Electronic Supplementary Material (ESI) for Nanoscale.

Cation-exchange Controlled Core-shell $MnS@Bi_2S_3$ Theranostic Platform for Multimodal Imaging Guided Radiation Therapy with Hyperthermia Boost

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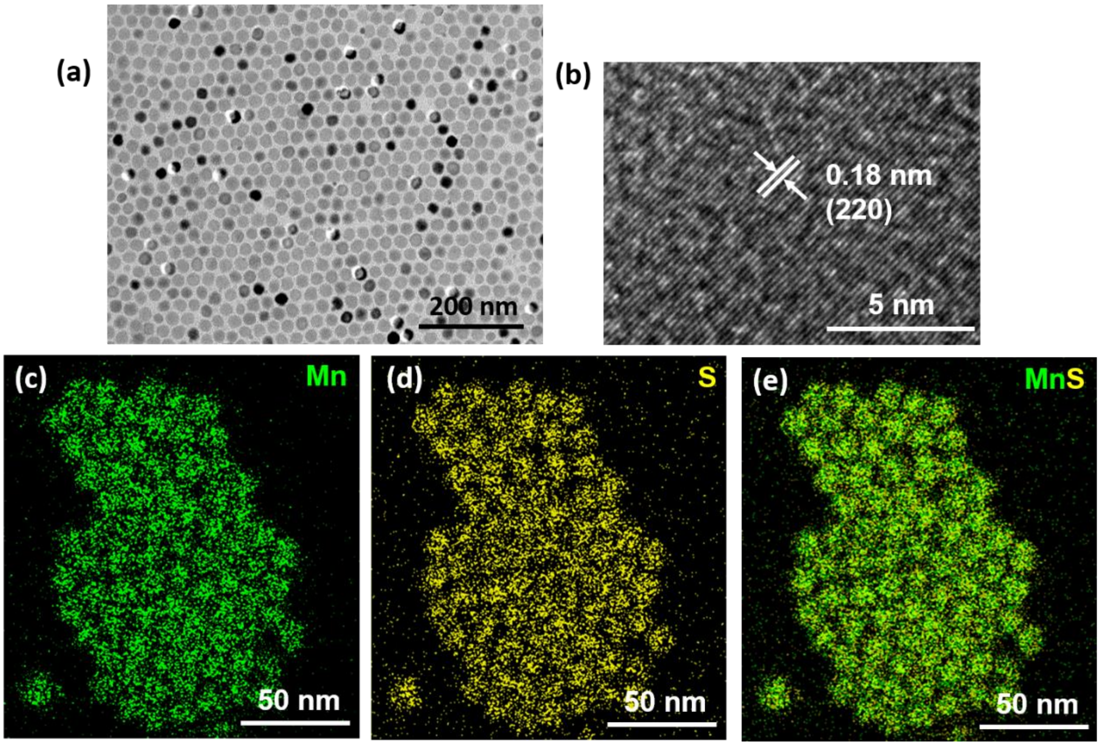


Figure S1. (a) TEM image of MnS NPs. (b) Corresponding HR-TEM image of MnS NPs. The elemental mapping images of Mn (c), S (d), and combined Mn and S (e), respectively.

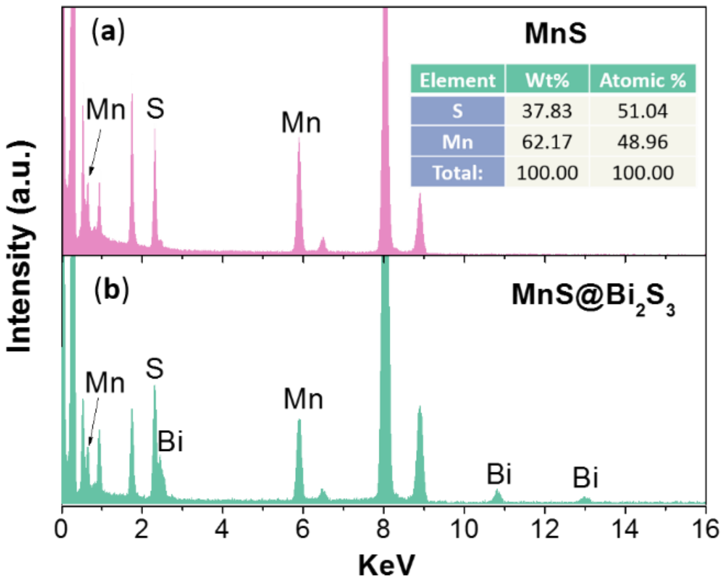


Figure S2. EDS spectra of MnS and MnS@Bi_2S_3 NPs.

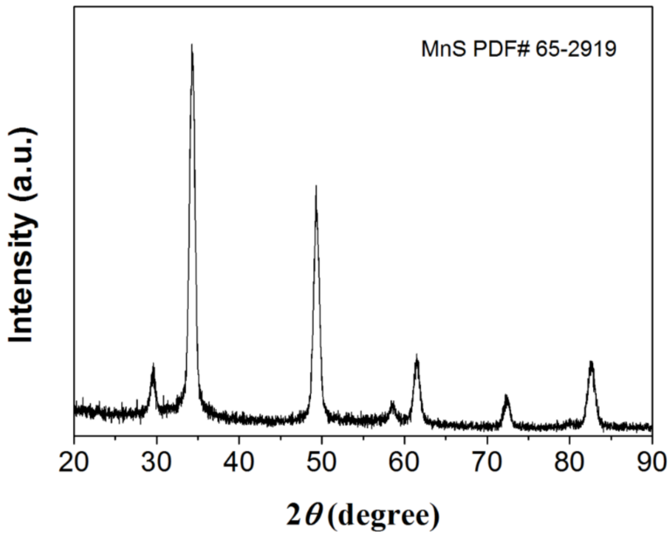


Figure S3. Powder XRD pattern of MnS.

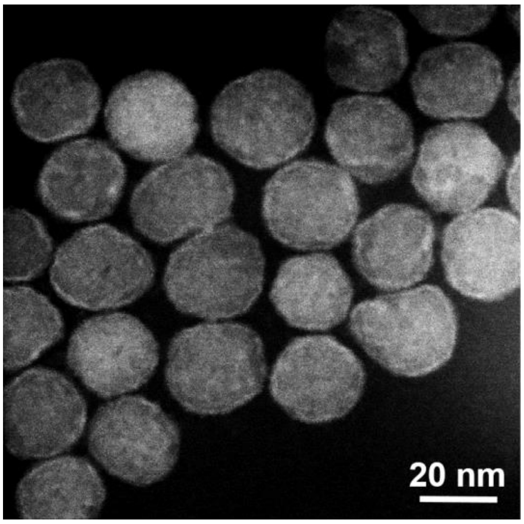


Figure S4. HAADF-STEM image of core-shell $MnS@Bi_2S_3$ NPs prepared at 160 °C for 30 min.

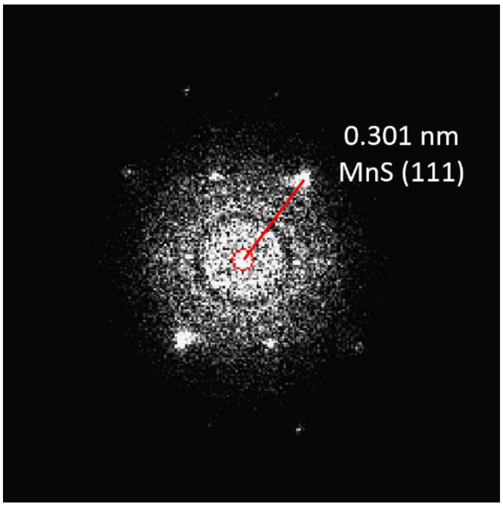


Figure S5. Fast Fourier transform (FFT) image of $MnS@Bi_2S_3$ HR-TEM image.

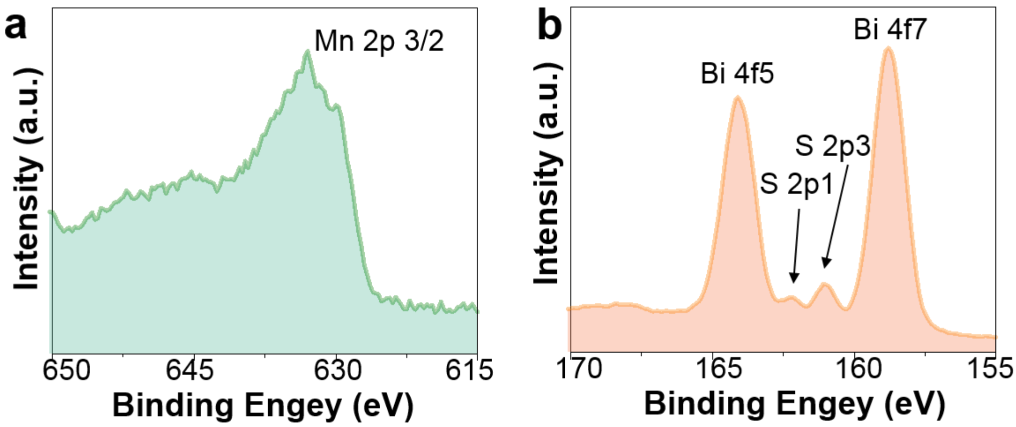


Figure S6. XPS patterns of $MnS@Bi_2S_3$ for the element of (a) Mn, (b) Bi and S.

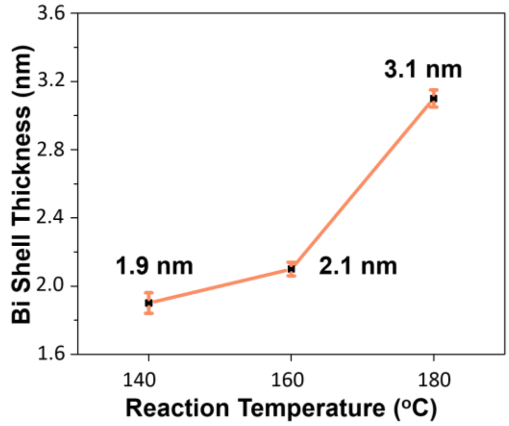


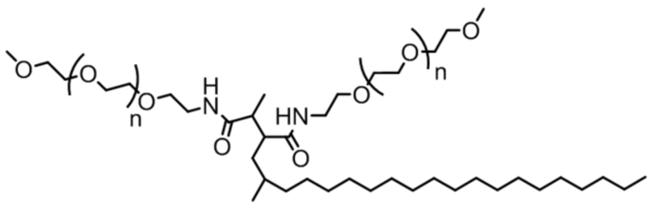
Figure S7. Statistics data of Bi_2S_3 shell thickness acquired under various reaction temperatures for 30 min

Table S1. $MnS@Bi_2S_3$ EDS data of Bi, Mn, and S element compositions acquired under various reaction temperatures for 30 min

Reaction Condition	140 °C， 30 min		160 °C， 30 min		180 °C， 30 min	
Element	Wt %	Atomic %	Wt %	Atomic %	Wt %	Atomic %
S	32.84	54.34	29.84	54.27	23.65	54.05
Mn	40.18	38.81	33.43	35.48	19.5	26.02
Bi	26.98	6.85	36.74	10.25	56.84	19.93
Total:	100	100	100	100	100	100
Similar Formula	$Mn_{11.3}S_{11.3}@Bi_2S_3$		$Mn_7S_7@Bi_2S_3$		$Mn_{2.6}S_{2.6}@Bi_2S_3$	
$MnS:Bi_2S_3$	11.3 : 1		7 : 1		2.6 : 1	

Table S2. $MnS@Bi_2S_3$ ICP-OES data of Bi and Mn elements composition acquired under various reaction temperatures for 30 min

	140 °C, 30 min	160 °C, 30 min	180 °C, 30 min
Mn	39.95%	33.55%	19.41%
Bi	27.10%	36.80%	56.99%



PMHC$_{18}$-mPEG$_{2000}$

poly(maleic anhydride-alt-1-octadecene)-
poly(ethylene glycol) methyl ethers)

Figure S8. The structure and its full name of $PMHC_{18}$-$mPEG_{2000}$

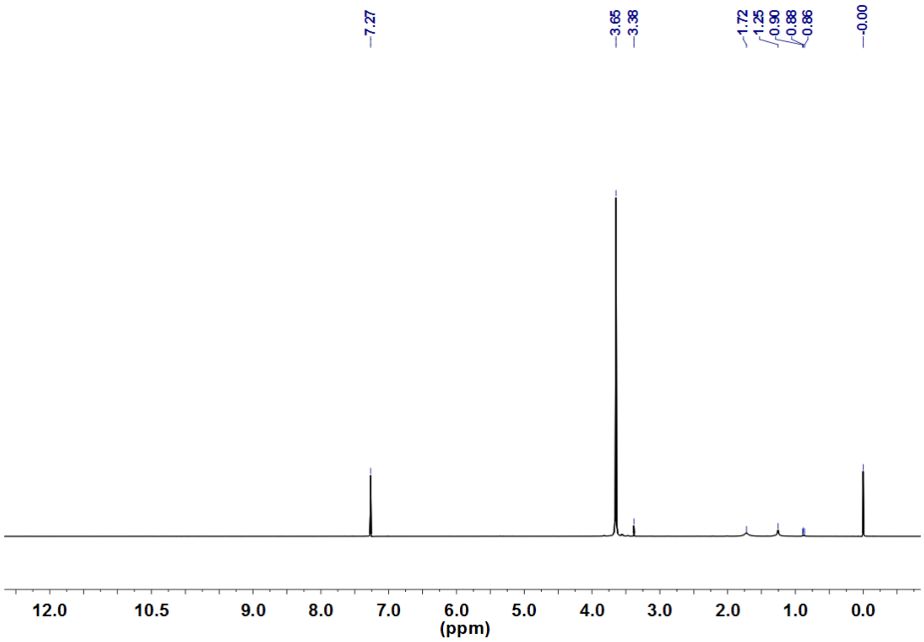


Figure S9. ^{1}H-NMR of $PMHC_{18}$-$mPEG_{2000}$

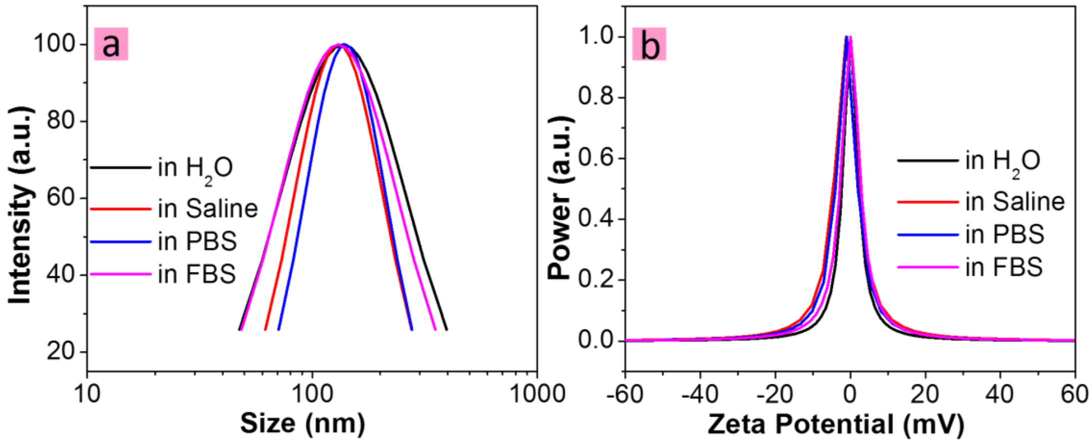


Figure S10. (a) DLS diameter and (b) zeta potential distribution of MnS@Bi_2S_3-PEG NPs in different solvents.

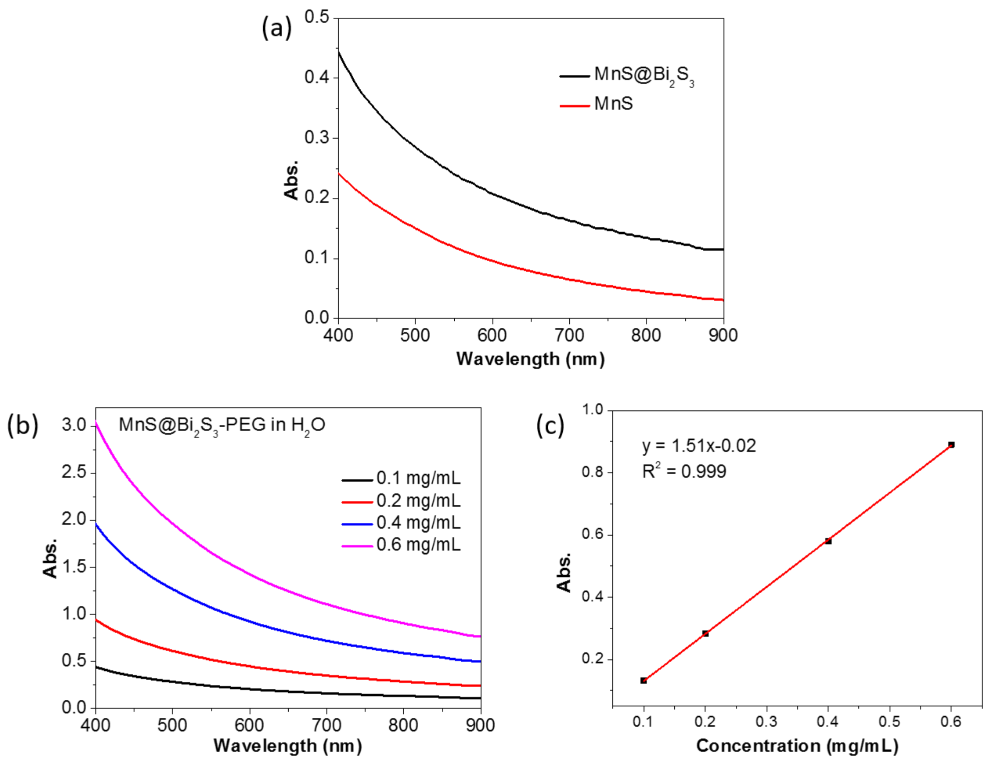


Figure S11. (a) UV-vis absorption of MnS in cyclohexane and MnS@Bi_2S_3-PEG in H_2O. (b) UV-vis absorption of MnS@Bi_2S_3-PEG in different concentration. (c) UV-vis absorption vs. concentration plot of MnS@Bi_2S_3-PEG in H_2O at 808 nm. (PMHC$_{18}$-mPEG$_{2000}$ was also modified on the MnS NPs surface according to the similar procedure of fabrication of PMHC$_{18}$-mPEG$_{2000}$ modified MnS@Bi_2S_3 NPs.)

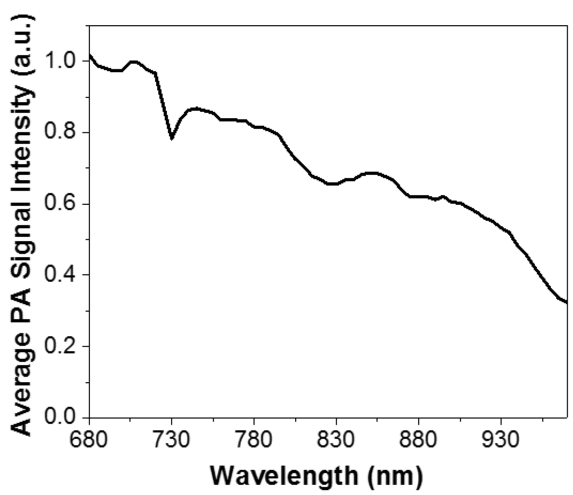


Figure S12. PA signal changing of MnS@Bi_2S_3-PEG excited under different absorption wavelength from 680 nm to 970 nm.

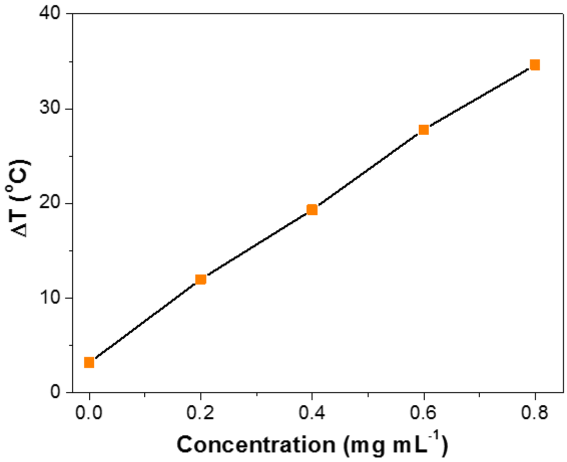


Figure S13. The relationship between different concentrations of MnS@Bi_2S_3-PEG NPs in H_2O vs increased temperature under the irradiation of 808 nm laser (800 mW cm^{-2}) for 10 min.

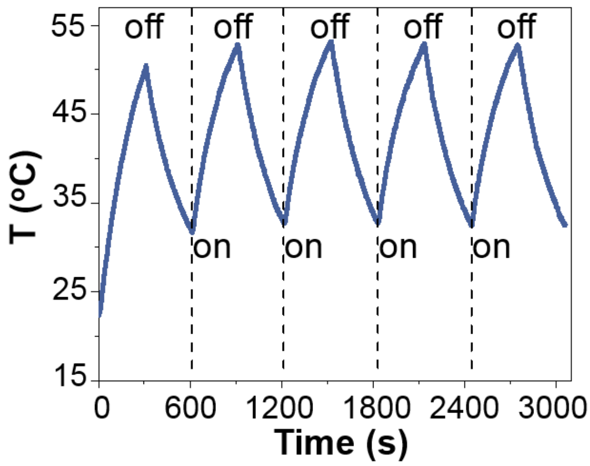


Figure S14. The temperature change curves of MnS@Bi_2S_3-PEG H_2O solutions (0.8 mg mL^{-1}) after multiple cycles of exposure to the 808 nm NIR laser irradiation (power density = 800 mW cm^{-2}).

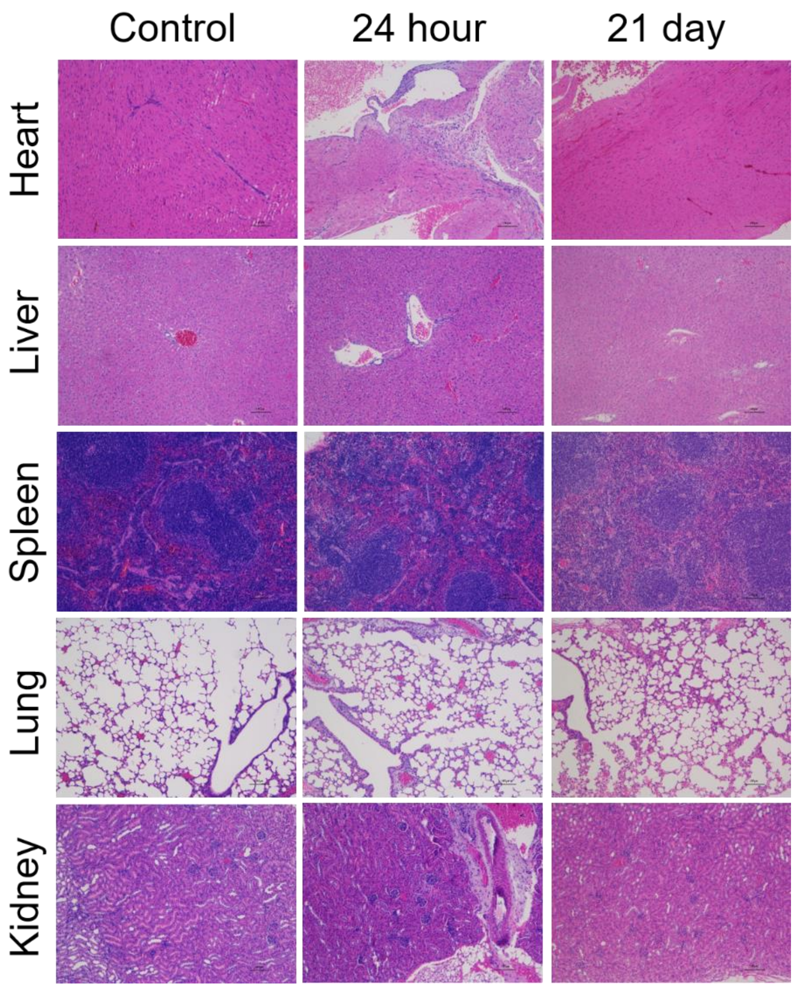


Figure S15. The H&E stained slices of different organs for a control group, and intravenous (i.v.) injected MnS@Bi_2S_3-PEG (20 mg kg^{-1}) after 24 h or 21 d including 100× magnifications.

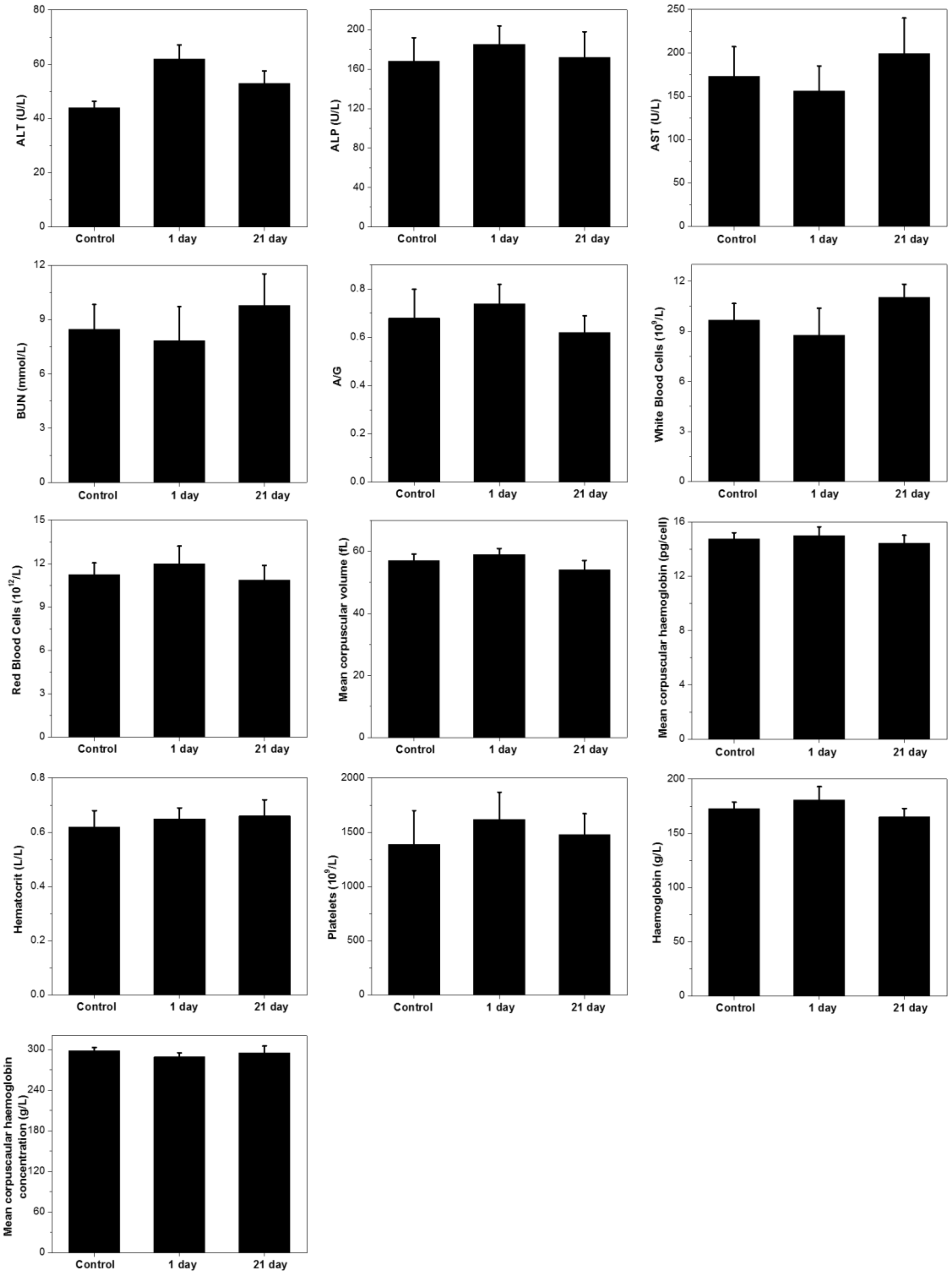


Figure S16. Blood analysis data of healthy BALB/c mice were intravenous (i.v.) injected $MnS@Bi_2S_3$-PEG (20 mg kg^{-1}) after 1d or 21 d. Healthy BALB/c mice were intravenous (i.v.) injected saline (200 μL) as control.