Table 4. Drug delivery system nanoparticles[#] and their effect on cancer resistance

DDS carrier	Nanoparticles modification	Encapsulated drug or toxic agent	Cells or tumor treated	Genes affected	Effect over resistance	Ref.
PLGA*	Dual RNAi delivery system (MDR1 and BCL2 siRNA)	Paclitaxel* and cisplatin*	ovarian cancer cells: SKOV3-TR and A2780-CP20	MDR1 and BCL2	Stimuli inhibition of drug efflux and cell defense pathways (enhanced drug sensitivity)	[85]
PLGA*	PLGA-encapsulated Disulfiram	Disulfiram*	Hepatocellular carcinoma (Huh7, PLC/PRF/5)	CHD4	Extended the half-life of Disulfiram	[212]
PLGA*	Pluronic and chitosan surface-functionalized PLGA nanoparticles	Camptothecin*	Colon-26 cells (Colon cancer cells)	MDR1	Downregulate the expression of MDR1 expression and enhanced tumor uptake. Induced tumor cell apoptosis, reduced systemic toxicity, and inhibited P-gp.	[214]
PLGA*	PLGA-curcumin nanoparticles	Curcumin*	CAL27-cisplatin-resistant human oral cancer cells	MDR1 Bcl-2	Suppress the protein and mRNA expression levels of MDR1. Downregulate the protein levels of Bcl-2. Intrinsic apoptotic pathway through regulating the function of MDR1 and the production of ROS	[213]
PEG* and PEI	hyaluronic acid (HA) based nanoparticle	MDR1 siRNA with paclitaxel*	SKOV-3TR and OVCAR8TR Ovarian cancer cells	MDR1	Down-regulation of MDR1 and P-gp expression. Inhibitory effect on the tumor growth. Decreased P-gp expression and increased apoptosis in MDR ovarian cancer mice model	[121]
ModifiePEG-PE micelles	Tf-conjugated polymeric micelles	R547 (a potent and selective ATP-competitive CDK inhibitor)	A2780 ovarian carcinoma cells	P21	*In vitro* and *in vivo* studies in ovarian cancer confirmed cytotoxicity and tumor growth inhibition.	[217]
Deoxycholic acid micelles	Folate-conjugated	Verapamil*, a P-gp inhibitor, and Paclitaxel*	MCF-7 and MCF-7/ADR (multi-drug-resistant variant), human breast carcinoma cell lines	MDR and P-gp	Verapamil-mediated overcome MDR solid tumors by targeting the delivery of micellar Paclitaxel into tumor cells.	[50]
Cationic liposome DOTA/DOPE*	systematic nanodelivery platform encapsulating human p53 or oligonucleotide	Temozolomide* and p53 therapy	Human GBM cell lines U87, T98G, and LN-18	p53	DDS crosses the blood-brain barrier and efficiently targets cancer stem cells and tumor cells, activating apoptosis.	[215]
Cationic liposome-PEG-PEI complex	Herceptin was non-covalently associated onto the surface of the nanocarrier	Curcumin* and doxorubicin*	SKBR3 (HER2-positive) and Hs578T (HER2-negative) breast cancer cells	HER2	Cytotoxicity improved. Anti-proliferative effect increased.	[216]
Micells TPGS* and siRNA	Herceptin-conjugated micelles	Docetaxel* and polo-like kinase 1 siRNA	MCF7 and SK-BR-3 cell lines Breast cancer cell	HER2	Co-delivery of drugs was sustained and controlled	[218]
amphiphilic polymer nanoparticle	coated magnetic iron oxide	Cisplatin* and near-infrared dye labeled HER2 antibody	SKOV3 ovarian cancer cell line. *In vivo* models female athymic nude mice	HER2	Inhibited the growth of the primary tumor, peritoneal, and lung metastasis in ovarian cancer. Shrinkage of tumor and primary tumors that had low levels of HER2.	[219]
Nanodiamond	Epirubicin* nanodiamond complex	Epirubicin*	LT2-MYC cell line from murine hepatoblastoma tumor model	CHD4	Nanodiamond-drug complex with epirubicin exhibited high stability and adsorption, promoting uptake and retention on tumor cells	[224]
Nickel oxide	Nickel-containing nanoparticles		H460 human large cell lung cancer	NDRG1 and HIF-1a	Activate a toxicity pathway characteristic of carcinogenic Ni compounds	[228]
Zinc oxide	ZnO nanoparticles		Jinghong-1 laying hen's ovarian granulosa cells	NDRG1	Upregulated the expression of NDRG1 and regulate proteins	[229]
Silver nanoparticles	Ag nanoparticles		MCF7 (breast cancer) and HeLa (cervical cancer) cells	HIF-1	HIF-1a signaling pathway disrupted and vascular endothelial growth factor to inhibit angiogenesis.	[230]