## Supporting Information

# Long-lived Dark Exciton Emission in Mn-doped $CsPbCl_3$ Perovskite Nanocrystals

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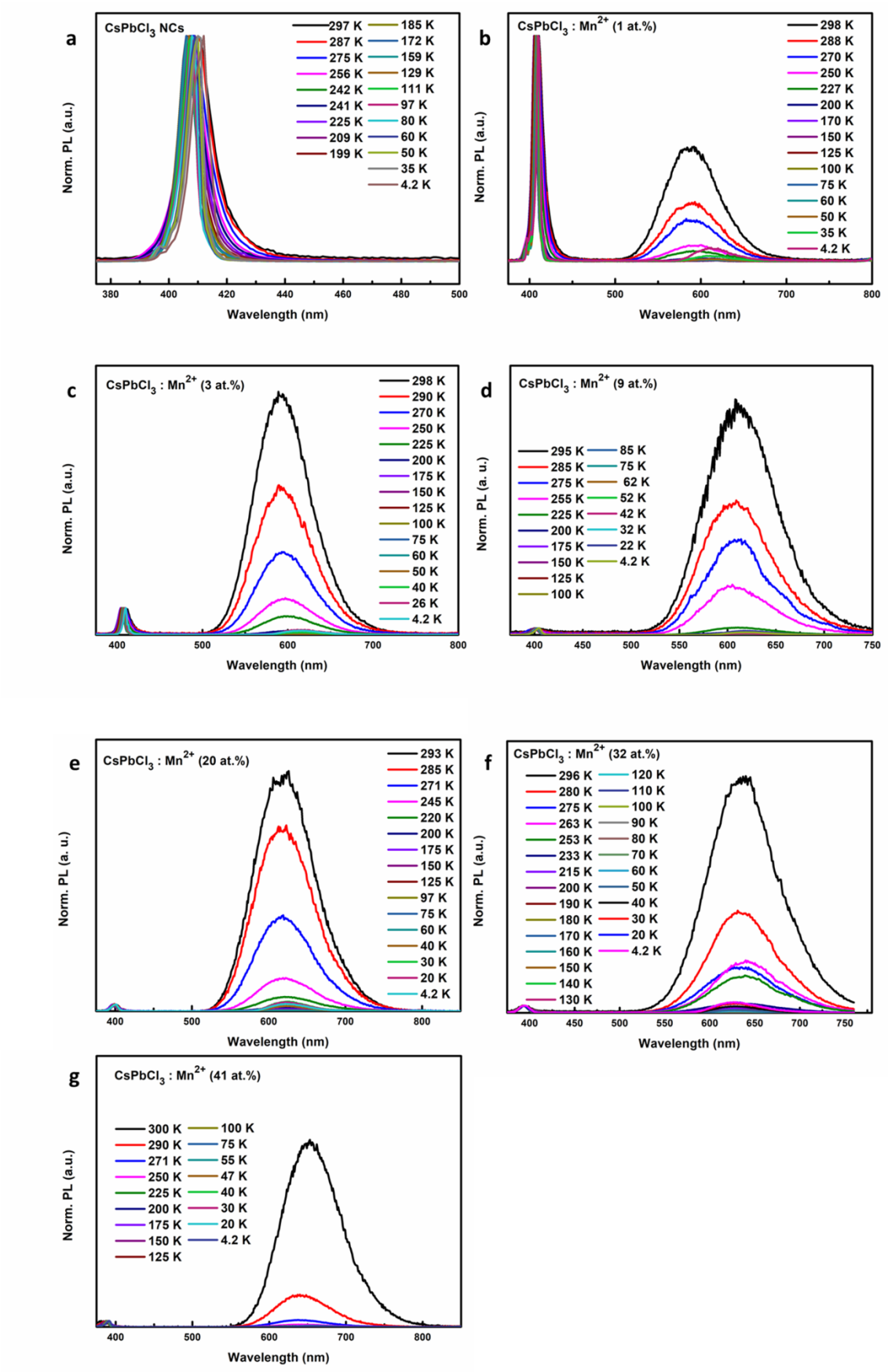



Figure S1. Normalized emission spectra of $CsPbCl_3$: $xMn^{2+}$ (x=0, 1 at.%, 3 at.%, 9 at.%, 20 at.%, 32 at.%, 41 at.%) NCs at different temperatures ($\lambda_{ex}$=355 nm)

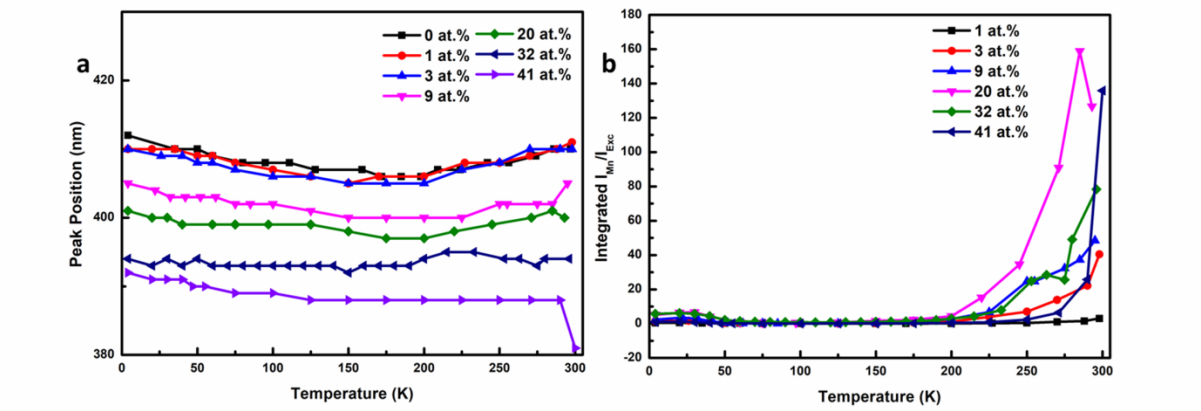



Figure S2.Optical properties of $CsPbCl_3$: $xMn^{2+}$ (x=0, 1 at.%, 3 at.%, 9 at.%, 20 at.%, 32 at.%, 41 at.%). (a) Exciton peak position as a function of temperature.(b) Integrated $I_{Mn}/I_{Exc}$ at different temperatures

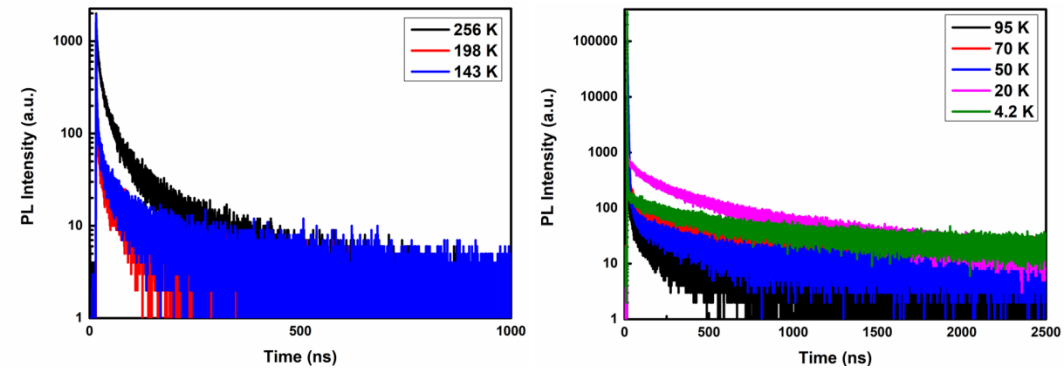



Figure S3. Exciton emission decay curve of pure (undoped) $CsPbCl_3$ NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)

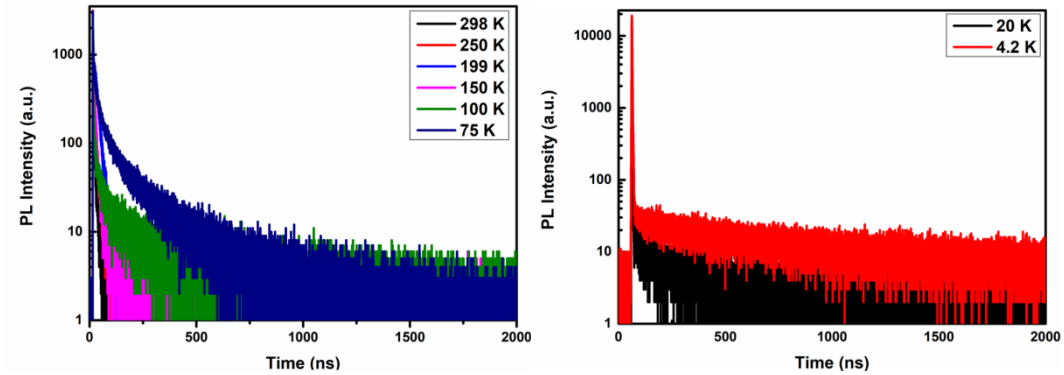



Figure S4. Exciton emission decay curves of $CsPbCl_3$: $Mn^{2+}$ (1 at.%) NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)

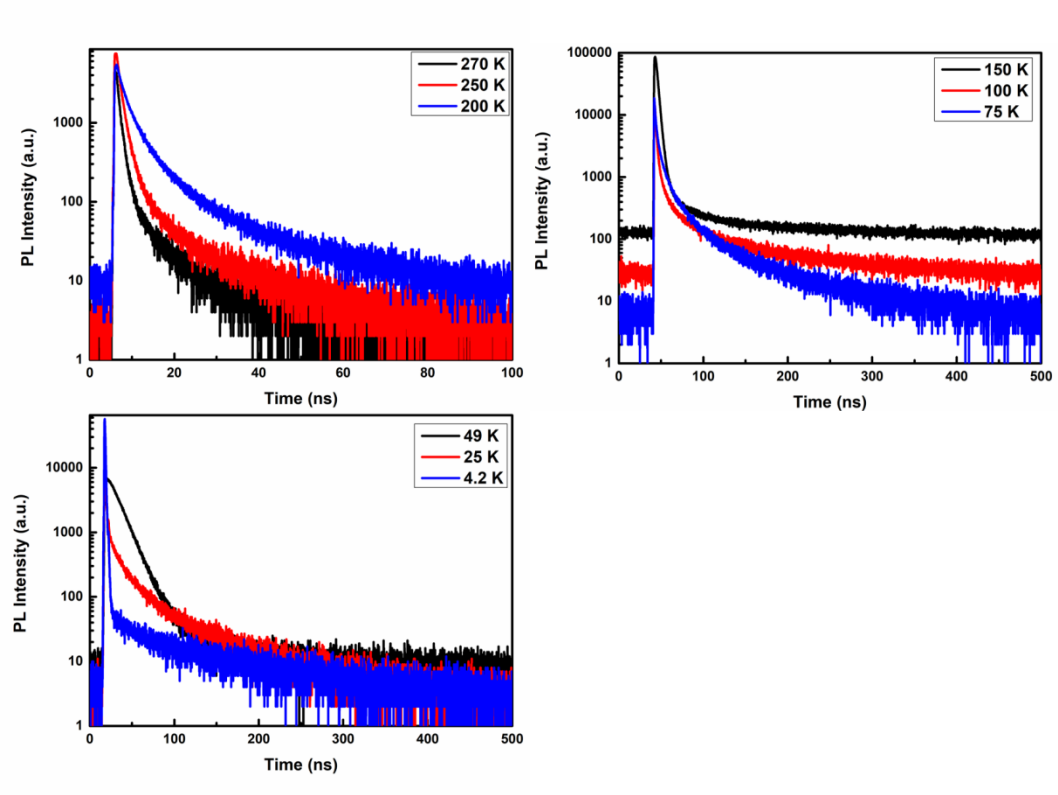



Figure S5. Exciton emission decay curve of sample $CsPbCl_3$: $Mn^{2+}$ (3 at.%) NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)

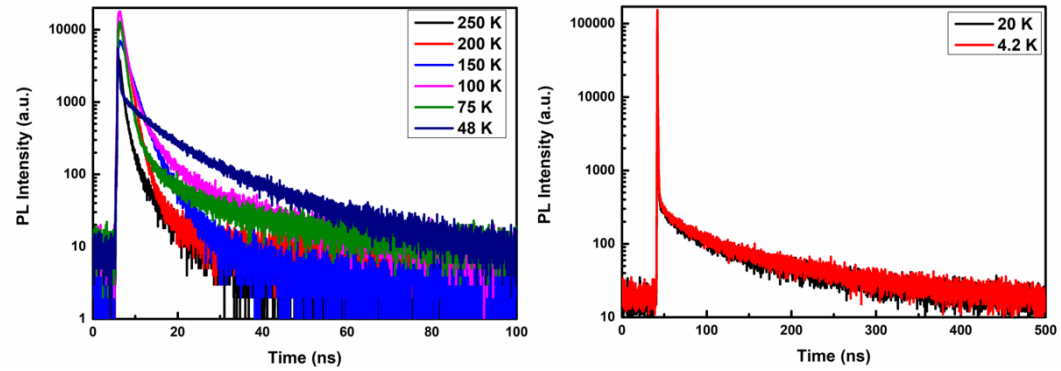
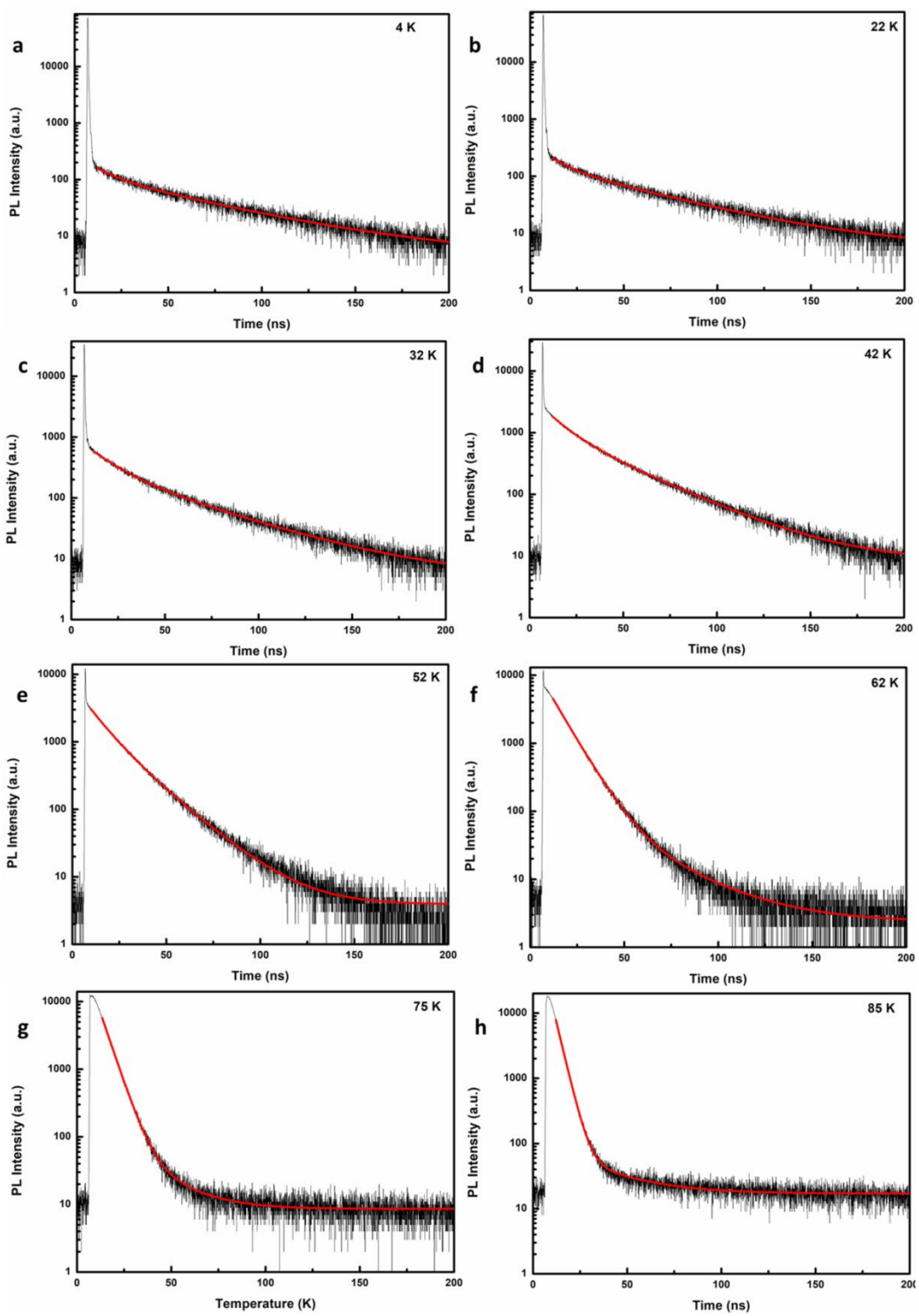



Figure S6. Exciton emission decay curve of sample $CsPbCl_3$: $Mn^{2+}$ (41 at.%) NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)


a
4 K
b
22 K
c
32 K
d
42 K
e
52 K
f
62 K
g
75 K
h
85 K
PL Intensity (a.u.)
Time (ns)
Temperature (K)

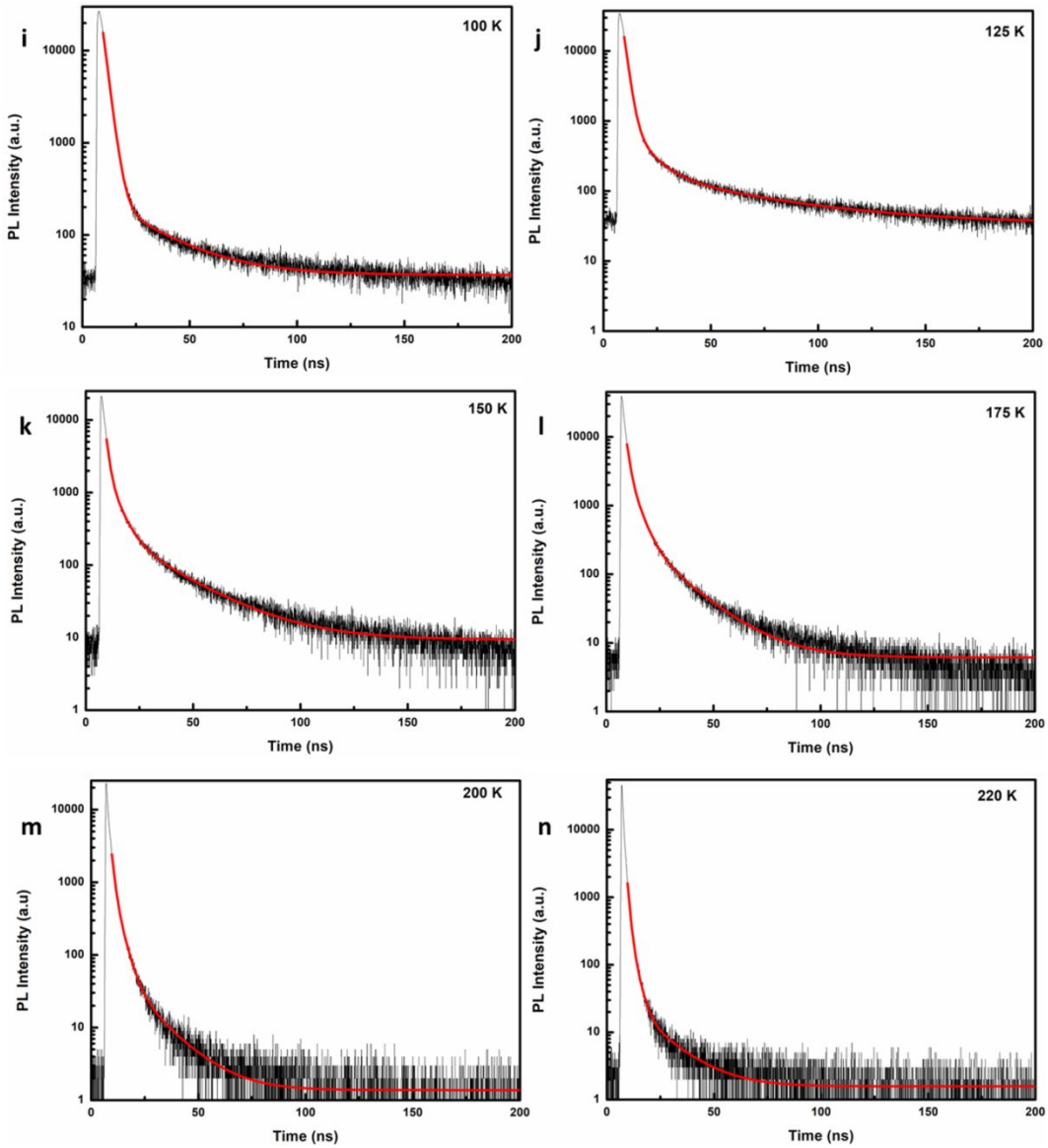
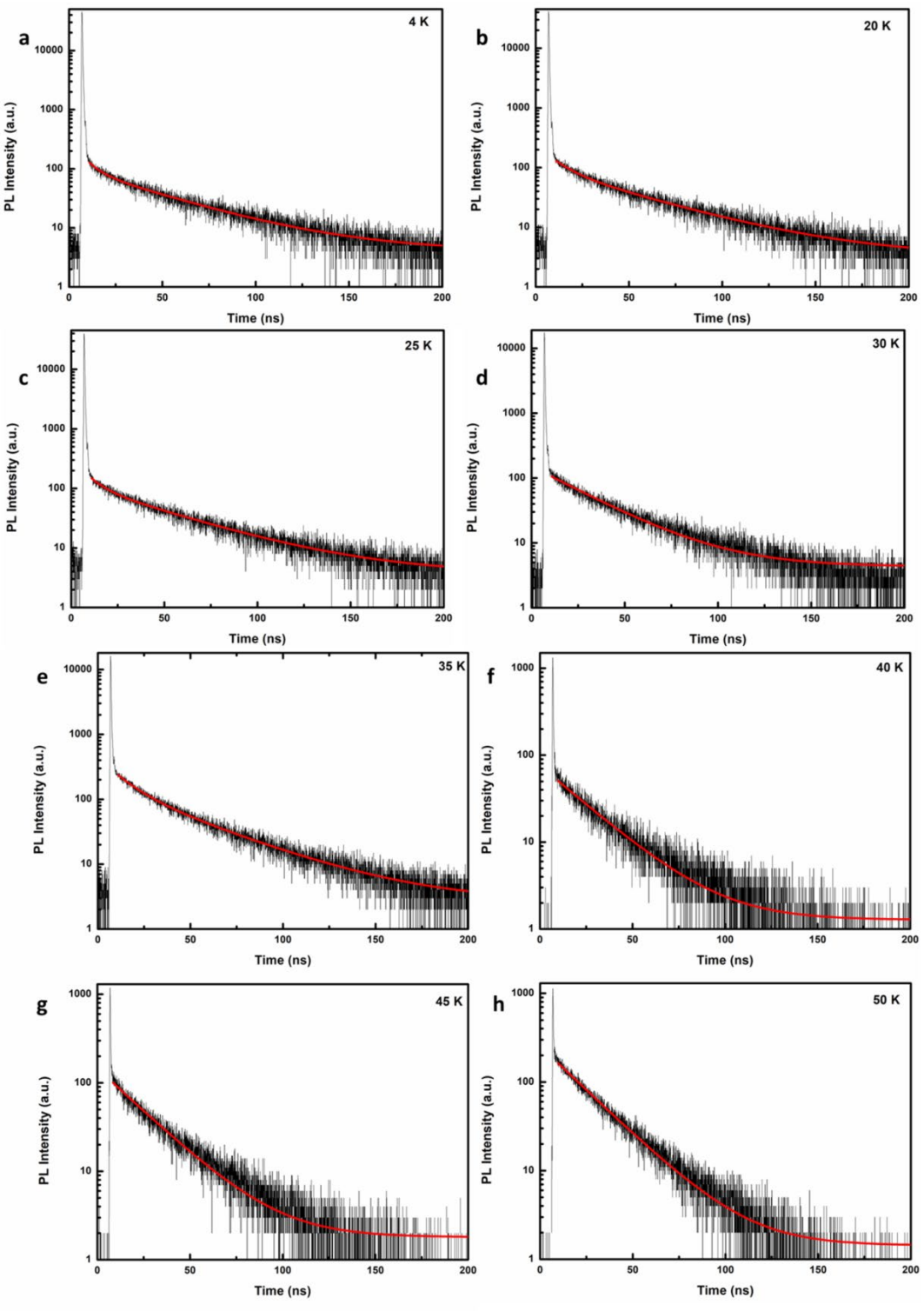



Figure S7. Exciton emission decay curves of $CsPbCl_3$: $Mn^{2+}$ (9 at.%) NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)


a
4 K
b
20 K
c
25 K
d
30 K
e
35 K
f
40 K
g
45 K
h
50 K
PL Intensity (a.u.)
Time (ns)

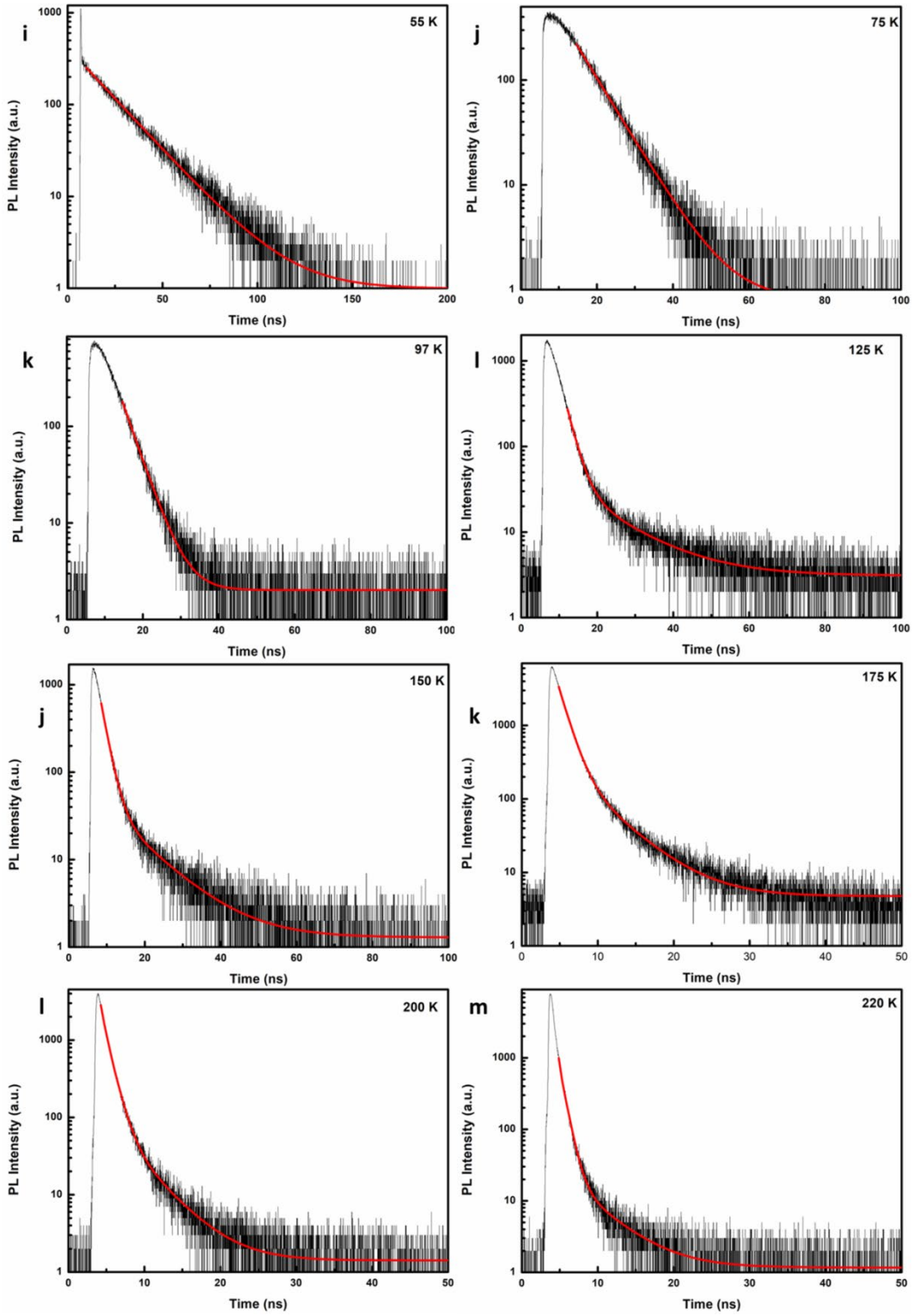
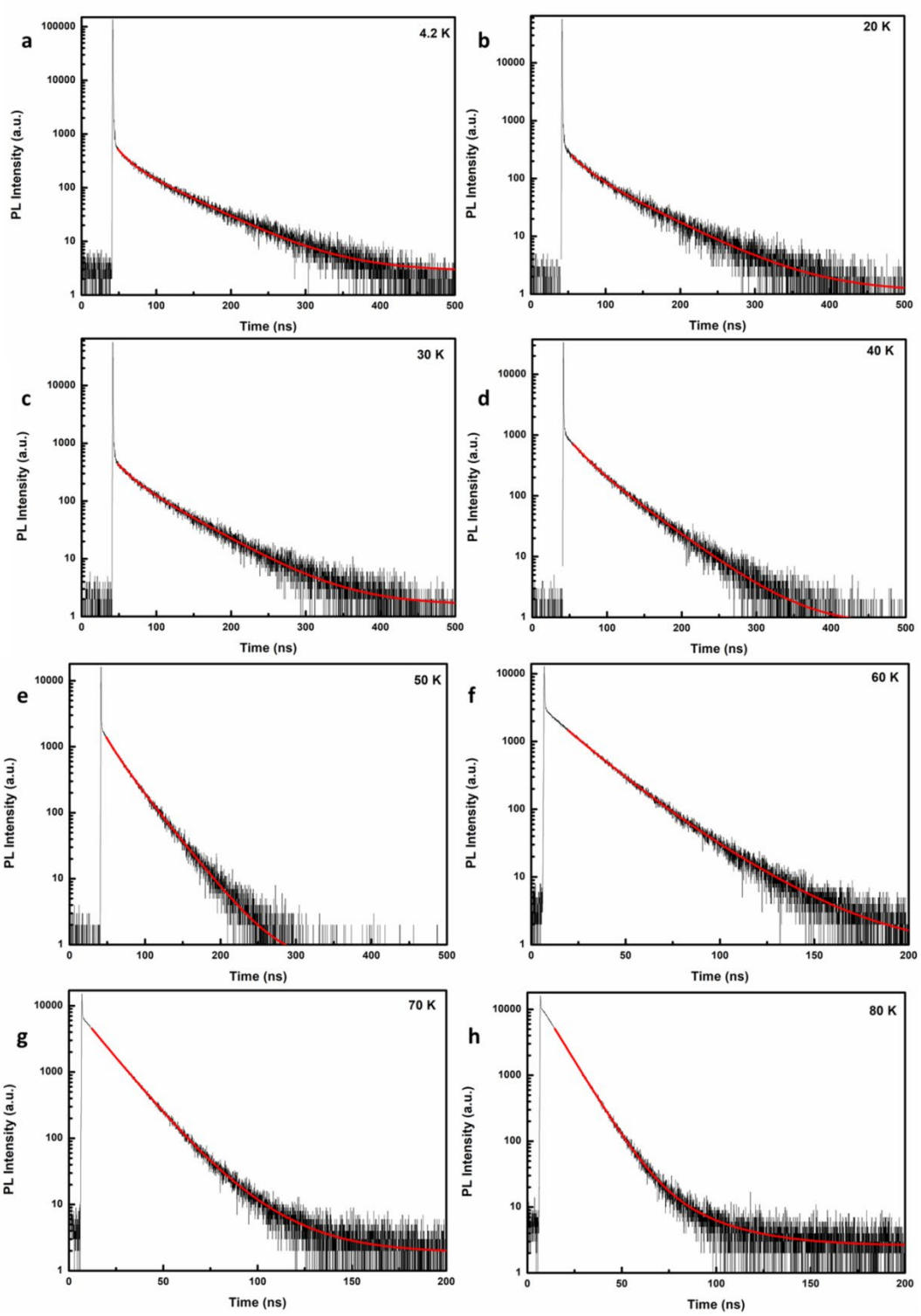
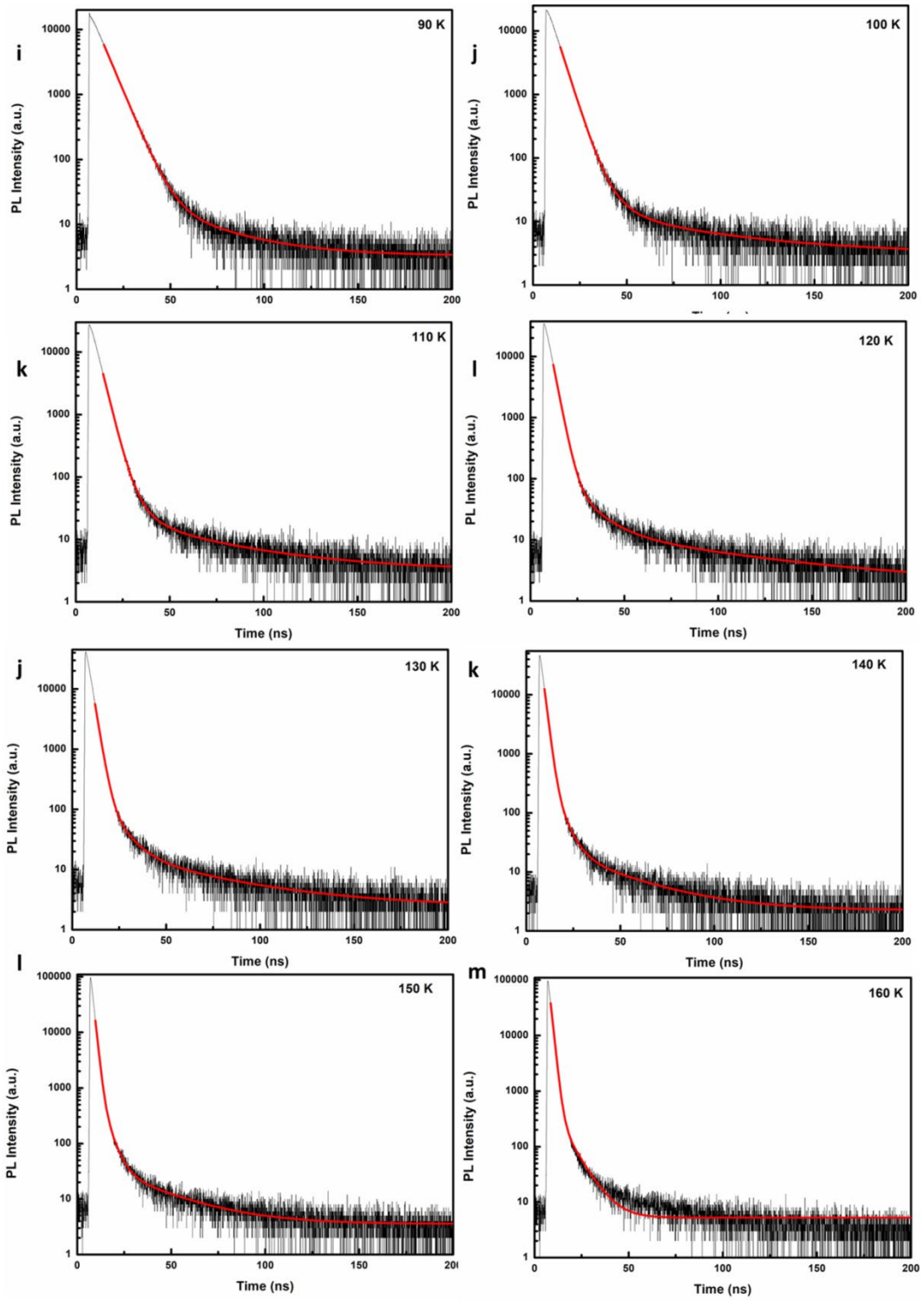



Figure S8. Exciton emission decay curves of $CsPbCl_3$: $Mn^{2+}$ (20 at.%) NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)


a
4.2 K
b
20 K
c
30 K
d
40 K
e
50 K
f
60 K
g
70 K
h
80 K
PL Intensity (a.u.)
Time (ns)


i
90 K
j
100 K
k
110 K
l
120 K
j
130 K
k
140 K
l
150 K
m
160 K
PL Intensity (a.u.)
Time (ns)

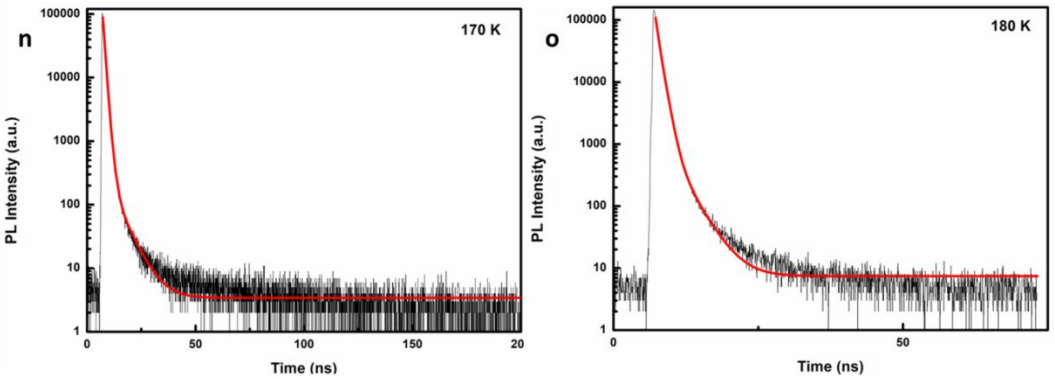



Figure S9. Exciton emission decay curves of $CsPbCl_3$: $Mn^{2+}$ (32 at.%) NCs at different temperatures plotted on semi-logarithmic scale ($\lambda_{ex}$ =376.8 nm, pulse width: 65 ps)