Electronic Supplementary Information (ESI)

Vibrating droplet generation to assemble zwitterion-coated gold-graphene oxide stealth nanovesicles for effective pancreatic cancer chemo-phototherapy

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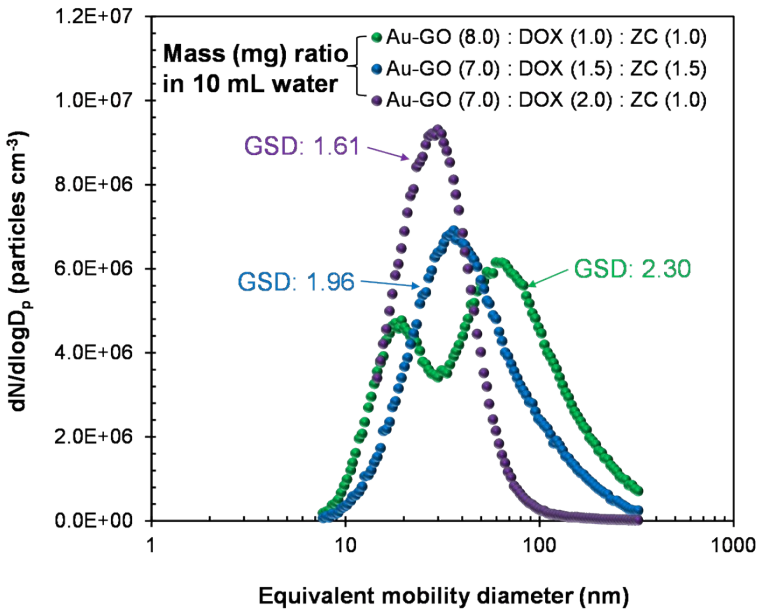

Fig. S1 SMPS measurements to confirm the optimum mass ratio among Au-GO, DOX, and ZC components. For mass ratio of 8.0:1.0:1.0 among Au-GO, DOX, and ZC, although a large proportion of the Au-GO particles were incorporated into ZC-DOX droplets, some of the particles remain in the initial state. This implies that the number concentration of ZC-DOX droplets was not sufficient to contain all the particles at the vibrating nozzle outlet. The size distributions changed when the mass ratio of particles was increased to 7.0. For the ratios of 7.0:1.5:1.5 and 7.0:2.0:1.0, the particles are shown to be nearly quantitatively incorporated into ZC-DOX droplets. Furthermore, the GSD reached 1.61 (close to quasi-monodisperse distribution, GSD: 1.15-1.50) when the ratio of ZC was decreased to 1.0.

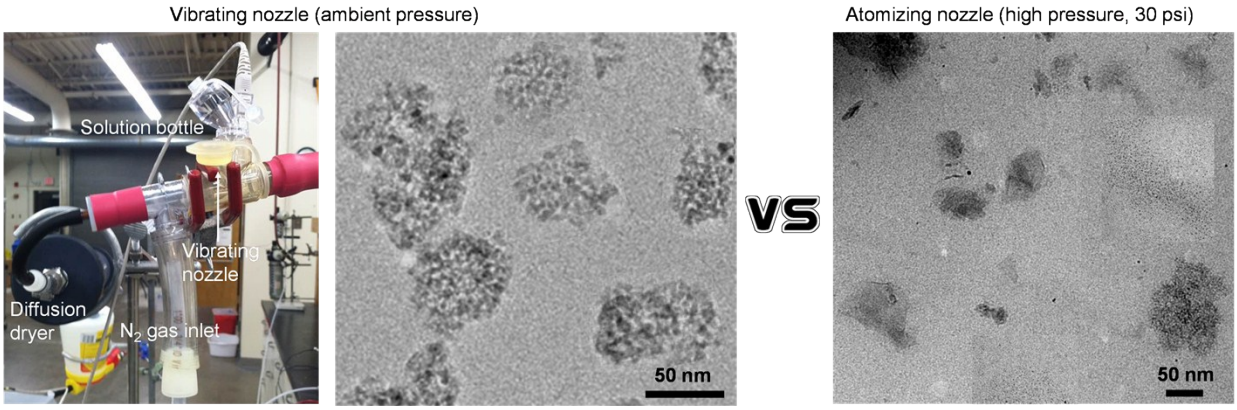

Fig. S2 Transmission electron microscopy (TEM) images of the products from vibrating (left) and atomizing (right) nozzles. The vibrating nozzle produced vesicular structures (i.e., gold-graphene oxide, doxorubicin, and zwitterionic chitosan [Au-GO@ZC-DOX]), while the atomizing nozzle produced segregated structures (i.e., dark dots-gold nanoparticles and thin sheets-GO@ZC-DOX). The main part of the experimental setup used to produce Au-GO@ZC-DOX nanovesicles (NVs) is shown in the photograph on the left. Briefly, the dispersion containing Au-GO, ZC, and DOX passes through a vibrating nozzle from a solution bottle. The generated droplets are then carried by N_2 gas flow to a diffusion dryer, which extracts the solvent for assembly of the NVs under ambient pressure and temperature conditions.

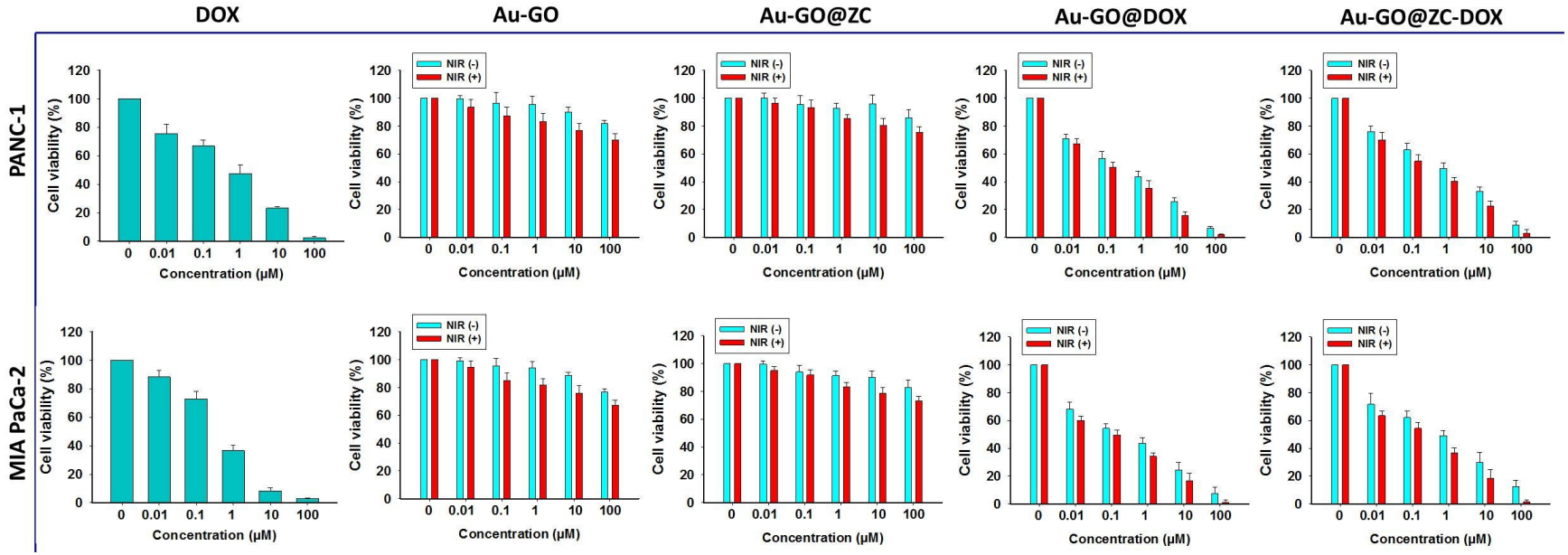

Fig. S3 *In vitro* cytotoxicity in PANC-1 and MIA PaCa-2 cells treated with doxorubicin (DOX), gold-graphene oxide (Au-GO), Au-GO coated with zwitterionic chitosan (Au-GO@ZC), Au-GO@DOX, or Au-GO@ZC-DOX with or without near infrared (NIR) laser irradiation (NIR exposure conditions: 808 nm, 3.0 W/cm^2, 5 min) is shown.

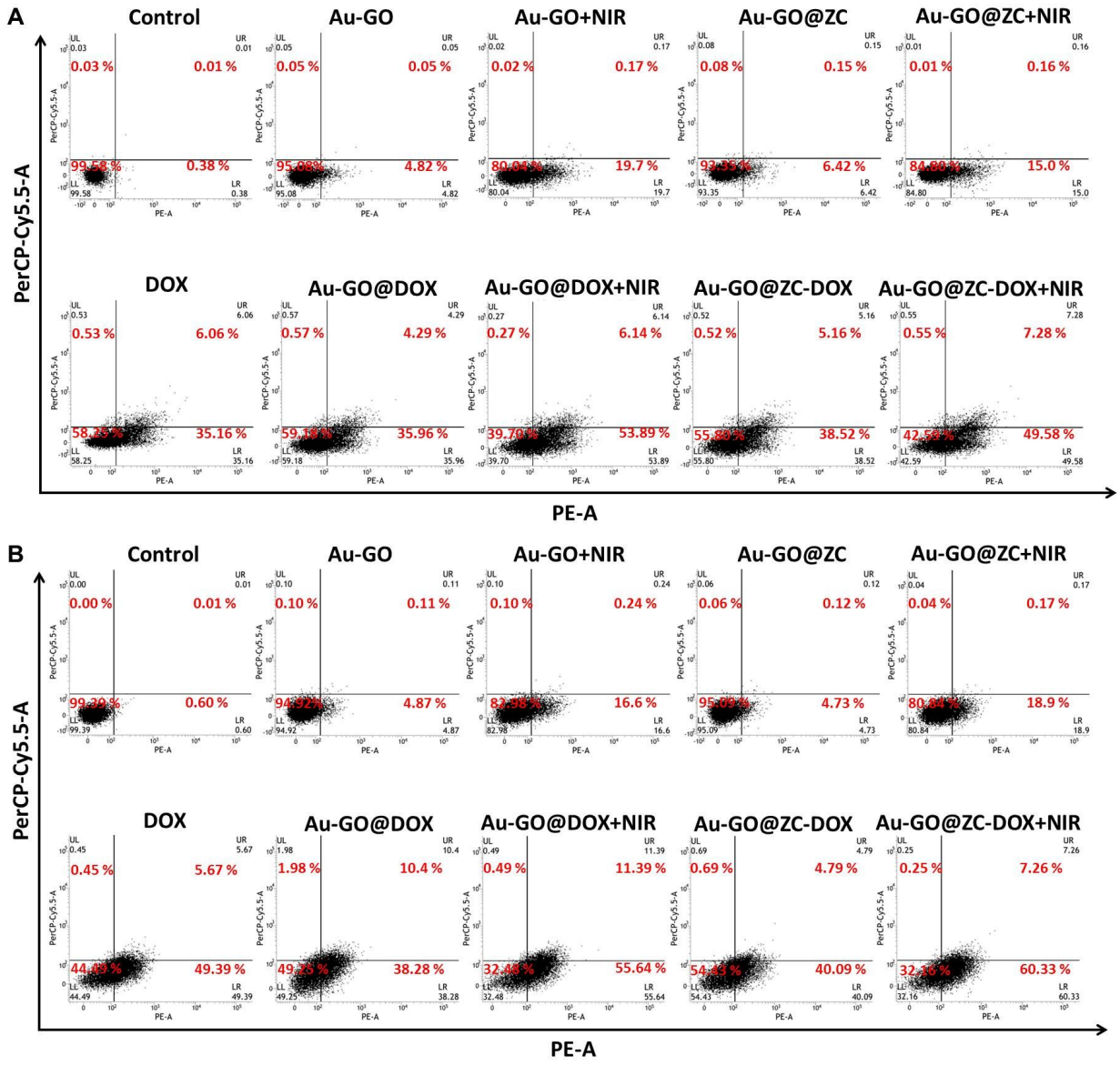

Fig. S4 Cellular apoptosis was determined in (A) PANC-1 and (B) MIA PaCa-2 cells following treatment with gold-graphene oxide (Au-GO), Au-GO coated with zwitterionic chitosan (Au-GO@ZC), doxorubicin (DOX), Au-GO@DOX, and Au-GO@ZC-DOX with or without near infrared (NIR) laser irradiation (NIR exposure conditions: 808 nm, 3.0 W/cm^2, 5 min).

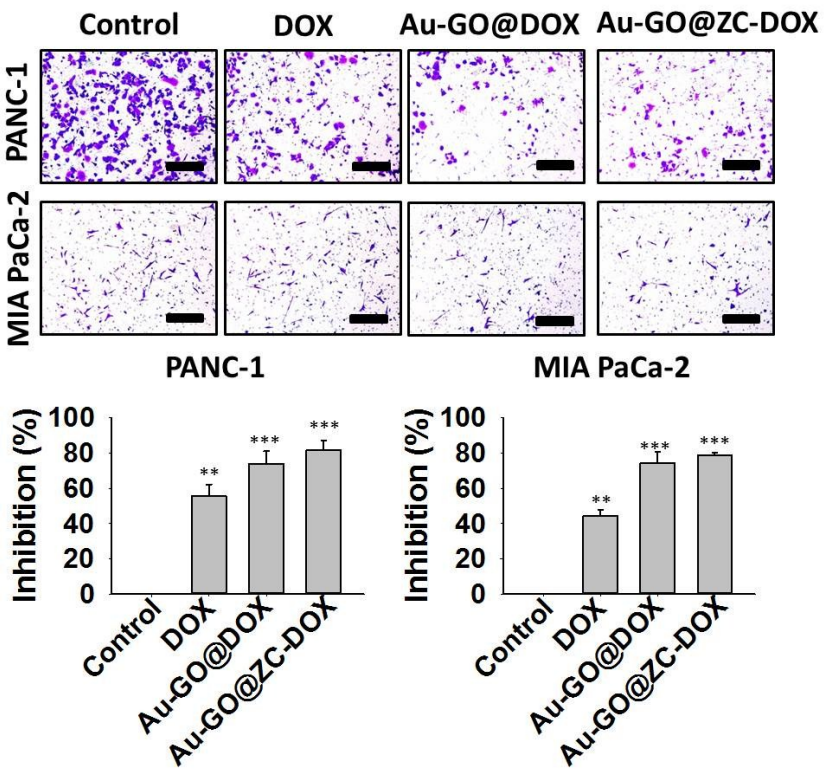

Fig. S5 Results of a transwell assay for measuring cell migration following treatment with doxorubicin (DOX), gold-graphene oxide containing DOX (Au-GO@DOX), and Au-GO@DOX coated with zwitterionic chitosan (Au-GO@ZC-DOX) (** $P < 0.01$, *** $P < 0.001$; scale bar = 250 μm) are shown.

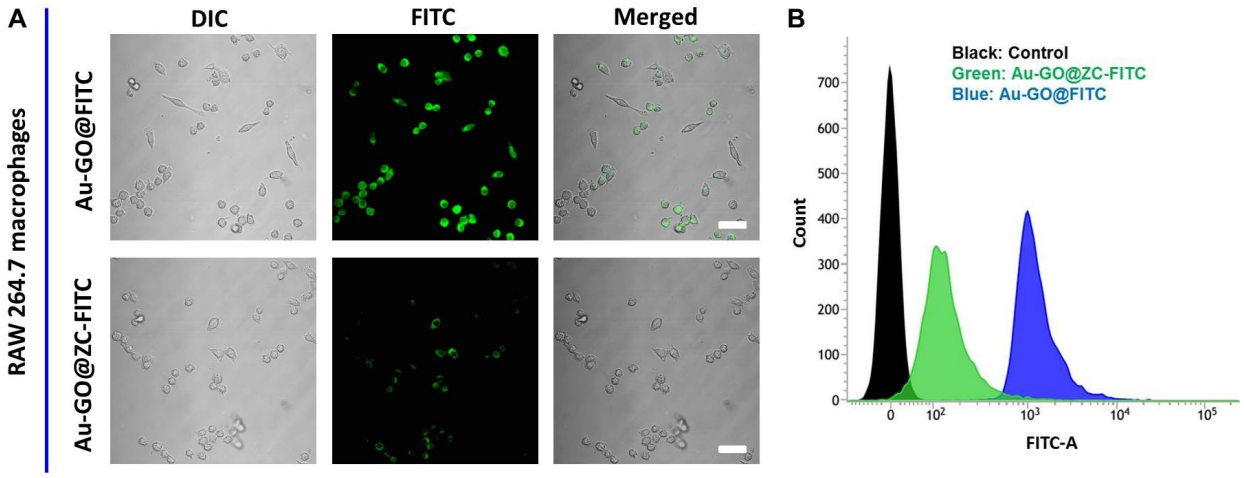

Fig. S6 Cellular uptake of gold-graphene oxide (Au-GO) loaded with fluorescein-5(6)-isothiocyanate (Au-GO@FITC) and Au-GO@FITC coated with zwitterionic chitosan (Au-GO@ZC-FITC) in RAW 264.7 macrophages was determined via (A) confocal imaging and (B) fluorescence-activated cell sorting (FACS) analysis (scale bar = 50 μm). DIC, differential interference contrast

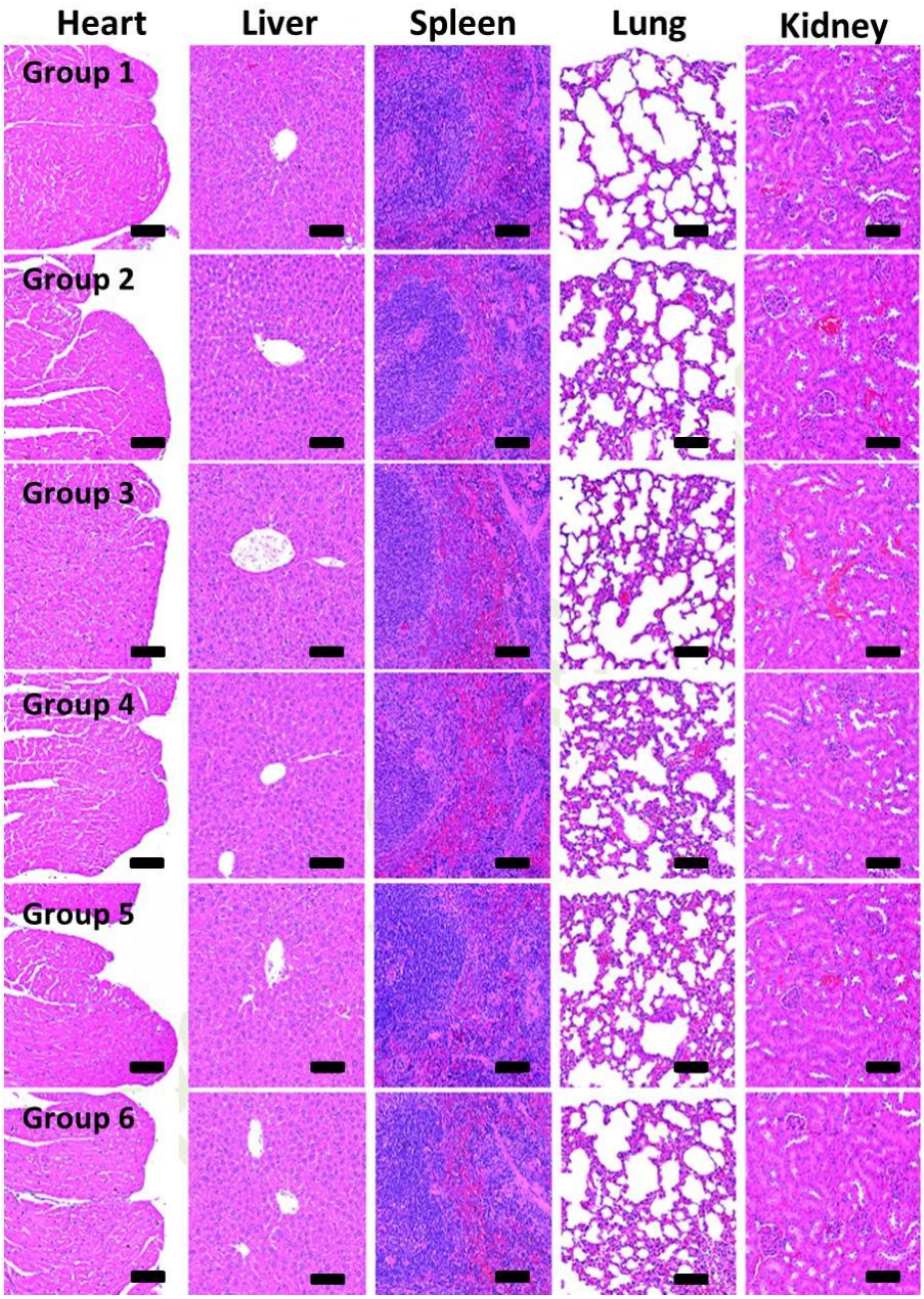

Fig. S7 Representative organ histopathological images (hematoxylin & eosin stained) of mice from different treatment groups are shown. Group 1: Control, Group 2: doxorubicin (DOX), Group 3: gold-graphene oxide containing DOX (Au-GO@DOX), Group 4: Au-GO@DOX receiving near infrared irradiation (Au-GO@DOX+NIR), Group 5: Au-GO@DOX coated with zwitterionic chitosan (Au-GO@ZC-DOX), Group 6: Au-GO@ZC-DOX+NIR (NIR exposure conditions: 808 nm, 3.0 W/cm^2, 5 min; scale bars: 120 μm).