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APPENDICES

Appendix A Determination of Ohmic Linear Regime

Linear regime or ohmic regime is the regime that applied voltage depends directly on the apply current according to ohmic law in equation (A1)

In this work, linear regime was determined by ploting applied voltage (V_a) versus current (I). The range that gives the straight line is acceptable for using in conductivity measurement. Figure A1 is the plot between V_a and I of the silicon wafer, as a standard material, using custom built two-point probe. This experiment was performed under 1 atm, 50% relative humidity, and 25°C.

$$V_0 = IR \tag{A1}$$

where V_o = applied voltage (V)

I = current (A)

R = resistance (Ω)

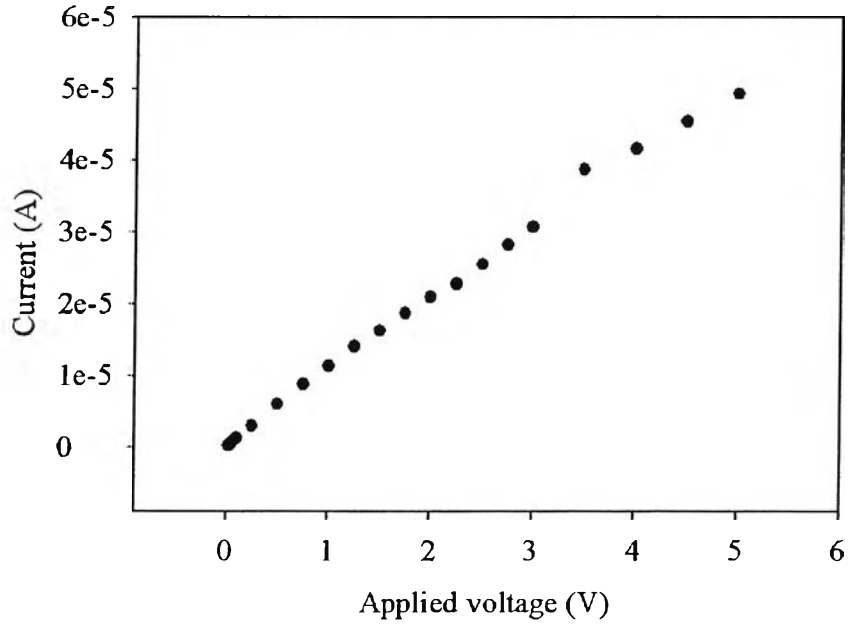

Figure A1 Linear regime of V_a and I of the silicon wafer, used as a standard material, obtained by the custom built two-point probe.

According to Figure A1, straight line is indicated the range of applied voltage and current corresponding to the ohmic law. The accepted range of those for using in conductivity measurement are 0.025 to 5 V and 3.57×10^{-7} to 4.93×10^{-5} A, respectively.

Table A1 Raw data of determination of linear regime from silicon wafer by using custom built two-point probe

Applied voltage (V)	Current (A)
0.025	3.57E-07
0.05	7.37E-07
0.075	1.03E-06
0.1	1.33E-06
0.25	3.09E-06
0.5	6.07E-06
0.75	8.85E-06
1	1.14E-05
1.25	1.41E-05
1.5	1.63E-05
1.75	1.87E-05
2	2.10E-05
2.25	2.28E-05
2.5	2.55E-05
2.75	2.82E-05
3	3.07E-05
3.5	3.87E-05
4	4.16E-05
4.5	4.54E-05
5	4.93E-05

Appendix B Determination of Geometric Correlation Factor (K) of Custom Built Two-Point Probe

Geometric correction factor (K) is a correction that takes into account of geometric effects. K factor can be determined by using the following equation (B1).

$$K = \frac{\rho_{ref} \times I}{t \times V} \qquad (B1)$$

where K = geometric correction factor

ρ_{ref} = resistivity of standard material (Ω.cm)

R = resistivity (Ω)

t = sheet thickness (cm)

V = applied voltage (V)

I = current (A)

For conductive samples, such as polyaniline in the doped form, the silicon wafer with known resistivity of 8.2028 ohm·cm and with the thickness of 200 μm was used as a standard material for the determination of geometric correction factor (K).

Table B1 Raw data of determination of the geometric correction factor (K) from silicon wafer, as a standard material

Applied voltage (V)	Current ($\times 10^5$) (A)	K
0.025	3.57E-07	0.0059
0.05	7.37E-07	0.0061
0.075	1.03E-06	0.0056
0.1	1.33E-06	0.0054
0.25	3.09E-06	0.0050
0.5	6.07E-06	0.0049
0.75	8.85E-06	0.0048
1	1.14E-05	0.0047
1.25	1.41E-05	0.0046
1.5	1.63E-05	0.0045
1.75	1.87E-05	0.0044
2	2.10E-05	0.0043
2.25	2.28E-05	0.0041
2.5	2.55E-05	0.0042
2.75	2.82E-05	0.0042
3	3.07E-05	0.0042
3.5	3.87E-05	0.0045
4	4.16E-05	0.0042
4.5	4.54E-05	0.0041
5	4.93E-05	0.0040
Average		**0.0047**
STD		**0.0006**

According to Figure A1, the accepted range for using in conductivity measurement of silicon wafer covered the range of applied voltage from 0.025 to 5 V.

Therefore, the geometric correction factor (K) for the conductive samples of custom built two-point probe is 0.0047.

In contrast, for insulating samples, such as polyaniline in the undoped form, the insulating standard with known resistivity of 1.69×10^{10} ohm·cm and thickness of 98.8 μm was used to determine the geometric correction factor (K).

Table B2 Raw data of determination of the geometric correction factor (K) from insulating paper, as an insulating standard material

Applied voltage (V)	Current ($\times 10^5$) (A)	K
5	3.85E-10	133.8786
10	7.50E-10	130.4012
15	1.16E-09	134.4582
20	1.61E-09	139.964
30	2.40E-09	139.0947
40	3.18E-09	138.2253
50	4.02E-09	139.7901
60	5.07E-09	146.9187
70	5.82E-09	144.5591
80	6.50E-09	141.268
90	7.30E-09	141.0265
100	7.91E-09	137.5298
Average		**138.9262**
STD		**4.5518**

The accepted range for using in conductivity measurement of silicon wafer covered the range of applied voltage from 5 to 100 V.

Therefore, the geometric correction factor (K) for the insulating samples of custom built two-point probe is about 139.

Appendix C Conductivity Measurement of the Doped Polyaniline Synthesized in the Presence of Chlorophyllin (Geometric correction factor (K) is 0.0047)

Table C1 Conductivity measurement of the doped conventional PANI synthesized without the presence of chlorophyllin seed

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
Conventional PANI	1.44E-2	0.025	2.48E-05	1.47E+01
	1.44E-2	0.05	5.11E-05	1.51E+01
	1.44E-2	0.075	7.71E-05	1.52E+01
	1.44E-2	0.1	1.03E-04	1.52E+01
	1.44E-2	0.25	2.74E-04	1.62E+01
Average				1.53E+01
Conventional PANI	1.44E-2	0.025	2.33E-05	1.38E+01
	1.44E-2	0.05	4.79E-05	1.42E+01
	1.44E-2	0.075	8.17E-05	1.61E+01
	1.44E-2	0.1	1.11E-04	1.64E+01
	1.44E-2	0.25	2.96E-04	1.75E+01
Average				1.56E+01
Conventional PANI	1.45E-2	0.025	2.45E-05	1.44E+01
	1.45E-2	0.05	5.25E-05	1.54E+01
	1.45E-2	0.075	7.85E-05	1.54E+01
	1.45E-2	0.1	1.16E-04	1.70E+01
	1.45E-2	0.25	2.96E-04	1.74E+01
Average				1.59E+01

Average conductivity	15.6 S/cm
STD	0.32

Table C2 Conductivity measurement of the doped PANI synthesized with 8.14×10^{-4} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 8.14×10^{-4} mole chlorophyllin/ mole aniline	1.26E-2	0.025	2.43E-05	1.64E+01
	1.26E-2	0.05	5.20E-05	1.76E+01
	1.26E-2	0.075	8.03E-05	1.81E+01
	1.26E-2	0.1	1.09E-04	1.84E+01
	1.26E-2	0.25	2.89E-04	1.95E+01
Average				1.80E+01
PANI with 8.14×10^{-4} mole chlorophyllin/ mole aniline	1.26E-2	0.025	2.56E-05	1.73E+01
	1.26E-2	0.05	5.35E-05	1.81E+01
	1.26E-2	0.075	8.43E-05	1.90E+01
	1.26E-2	0.1	1.10E-04	1.86E+01
	1.26E-2	0.25	3.01E-04	2.03E+01
Average				1.86E+01
PANI with 8.14×10^{-4} mole chlorophyllin/ mole aniline	1.24E-2	0.025	2.39E-05	1.64E+01
	1.24E-2	0.05	5.15E-05	1.77E+01
	1.24E-2	0.075	7.95E-05	1.82E+01
	1.24E-2	0.1	1.09E-04	1.87E+01
	1.24E-2	0.25	2.96E-04	2.03E+01
Average				1.83E+01

Average conductivity 18.3 S/cm
STD 0.33

Table C3 Conductivity measurement of the doped PANI synthesized with 8.14×10^{-3} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 8.14×10^{-3} mole chlorophyllin/ mole aniline	1.11E-2	0.025	2.68E-05	2.05E+01
	1.11E-2	0.05	5.72E-05	2.19E+01
	1.11E-2	0.075	8.78E-05	2.24E+01
	1.11E-2	0.1	1.18E-04	2.26E+01
	1.11E-2	0.25	3.21E-04	2.46E+01
Average				2.24E+01
PANI with 8.14×10^{-3} mole chlorophyllin/ mole aniline	1.11E-2	0.025	2.10E+01	2.10E+01
	1.11E-2	0.05	2.22E+01	2.22E+01
	1.11E-2	0.075	2.28E+01	2.28E+01
	1.11E-2	0.1	2.30E+01	2.30E+01
	1.11E-2	0.25	2.55E+01	2.55E+01
Average				2.29E+01
PANI with 8.14×10^{-3} mole chlorophyllin/ mole aniline	1.11E-2	0.025	2.58E-05	1.98E+01
	1.11E-2	0.05	5.63E-05	2.16E+01
	1.11E-2	0.075	8.53E-05	2.18E+01
	1.11E-2	0.1	9.66E-05	1.85E+01
	1.11E-2	0.25	3.01E-04	2.31E+01
Average				2.10E+01

Average conductivity 22.1 S/cm
STD 1.02

Table C4 Conductivity measurement of the doped PANI synthesized with 1.63×10^{-2} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 1.63×10^{-2} mole chlorophyllin/ mole aniline	1.24E-2	0.05	3.25E-05	1.12E+01
	1.24E-2	0.075	5.48E-05	1.25E+01
	1.24E-2	0.1	7.39E-05	1.27E+01
	1.24E-2	0.25	1.89E-04	1.30E+01
	1.24E-2	0.5	3.84E-04	1.32E+01
Average				1.25E+01
PANI with 1.63×10^{-2} mole chlorophyllin/ mole aniline	1.24E-2	0.05	3.55E-05	1.22E+01
	1.24E-2	0.075	5.42E-05	1.24E+01
	1.24E-2	0.1	7.30E-05	1.25E+01
	1.24E-2	0.25	1.85E-04	1.27E+01
	1.24E-2	0.5	3.79E-04	1.30E+01
Average				1.26E+01
PANI with 1.63×10^{-2} mole chlorophyllin/ mole aniline	1.29E-2	0.05	1.62E-05	1.07E+01
	1.29E-2	0.075	3.50E-05	1.15E+01
	1.29E-2	0.1	5.41E-05	1.19E+01
	1.29E-2	0.25	7.34E-05	1.21E+01
	1.29E-2	0.5	1.91E-04	1.26E+01
Average				1.18E+01

Average conductivity 12.3 S/cm
STD 0.44

Table C5 Conductivity measurement of the doped PANI synthesized with 4.07×10^{-2} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 4.07×10^{-2} mole chlorophyllin/ mole aniline	1.82E-2	0.025	1.62E-05	7.58
	1.82E-2	0.05	3.50E-05	8.18
	1.82E-2	0.075	5.41E-05	8.43
	1.82E-2	0.1	7.34E-05	8.58
	1.82E-2	0.25	1.91E-04	8.93
Average				8.34
PANI with 4.07×10^{-2} mole chlorophyllin/ mole aniline	1.56E-2	0.025	1.70E-05	7.95
	1.56E-2	0.05	3.61E-05	8.44
	1.56E-2	0.075	5.51E-05	8.59
	1.56E-2	0.1	7.42E-05	8.67
	1.56E-2	0.25	1.92E-04	8.98
Average				8.53
PANI with 4.07×10^{-2} mole chlorophyllin/ mole aniline	1.56E-2	0.025	1.54E-05	7.24
	1.56E-2	0.05	3.33E-05	7.83
	1.56E-2	0.075	5.13E-05	8.04
	1.56E-2	0.1	6.97E-05	8.19
	1.56E-2	0.25	1.82E-04	8.56
Average				7.97

Average conductivity 8.28 S/cm
STD 0.28

Appendix D Conductivity Measurement of the Undoped Polyaniline Synthesized in the Presence of Chlorophyllin (Geometric correction factor (K) is 139)

Table D1 Conductivity measurement of the undoped conventional PANI synthesized without the presence of chlorophyllin seed

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
Undoped conventional PANI	2.60E-2	0.75	7.70E-11	2.84E-11
	2.60E-2	1	1.01E-10	2.79E-11
	2.60E-2	1.25	1.24E-10	2.74E-11
	2.60E-2	1.5	1.46E-10	2.69E-11
	2.60E-2	1.75	1.70E-10	2.69E-11
Average				2.75E-11
Undoped conventional PANI	2.60E-2	0.75	7.66E-11	2.83E-11
	2.60E-2	1	1.00E-10	2.77E-11
	2.60E-2	1.25	1.23E-10	2.72E-11
	2.60E-2	1.5	1.46E-10	2.69E-11
	2.60E-2	1.75	1.69E-10	2.67E-11
Average				2.74E-11
Undoped conventional PANI	2.11E-2	0.75	7.00E-11	3.18E-11
	2.11E-2	1	8.84E-11	3.01E-11
	2.11E-2	1.25	1.06E-10	2.89E-11
	2.11E-2	1.5	1.24E-10	2.82E-11
	2.11E-2	1.75	1.43E-10	2.79E-11
Average				2.94E-11

Average conductivity 2.81E-11 S/cm
STD 1.12E-12

Table D2 Conductivity measurement of the undoped PANI synthesized with 8.14×10^{-4} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 8.14×10^{-4} mole chlorophyllin/ mole aniline	2.07E-2	0.75	6.40E-11	2.97E-11
	2.07E-2	1	8.14E-11	2.83E-11
	2.07E-2	1.25	9.87E-11	2.74E-11
	2.07E-2	1.5	1.16E-10	2.69E-11
	2.07E-2	1.75	1.33E-10	2.64E-11
Average				2.77E-11
PANI with 8.14×10^{-4} mole chlorophyllin/ mole aniline	2.07E-2	0.75	6.27E-11	2.91E-11
	2.07E-2	1	8.03E-11	2.79E-11
	2.07E-2	1.25	9.75E-11	2.71E-11
	2.07E-2	1.5	1.14E-10	2.64E-11
	2.07E-2	1.75	1.32E-10	2.62E-11
Average				2.73E-11
PANI with 8.14×10^{-4} mole chlorophyllin/ mole aniline	2.31E-2	0.75	6.43E-11	3.07E-11
	2.31E-2	1	8.26E-11	2.96E-11
	2.31E-2	1.25	1.01E-10	2.89E-11
	2.31E-2	1.5	1.20E-10	2.86E-11
	2.31E-2	1.75	1.39E-10	2.84E-11
Average				2.92E-11

Average conductivity 2.81E-11 S/cm
STD 1.00E-12

Table D3 Conductivity measurement of the undoped PANI synthesized with 8.14×10^{-3} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 8.14×10^{-3} mole chlorophyllin/ mole aniline	1.67E-2	0.75	5.72E-11	3.29E-11
	1.67E-2	1	7.34E-11	3.16E-11
	1.67E-2	1.25	8.89E-11	3.06E-11
	1.67E-2	1.5	1.04E-10	2.99E-11
	1.67E-2	1.75	1.21E-10	2.98E-11
Average				3.10E-11
PANI with 8.14×10^{-3} mole chlorophyllin/ mole aniline	1.67E-2	0.75	5.54E-11	3.18E-11
	1.67E-2	1	7.24E-11	3.12E-11
	1.67E-2	1.25	8.91E-11	3.07E-11
	1.67E-2	1.5	1.05E-10	3.02E-11
	1.67E-2	1.75	1.22E-10	3.00E-11
Average				3.08E-11
PANI with 8.14×10^{-3} mole chlorophyllin/ mole aniline	1.74E-2	0.75	5.72E-11	3.15E-11
	1.74E-2	1	7.34E-11	3.03E-11
	1.74E-2	1.25	8.89E-11	2.94E-11
	1.74E-2	1.5	1.04E-10	2.87E-11
	1.74E-2	1.75	1.21E-10	2.86E-11
Average				2.97E-11

Average conductivity 3.05E-11 S/cm
STD 6.75E-13

Table D4 Conductivity measurement of the undoped PANI synthesized with 1.63×10^{-2} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 1.63×10^{-2} mole chlorophyllin/ mole aniline	1.51E-2	0.75	5.40E-11	3.43E-11
	1.51E-2	1	6.94E-11	3.31E-11
	1.51E-2	1.25	8.41E-11	3.21E-11
	1.51E-2	1.5	9.88E-11	3.14E-11
	1.51E-2	1.75	1.13E-10	3.08E-11
Average				3.23E-11
PANI with 1.63×10^{-2} mole chlorophyllin/ mole aniline	1.51E-2	0.75	5.01E-11	3.18E-11
	1.51E-2	1	6.60E-11	3.14E-11
	1.51E-2	1.25	8.18E-11	3.12E-11
	1.51E-2	1.5	9.71E-11	3.08E-11
	1.51E-2	1.75	1.13E-10	3.08E-11
Average				3.12E-11
PANI with 1.63×10^{-2} mole chlorophyllin/ mole aniline	1.50E-2	0.75	5.18E-11	3.31E-11
	1.50E-2	1	6.69E-11	3.21E-11
	1.50E-2	1.25	8.21E-11	3.15E-11
	1.50E-2	1.5	9.75E-11	3.12E-11
	1.50E-2	1.75	1.13E-10	3.10E-11
Average				3.18E-11

Average conductivity 3.18E-11 S/cm
STD 5.51E-13

Table D5 Conductivity measurement of the undoped PANI synthesized with 4.07×10^{-2} mole chlorophyllin/mole aniline

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI with 4.07×10^{-2} mole chlorophyllin/ mole aniline	2.42E-2	0.75	7.96E-11	3.16E-11
	2.42E-2	1	1.03E-10	3.06E-11
	2.42E-2	1.25	1.28E-10	3.04E-11
	2.42E-2	1.5	1.52E-10	3.01E-11
	2.42E-2	1.75	1.76E-10	2.99E-11
Average				3.05E-11
PANI with 4.07×10^{-2} mole chlorophyllin/ mole aniline	2.42E-2	0.75	8.45E-11	3.35E-11
	2.42E-2	1	1.11E-10	3.30E-11
	2.42E-2	1.25	1.38E-10	3.28E-11
	2.42E-2	1.5	1.65E-10	3.27E-11
	2.42E-2	1.75	1.91E-10	3.24E-11
Average				3.29E-11
PANI with 4.07×10^{-2} mole chlorophyllin/ mole aniline	2.42E-2	0.75	8.81E-11	3.49E-11
	2.42E-2	1	1.16E-10	3.45E-11
	2.42E-2	1.25	1.45E-10	3.45E-11
	2.42E-2	1.5	1.72E-10	3.41E-11
	2.42E-2	1.75	2.00E-10	3.40E-11
Average				3.44E-11

Average conductivity 3.26E-11 S/cm
STD 1.94E-12

Appendix E Conductivity Measurement of the Doped Polyaniline Synthesized in the Presence of CM-chitin (Geometric correction factor (K) is 0.0047)

Table E1 Conductivity measurement of the doped conventional PANI synthesized without the presence of CM-chitin template

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
Conventional PANI	1.44E-2	0.025	2.48E-05	1.47E+01
	1.44E-2	0.05	5.11E-05	1.51E+01
	1.44E-2	0.075	7.71E-05	1.52E+01
	1.44E-2	0.1	1.03E-04	1.52E+01
	1.44E-2	0.25	2.74E-04	1.62E+01
Average				1.53E+01
Conventional PANI	1.44E-2	0.025	2.33E-05	1.38E+01
	1.44E-2	0.05	4.79E-05	1.42E+01
	1.44E-2	0.075	8.17E-05	1.61E+01
	1.44E-2	0.1	1.11E-04	1.64E+01
	1.44E-2	0.25	2.96E-04	1.75E+01
Average				1.56E+01
Conventional PANI	1.45E-2	0.025	2.45E-05	1.44E+01
	1.45E-2	0.05	5.25E-05	1.54E+01
	1.45E-2	0.075	7.85E-05	1.54E+01
	1.45E-2	0.1	1.16E-04	1.70E+01
	1.45E-2	0.25	2.96E-04	1.74E+01
Average				1.59E+01

Average conductivity 15.6 S/cm
STD 0.32

Table E2 Conductivity measurement of the doped PANI synthesized with 0.5 wt% CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(0.5CM-chitin)	1.17E-2	0.025	2.58E-05	1.88E+01
	1.17E-2	0.05	5.40E-05	1.96E+01
	1.17E-2	0.075	8.32E-05	2.02E+01
	1.17E-2	0.1	1.18E-04	2.15E+01
	1.17E-2	0.25	3.15E-04	2.29E+01
Average				2.06E+01
PANI-(0.5CM-chitin)	1.42E-2	0.025	2.91E-5	1.74E+01
	1.42E-2	0.05	6.10E-5	1.83E+01
	1.42E-2	0.075	9.32E-5	1.86E+01
	1.42E-2	0.1	1.30E-4	1.95E+01
	1.42E-2	0.25	4.02E-4	2.41E+01
Average				1.96E+01
PANI-(0.5CM-chitin)	1.42E-2	0.025	3.22E-5	1.93E+01
	1.42E-2	0.05	6.91E-5	2.07E+01
	1.42E-2	0.075	9.56E-5	1.91E+01
	1.42E-2	0.1	1.50E-4	2.25E+01
	1.42E-2	0.25	4.22E-4	2.53E+01
Average				2.14E+01

Average conductivity 20.5 S/cm
STD 0.90

Table E3 Conductivity measurement of the doped PANI synthesized with 1 wt% CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CM-chitin)	1.30E-2	0.025	2.53E-05	1.66E+01
	1.30E-2	0.05	5.22E-05	1.71E+01
	1.30E-2	0.075	7.90E-05	1.72E+01
	1.30E-2	0.1	1.06E-04	1.73E+01
	1.30E-2	0.25	3.13E-04	2.05E+01
Average				1.77E+01
PANI-(1CM-chitin)	1.30E-2	0.025	2.42E-5	1.58E+01
	1.30E-2	0.05	5.18E-5	1.70E+01
	1.30E-2	0.075	8.01E-5	1.75E+01
	1.30E-2	0.1	1.11E-4	1.82E+01
	1.30E-2	0.25	3.29E-4	2.15E+01
Average				1.80E+01
PANI-(1CM-chitin)	1.14E-2	0.025	2.50 E-5	1.87E+01
	1.14E-2	0.05	5.11E-5	1.91E+01
	1.14E-2	0.075	7.72E-5	1.92E+01
	1.14E-2	0.1	1.03 E-4	1.92E+01
	1.14E-2	0.25	2.90E-4	2.16E+01
Average				1.96E+01

Average conductivity 18.4 S/cm
STD 0.99

Table E4 Conductivity measurement of the doped PANI synthesized with 2 wt% CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(2CM-chitin)	1.00E-2	0.025	1.92E-05	1.63E+01
	1.00E-2	0.05	4.00E-05	1.70E+01
	1.00E-2	0.075	6.41E-05	1.82E+01
	1.00E-2	0.1	9.41E-05	2.00E+01
	1.00E-2	0.25	2.55E-04	2.17E+01
Average				1.87E+01
PANI-(2CM-chitin)	1.00E-2	0.025	2.16E-05	1.84E+01
	1.00E-2	0.05	4.57E-05	1.94E+01
	1.00E-2	0.075	7.20E-05	2.04E+01
	1.00E-2	0.1	1.10E-04	2.34E+01
	1.00E-2	0.25	2.88E-04	2.45E+01
Average				2.12E+01
PANI-(2CM-chitin)	1.09E-2	0.025	2.37E-05	1.85E+01
	1.09E-2	0.05	4.71E-05	1.83E+01
	1.09E-2	0.075	7.03E-05	1.83E+01
	1.09E-2	0.1	9.82E-05	1.91E+01
	1.09E-2	0.25	2.76E-04	2.15E+01
Average				1.91E+01

Average conductivity	19.7 S/cm
STD	1.37

Appendix F Conductivity Measurement of the Undoped Polyaniline Synthesized in the Presence of CM-chitin (Geometric correction factor (K) is 139)

Table F1 Conductivity measurement of the undoped conventional PANI synthesized without the presence of CM-chitin template

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
Conventional PANI	1.45E-2	1	7.54E-11	3.74E-11
	1.45E-2	1.25	9.29E-11	3.69E-11
	1.45E-2	1.5	1.09E-10	3.61E-11
	1.45E-2	1.75	1.30E-10	3.69E-11
	1.45E-2	2	1.44E-10	3.57E-11
Average				3.66E-11
Conventional PANI	1.45E-2	1	7.71E-5	3.83E-11
	1.45E-2	1.25	9.39E-5	3.73E-11
	1.45E-2	1.5	1.10E-4	3.64E-11
	1.45E-2	1.75	1.26E-4	3.57E-11
	1.45E-2	2	1.43E-4	3.55E-11
Average				3.66E-11
Conventional PANI	1.34E-2	1	7.34E-11	3.94E-11
	1.34E-2	1.25	8.97E-11	3.85E-11
	1.34E-2	1.5	1.07E-10	3.83E-11
	1.34E-2	1.75	1.23E-10	3.77E-11
	1.34E-2	2	1.40E-10	3.76E-11
Average				3.83E-11

Average conductivity 3.72E-12 S/cm
STD 9.86E-13

Table F2 Conductivity measurement of the undoped PANI synthesized with 0.5 wt% CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(0.5CM-chitin)	1.16E-2	1	6.54E-11	4.06E-11
	1.16E-2	1.25	8.06E-11	4.00E-11
	1.16E-2	1.5	9.56E-11	3.95E-11
	1.16E-2	1.75	1.10E-10	3.90E-11
	1.16E-2	2	1.24E-10	3.85E-11
Average				3.95E-11
PANI-(0.5CM-chitin)	1.24E-2	1	6.81E-11	3.95E-11
	1.24E-2	1.25	8.28E-11	3.84E-11
	1.24E-2	1.5	9.83E-11	3.80E-11
	1.24E-2	1.75	1.13E-10	3.75E-11
	1.24E-2	2	1.29E-10	3.74E-11
Average				3.82E-11
PANI-(0.5CM-chitin)	1.24E-2	1	6.53E-11	3.79E-11
	1.24E-2	1.25	8.19E-11	3.80E-11
	1.24E-2	1.5	9.71E-11	3.76E-11
	1.24E-2	1.75	1.13E-10	3.75E-11
	1.24E-2	2	1.29E-10	3.74E-11
Average				3.77E-11

Average conductivity 3.84E-11 S/cm
STD 9.48E-13

Table F3 Conductivity measurement of the undoped PANI synthesized with 1 wt% CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CM-chitin)	1.50E-2	1	6.89E-11	3.30E-11
	1.50E-2	1.25	8.47E-11	3.25E-11
	1.50E-2	1.5	1.01E-10	3.23E-11
	1.50E-2	1.75	1.16E-10	3.18E-11
	1.50E-2	2	1.32E-10	3.17E-11
Average				3.23E-11
PANI-(1CM-chitin)	1.50E-2	1	6.71E-11	3.22E-11
	1.50E-2	1.25	8.30E-11	3.18E-11
	1.50E-2	1.5	9.97E-11	3.19E-11
	1.50E-2	1.75	1.16E-10	3.18E-11
	1.50E-2	2	1.32E-10	3.17E-11
Average				3.19E-11
PANI-(1CM-chitin)	1.63E-2	1	6.93E-11	3.06E-11
	1.63E-2	1.25	8.53E-11	3.01E-11
	1.63E-2	1.5	1.01E-10	2.97E-11
	1.63E-2	1.75	1.18E-10	2.98E-11
	1.63E-2	2	1.34E-10	2.96E-11
Average				3.00E-11

Average conductivity 3.14E-11 S/cm
STD 1.23E-11

Table F4 Conductivity measurement of the undoped PANI synthesized with 2 wt% CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(2CM-chitin)	1.81E-2	1	8.11E-11	3.22E-11
	1.81E-2	1.25	9.94E-11	3.16E-11
	1.81E-2	1.5	1.17E-10	3.10E-11
	1.81E-2	1.75	1.34E-10	3.04E-11
	1.81E-2	2	1.52E-10	3.02E-11
Average				3.11E-11
PANI-(2CM-chitin)	1.81E-2	1	7.86E-11	3.12E-11
	1.81E-2	1.25	9.73E-11	3.09E-11
	1.81E-2	1.5	1.15E-10	3.05E-11
	1.81E-2	1.75	1.33E-10	3.02E-11
	1.81E-2	2	1.51E-10	3.00E-11
Average				3.06E-11
PANI-(2CM-chitin)	1.76E-2	1	8.20E-11	3.35E-11
	1.76E-2	1.25	1.06E-10	3.47E-11
	1.76E-2	1.5	1.19E-10	3.24E-11
	1.76E-2	1.75	1.37E-10	3.20E-11
	1.76E-2	2	1.54E-10	3.15E-11
Average				3.28E-11

Average conductivity 3.15E-11 S/cm
STD 1.17E-12

Appendix G Conductivity Measurement of the Doped Polyaniline Synthesized in the Presence of Cross-linked CM-chitin (Geometric correction factor (K) is 0.0047)

Table G1 Conductivity measurement of the doped conventional PANI synthesized without the presence of cross-linked CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
Conventional PANI	1.44E-2	0.025	2.48E-05	1.47E+01
	1.44E-2	0.05	5.11E-05	1.51E+01
	1.44E-2	0.075	7.71E-05	1.52E+01
	1.44E-2	0.1	1.03E-04	1.52E+01
	1.44E-2	0.25	2.74E-04	1.62E+01
Average				1.53E+01
Conventional PANI	1.44E-2	0.025	2.33E-05	1.38E+01
	1.44E-2	0.05	4.79E-05	1.42E+01
	1.44E-2	0.075	8.17E-05	1.61E+01
	1.44E-2	0.1	1.11E-04	1.64E+01
	1.44E-2	0.25	2.96E-04	1.75E+01
Average				1.56E+01
Conventional PANI	1.45E-2	0.025	2.45E-05	1.44E+01
	1.45E-2	0.05	5.25E-05	1.54E+01
	1.45E-2	0.075	7.85E-05	1.54E+01
	1.45E-2	0.1	1.16E-04	1.70E+01
	1.45E-2	0.25	2.96E-04	1.74E+01
Average				1.59E+01

Average conductivity 15.6 S/cm
STD 0.32

Table G2 Conductivity measurement of the doped PANI synthesized with non cross-linked CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-0Glu)	1.21E-2	0.025	2.76E-05	1.94E+01
	1.21E-2	0.05	5.80E-05	2.04E+01
	1.21E-2	0.075	8.98E-05	2.11E+01
	1.21E-2	0.1	1.31E-04	2.30E+01
	1.21E-2	0.25	4.13E-04	2.90E+01
Average				2.26E+01
PANI-(1CMCT-0Glu)	1.53E-2	0.025	4.20E-05	2.34E+01
	1.53E-2	0.05	9.09E-05	2.53E+01
	1.53E-2	0.075	1.38E-04	2.56E+01
	1.53E-2	0.1	1.85E-04	2.57E+01
	1.53E-2	0.25	4.85E-04	2.70E+01
Average				2.54E+01
PANI-(1CMCT-0Glu)	1.53E-2	0.025	4.14E-05	2.30E+01
	1.53E-2	0.05	8.94E-05	2.49E+01
	1.53E-2	0.075	1.41E-04	2.61E+01
	1.53E-2	0.1	1.90E-04	2.64E+01
	1.53E-2	0.25	4.65E-04	2.59E+01
Average				2.53E+01

Average conductivity 24.4 S/cm
STD 1.58

Table G3 Conductivity measurement of the doped PANI synthesized with 3 μmole added CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-3Glu)	1.15E-2	0.025	2.99E-05	2.21E+01
	1.15E-2	0.05	6.40E-05	2.37E+01
	1.15E-2	0.075	9.80E-05	2.42E+01
	1.15E-2	0.1	1.42E-04	2.63E+01
	1.15E-2	0.25	3.56E-04	2.63E+01
Average				2.45E+01
PANI-(1CMCT-3Glu)	1.14E-2	0.025	3.26E-05	2.43E+01
	1.14E-2	0.05	7.31E-05	2.73E+01
	1.14E-2	0.075	1.15E-04	2.86E+01
	1.14E-2	0.1	1.63E-04	3.04E+01
	1.14E-2	0.25	3.65E-04	2.72E+01
Average				2.76E+01
PANI-(1CMCT-3Glu)	1.14E-2	0.025	3.45E-05	2.58E+01
	1.14E-2	0.05	7.30E-05	2.72E+01
	1.14E-2	0.075	1.15E-04	2.86E+01
	1.14E-2	0.1	1.71E-04	3.19E+01
	1.14E-2	0.25	3.83E-04	2.86E+01
Average				2.84E+01

Average conductivity 26.8 S/cm
STD 2.05

Table G4 Conductivity measurement of the doped PANI synthesized with 9 μmole added CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-9Glu)	3.07E-2	0.025	1.43E-04	3.96E+01
	3.07E-2	0.05	3.03E-04	4.20E+01
	3.07E-2	0.075	4.56E-04	4.21E+01
	3.07E-2	0.1	6.06E-04	4.20E+01
	3.07E-2	0.25	1.57E-03	4.35E+01
Average				4.19E+01
PANI-(1CMCT-9Glu)	3.07E-2	0.025	1.33E-04	3.69E+01
	3.07E-2	0.05	2.84E-04	3.94E+01
	3.07E-2	0.075	4.34E-04	4.01E+01
	3.07E-2	0.1	5.87E-04	4.07E+01
	3.07E-2	0.25	1.56E-03	4.32E+01
Average				4.01E+01
PANI-(1CMCT-9Glu)	2.79E-2	0.025	1.16E-04	3.54E+01
	2.79E-2	0.05	2.42E-04	3.69E+01
	2.79E-2	0.075	3.65E-04	3.71E+01
	2.79E-2	0.1	4.87E-04	3.71E+01
	2.79E-2	0.25	1.36E-03	4.15E+01
Average				3.76E+01

Average conductivity 39.8 S/cm
STD 2.13

Table G5 Conductivity measurement of the doped PANI synthesized with 18 μmole added CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-18Glu)	2.76E-2	0.01	5.20E-05	4.01E+01
	2.76E-2	0.025	9.04E-05	2.79E+01
	2.76E-2	0.05	1.90E-04	2.93E+01
	2.76E-2	0.075	2.88E-04	2.96E+01
	2.76E-2	0.1	3.86E-04	2.98E+01
Average				3.13E+01
PANI-(1CMCT-18Glu)	2.35E-2	0.025	7.86E-05	2.85E+01
	2.35E-2	0.05	1.66E-04	3.01E+01
	2.35E-2	0.075	2.58E-04	3.11E+01
	2.35E-2	0.1	3.47E-04	3.14E+01
	2.35E-2	0.25	8.78E-04	3.18E+01
Average				3.06E+01
PANI-(1CMCT-18Glu)	2.35E-2	0.025	8.07E-05	2.92E+01
	2.35E-2	0.05	1.78E-04	3.22E+01
	2.35E-2	0.075	2.72E-04	3.28E+01
	2.35E-2	0.1	3.64E-04	3.30E+01
	2.35E-2	0.25	9.76E-04	3.53E+01
Average				3.25E+01

Average conductivity 31.5 S/cm
STD 0.98

Appendix H Conductivity Measurement of the Undoped Polyaniline Synthesized in the Presence of Cross-linked CM-chitin (Geometric correction factor (K) is 139)

Table H1 Conductivity measurement of the undoped conventional PANI synthesized without the presence of cross-linked CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
Conventional PANI	1.45E-2	1	7.54E-11	3.74E-11
	1.45E-2	1.25	9.29E-11	3.69E-11
	1.45E-2	1.5	1.09E-10	3.61E-11
	1.45E-2	1.75	1.30E-10	3.69E-11
	1.45E-2	2	1.44E-10	3.57E-11
Average				3.66E-11
Conventional PANI	1.45E-2	1	7.71E-11	3.83E-11
	1.45E-2	1.25	9.39E-11	3.73E-11
	1.45E-2	1.5	1.10E-10	3.64E-11
	1.45E-2	1.75	1.26E-10	3.57E-11
	1.45E-2	2	1.43E-10	3.55E-11
Average				3.66E-11
Conventional PANI	1.34E-2	1	7.34E-11	3.94E-11
	1.34E-2	1.25	8.97E-11	3.85E-11
	1.34E-2	1.5	1.07E-10	3.83E-11
	1.34E-2	1.75	1.23E-10	3.77E-11
	1.34E-2	2	1.40E-10	3.76E-11
Average				3.83E-11

Average conductivity 3.72E-11 S/cm
STD 9.86E-13

Table H2 Conductivity measurement of the undoped PANI synthesized with non cross-linked CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-0Glu)	0.99E-2	0.75	4.36E-11	4.22E-11
	0.99E-2	1	5.83E-11	4.24E-11
	0.99E-2	1.25	7.18E-11	4.17E-11
	0.99E-2	1.5	8.55E-11	4.14E-11
	0.99E-2	1.75	9.78E-11	4.06E-11
Average				4.17E-11
PANI-(1CMCT-0Glu)	1.10E-2	0.75	4.55E-11	3.97E-11
	1.10E-2	1	6.01E-11	3.93E-11
	1.10E-2	1.25	7.45E-11	3.90E-11
	1.10E-2	1.5	8.96E-11	3.91E-11
	1.10E-2	1.75	1.04E-10	3.89E-11
Average				3.92E-11
PANI-(1CMCT-0Glu)	1.10E-2	0.75	4.36E-11	3.80E-11
	1.10E-2	1	5.94E-11	3.88E-11
	1.10E-2	1.25	7.51E-11	3.93E-11
	1.10E-2	1.5	9.01E-11	3.93E-11
	1.10E-2	1.75	1.05E-10	3.92E-11
Average				3.89E-11

Average conductivity 3.99E-11 S/cm
STD 1.51E-12

Table H3 Conductivity measurement of the undoped PANI synthesized with 3 μmole added CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-3Glu)	1.20E-2	0.75	4.38E-11	3.50E-11
	1.20E-2	1	5.82E-11	3.49E-11
	1.20E-2	1.25	7.16E-11	3.43E-11
	1.20E-2	1.5	8.44E-11	3.37E-11
	1.20E-2	1.75	9.76E-11	3.34E-11
Average				3.43E-11
PANI-(1CMCT-3Glu)	1.20E-2	0.75	4.40E-11	3.52E-11
	1.20E-2	1	5.52E-11	3.31E-11
	1.20E-2	1.25	6.92E-11	3.32E-11
	1.20E-2	1.5	8.23E-11	3.29E-11
	1.20E-2	1.75	9.62E-11	3.30E-11
Average				3.35E-11
PANI-(1CMCT-3Glu)	1.02E-2	0.75	4.05E-11	3.81E-11
	1.02E-2	1	5.41E-11	3.82E-11
	1.02E-2	1.25	6.69E-11	3.77E-11
	1.02E-2	1.5	8.01E-11	3.77E-11
	1.02E-2	1.75	4.05E-11	3.78E-11
Average				3.79E-11

Average conductivity 3.52E-11 S/cm
STD 2.36E-12

Table H4 Conductivity measurement of the undoped PANI synthesized with 9 μmole added CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-9Glu)	1.22E-2	0.75	3.98E-11	3.13E-11
	1.22E-2	1	5.35E-11	3.15E-11
	1.22E-2	1.25	6.67E-11	3.15E-11
	1.22E-2	1.5	7.97E-11	3.13E-11
	1.22E-2	1.75	9.31E-11	3.14E-11
Average				3.14E-11
PANI-(1CMCT-9Glu)	1.22E-2	0.75	3.72E-11	2.92E-11
	1.22E-2	1	5.31E-11	3.13E-11
	1.22E-2	1.25	6.53E-11	3.08E-11
	1.22E-2	1.5	7.91E-11	3.11E-11
	1.22E-2	1.75	9.26E-11	3.12E-11
Average				3.07E-11
PANI-(1CMCT-9Glu)	1.35E-2	0.75	4.19E-11	2.98E-11
	1.35E-2	1	5.57E-11	2.97E-11
	1.35E-2	1.25	6.99E-11	2.98E-11
	1.35E-2	1.5	8.43E-11	2.99E-11
	1.35E-2	1.75	4.19E-11	2.99E-11
Average				2.98E-11

Average conductivity 3.07E-11 S/cm
STD 7.97E-13

Table H5 Conductivity measurement of the undoped PANI synthesized with 18 μmole added CM-chitin

Sample	Thickness (cm)	Applied voltage (V)	Current (A)	Conductivity (S/cm)
PANI-(1CMCT-18Glu)	1.93E-2	0.75	4.13E-11	2.05E-11
	1.93E-2	1	5.58E-11	2.08E-11
	1.93E-2	1.25	6.99E-11	2.08E-11
	1.93E-2	1.5	8.54E-11	2.12E-11
	1.93E-2	1.75	9.80E-11	2.09E-11
Average				2.09E-11
PANI-(1CMCT-18Glu)	1.93E-2	0.75	3.97E-11	1.97E-11
	1.93E-2	1	5.46E-11	2.04E-11
	1.93E-2	1.25	6.91E-11	2.06E-11
	1.93E-2	1.5	8.30E-11	2.06E-11
	1.93E-2	1.75	9.73E-11	2.07E-11
Average				2.04E-11
PANI-(1CMCT-18Glu)	1.98E-2	0.75	3.87E-11	1.87E-11
	1.9E-2	1	5.23E-11	1.90E-11
	1.98E-2	1.25	6.59E-11	1.92E-11
	1.98E-2	1.5	7.86E-11	1.90E-11
	1.98E-2	1.75	9.12E-11	1.89E-11
Average				1.90E-11

Average conductivity 2.01E-11 S/cm
STD 9.81E-13

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