

Appendix

A. Cut off solvents**Table 37** The solvent for UV-Visible spectrum and the minimum values for Measurement

Solvents	λ (nm)
CH ₂ Cl ₂	230
DMF	270
DMSO	265
EtOH	195
MeOH	195
CH ₃ CN	195

B. Bond distances (Å) and bond angles (°)

Table 38 The bond distances (Å) and bond angles (°) of [Ru(azpy)₃](PF₆)₂ complex

Bond distances

Atoms	(Angstroms)
Ru(2)-N(17)	2.026(8)
Ru(2)-N(12)	2.038(8)
Ru(2)-N(18)	2.062(8)
Ru(2)-N(20)	2.050(9)
Ru(2)-N(15)	2.056(9)
Ru(2)-N(14)	2.051(8)
N(17)-N(16)	1.30(1)
N(17)-C(50)	1.42(1)
N(12)-C(38)	1.36(1)
N(12)-C(34)	1.34(1)
N(18)-C(60)	1.40(1)
N(18)-C(56)	1.29(1)
N(20)-N(19)	1.31(1)
N(20)-C(61)	1.49(1)
N(15)-C(49)	1.40(1)
N(15)-C(45)	1.37(1)
N(14)-N(13)	1.25(1)
N(14)-C(39)	1.49(1)
N(16)-C(49)	1.36(1)
C(40)-H(40)	.93(1)

Table 38 (continued)

Atoms	(Angstroms)
C(40)-C(39)	1.32(1)
C(40)-C(41)	1.44(1)
N(19)-C(60)	1.35(1)
C(61)-C(62)	1.33(1)
C(61)-C(66)	1.41(1)
C(51)-C(52)	1.33(2)
C(51)-C(50)	1.43(1)
C(51)-H(51)	.92(5)
N(13)-C(38)	1.30(1)
C(39)-C(44)	1.39(2)
C(54)-H(54)	.93(1)
C(54)-C(55)	1.42(2)
C(54)-C(53)	1.37(2)
C(49)-C(48)	1.37(2)
C(41)-H(41)	.93(1)
C(41)-C(42)	1.39(2)
C(55)-C(50)	1.27(1)
C(55)-H(55)	.74(4)
C(37)-C(38)	1.42(1)
C(37)-C(36)	1.38(1)
C(37)-H(37)	.73(6)
C(52)-C(53)	1.35(2)
C(52)-H(52)	.91(6)
C(62)-C(63)	1.44(2)

Table 38 (continued)

Atoms	(Angstroms)
C(62)-H(62)	.99(5)
C(60)-C(59)	1.41(1)
C(58)-C(59)	1.36(2)
C(58)-C(57)	1.36(2)
C(58)-H(58)	.76(6)
C(56)-C(57)	1.31(2)
C(56)-H(56)	1.13(6)
C(34)-C(35)	1.38(2)
C(34)-H(34)	.90(4)
C(59)-H(59)	.85(5)
C(44)-C(43)	1.38(2)
C(44)-H(44)	.71(4)
C(57)-H(57)	.90(4)
C(48)-C(47)	1.37(2)
C(48)-H(48)	.88(4)
C(66)-C(65)	1.34(2)
C(66)-H(66)	.61(6)
C(45)-C(46)	1.46(2)
C(53)-H(53)	.81(6)
C(47)-C(46)	1.32(2)
C(42)-H(42)	.93(1)
C(42)-C(43)	1.37(2)
C(35)-C(36)	1.33(2)
C(35)-H(35)	.88(6)

Table 38 (continued)

Atoms	(Angstroms)
C(63)-C(64)	1.41(2)
C(63)-H(63)	.87(6)
C(46)-H(46)	.66(5)
C(64)-C(65)	1.34(2)
C(64)-H(64)	.90(6)
C(43)-H(43)	1.01(8)
C(65)-H(65)	1.08(6)
C(36)-H(36)	.89(5)
P(1)-F(12)	1.623(8)
P(1)-F(8)	1.622(7)
P(1)-F(13)	1.614(8)
P(1)-F(11)	1.559(8)
P(1)-F(9)	1.58(1)
P(1)-F(10)	1.556(9)
Ru(1)-N(3)	2.111(8)
Ru(1)-N(7)	2.043(8)
Ru(1)-N(1)	2.068(8)
Ru(1)-N(4)	2.059(8)
Ru(1)-N(9)	2.050(8)
Ru(1)-N(6)	1.989(8)
N(3)-N(2)	1.24(1)
N(3)-C(6)	1.46(1)
N(7)-C(23)	1.39(1)
N(7)-C(27)	1.33(1)

Table 38 (contonued)

Atoms	(Angstroms)
N(1)-C(5)	1.32(1)
N(1)-C(1)	1.32(1)
N(4)-C(16)	1.35(1)
N(4)-C(12)	1.33(1)
N(9)-N(8)	1.24(1)
N(9)-C(28)	1.39(1)
N(6)-C(17)	1.43(1)
N(6)-N(5)	1.29(1)
N(2)-C(5)	1.41(1)
N(8)-C(27)	1.45(1)
C(2)-C(3)	1.42(1)
C(2)-C(1)	1.32(2)
C(2)-H(2)	1.13(6)
C(5)-C(4)	1.39(2)
C(7)-H(7)	.931(9)
C(7)-C(6)	1.33(1)
C(7)-C(8)	1.41(1)
C(28)-C(29)	1.45(2)
C(28)-C(33)	1.35(2)
C(17)-C(22)	1.41(2)
C(17)-C(18)	1.36(2)
N(5)-C(16)	1.48(1)
C(16)-C(15)	1.33(2)
C(29)-C(30)	1.31(2)

Table 38 (continued)

Atoms	(Angstroms)
C(29)-H(29)	.73(8)
C(23)-C(24)	1.43(1)
C(23)-H(23)	.79(5)
C(6)-C(11)	1.48(1)
C(32)-C(33)	1.41(2)
C(32)-C(31)	1.39(2)
C(32)-H(32)	1.06(7)
C(15)-C(14)	1.35(2)
C(15)-H(15)	1.05(6)
C(27)-C(26)	1.32(1)
C(14)-H(14)	.93(1)
C(14)-C(13)	1.42(1)
C(12)-H(12)	.930(9)
C(12)-C(13)	1.37(1)
C(25)-H(25)	.93(1)
C(25)-C(24)	1.37(2)
C(25)-C(26)	1.39(2)
C(22)-C(21)	1.33(2)
C(22)-H(22)	.94(6)
C(24)-H(24)	.93(1)
C(18)-C(19)	1.40(2)
C(18)-H(18)	1.08(4)
C(33)-H(33)	1.10(4)
C(3)-C(4)	1.37(2)

Table 38 (continued)

Atoms	(Angstroms)
C(26)-H(26)	.931(9)
C(1)-H(45)	1.01(4)
C(30)-H(30)	.93(1)
C(30)-C(31)	1.34(2)
C(20)-C(21)	1.34(2)
C(20)-C(19)	1.38(2)
C(20)-H(20)	.83(6)
C(13)-H(13)	.93(1)
C(10)-C(11)	1.34(2)
C(10)-C(9)	1.35(2)
C(10)-H(10)	.66(5)
C(4)-H(4)	.93(1)
C(31)-H(31)	.93(1)
C(21)-H(21)	.93(1)
C(11)-H(11)	.93(1)
C(8)-H(8)	.93(1)
C(8)-C(9)	1.42(2)
C(19)-H(19)	.93(1)
C(9)-H(9)	.93(1)
P(2)-F(16)	1.566(9)
P(2)-F(18)	1.576(9)
P(2)-F(17)	1.555(8)
P(2)-F(15)	1.610(8)
P(2)-F(14)	1.602(9)

Table 38 (continued)

Atoms	(Angstroms)
P(3)-F(5)	1.54(1)
P(3)-F(3)	1.626(9)
P(3)-F(7)	1.57(1)
P(3)-F(2)	1.54(1)
P(3)-F(4)	1.549(9)
P(3)-F(6)	1.49(1)
P(4)-F(20)	1.616(9)
P(4)-F(22)	1.58(1)
P(4)-F(24)	1.49(1)
P(4)-F(27)	1.565(9)
P(4)-F(26)	1.533(8)
P(4)-F(25)	1.462(9)

Table 38 (continued)Bond angle (°)

Atoms	Angles (°)
N(17)-Ru(2)-N(12)	104.2(3)
N(17)-Ru(2)-N(18)	95.5(3)
N(17)-Ru(2)-N(20)	79.4(3)
N(17)-Ru(2)-N(15)	76.6(3)
N(17)-Ru(2)-N(14)	172.0(3)
N(12)-Ru(2)-N(18)	93.2(3)
N(12)-Ru(2)-N(20)	170.5(4)
N(12)-Ru(2)-N(15)	89.5(3)
N(12)-Ru(2)-N(14)	74.0(3)
N(18)-Ru(2)-N(20)	77.6(4)
N(18)-Ru(2)-N(15)	172.1(3)
N(18)-Ru(2)-N(14)	92.4(3)
N(20)-Ru(2)-N(15)	100.0(4)
N(20)-Ru(2)-N(14)	103.6(3)
N(15)-Ru(2)-N(14)	95.5(3)
Ru(2)-N(17)-N(16)	119.8(6)
Ru(2)-N(17)-C(50)	128.8(7)
N(16)-N(17)-C(50)	109.9(8)
Ru(2)-N(12)-C(38)	113.4(6)
Ru(2)-N(12)-C(34)	126.4(7)
C(38)-N(12)-C(34)	119.5(9)
Ru(2)-N(18)-C(60)	107.9(6)
Ru(2)-N(18)-C(56)	133.1(7)

Table 38 (continued)

Atoms	Angles (°)
C(60)-N(18)-C(56)	118.6(8)
Ru(2)-N(20)-N(19)	119.8(7)
Ru(2)-N(20)-C(61)	126.5(7)
N(19)-N(20)-C(61)	113.6(8)
Ru(2)-N(15)-C(49)	111.9(7)
Ru(2)-N(15)-C(45)	128.4(7)
C(49)-N(15)-C(45)	119.6(9)
Ru(2)-N(14)-N(13)	119.6(6)
Ru(2)-N(14)-C(39)	119.8(6)
N(13)-N(14)-C(39)	119.9(8)
N(17)-N(16)-C(49)	112.8(7)
H(40)-C(40)-C(39)	122(1)
H(40)-C(40)-C(41)	122(1)
C(39)-C(40)-C(41)	117(1)
N(20)-N(19)-C(60)	109.5(8)
N(20)-C(61)-C(62)	118.9(8)
N(20)-C(61)-C(66)	117.5(9)
C(62)-C(61)-C(66)	123.5(9)
C(52)-C(51)-C(50)	115(1)
C(52)-C(51)-H(51)	126(3)
C(50)-C(51)-H(51)	120(3)
N(14)-N(13)-C(38)	114.3(8)
N(14)-C(39)-C(40)	121.5(8)
N(14)-C(39)-C(44)	116.4(9)

Table 38 (continued)

Atoms	Angles (°)
H(54)-C(54)-C(55)	120(1)
H(54)-C(54)-C(53)	120(1)
C(55)-C(54)-C(53)	119(1)
N(15)-C(49)-N(16)	118.0(9)
N(15)-C(49)-C(48)	118.3(9)
N(16)-C(49)-C(48)	123.7(8)
C(40)-C(41)-H(41)	121(1)
C(40)-C(41)-C(42)	119(1)
H(41)-C(41)-C(42)	121(1)
C(54)-C(55)-C(50)	124(1)
C(54)-C(55)-H(55)	120(4)
C(50)-C(55)-H(55)	115(4)
C(38)-C(37)-C(36)	120(1)
C(38)-C(37)-H(37)	105(5)
C(36)-C(37)-H(37)	133(5)
C(51)-C(52)-C(53)	130(1)
C(51)-C(52)-H(52)	116(4)
C(53)-C(52)-H(52)	114(4)
N(12)-C(38)-N(13)	117.9(8)
N(12)-C(38)-C(37)	118.6(9)
N(13)-C(38)-C(37)	123.5(8)
N(17)-C(50)-C(51)	116.2(8)
N(17)-C(50)-C(55)	125.3(9)
C(51)-C(50)-C(55)	119(1)

Table 38 (continued)

Atoms	Angles (°)
C(61)-C(62)-C(63)	118(1)
C(61)-C(62)-H(62)	125(3)
C(63)-C(62)-H(62)	117(4)
N(18)-C(60)-N(19)	124.0(8)
N(18)-C(60)-C(59)	118.0(9)
N(19)-C(60)-C(59)	117.6(8)
C(59)-C(58)-C(57)	116(1)
C(59)-C(58)-H(58)	121(4)
C(57)-C(58)-H(58)	123(4)
N(18)-C(56)-C(57)	123(1)
N(18)-C(56)-H(56)	111(3)
C(57)-C(56)-H(56)	126(3)
N(12)-C(34)-C(35)	122(1)
N(12)-C(34)-H(34)	117(3)
C(35)-C(34)-H(34)	121(3)
C(60)-C(59)-C(58)	120.9(9)
C(60)-C(59)-H(59)	117(4)
C(58)-C(59)-H(59)	123(4)
C(39)-C(44)-C(43)	124(1)
C(39)-C(44)-H(44)	127(4)
C(43)-C(44)-H(44)	108(4)
C(58)-C(57)-C(56)	124(1)
C(58)-C(57)-H(57)	125(3)
C(56)-C(57)-H(57)	112(3)

Table (continued)

Atoms	Angles (°)
C(47)-C(48)-H(48)	127(3)
C(61)-C(66)-C(65)	118(1)
C(61)-C(66)-H(66)	119(6)
C(65)-C(66)-H(66)	116(6)
N(15)-C(45)-C(46)	116(1)
C(54)-C(53)-C(52)	113(1)
C(54)-C(53)-H(53)	126(5)
C(52)-C(53)-H(53)	121(5)
C(48)-C(47)-C(46)	114(1)
C(41)-C(42)-H(42)	117(1)
C(41)-C(42)-C(43)	125(1)
H(42)-C(42)-C(43)	117(1)
C(34)-C(35)-C(36)	121(1)
C(34)-C(35)-H(35)	119(3)
C(36)-C(35)-H(35)	121(3)
C(62)-C(63)-C(64)	117(1)
C(62)-C(63)-H(63)	123(4)
C(64)-C(63)-H(63)	120(4)
C(45)-C(46)-C(47)	126(1)
C(45)-C(46)-H(46)	109(5)
C(47)-C(46)-H(46)	125(5)
C(63)-C(64)-C(65)	122(1)
C(63)-C(64)-H(64)	116(4)
C(65)-C(64)-H(64)	121(4)
C(44)-C(43)-C(42)	113(1)

Table 38 (continued)

Atoms	Angles (°)
C(44)-C(43)-H(43)	125(4)
C(42)-C(43)-H(43)	122(4)
C(66)-C(65)-C(64)	121(1)
C(66)-C(65)-H(65)	114(4)
C(64)-C(65)-H(65)	124(3)
C(37)-C(36)-C(35)	119(1)
C(37)-C(36)-H(36)	119(4)
C(35)-C(36)-H(36)	122(3)
F(12)-P(1)-F(8)	87.4(4)
F(12)-P(1)-F(13)	86.9(4)
F(12)-P(1)-F(11)	93.4(4)
F(12)-P(1)-F(9)	177.8(5)
F(12)-P(1)-F(10)	88.1(5)
F(8)-P(1)-F(13)	85.1(4)
F(8)-P(1)-F(11)	177.5(4)
F(8)-P(1)-F(9)	92.8(4)
F(8)-P(1)-F(10)	93.5(5)
F(13)-P(1)-F(11)	92.6(5)
F(13)-P(1)-F(9)	90.9(5)
F(13)-P(1)-F(10)	174.9(5)
F(11)-P(1)-F(9)	86.3(5)
F(11)-P(1)-F(10)	88.8(5)
F(9)-P(1)-F(10)	94.1(5)
N(3)-Ru(1)-N(7)	97.7(3)

Table 38 (continued)

Atoms	Angles (°)
N(3)-Ru(1)-N(1)	73.9(3)
N(3)-Ru(1)-N(4)	103.0(3)
N(3)-Ru(1)-N(9)	80.9(3)
N(3)-Ru(1)-N(6)	169.8(3)
N(7)-Ru(1)-N(1)	170.7(3)
N(7)-Ru(1)-N(4)	95.4(3)
N(7)-Ru(1)-N(9)	74.5(3)
N(7)-Ru(1)-N(6)	92.5(3)
N(1)-Ru(1)-N(4)	90.5(3)
N(1)-Ru(1)-N(9)	99.8(3)
N(1)-Ru(1)-N(6)	95.9(3)
N(4)-Ru(1)-N(9)	169.6(3)
N(4)-Ru(1)-N(6)	76.9(3)
N(9)-Ru(1)-N(6)	101.0(3)
Ru(1)-N(3)-N(2)	119.0(6)
Ru(1)-N(3)-C(6)	122.9(6)
N(2)-N(3)-C(6)	116.5(8)
Ru(1)-N(7)-C(23)	124.6(7)
Ru(1)-N(7)-C(27)	118.7(7)
C(23)-N(7)-C(27)	116.4(9)
Ru(1)-N(1)-C(5)	114.8(6)
Ru(1)-N(1)-C(1)	129.0(7)
C(5)-N(1)-C(1)	116.2(8)
Ru(1)-N(4)-C(16)	113.8(6)

Table 38 (continued)

Atoms	Angles (°)
Ru(1)-N(4)-C(12)	130.2(6)
C(16)-N(4)-C(12)	115.9(8)
Ru(1)-N(9)-N(8)	118.1(6)
Ru(1)-N(9)-C(28)	127.2(7)
N(8)-N(9)-C(28)	112.7(8)
Ru(1)-N(6)-C(17)	127.5(6)
Ru(1)-N(6)-N(5)	123.0(6)
C(17)-N(6)-N(5)	109.0(8)
N(3)-N(2)-C(5)	112.7(7)
N(9)-N(8)-C(27)	116.9(8)
C(3)-C(2)-C(1)	117(1)
C(3)-C(2)-H(2)	119(3)
C(1)-C(2)-H(2)	123(3)
N(1)-C(5)-N(2)	118.1(8)
N(1)-C(5)-C(4)	126.9(9)
N(2)-C(5)-C(4)	115.0(8)
H(7)-C(7)-C(6)	118(1)
H(7)-C(7)-C(8)	118(1)
C(6)-C(7)-C(8)	123.0(9)
N(9)-C(28)-C(29)	118.5(9)
N(9)-C(28)-C(33)	124.4(9)
C(29)-C(28)-C(33)	117(1)
N(6)-C(17)-C(22)	116.0(9)
N(6)-C(17)-C(18)	122.5(9)

Table 38 (continued)

Atoms	Angles (°)
C(22)-C(17)-C(18)	121(1)
N(6)-N(5)-C(16)	109.7(8)
N(4)-C(16)-N(5)	116.6(9)
N(4)-C(16)-C(15)	127(1)
N(5)-C(16)-C(15)	116(1)
C(28)-C(29)-C(30)	120(1)
C(28)-C(29)-H(29)	114(6)
C(30)-C(29)-H(29)	125(7)
N(7)-C(23)-C(24)	120.8(9)
N(7)-C(23)-H(23)	123(4)
C(24)-C(23)-H(23)	116(4)
N(3)-C(6)-C(7)	121.1(8)
N(3)-C(6)-C(11)	114.6(9)
C(7)-C(6)-C(11)	124.2(9)
C(33)-C(32)-C(31)	119(1)
C(33)-C(32)-H(32)	117(3)
C(31)-C(32)-H(32)	121(4)
C(16)-C(15)-C(14)	117(1)
C(16)-C(15)-H(15)	121(3)
C(14)-C(15)-H(15)	120(3)
N(7)-C(27)-N(8)	110.2(9)
N(7)-C(27)-C(26)	127.3(9)
N(8)-C(27)-C(26)	122.4(9)
C(15)-C(14)-H(14)	120(1)

Table 38 (continued)

Atoms	Angles (°)
C(15)-C(14)-C(13)	120(1)
H(14)-C(14)-C(13)	120(1)
N(4)-C(12)-H(12)	118.7(9)
N(4)-C(12)-C(13)	122.5(9)
H(12)-C(12)-C(13)	118.7(9)
H(25)-C(25)-C(24)	119(1)
H(25)-C(25)-C(26)	119(1)
C(24)-C(25)-C(26)	122(1)
C(17)-C(22)-C(21)	121(1)
C(17)-C(22)-H(22)	119(3)
C(21)-C(22)-H(22)	120(3)
C(23)-C(24)-C(25)	116(1)
C(23)-C(24)-H(24)	121.8(9)
C(25)-C(24)-H(24)	122(1)
C(17)-C(18)-C(19)	113(1)
C(17)-C(18)-H(18)	117(2)
C(19)-C(18)-H(18)	129(2)
C(28)-C(33)-C(32)	122(1)
C(28)-C(33)-H(33)	119(2)
C(32)-C(33)-H(33)	119(2)
C(2)-C(3)-C(4)	121(1)
C(2)-C(3)-H(3)	119(3)
C(4)-C(3)-H(3)	120(3)
C(27)-C(26)-C(25)	117(1)

Table 38 (continued)

Atoms	Angles (°)
C(27)-C(26)-H(26)	122(1)
C(25)-C(26)-H(26)	122(1)
N(1)-C(1)-C(2)	124.8(9)
N(1)-C(1)-H(45)	115(2)
C(2)-C(1)-H(45)	120(2)
C(29)-C(30)-H(30)	118(1)
C(29)-C(30)-C(31)	124(1)
H(30)-C(30)-C(31)	118(1)
C(21)-C(20)-C(19)	116(1)
C(21)-C(20)-H(20)	120(4)
C(19)-C(20)-H(20)	124(4)
C(14)-C(13)-C(12)	118.1(9)
C(14)-C(13)-H(13)	121(1)
C(12)-C(13)-H(13)	121(1)
C(11)-C(10)-C(9)	123(1)
C(11)-C(10)-H(10)	109(5)
C(9)-C(10)-H(10)	128(5)
C(5)-C(4)-C(3)	114(1)
C(5)-C(4)-H(4)	123(1)
C(3)-C(4)-H(4)	123(1)
C(32)-C(31)-C(30)	118(1)
C(32)-C(31)-H(31)	121(1)
C(30)-C(31)-H(31)	121(1)
C(22)-C(21)-C(20)	122(1)

Table 38 (continued)

Atoms	Angles (°)
C(22)-C(21)-H(21)	119(1)
C(20)-C(21)-H(21)	119(1)
C(6)-C(11)-C(10)	112(1)
C(6)-C(11)-H(11)	124(1)
C(10)-C(11)-H(11)	124(1)
C(7)-C(8)-H(8)	124.7(9)
C(7)-C(8)-C(9)	111(1)
H(8)-C(8)-C(9)	125(1)
C(18)-C(19)-C(20)	126(1)
C(18)-C(19)-H(19)	117(1)
C(20)-C(19)-H(19)	117(1)
C(10)-C(9)-C(8)	127(1)
C(10)-C(9)-H(9)	116(1)
C(8)-C(9)-H(9)	116(1)
F(16)-P(2)-F(18)	92.1(4)
F(16)-P(2)-F(17)	91.5(5)
F(16)-P(2)-F(15)	86.3(4)
F(16)-P(2)-F(14)	90.8(5)
F(16)-P(2)-F(19)	179.3(5)
F(18)-P(2)-F(17)	95.0(4)
F(18)-P(2)-F(15)	177.8(5)
F(18)-P(2)-F(14)	86.4(5)
F(18)-P(2)-F(19)	87.9(5)
F(17)-P(2)-F(15)	86.6(4)

Table 38 (continued)

Atoms	Angles (°)
F(17)-P(2)-F(14)	177.3(5)
F(17)-P(2)-F(19)	89.2(5)
F(15)-P(2)-F(14)	92.1(5)
F(15)-P(2)-F(19)	93.7(5)
F(14)-P(2)-F(19)	88.5(5)
F(5)-P(3)-F(3)	92.1(5)
F(5)-P(3)-F(7)	92.3(5)
F(5)-P(3)-F(2)	173.6(6)
F(5)-P(3)-F(4)	90.7(5)
F(5)-P(3)-F(6)	94.8(5)
F(3)-P(3)-F(7)	90.1(5)
F(3)-P(3)-F(2)	82.2(5)
F(3)-P(3)-F(4)	86.1(5)
F(3)-P(3)-F(6)	172.3(6)
F(7)-P(3)-F(2)	90.6(6)
F(7)-P(3)-F(4)	175.2(6)
F(7)-P(3)-F(6)	93.0(7)
F(2)-P(3)-F(4)	86.1(6)
F(2)-P(3)-F(6)	90.7(6)
F(4)-P(3)-F(6)	90.5(6)
F(20)-P(4)-F(22)	174.0(6)
F(20)-P(4)-F(24)	86.4(7)
F(20)-P(4)-F(27)	89.9(5)
F(20)-P(4)-F(26)	96.3(6)

Table 38 (continued)

Atoms	Angles (°)
F(20)-P(4)-F(25)	96.8(5)
F(22)-P(4)-F(24)	90.0(7)
F(22)-P(4)-F(27)	85.1(5)
F(22)-P(4)-F(26)	86.8(6)
F(22)-P(4)-F(25)	87.9(5)
F(24)-P(4)-F(27)	87.8(8)
F(24)-P(4)-F(26)	173.8(7)
F(24)-P(4)-F(25)	89.5(8)
F(27)-P(4)-F(26)	86.7(6)
F(27)-P(4)-F(25)	172.5(5)
F(26)-P(4)-F(25)	95.7(6)

Table 39 The bond distances (\AA) and bond angles ($^\circ$) of $[\text{Ru}(\text{azpy})_2\text{bpy}](\text{PF}_6)_2$ complex

Bond distances

Atoms	(Angstroms)
Ru(1)-N(8)	2.003(5)
Ru(1)-N(5)	2.036(5)
Ru(1)-N(6)	2.039(6)
Ru(1)-N(3)	2.047(5)
Ru(1)-N(2)	2.082(5)
Ru(1)-N(1)	2.090(5)
C(13)-C(14)	1.368(12)
C(13)-C(12)	1.376(12)
N(3)-C(11)	1.327(9)
N(3)-C(15)	1.355(8)
N(5)-N(4)	1.272(7)
N(5)-C(16)	1.449(8)
N(1)-C(1)	1.340(9)
N(1)-C(5)	1.355(8)
N(2)-C(10)	1.336(9)
N(2)-C(6)	1.346(8)
N(8)-N(7)	1.269(8)
N(8)-C(28)	1.452(8)
N(6)-C(22)	1.338(9)
N(6)-C(27)	1.348(9)
C(15)-C(14)	1.383(10)
C(15)-N(4)	1.404(9)

Table 39 (continued)

Atoms	(Angstroms)
C(5)-C(4)	1.366(10)
C(5)-C(6)	1.484(10)
C(6)-C(7)	1.378(10)
N(7)-C(27)	1.400(9)
C(10)-C(9)	1.366(11)
C(17)-C(18)	1.368(11)
C(17)-C(16)	1.374(10)
C(28)-C(29)	1.383(10)
C(28)-C(33)	1.383(10)
C(33)-C(32)	1.363(11)
C(12)-C(11)	1.370(11)
C(31)-C(32)	1.371(12)
C(31)-C(30)	1.388(12)
C(9)-C(8)	1.354(13)
C(29)-C(30)	1.366(11)
C(16)-C(21)	1.380(10)
C(20)-C(19)	1.363(14)
C(20)-C(21)	1.384(12)
C(4)-C(3)	1.377(14)
C(1)-C(2)	1.368(11)
C(2)-C(3)	1.333(13)
C(22)-C(23)	1.360(12)
C(18)-C(19)	1.365(14)
C(27)-C(25)	1.385(12)

Table 39 (continued)

Atoms	(Angstroms)
C(7)-C(8)	1.369(13)
P(1)-F(3)	1.559(6)
P(1)-F(1)	1.561(6)
P(1)-F(5)	1.571(6)
P(1)-F(2)	1.573(7)
P(1)-F(4)	1.584(5)
P(1)-F(6)	1.585(5)
P(2)-F(8)	1.437(9)
P(2)-F(9)	1.481(9)
P(2)-F(11)	1.478(10)
P(2)-F(12)	1.525(8)
P(2)-F(10)	1.532(8)
P(2)-F(7)	1.540(8)
C(23)-C(24)	1.360(15)
C(25)-C(24)	1.367(15)

Table 39 (continued)Bond angle (°)

Atoms	Angles (°)
N(8)-Ru(1)-N(5)	83.4(2)
N(8)-Ru(1)-N(6)	76.1(2)
N(5)-Ru(1)-N(6)	98.1(2)
N(8)-Ru(1)-N(3)	96.8(2)
N(5)-Ru(1)-N(3)	75.9(2)
N(6)-Ru(1)-N(3)	171.3(2)
N(8)-Ru(1)-N(2)	96.9(2)
N(5)-Ru(1)-N(2)	175.9(2)
N(6)-Ru(1)-N(2)	86.0(2)
N(3)-Ru(1)-N(2)	100.0(2)
N(8)-Ru(1)-N(1)	172.7(2)
N(5)-Ru(1)-N(1)	102.1(2)
N(6)-Ru(1)-N(1)	98.3(2)
N(3)-Ru(1)-N(1)	89.2(2)
N(2)-Ru(1)-N(1)	77.9(2)
C(14)-C(13)-C(12)	119.6(8)
C(11)-N(3)-C(15)	117.0(6)
C(11)-N(3)-Ru(1)	129.7(5)
C(15)-N(3)-Ru(1)	112.9(4)
N(4)-N(5)-C(16)	113.2(5)
N(4)-N(5)-Ru(1)	119.5(4)
C(16)-N(5)-Ru(1)	126.1(4)
C(1)-N(1)-C(5)	118.0(6)

Table 39 (continued)

Atoms	Angles (°)
C(1)-N(1)-Ru(1)	126.1(5)
C(5)-N(1)-Ru(1)	115.9(5)
C(10)-N(2)-C(6)	117.7(6)
C(10)-N(2)-Ru(1)	125.7(5)
C(6)-N(2)-Ru(1)	116.4(5)
N(7)-N(8)-C(28)	115.2(5)
N(7)-N(8)-Ru(1)	121.7(4)
C(28)-N(8)-Ru(1)	122.6(4)
C(22)-N(6)-C(27)	117.3(7)
C(22)-N(6)-Ru(1)	129.8(5)
C(27)-N(6)-Ru(1)	112.9(5)
N(3)-C(15)-C(14)	123.3(7)
N(3)-C(15)-N(4)	117.5(6)
C(14)-C(15)-N(4)	119.2(7)
N(1)-C(5)-C(4)	120.9(8)
N(1)-C(5)-C(6)	114.8(6)
C(4)-C(5)-C(6)	124.2(7)
N(2)-C(6)-C(7)	121.1(7)
N(2)-C(6)-C(5)	115.1(6)
C(7)-C(6)-C(5)	123.7(7)
N(8)-N(7)-C(27)	110.9(6)
N(5)-N(4)-C(15)	112.2(5)
N(2)-C(10)-C(9)	123.3(8)
C(18)-C(17)-C(16)	118.7(8)

Table 39 (continued)

Atoms	Angles (°)
C(29)-C(28)-C(33)	121.0(7)
C(29)-C(28)-N(8)	118.9(6)
C(33)-C(28)-N(8)	119.7(6)
C(32)-C(33)-C(28)	119.1(8)
C(11)-C(12)-C(13)	119.1(8)
C(32)-C(31)-C(30)	118.6(8)
C(8)-C(9)-C(10)	118.9(9)
C(30)-C(29)-C(28)	118.3(8)
C(17)-C(16)-C(21)	121.5(7)
C(17)-C(16)-N(5)	120.4(6)
C(21)-C(16)-N(5)	118.1(6)
N(3)-C(11)-C(12)	123.2(8)
C(19)-C(20)-C(21)	121.2(10)
C(5)-C(4)-C(3)	119.6(9)
C(16)-C(21)-C(20)	117.9(9)
N(1)-C(1)-C(2)	122.3(8)
C(3)-C(2)-C(1)	119.7(9)
C(33)-C(32)-C(31)	121.4(9)
N(6)-C(22)-C(23)	122.9(9)
C(13)-C(14)-C(15)	117.9(8)
C(29)-C(30)-C(31)	121.5(8)
C(19)-C(18)-C(17)	121.2(9)
N(6)-C(27)-C(25)	122.7(8)
N(6)-C(27)-N(7)	118.3(7)

Table 39 (continued)

Atoms	Angles (°)
C(25)-C(27)-N(7)	119.0(8)
C(8)-C(7)-C(6)	119.8(8)
C(2)-C(3)-C(4)	119.4(8)
C(9)-C(8)-C(7)	119.1(8)
C(18)-C(19)-C(20)	119.5(9)
F(3)-P(1)-F(1)	89.8(4)
F(3)-P(1)-F(5)	92.1(5)
F(1)-P(1)-F(5)	90.9(4)
F(3)-P(1)-F(2)	89.7(5)
F(1)-P(1)-F(2)	92.0(4)
F(5)-P(1)-F(2)	176.6(4)
F(3)-P(1)-F(4)	90.3(3)
F(1)-P(1)-F(4)	178.8(4)
F(5)-P(1)-F(4)	87.9(4)
F(2)-P(1)-F(4)	89.2(4)
F(3)-P(1)-F(6)	178.9(5)
F(1)-P(1)-F(6)	90.6(4)
F(5)-P(1)-F(6)	89.0(4)
F(2)-P(1)-F(6)	89.2(4)
F(4)-P(1)-F(6)	89.3(3)
F(8)-P(2)-F(9)	90.0(9)
F(8)-P(2)-F(11)	178.5(10)
F(9)-P(2)-F(11)	89.4(9)
F(8)-P(2)-F(12)	91.2(8)

Table 39 (continued)

Atoms	Angles (°)
F(9)-P(2)-F(12)	178.4(7)
F(11)-P(2)-F(12)	89.5(8)
F(8)-P(2)-F(10)	89.9(8)
F(9)-P(2)-F(10)	90.8(6)
F(11)-P(2)-F(10)	88.8(8)
F(12)-P(2)-F(10)	90.3(5)
F(8)-P(2)-F(7)	91.5(8)
F(9)-P(2)-F(7)	89.6(5)
F(11)-P(2)-F(7)	89.8(8)
F(12)-P(2)-F(7)	89.2(5)
F(10)-P(2)-F(7)	178.5(7)
C(22)-C(23)-C(240)	119.3(9)
C(24)-C(25)-C(27)	117.8(10)
C(23)-C(24)-C(25)	120.0(10)

Table 40 The bond distances (Å) and bond angles (°) of [Ru(azpy)₂phen](BF₄)₂ complex

Bond distances

Atoms	(Angstroms)
F(8)-B(1)	1.214(16)
Ru(1)-N(5)	2.014(6)
Ru(1)-N(8)	2.021(5)
Ru(1)-N(3)	2.050(6)
Ru(1)-N(6)	2.054(6)
Ru(1)-N(2)	2.086(6)
Ru(1)-N(1)	2.085(6)
N(5)-N(4)	1.284(8)
N(5)-C(18)	1.432(9)
N(8)-N(7)	1.279(8)
N(8)-C(29)	1.430(8)
N(1)-C(12)	1.358(10)
N(1)-C(1)	1.365(10)
N(6)-C(24)	1.333(9)
N(6)-C(28)	1.349(9)
C(3)-N(2)	1.347(10)
C(3)-C(4)	1.404(12)
N(3)-C(13)	1.331(9)
N(3)-C(17)	1.355(9)
C(34)-C(29)	1.384(11)
C(34)-C(33)	1.386(13)
C(6)-C(2)	1.396(11)

Table 40 (continued)

Atoms	(Angstroms)
C(6)-C(5)	1.412(14)
C(6)-C(7)	1.487(16)
C(28)-C(27)	1.368(11)
C(28)-N(7)	1.408(9)
C(14)-C(15)	1.376(14)
C(14)-C(13)	1.389(12)
C(18)-C(23)	1.366(11)
C(18)-C(19)	1.378(11)
N(2)-C(2)	1.362(10)
C(2)-C(1)	1.396(11)
C(29)-C(30)	1.398(11)
C(19)-C(20)	1.358(11)
C(1)-C(9)	1.411(11)
N(4)-C(17)	1.394(10)
C(24)-C(25)	1.375(12)
C(25)-C(26)	1.356(14)
C(23)-C(22)	1.404(12)
C(26)-C(27)	1.401(14)
C(11)-C(10)	1.331(15)
C(11)-C(12)	1.395(13)
C(9)-C(8)	1.409(15)
C(9)-C(10)	1.455(16)
C(21)-C(22)	1.361(15)
C(21)-C(20)	1.378(14)

Table 40 (continued)

Atoms	(Angstroms)
C(17)-C(16)	1.368(11)
C(30)-C(31)	1.376(12)
C(15)-C(16)	1.415(13)
C(5)-C(4)	1.319(15)
C(33)-C(32)	1.369(16)
C(8)-C(7)	1.286(17)
C(31)-C(32)	1.384(16)
F(1)-B(1)	1.351(12)
F(2)-B(1)	1.346(14)
B(1)-F(4)	1.321(14)
B(1)-F(3)	1.353(12)
B(1)-F(9)	1.181(16)
B(1)-F(7)	1.226(14)
B(1)-F(10)	1.317(12)

Table 40 (continued)Bond angle (°)

Atoms	Angles (°)
N(5)-Ru(1)-N(8)	85.4(2)
N(5)-Ru(1)-N(3)	76.3(2)
N(8)-Ru(1)-N(3)	99.7(2)
N(5)-Ru(1)-N(6)	99.3(2)
N(8)-Ru(1)-N(6)	76.1(2)
N(3)-Ru(1)-N(6)	174.3(2)
N(5)-Ru(1)-N(2)	97.0(2)
N(8)-Ru(1)-N(2)	174.4(2)
N(3)-Ru(1)-N(2)	85.8(2)
N(6)-Ru(1)-N(2)	98.5(2)
N(5)-Ru(1)-N(1)	174.1(2)
N(8)-Ru(1)-N(1)	99.2(2)
N(3)-Ru(1)-N(1)	99.2(2)
N(6)-Ru(1)-N(1)	85.4(2)
N(2)-Ru(1)-N(1)	78.7(2)
N(4)-N(5)-C(18)	114.1(6)
N(4)-N(5)-Ru(1)	120.7(5)
C(18)-N(5)-Ru(1)	124.1(5)
N(7)-N(8)-C(29)	113.5(5)
N(7)-N(8)-Ru(1)	120.4(4)
C(29)-N(8)-Ru(1)	125.2(4)
C(12)-N(1)-C(1)	119.1(7)
C(12)-N(1)-Ru(1)	127.8(5)

Table 40 (continued)

Atoms	Angles (°)
N(5)-Ru(1)-N(8)	85.4(2)
C(1)-N(1)-Ru(1)	112.9(5)
C(24)-N(6)-C(28)	117.1(6)
C(24)-N(6)-Ru(1)	129.3(5)
C(28)-N(6)-Ru(1)	113.5(5)
N(2)-C(3)-C(4)	122.0(9)
C(13)-N(3)-C(17)	117.8(7)
C(13)-N(3)-Ru(1)	129.3(6)
C(17)-N(3)-Ru(1)	112.9(5)
C(29)-C(34)-C(33)	118.5(10)
C(2)-C(6)-C(5)	118.1(9)
C(2)-C(6)-C(7)	116.0(10)
C(5)-C(6)-C(7)	125.9(9)
N(6)-C(28)-C(27)	124.2(8)
N(6)-C(28)-N(7)	117.4(6)
C(27)-C(28)-N(7)	118.3(7)
C(15)-C(14)-C(13)	118.9(9)
C(23)-C(18)-C(19)	120.6(7)
C(23)-C(18)-N(5)	118.9(7)
C(19)-C(18)-N(5)	120.3(7)
N(8)-N(7)-C(28)	112.1(6)
C(3)-N(2)-C(2)	118.5(6)
C(3)-N(2)-Ru(1)	127.6(5)
C(2)-N(2)-Ru(1)	113.7(5)

Table 40 (continued)

Atoms	Angles (°)
N(2)-C(2)-C(1)	116.6(7)
N(2)-C(2)-C(6)	121.2(8)
C(1)-C(2)-C(6)	122.2(8)
C(34)-C(29)-C(30)	121.3(7)
C(34)-C(29)-N(8)	118.9(7)
C(30)-C(29)-N(8)	119.8(7)
C(20)-C(19)-C(18)	120.0(8)
N(1)-C(1)-C(2)	117.9(7)
N(1)-C(1)-C(9)	123.4(8)
C(2)-C(1)-C(9)	118.7(8)
N(5)-N(4)-C(17)	111.6(6)
N(6)-C(24)-C(25)	122.8(7)
C(26)-C(25)-C(24)	119.2(8)
C(18)-C(23)-C(22)	119.8(9)
C(25)-C(26)-C(27)	120.0(9)
C(10)-C(11)-C(12)	123.4(9)
C(8)-C(9)-C(1)	119.3(10)
C(8)-C(9)-C(10)	125.1(9)
C(1)-C(9)-C(10)	115.7(9)
N(1)-C(12)-C(11)	119.6(9)
C(22)-C(21)-C(20)	121.7(9)
N(3)-C(17)-C(16)	123.9(7)
N(3)-C(17)-N(4)	118.2(6)
C(16)-C(17)-N(4)	117.9(7)

Table 40 (continued)

Atoms	Angles (°)
C(19)-C(20)-C(21)	119.6(9)
C(31)-C(30)-C(29)	118.4(9)
C(21)-C(22)-C(23)	118.3(9)
N(3)-C(13)-C(14)	122.8(8)
C(14)-C(15)-C(16)	119.3(9)
C(4)-C(5)-C(6)	120.6(8)
C(5)-C(4)-C(3)	119.4(9)
C(32)-C(33)-C(34)	120.8(10)
C(17)-C(16)-C(15)	117.3(9)
C(7)-C(8)-C(9)	122.6(10)
C(32)-C(31)-C(30)	120.8(10)
C(8)-C(7)-C(6)	121.2(10)
C(11)-C(10)-C(9)	118.8(8)
C(31)-C(32)-C(33)	120.1(9)
C(28)-C(27)-C(26)	116.6(9)
F(4)-B(1)-F(2)	107.7(10)
F(4)-B(1)-F(1)	107.8(10)
F(2)-B(1)-F(1)	112.6(10)
F(4)-B(1)-F(3)	111.4(11)
F(2)-B(1)-F(3)	107.3(10)
F(1)-B(1)-F(3)	110.1(9)
F(9)-B(1)-F(7)	129(2)
F(9)-B(1)-F(8)	86.7(15)
F(7)-B(1)-F(8)	103.6(15)

Table 40 (continued)

Atoms	Angles (°)
F(9)-B(1)-F(10)	118(2)
F(7)-B(1)-F(10)	99.2(10)
F(8)-B(1)-F(10)	120.5(19)

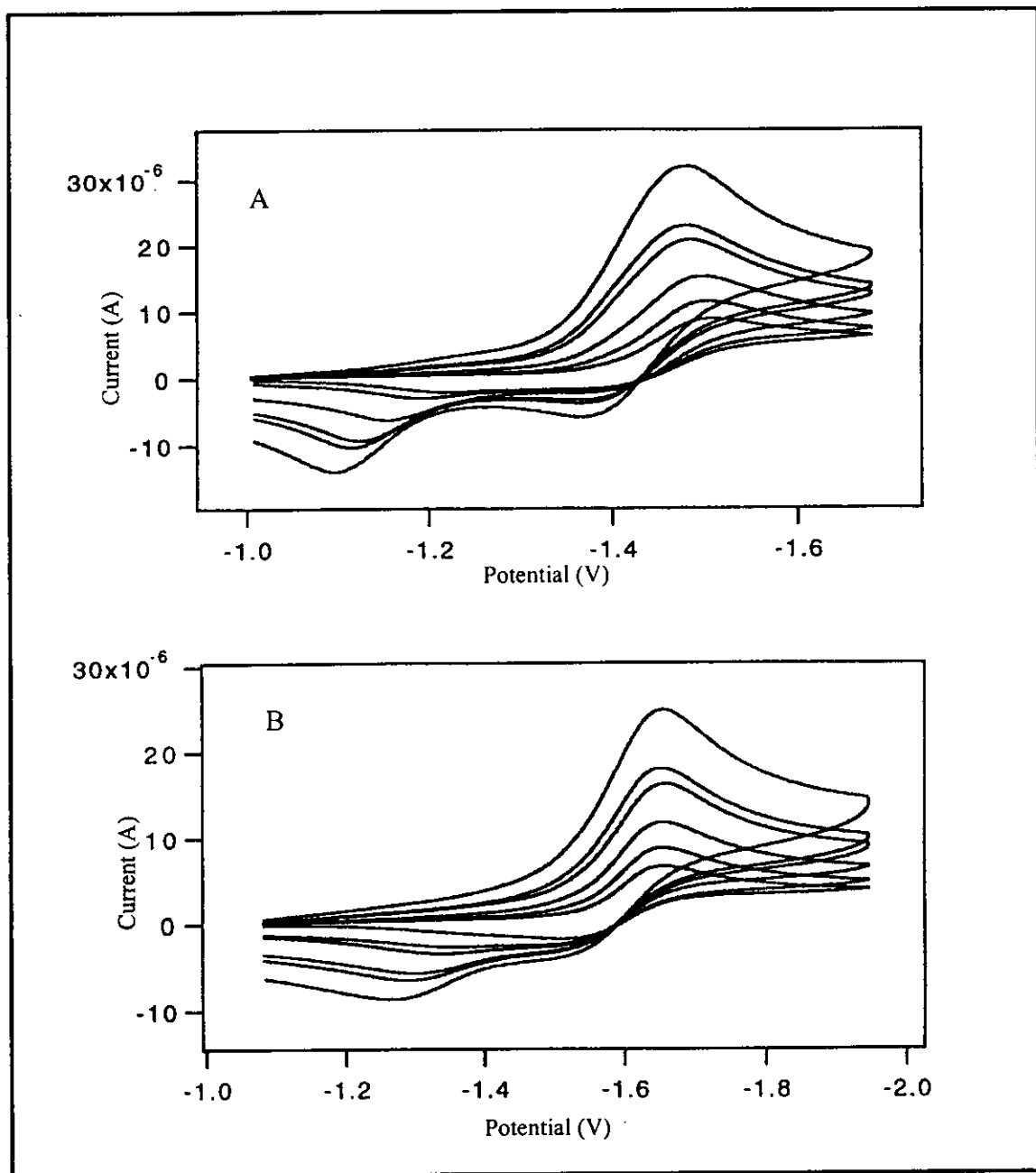


Figure 82 Cyclic voltammogram of azpym (A) and azpy (B) with various scan rates 50-1000 mV/s in the reduction range.

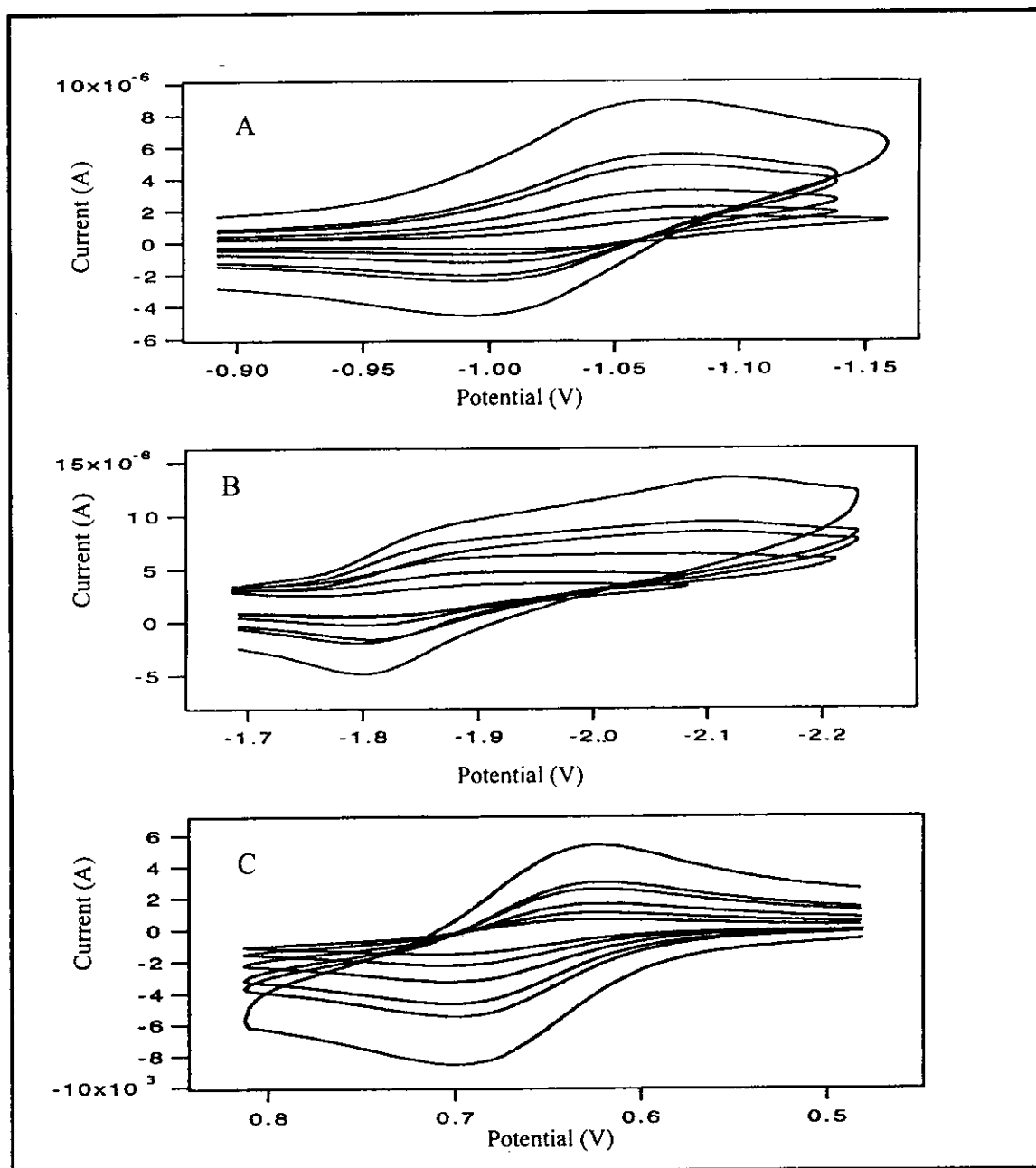


Figure 83 Cyclic voltammogram of $\text{Ru}(\text{azpy})_2\text{Cl}$ - couple I (A), couple II (B) in the reduction and couple $\text{Ru}(\text{II}/\text{III})$ in the oxidation range with various scan rates 50-1000 mV/s.

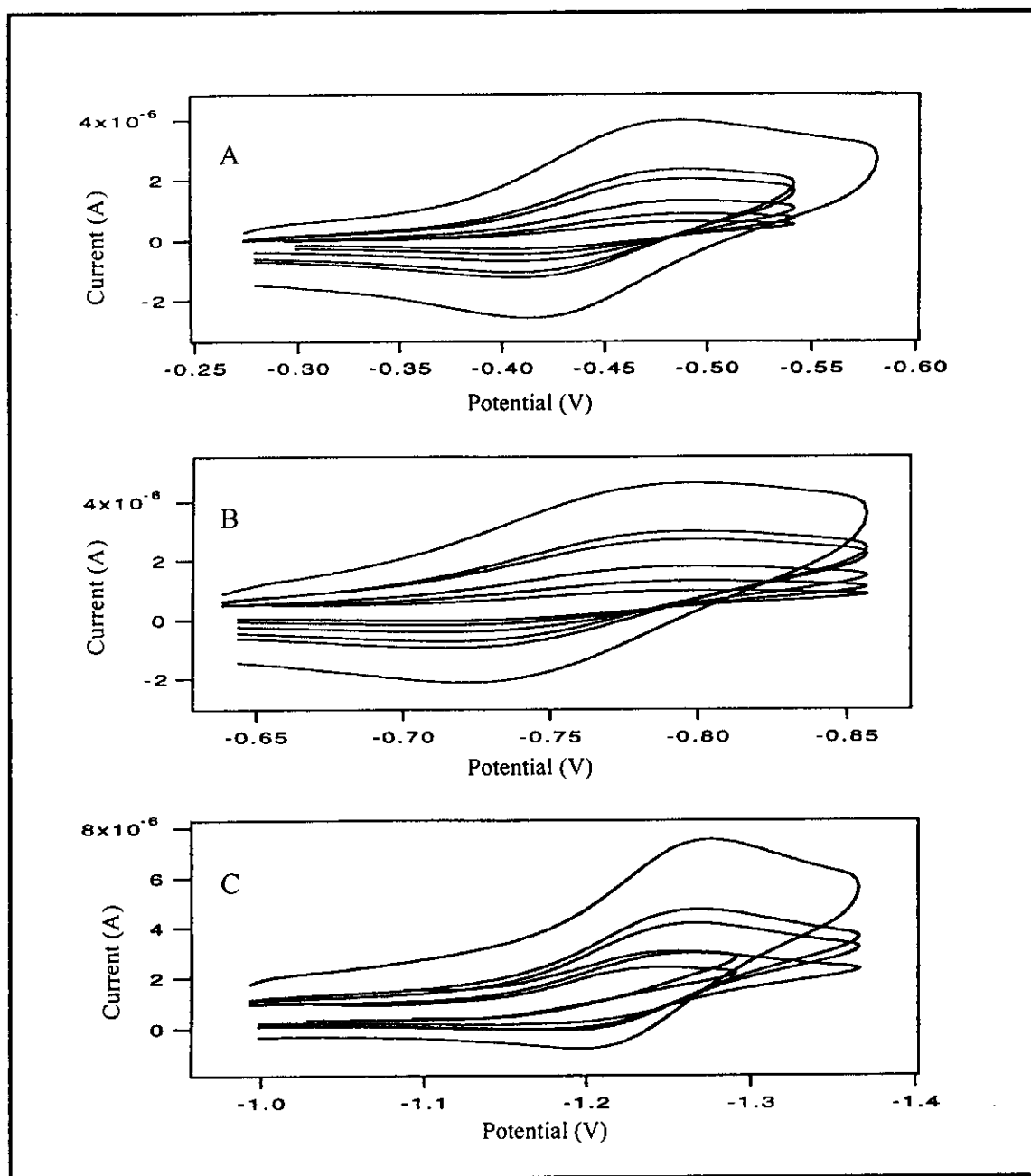


Figure 84 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_3](\text{PF}_6)_2$ - couple I (A), couple II (B) and couple III (C) with various scan rates 50-1000 mV/s in the reduction range.

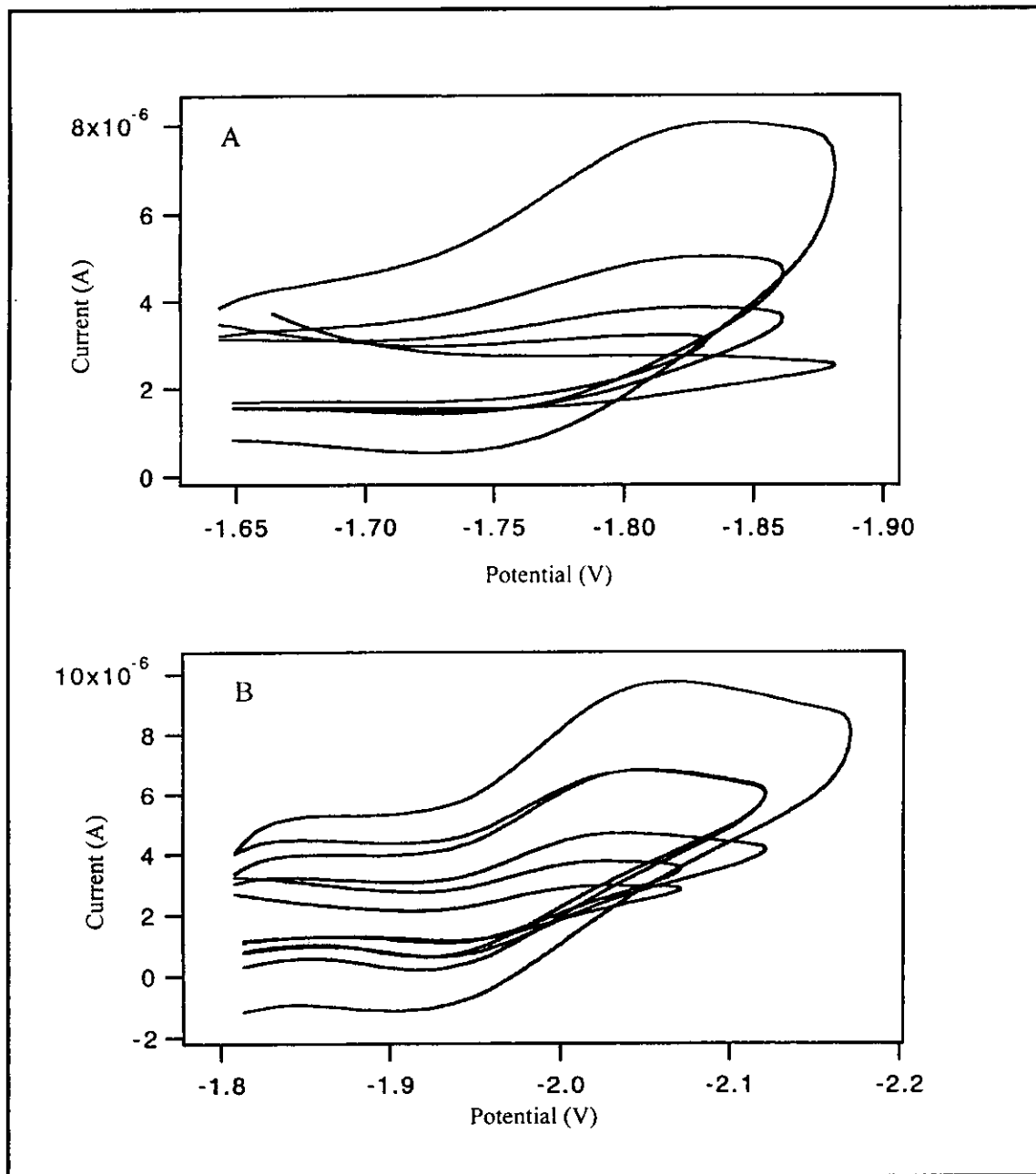


Figure 85 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_3](\text{PF}_6)_2$ - couple IV (A) and couple V (B) with various scan rates 50-1000 mV/s in the reduction range.

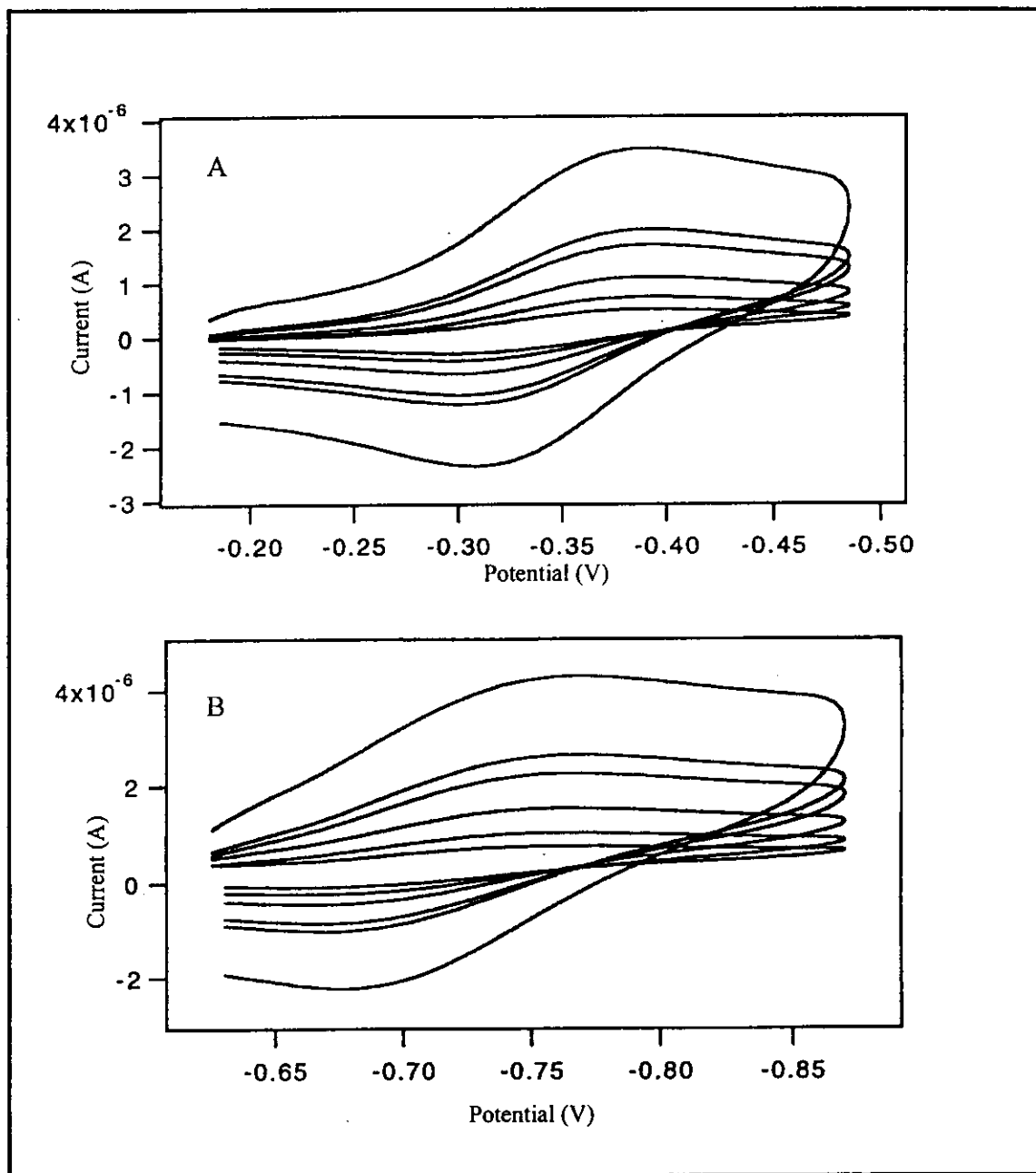


Figure 86 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_2\text{azpym}](\text{PF}_6)_2$ - couple I (A) and couple II (B) with various scan rates 50-1000 mV/s in the reduction range.

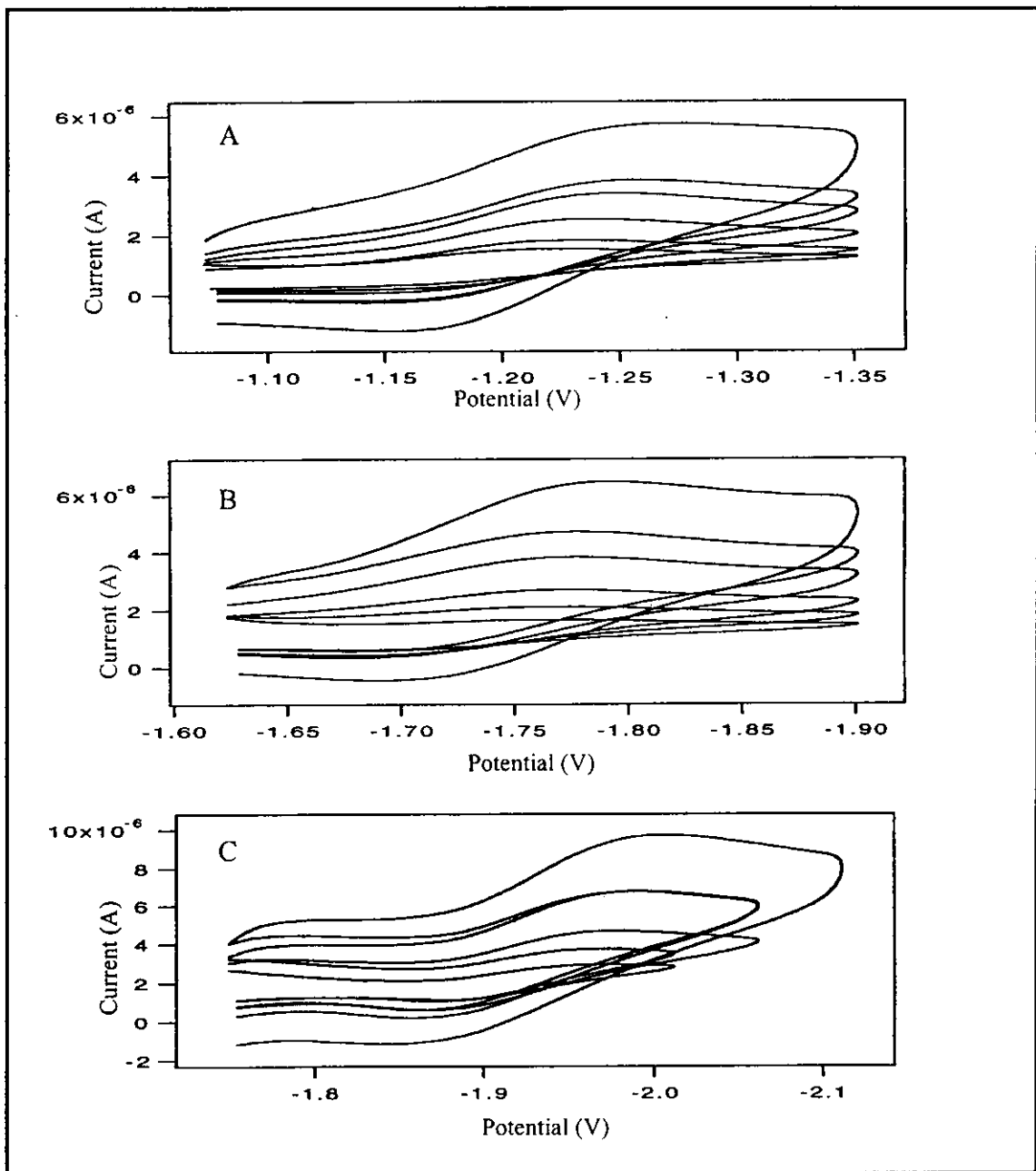


Figure 87 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_2\text{azpym}](\text{PF}_6)_2$ - couple III (A), couple VI (B) and couple V (C) with various scan rates 50-1000 mV/s in the reduction range.

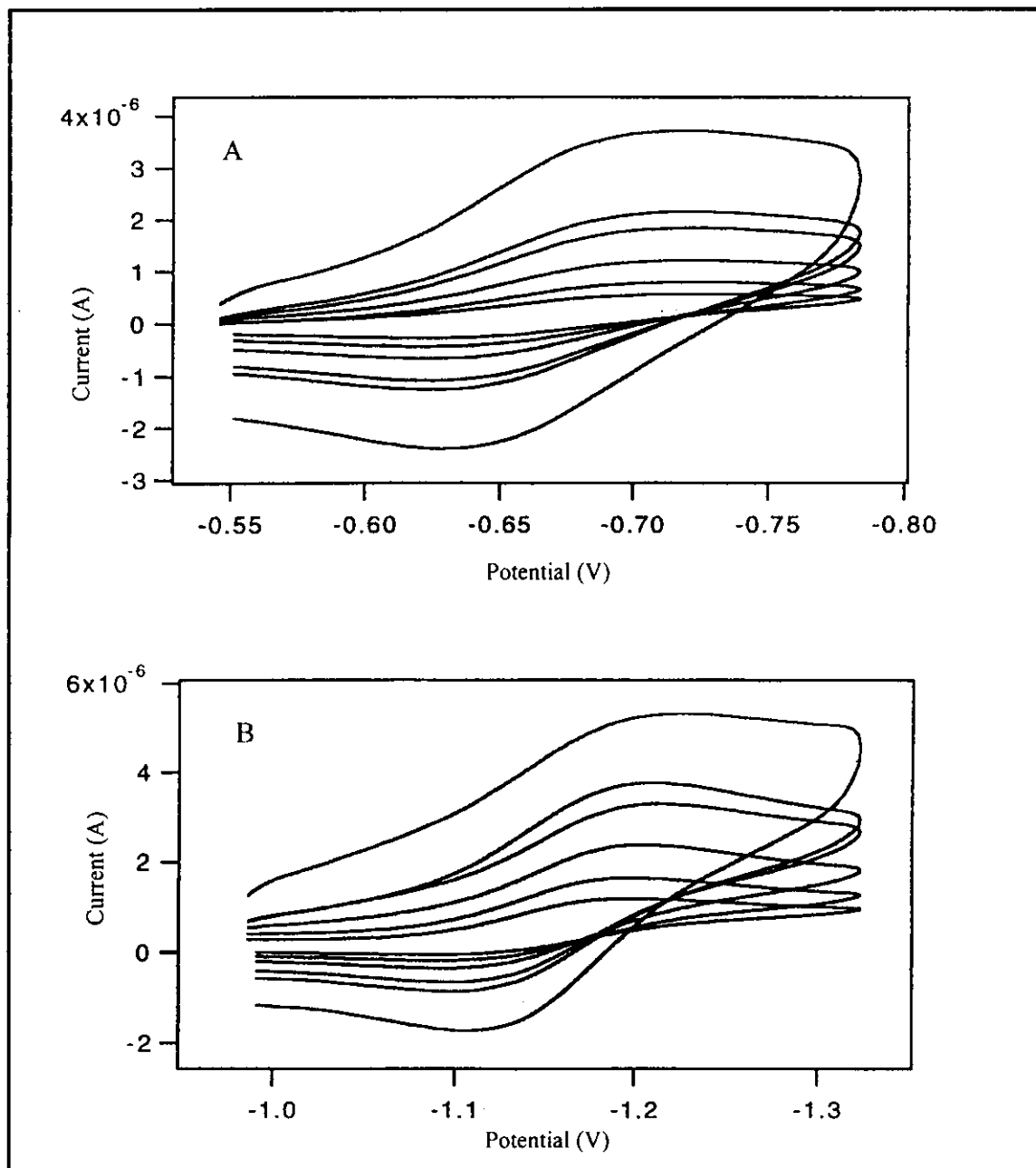


Figure 88 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_2\text{bpy}](\text{PF}_6)_2$ - couple I (A) and couple II (B) with various scan rates 50-1000 mV/s in the reduction range.

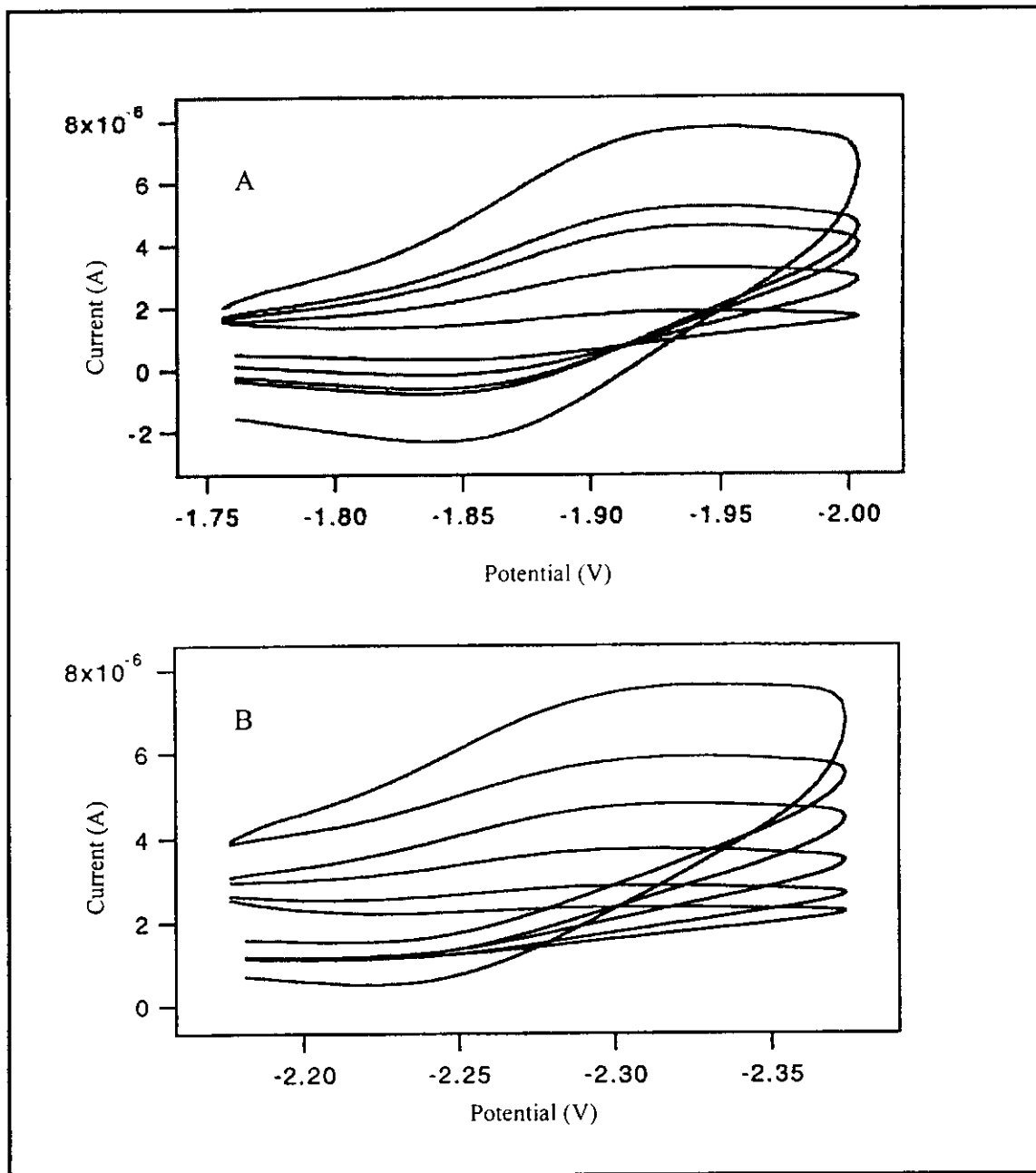


Figure 89 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_2\text{bpy}](\text{PF}_6)_2$ - couple III (A) and couple VI (B) with various scan rates 50-1000 mV/s in the reduction range.

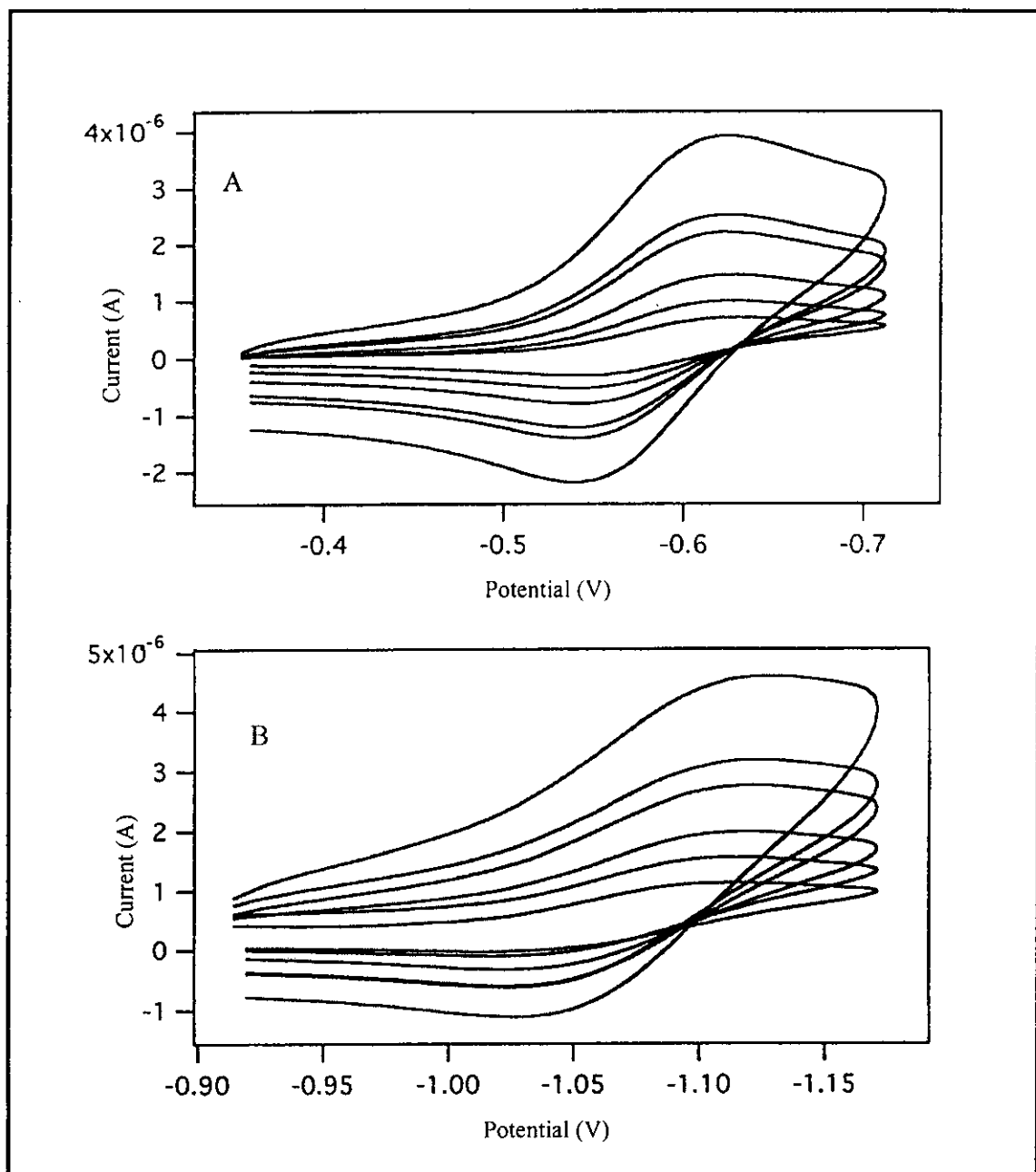


Figure 90 Cyclic voltammogram of [Ru(azpy)₂phen](BF₄)₂-couple I(A) and couple II (B) with various scan rates 50-1000 mV/s in the reduction range.

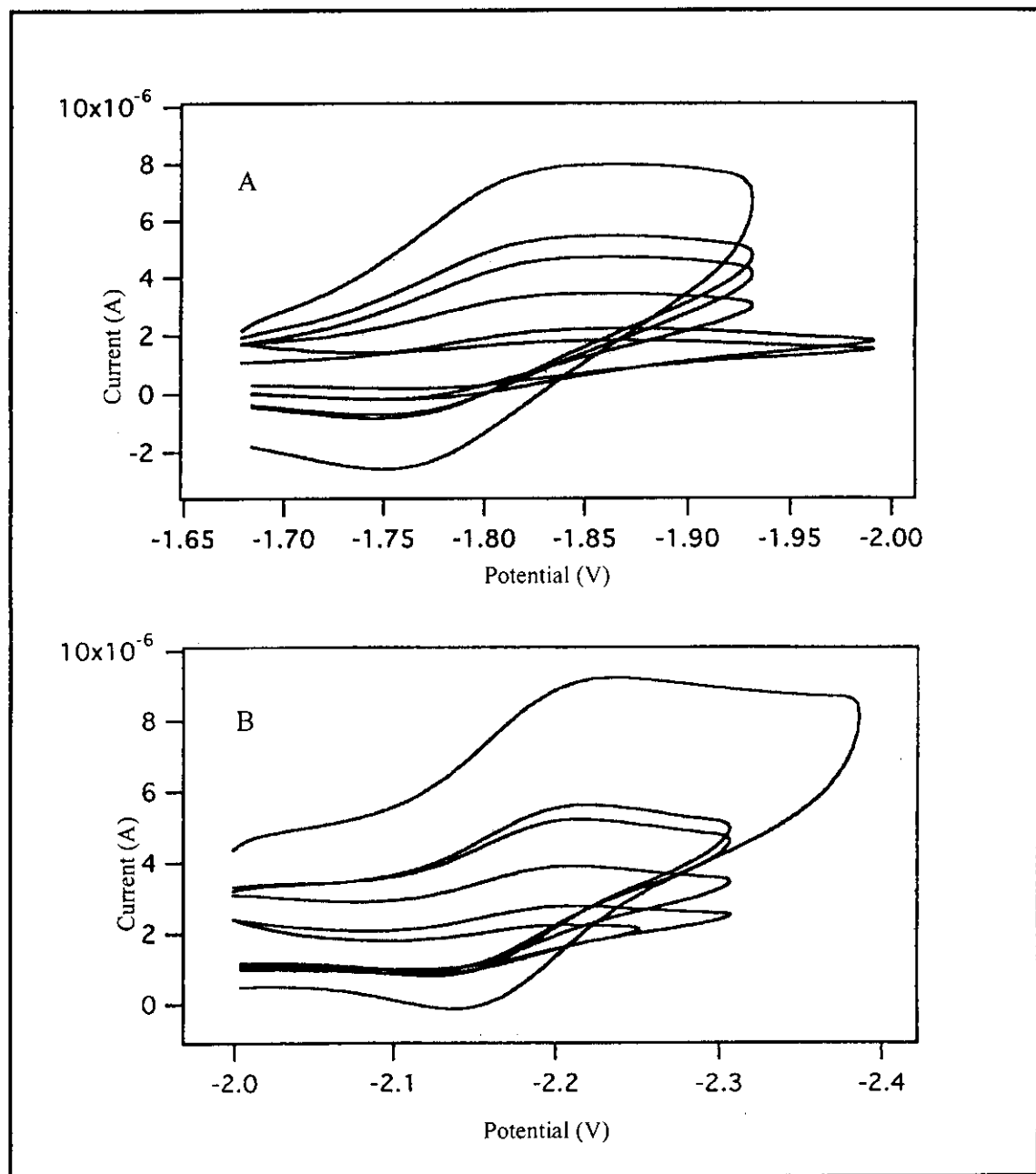


Figure 91 Cyclic voltammogram of $[\text{Ru}(\text{azpy})_2\text{phen}](\text{BF}_4)_2$ -couple III (A) and couple IV (B) with various scan rates 50-1000 mV/s in the reduction range.