Facile synthesis of $PbS_{1-x}Se_x$ ($0 \leq x \leq 1$) solid solution using *bis*(N,N-diethyl-N′-naphthoylchalcogenoureato)lead(II) complexes

S. A. Saah,[a,b] M. D. Khan,[c,d] P. D. McNaughter,[d] J. A. M. Awudza,[a] N. Revaprasadu[c]* and P. O'Brien[d,e]*

[a]Department of Chemistry, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[b]Department of Chemical Sciences, University of Energy and Natural Resources, Sunyani, Ghana.
[c]Department of Chemistry, University of Zululand Private bag X1001 KwaDlangezwa 3880 South Africa.
[d]School of Chemistry, The University of Manchester, Oxford Road, Manchester M13 9PL UK
[e]School of Materials, The University of Manchester, Oxford Road, Manchester, M13 9PL, UK
*E-mail: paul.obrien@manchester.ac.uk

Supplementary Data

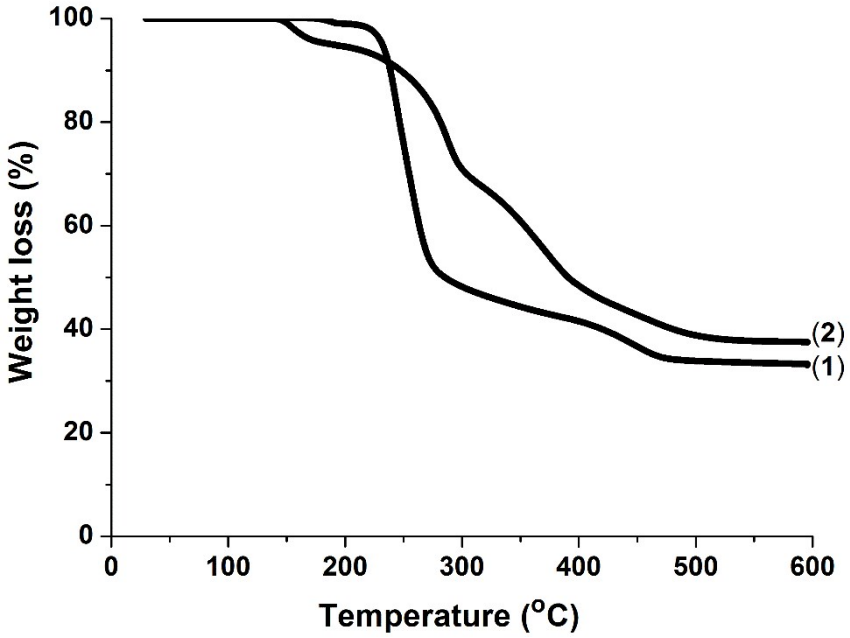

Figure S1. Thermogravimetric analysis (TGA) of complexes (**1**) and (**2**) at a heating rate of 10 °C min^{-1} under nitrogen.

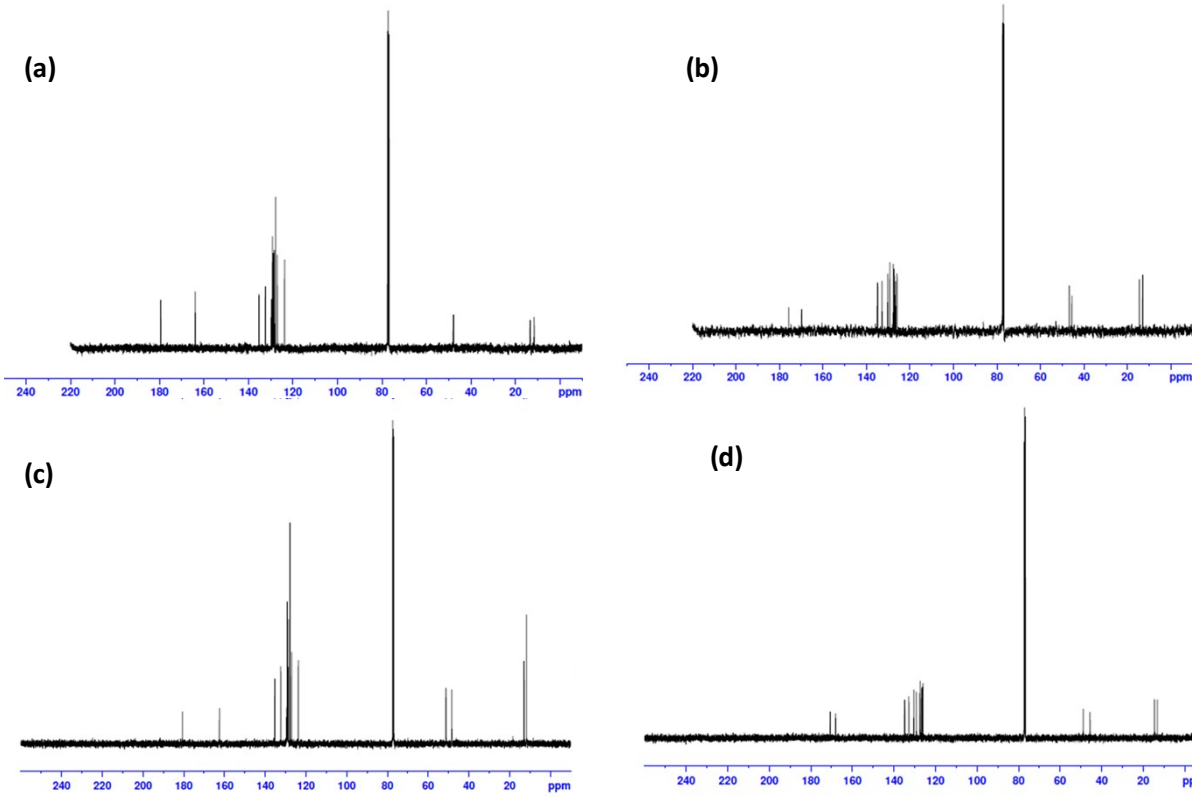

Figure S2. ^{13}C NMR of (a) N,N-diethyl-N′-naphthoylthiourea ligand, (b) bis(N,N-diethyl-N′-naphthoylthioureato)lead(II) complex, (c) N,N-diethyl-N′-naphthoylselenourea ligand and (d) bis(N,N-diethyl-N′-naphthoylselenoureato)lead(II) complex

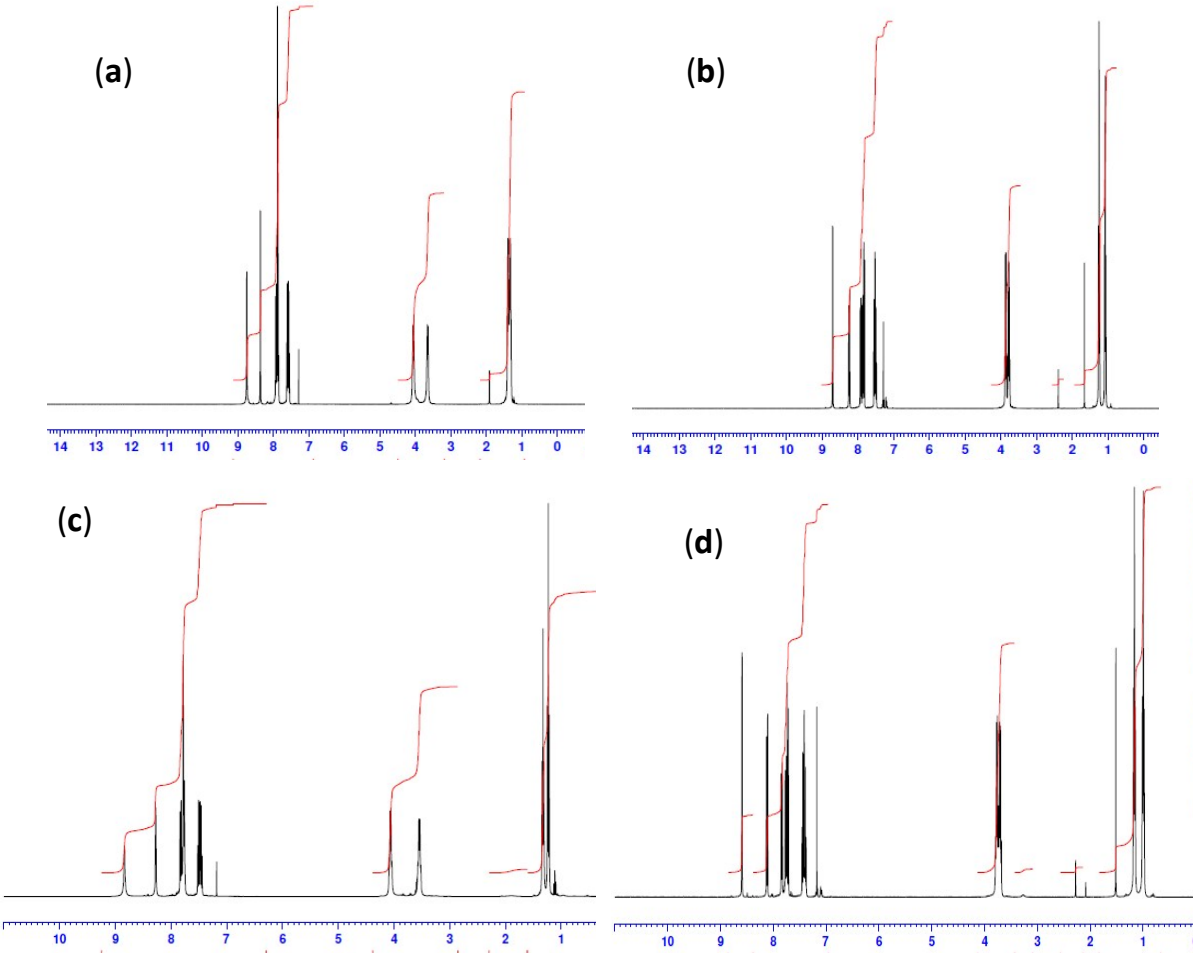

Figure S3. ^{1}H NMR of (a) N,N-diethyl-N′-naphthoylthiourea ligand, (b) bis(N,N-diethyl-N′-naphthoylthioureato)lead(II) complex, (c) N,N-diethyl-N′-naphthoylselenourea ligand and (d) bis(N,N-diethyl-N′-naphthoylselenoureato)lead(II) complex

Table S1 Mass of complexes used as injection mixture

χ_{Se} in injection mixture	Mass of (**1**)/ g	Mass of (**2**)/ g
0	0.1	0
0.1	0.089	0.011
0.2	0.077	0.023
0.3	0.067	0.033
0.4	0.056	0.044
0.5	0.046	0.054
0.6	0.036	0.064
0.7	0.027	0.073
0.8	0.018	0.082
0.9	0.009	0.091
1	0	0.1

Table S2. Elemental composition obtained by EDX analysis for different mole fractions of [Se]/[S+Se] in feed precursor.

Mole fraction of Se in feed precursor	% Pb	% S	% Se
0	51.12	48.58	0
0.1	49.28	45.36	5.36
0.2	51.68	35.9	12.41
0.3	48.36	33.29	18.35
0.4	42.70	29.9	27.3
0.5	50.73	21.37	27.9
0.6	49.08	17.64	32.28
0.7	49.46	12.64	37.9
0.8	50.24	9.14	40.62
0.9	47.96	7.22	44.82
1	50.12	0	49.88

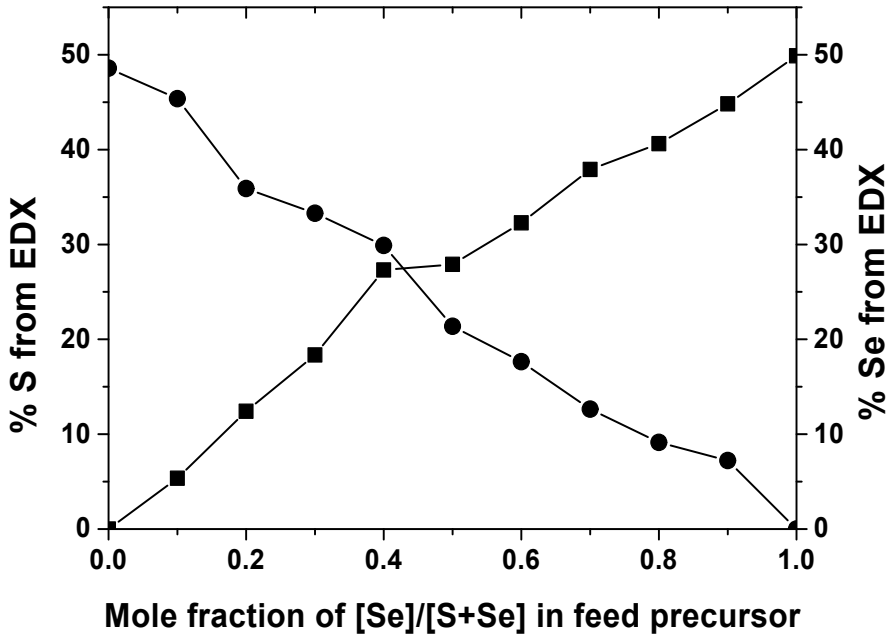

Figure S4. A plot of % S (circle) and % Se (square) from EDX against mole fraction of [Se]/[S+Se] in feed precursor.

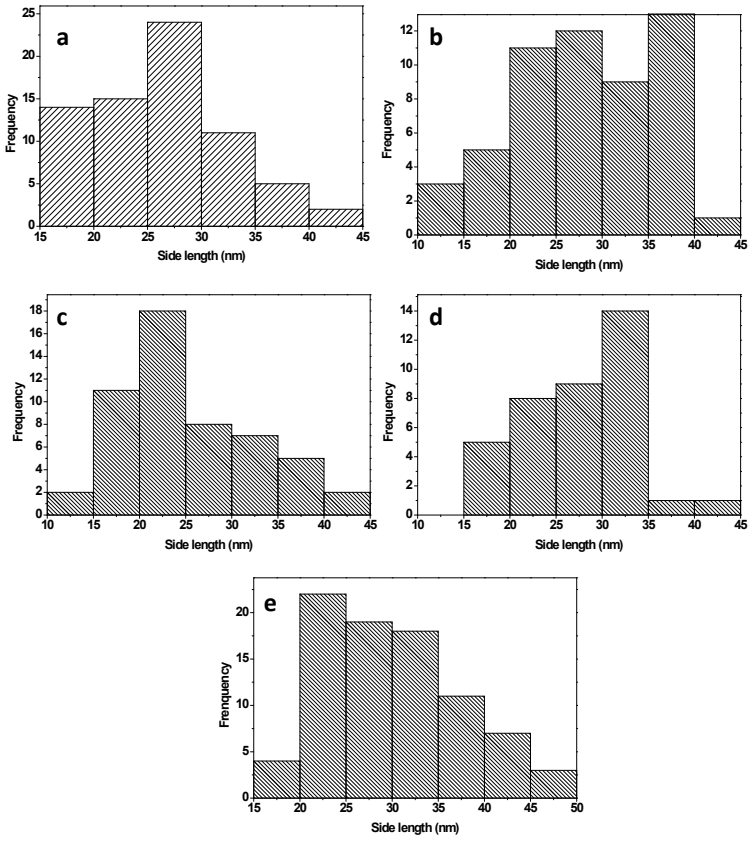

Figure S5. Size distribution from TEM images of $PbS_xSe_{(1-x)}$ obtained at x_{Se} values of (A) 0, (B) 0. 3, (C) 0.5, (D) 0.8, (E) 1.

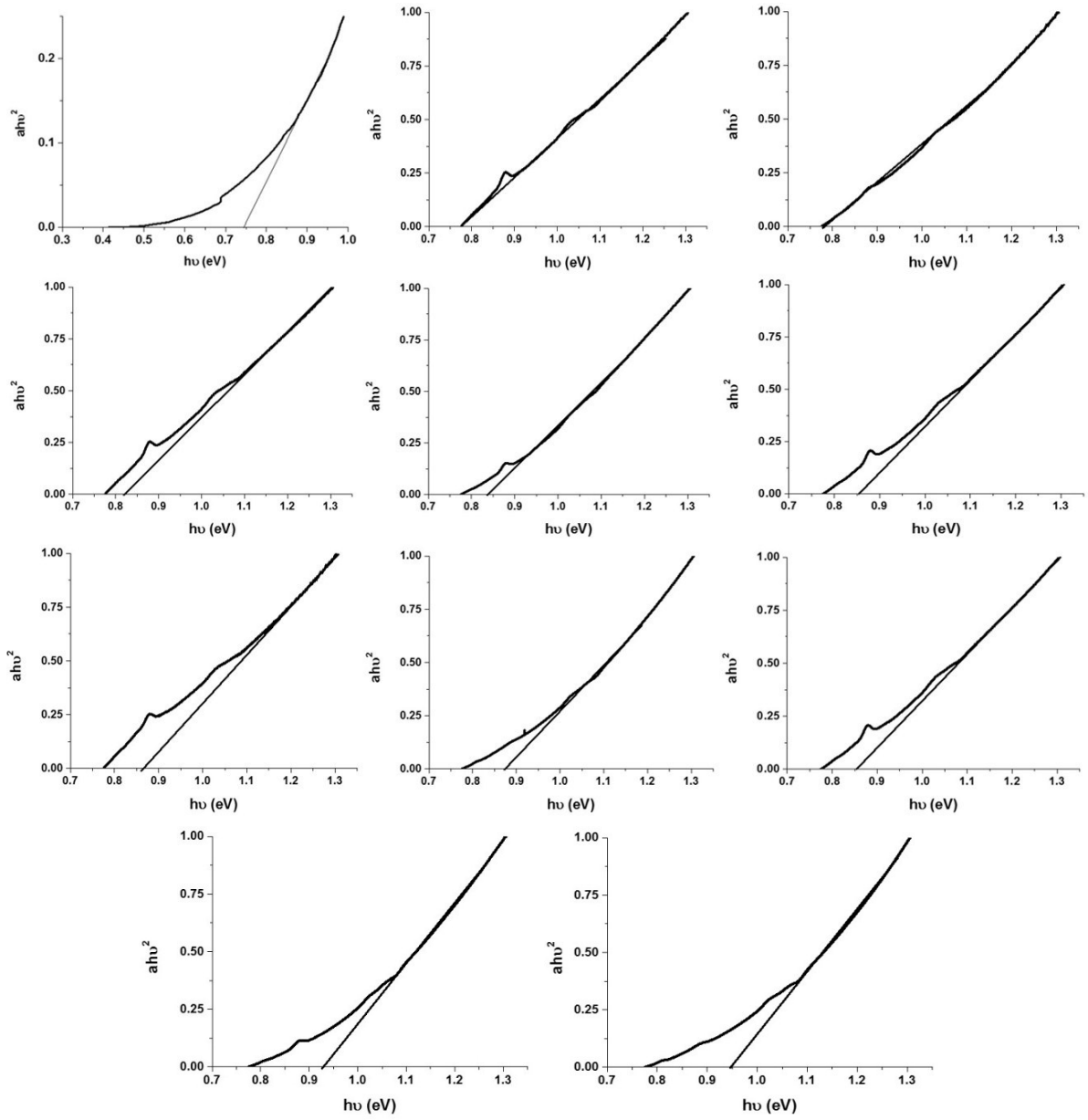

Figure S6. Band gap calculation by Tauc plots for $PbS_{1-x}Se_x$ $(0 \leq x \leq 1)$ series.