Fig. S1 The XRD pattern of magnetic MWNTs-Fe₃O₄ nanomaterials.
**Fig. S2** The Raman spectra of acid-treated MWNTs and magnetic MWNTs-Fe$_3$O$_4$ nanomaterials. The Raman spectrum of acid-treated MWNTs showed the similar intensity of D bands (1339 cm$^{-1}$) in comparison to G bands (1597 cm$^{-1}$), which was due to the presence of more defects at the surface of MWNTs. A small shift in G band and D band peaks was observed in the case of magnetic MWNTs-Fe$_3$O$_4$ nanocomposites. Along with a shift in G and D bands, the characteristic band centered at 680 cm$^{-1}$ was observed at lower Raman shift values in the magnetic MWNTs-Fe$_3$O$_4$. This band indicated that the magnetite nanoparticles were successfully immobilized on the surface of MWNTs.
Fig. S3 The hysteresis loops of a) MWNTs-Fe$_3$O$_4$ and b) Fe$_3$O$_4$ nanoparticles. The two nanoparticles exhibited a superparamagnetic behavior, that is, no remanence was detected at room temperature (above inset). Meanwhile, the PL-MWNTs-Fe$_3$O$_4$ nanomaterials in their homogeneous dispersion showed fast moment to the applied magnetic field (2000 Oe) (below inset).
**Fig. S4** Representative TEM image of the synthesized magnetic MWNTs-Fe$_3$O$_4$ nanomaterials with octopus claw-like nanostructures using NaAc.
Fig. S5 Representative TEM image of the synthesized magnetite nanoparticles.
Fig. S6  TGA of (a) MWNTs-Fe$_3$O$_4$ and (b) PL-MWNTs-Fe$_3$O$_4$. The result indicated that about 22 wt% polyethylene glycol based on the total weight of the MWNTs-Fe$_3$O$_4$ could be covalent.
**Fig. S7** Confocal fluorescence microscopy images of FITC uptake by U87 cancer cells. The control experiment was investigated by using FITC instead of FITC-labeled nanomaterials in our study, hardly any green fluorescence of FITC was observed, which showed that FITC-labeled MWNTs-Fe$_3$O$_4$ nanomaterials could be used as fluorescent probes for cell imaging.
Fig. S8 Infrared thermal images of (a) PL-MWNTs-Fe₃O₄-injected and (b) PL-MWNTs-injected U87 tumor sample at different time points (0, 15, 30 sec) under NIR laser irradiation.
Fig. S9 Histological analysis of surviving mice following PL-MWNTs-Fe₃O₄ nanomaterials-based photothermal therapy reveals no overt pathological changes. No significant lesions were detected.