01	14.59
					250	1.57E+00	1.96E+00	1.11E-01	6.00
					125	1.61E+00	1.91E+00	6.20E-02	3.35
					62.5	1.54E+00	1.89E+00	4.00E-02	2.16
					31.25	1.66E+00	1.87E+00	2.00E-02	1.08
					15.63	-	-	-	-
					7.81	-	-	-	-
HNO_3 #3	10	2.44	1.83	1.41	1000	1.58E+00	1.74E+00	3.30E-01	23.41
					500	1.47E+00	1.66E+00	2.51E-01	17.81

Acid	Doping ratio	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					250	1.53E+00	1.62E+00	2.09E-01	14.84
					125	1.53E+00	1.75E+00	3.40E-01	24.12
					62.5	1.59E+00	1.69E+00	2.80E-01	19.87
					31.25	1.53E+00	1.54E+00	1.27E-01	9.02
					15.63	1.46E+00	1.52E+00	1.06E-01	7.54
					7.81	1.49E+00	1.49E+00	8.13E-02	5.76
					3.91	1.44E+00	1.45E+00	3.83E-02	2.71
					1.95	1.42E+00	1.44E+00	3.13E-02	2.22

The conductivity measurement upon exposure to CO of doped polyaniline at various temperatures is shown in Table M.2.

Table M.2 Raw data of conductivity measurement upon exposure to CO for CSA and HNO_3 doped polyanilines (N_A/N_{EB} = 10) at 35, 45 and 55 °C

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
CSA #1	35	1.89	1.62	0.25	1000	1.06E+00	9.05E-01	6.59E-01	267.44
					500	7.60E-01	6.79E-01	4.33E-01	175.68
					250	6.49E-01	6.68E-01	4.22E-01	171.38
					125	6.28E-01	6.08E-01	3.62E-01	146.85
					62.5	3.96E-01	5.26E-01	2.80E-01	113.56
					31.25	3.09E-01	3.79E-01	1.33E-01	53.88
					15.63	3.09E-01	3.51E-01	1.04E-01	42.39
					7.81	2.54E-01	3.46E-01	9.97E-02	40.48
					3.91	2.35E-01	3.27E-01	8.06E-02	32.72
CSA #2	35	2.59	2.00	1.35	1000	1.96E+00	1.96E+00	6.19E-01	45.97
					500	1.94E+00	1.95E+00	6.07E-01	45.10
					250	1.74E+00	1.79E+00	4.44E-01	32.99
					125	1.63E+00	1.69E+00	3.44E-01	25.56
					62.5	1.53E+00	1.59E+00	2.44E-01	18.13
					31.25	1.48E+00	1.58E+00	2.34E-01	17.38
					15.63	1.34E+00	1.54E+00	1.90E-01	14.09
					7.81	-	-	-	-
					3.91	-	-	-	-
CSA #1	45	2.23	2.35	0.76	1000	2.04E+00	1.63E+00	8.70E-01	115.08
					500	7.26E-01	1.44E+00	6.84E-01	90.48
					250	1.27E+00	1.24E+00	4.80E-01	63.49
					125	1.14E+00	8.90E-01	1.34E-01	17.78
					62.5	9.69E-01	8.87E-01	1.31E-01	17.31
					31.25	9.46E-01	7.96E-01	4.00E-02	5.29
					15.63	8.60E-01	7.89E-01	3.30E-02	4.37

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					7.81	-	-	-	-
					3.91	-	-	-	-
CSA #2	45	2.77	1.45	1.21	1000	1.44E+00	1.70E+00	4.94E-01	40.79
					500	1.16E+00	1.67E+00	4.56E-01	37.68
					250	1.10E+00	1.62E+00	4.10E-01	33.88
					125	1.23E+00	1.56E+00	3.50E-01	28.93
					62.5	1.11E+00	1.46E+00	2.50E-01	20.66
					31.25	9.65E-01	1.41E+00	2.00E-01	16.53
					15.63	9.49E-01	1.39E+00	1.80E-01	14.88
					7.81	9.91E-01	1.38E+00	1.65E-01	13.64
					3.91	8.61E-01	1.36E+00	1.49E-01	12.31
CSA #1	55	2.22	1.27	0.06	1000	1.34E-01	1.30E-01	7.40E-02	132.14
					500	1.01E-01	1.10E-01	5.40E-02	96.43
					250	8.76E-02	1.03E-01	4.70E-02	83.93
					125	9.62E-02	9.62E-02	4.02E-02	71.79
					62.5	9.74E-02	8.08E-02	2.48E-02	44.21
					31.25	7.50E-02	7.69E-02	2.09E-02	37.32
					15.63	6.40E-02	7.10E-02	1.50E-02	26.79
					7.81	-	-	-	-
					3.91	-	-	-	-
CSA #2	55	0.34	0.27	0.04	1000	1.04E-01	1.15E-01	7.52E-02	189.90
					500	8.96E-02	8.97E-02	5.01E-02	126.52
					250	8.02E-02	7.45E-02	3.49E-02	88.13
					125	5.48E-02	6.59E-02	2.63E-02	66.41
					62.5	4.60E-02	4.69E-02	7.30E-03	18.43
					31.25	6.50E-02	4.46E-02	5.00E-03	12.63
					15.63	1.37E-02	4.23E-02	2.70E-03	6.82
					7.81	-	-	-	-
					3.91	-	-	-	-

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	$\%\Delta\sigma$
HNO_3 #1	35	1.00	0.50	1.36	1000	1.73E+00	2.02E+00	6.60E-01	48.56
					500	1.73E+00	1.91E+00	5.50E-01	40.47
					250	1.52E+00	1.55E+00	1.90E-01	14.00
					125	1.47E+00	1.73E+00	3.70E-01	27.23
					62.5	1.45E+00	1.59E+00	2.33E-01	17.12
					31.25	1.44E+00	1.59E+00	2.27E-01	16.69
					15.63	1.42E+00	1.54E+00	1.76E-01	12.97
					7.81	1.45E+00	1.52E+00	1.61E-01	11.86
					3.91	1.42E+00	1.51E+00	1.50E-01	11.05
HNO_3 #2	35	2.71	2.25	1.21	1000	1.26E+00	2.01E+00	8.04E-01	66.40
					500	1.30E+00	1.71E+00	5.01E-01	41.37
					250	1.25E+00	1.60E+00	3.89E-01	32.17
					125	1.15E+00	1.40E+00	1.94E-01	16.03
					62.5	1.37E+00	1.33E+00	1.22E-01	10.08
					31.25	1.02E+00	1.29E+00	8.00E-02	6.61
					15.63	1.20E+00	1.28E+00	7.00E-02	5.79
					7.81	-	-	-	-
					3.91	-	-	-	-
HNO_3 #1	45	2.91	1.97	1.47	1000	1.15E+00	2.01E+00	5.42E-01	36.90
					500	1.67E+00	1.97E+00	5.01E-01	34.10
					250	1.66E+00	1.84E+00	3.71E-01	25.26
					125	1.45E+00	1.73E+00	2.61E-01	17.77
					62.5	1.52E+00	1.69E+00	2.21E-01	15.04
					31.25	1.47E+00	1.68E+00	2.11E-01	14.36
					15.63	1.44E+00	1.66E+00	1.93E-01	13.14
					7.81	-	-	-	-
					3.91	-	-	-	-

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	$\%\Delta\sigma$
HNO_3 #2	45	1.97	2.21	1.32	1000	1.64E+00	1.79E+00	4.70E-01	35.61
					500	1.52E+00	1.78E+00	4.60E-01	34.85
					250	1.43E+00	1.72E+00	4.00E-01	30.30
					125	1.42E+00	1.69E+00	3.70E-01	28.03
					62.5	1.40E+00	1.66E+00	3.40E-01	25.76
					31.25	1.36E+00	1.59E+00	2.70E-01	20.45
					15.63	1.06E+00	1.58E+00	2.60E-01	19.70
					7.81	1.02E+00	1.54E+00	2.20E-01	16.67
					3.91	9.56E-01	1.54E+00	2.20E-01	16.67
HNO_3 #1	55	1.27	1.04	0.40	1000	1.02E+00	9.49E-01	5.47E-01	136.07
					500	8.02E-01	9.26E-01	5.24E-01	130.30
					250	9.26E-01	7.80E-01	3.78E-01	94.03
					125	9.46E-01	6.24E-01	2.22E-01	55.22
					62.5	7.06E-01	6.42E-01	2.40E-01	59.70
					31.25	7.26E-01	6.28E-01	2.26E-01	56.22
					15.63	6.92E-01	6.22E-01	2.20E-01	54.73
					7.81	-	-	-	-
					3.91	-	-	-	-
HNO_3 #2	55	1.56	1.45	0.36	1000	9.74E-01	1.19E+00	8.33E-01	233.43
					500	9.26E-01	9.82E-01	6.25E-01	175.20
					250	7.15E-01	9.07E-01	5.50E-01	154.05
					125	6.78E-01	6.42E-01	2.85E-01	79.85
					62.5	7.50E-02	5.23E-01	1.66E-01	46.54
					31.25	7.20E-02	4.98E-01	1.41E-01	39.53
					15.63	6.30E-02	4.88E-01	1.31E-01	36.73
					7.81	-	-	-	-
					3.91	-	-	-	-

The conductivity measurement upon exposure to CO of doped polyaniline blend with 30 %wt polyimide at various temperatures is shown in Table M.3.

Table M.3 Raw data of conductivity measurement upon exposure to CO for CSA and HNO_3 doped polyanilines (N_A/N_{EB} = 10) blend with 30 %wt polyimide at 25, 35, 45 and 55 °C

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
CSA #1	25	1.30	1.70	0.50	1000	1.12E+00	1.38E+00	8.84E-01	177.37
					500	8.35E-01	8.70E-01	3.72E-01	74.54
					250	9.87E-01	5.28E-01	2.93E-02	5.88
					125	5.76E-01	6.11E-01	1.13E-01	22.59
					62.5	7.41E-01	7.40E-01	2.41E-01	48.37
					31.25	8.77E-01	7.52E-01	2.53E-01	50.81
					15.63	5.01E-01	5.85E-01	8.65E-02	17.36
					7.81	5.58E-01	5.71E-01	7.25E-02	14.54
					3.91	5.10E-01	5.05E-01	6.10E-03	1.22
CSA #2	25	0.55	0.27	0.11	1000	2.03E-01	2.20E-01	1.12E-01	103.14
					500	1.48E-01	1.64E-01	5.54E-02	51.15
					250	1.39E-01	1.45E-01	3.64E-02	33.61
					125	1.27E-01	1.33E-01	2.50E-02	23.08
					62.5	1.24E-01	1.31E-01	2.27E-02	20.96
					31.25	1.19E-01	1.24E-01	1.61E-02	14.87
					15.63	1.17E-01	1.20E-01	1.19E-02	10.99
					7.81	1.11E-01	1.18E-01	9.50E-03	8.77
					3.91	1.09E-01	1.11E-01	2.70E-03	2.49
CSA #3	25	1.00	0.39	0.16	1000	2.70E-01	3.96E-01	2.39E-01	152.75
					500	2.09E-01	2.86E-01	1.29E-01	82.63
					250	2.00E-01	2.68E-01	1.12E-01	71.33
					125	2.21E-01	2.43E-01	8.65E-02	55.24
					62.5	2.08E-01	2.25E-01	6.85E-02	43.74
					31.25	1.63E-01	2.15E-01	5.86E-02	37.42
					15.63	1.84E-01	2.09E-01	5.25E-02	33.52

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					7.81	1.73E-01	1.96E-01	3.96E-02	25.29
					3.91	1.76E-01	1.69E-01	1.28E-02	8.17
CSA #4	25	1.22	0.39	0.10	1000	2.91E-01	3.87E-01	2.85E-01	280.56
					500	2.02E-01	2.86E-01	1.84E-01	181.61
					250	2.06E-01	2.21E-01	1.19E-01	117.61
					125	2.04E-01	2.06E-01	1.04E-01	102.44
					62.5	1.36E-01	1.85E-01	8.33E-02	82.06
					31.25	1.03E-01	1.24E-01	2.20E-02	21.70
					15.63	1.04E-01	1.14E-01	1.21E-02	11.94
					7.81	1.02E-01	1.10E-01	8.00E-03	7.88
					3.91	9.56E-02	1.07E-01	5.37E-03	5.29
CSA #1	35	1.08	0.74	0.34	1000	4.67E-01	7.11E-01	3.75E-01	111.93
					500	3.87E-01	7.06E-01	3.71E-01	110.56
					250	5.38E-01	8.04E-01	4.69E-01	139.87
					125	5.82E-01	7.15E-01	3.80E-01	113.18
					62.5	5.19E-01	6.67E-01	3.31E-01	98.84
					31.25	5.63E-01	5.63E-01	2.28E-01	67.94
					15.63	3.75E-01	4.97E-01	1.61E-01	48.08
					7.81	3.49E-01	4.30E-01	9.49E-02	28.30
					3.91	3.07E-01	4.17E-01	8.19E-02	24.43
CSA #2	35	1.84	1.50	0.90	1000	1.29E+00	1.54E+00	6.46E-01	72.18
					500	1.22E+00	1.21E+00	3.18E-01	35.55
					250	1.19E+00	1.12E+00	2.21E-01	24.72
					125	1.01E+00	9.80E-01	8.44E-02	9.42
					62.5	7.28E-01	9.38E-01	4.24E-02	4.73
					31.25	8.25E-02	9.29E-01	3.30E-02	3.68
					15.63	7.16E-02	9.21E-01	2.54E-02	2.84
					7.81	4.28E-01	9.05E-01	9.40E-03	1.05
					3.91	7.20E-01	8.97E-01	9.00E-04	0.10
CSA #1	45	1.68	1.54	0.96	1000	1.47E+00	1.52E+00	5.61E-01	58.23
					500	1.33E+00	1.50E+00	5.40E-01	56.02

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					250	1.39E+00	1.37E+00	4.10E-01	42.55
					125	1.25E+00	1.34E+00	3.75E-01	38.91
					62.5	3.61E-02	1.31E+00	3.47E-01	35.98
					31.25	1.26E+00	1.27E+00	3.05E-01	31.64
					15.63	1.19E+00	1.27E+00	3.02E-01	31.40
					7.81	1.17E+00	1.26E+00	3.01E-01	31.23
					3.91	1.17E+00	1.26E+00	2.93E-01	30.43
CSA #2	45	1.25	1.24	0.88	1000	1.09E+00	1.20E+00	3.18E-01	36.17
					500	1.03E+00	1.18E+00	2.99E-01	34.03
					250	9.60E-01	1.10E+00	2.18E-01	24.85
					125	9.11E-01	1.06E+00	1.81E-01	20.56
					62.5	9.05E-01	1.08E+00	2.02E-01	23.03
					31.25	9.35E-01	1.03E+00	1.56E-01	17.77
					15.63	8.97E-01	1.03E+00	1.47E-01	16.79
					7.81	8.80E-01	9.74E-01	9.63E-02	10.96
					3.91	8.43E-01	9.63E-01	8.45E-02	9.62
CSA #1	55	0.57	0.20	0.03	1000	8.01E-02	2.26E-01	1.99E-01	742.16
					500	1.57E-02	1.99E-01	1.72E-01	643.28
					250	8.79E-02	1.17E-01	9.05E-02	337.69
					125	1.18E-01	1.64E-01	1.38E-01	513.06
					62.5	1.03E-01	1.74E-01	1.47E-01	548.51
					31.25	1.17E-01	1.68E-01	1.41E-01	527.24
					15.63	1.58E-01	1.92E-01	1.65E-01	616.79
					7.81	1.62E-01	1.86E-01	1.60E-01	595.52
					3.91	1.21E-01	1.97E-01	1.70E-01	635.82
CSA #2	55	0.78	0.63	0.15	1000	2.39E-01	4.37E-01	2.86E-01	189.52
					500	2.10E-01	3.94E-01	2.43E-01	161.21
					250	2.22E-01	3.64E-01	2.14E-01	141.58
					125	2.25E-01	3.18E-01	1.67E-01	110.61
					62.5	1.08E+03	1.81E-01	3.05E-02	20.23
					31.25	9.39E-02	1.97E-01	4.63E-02	30.70

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					15.63	8.24E-02	1.61E-01	1.03E-02	6.83
					7.81	1.13E-01	1.71E-01	2.03E-02	13.46
					3.91	1.60E-01	2.20E-01	6.90E-02	45.76
HNO_3 #1	25	1.60	0.11	0.03	1000	5.30E-02	1.05E-01	7.68E-02	267.34
					500	3.99E-02	9.14E-02	6.27E-02	218.38
					250	4.35E-02	5.54E-02	2.67E-02	92.85
					125	4.96E-02	7.25E-02	4.38E-02	152.49
					62.5	3.08E-02	5.54E-02	2.67E-02	92.85
					31.25	3.96E-02	6.74E-02	3.87E-02	134.80
					15.63	3.02E-02	3.39E-02	5.19E-03	18.07
					7.81	2.85E-02	3.61E-02	7.35E-03	25.59
					3.91	3.19E-02	0.042136	1.34E-02	46.74
HNO_3 #2	25	2.19	1.34	1.03	1000	1.24E+00	1.41E+00	3.73E-01	36.16
					500	1.33E+00	1.33E+00	3.02E-01	29.27
					250	1.20E+00	1.23E+00	1.94E-01	18.79
					125	1.05E+00	1.13E+00	9.76E-02	9.46
					62.5	1.05E+00	1.10E+00	6.33E-02	6.13
					31.25	1.09E+00	1.10E+00	6.30E-02	6.10
					15.63	1.06E+00	1.09E+00	5.50E-02	5.33
					7.81	1.08E+00	1.10E+00	6.57E-02	6.37
					3.91	1.07E+00	1.08E+00	4.77E-02	4.62
HNO_3 #3	25	1.12	1.10	0.69	1000	6.22E-01	1.07E+00	3.87E-01	56.44
					500	7.55E-01	9.82E-01	2.97E-01	43.32
					250	7.07E-01	9.25E-01	2.39E-01	34.93
					125	6.63E-01	8.25E-01	1.40E-01	20.39
					62.5	6.29E-01	8.00E-01	1.15E-01	16.77
					31.25	6.01E-01	7.53E-01	6.75E-02	9.85
					15.63	5.91E-01	7.79E-01	9.35E-02	13.64
					7.81	6.12E-01	7.20E-01	3.46E-02	5.05
HNO_3 #4	25	1.02	0.51	0.23	1000	4.03E-01	5.44E-01	3.12E-01	134.78
					500	3.96E-01	4.74E-01	2.42E-01	104.74

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					250	3.24E-01	4.04E-01	1.72E-01	74.30
					125	3.07E-01	3.77E-01	1.45E-01	62.64
					62.5	2.87E-01	3.26E-01	9.46E-02	40.86
					31.25	2.53E-01	2.76E-01	4.40E-02	19.00
					15.63	2.31E-01	2.65E-01	3.36E-02	14.51
					7.81	2.19E-01	2.35E-01	3.09E-03	1.33
					3.91	2.24E-01	2.30E-01	-1.31E-03	-0.57
HNO_3 #1	35	1.33	0.43	0.02	1000	3.48E-01	3.99E-01	2.99E-01	298.90
					500	3.05E-01	3.80E-01	2.80E-01	280.30
					250	3.28E-01	3.71E-01	2.71E-01	270.60
					125	3.19E-01	3.50E-01	2.50E-01	249.70
					62.5	3.07E-01	3.27E-01	2.27E-01	226.90
					31.25	-	-	-	-
					15.63	-	-	-	-
					7.81	-	-	-	-
HNO_3 #2	35	1.39	0.02	0.03	1000	5.98E-02	2.56E-01	2.27E-01	765.54
					500	6.37E-02	2.52E-01	2.23E-01	752.77
					250	4.00E-02	2.27E-01	1.97E-01	665.74
					125	3.75E-02	2.13E-01	1.83E-01	618.92
					62.5	4.93E-02	1.69E-01	1.39E-01	469.93
					31.25	2.55E-02	9.72E-02	6.76E-02	228.24
					15.63	6.16E-03	6.57E-02	3.61E-02	121.82
					7.81	1.36E-02	5.24E-02	2.28E-02	76.89
					3.91	1.40E-02	5.32E-02	2.36E-02	79.73
HNO_3 #1	45	0.55	0.40	0.09	1000	3.49E-01	5.01E-01	4.15E-01	480.88
					500	4.27E-01	4.27E-01	3.41E-01	395.25
					250	3.07E-01	3.15E-01	2.28E-01	264.54
					125	9.18E-02	2.47E-01	1.61E-01	186.10
					62.5	1.84E-01	1.86E-01	9.99E-02	115.76
					31.25	1.20E-01	1.78E-01	9.14E-02	105.91
					15.63	1.08E-01	1.50E-01	6.39E-02	74.04

Acid	Temp. (°C)	σ_{air} (S/cm)	$\sigma_{N2,ini}$ (S/cm)	$\sigma_{N2,f}$ (S/cm)	[CO] (ppm)	σ_{vac} (S/cm)	σ_{CO} (S/cm)	$\Delta\sigma$ (S/cm)	%$\Delta\sigma$
					7.81	1.01E-01	1.25E-01	3.87E-02	44.84
					3.91	9.24E-02	1.18E-01	3.15E-02	36.50
HNO_3 #2	45	0.54	0.42	0.05	1000	1.26E-01	3.59E-01	3.06E-01	584.87
					500	1.16E-01	2.96E-01	2.44E-01	465.89
					250	1.41E-01	2.37E-01	1.84E-01	351.87
					125	1.91E-01	2.79E-01	2.26E-01	431.89
					62.5	1.82E-01	2.44E-01	1.91E-01	365.24
					31.25	1.32E-01	1.73E-01	1.20E-01	230.02
					15.63	1.24E-01	1.64E-01	1.11E-01	212.26
					7.81	1.39E-01	1.27E-01	7.45E-02	142.36
					3.91	1.22E-01	1.19E-01	6.69E-02	127.85
HNO_3 #1	55	1.01	0.71	0.05	1000	3.64E-01	3.71E-01	3.21E-01	641.60
					500	1.38E-01	3.02E-01	2.52E-01	503.80
					250	9.21E-02	2.87E-01	2.37E-01	474.20
					125	1.98E-02	8.07E-02	3.07E-02	61.40
					62.5	3.12E-02	5.03E-02	3.00E-04	0.60
					31.25	-	-	-	-
					15.63	-	-	-	-
					7.81	-	-	-	-
					3.91	-	-	-	-
HNO_3 #2	55	0.88	0.93	0.12	1000	3.49E-01	5.64E-01	4.41E-01	358.21
					500	2.58E-01	4.28E-01	3.05E-01	247.64
					250	2.59E-01	4.15E-01	2.92E-01	237.15
					125	2.25E-01	3.34E-01	2.11E-01	171.30
					62.5	1.33E-01	2.15E-01	9.23E-02	75.04
					31.25	1.25E-01	2.62E-01	1.39E-01	112.76
					15.63	1.20E-01	2.33E-01	1.10E-01	89.67
					7.81	1.17E-01	2.29E-01	1.06E-01	86.26
					3.91	2.05E-01	2.50E-01	1.27E-01	103.58

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