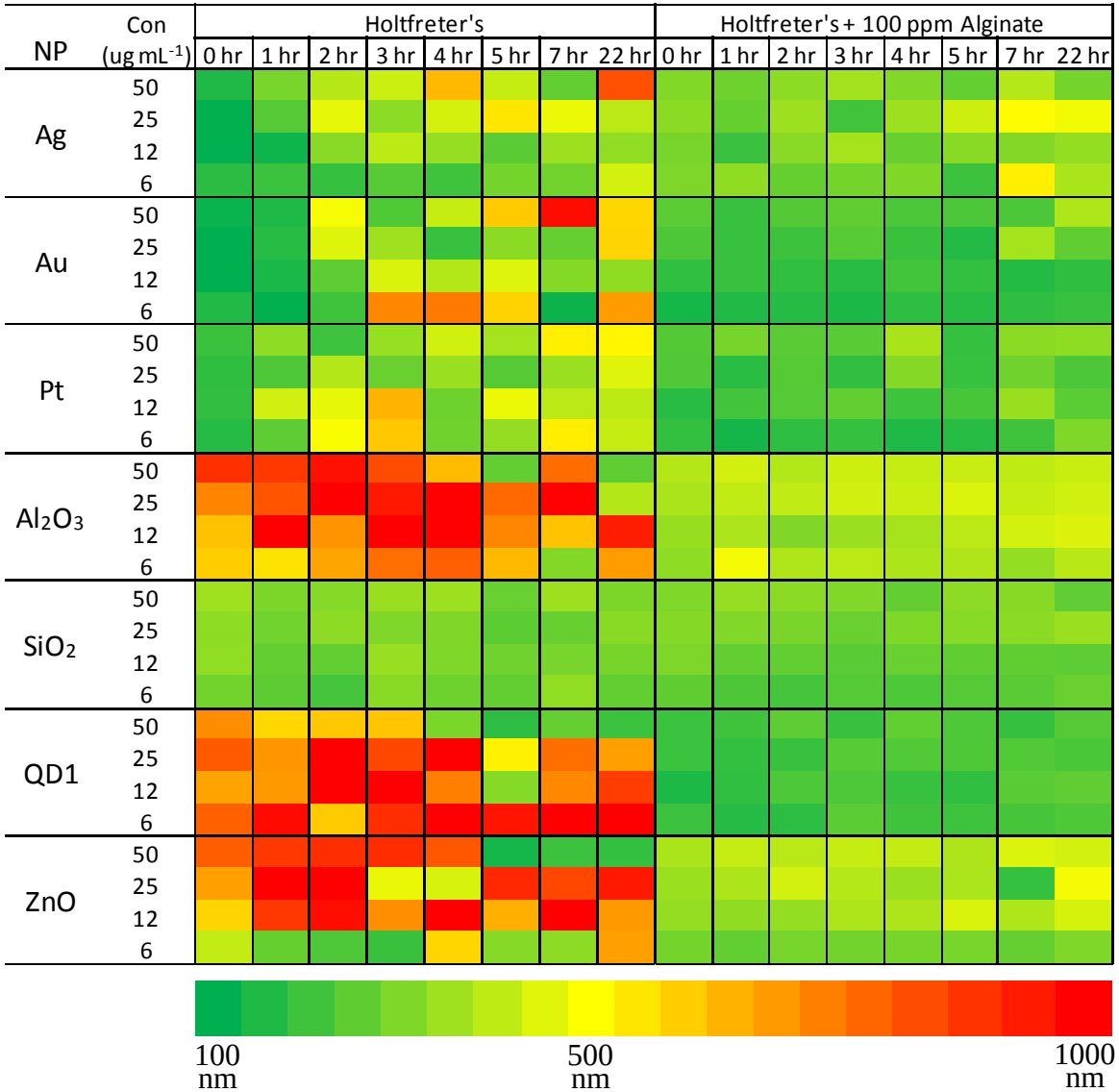
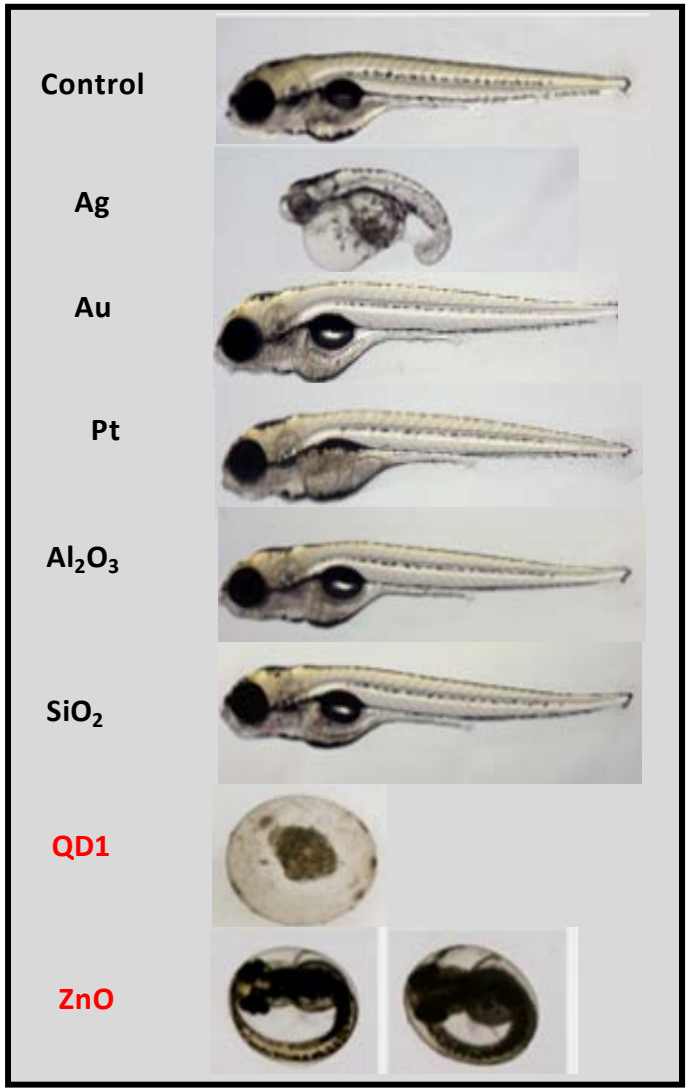
NP Agglomeration Kinetics in Holtfreter's Solution

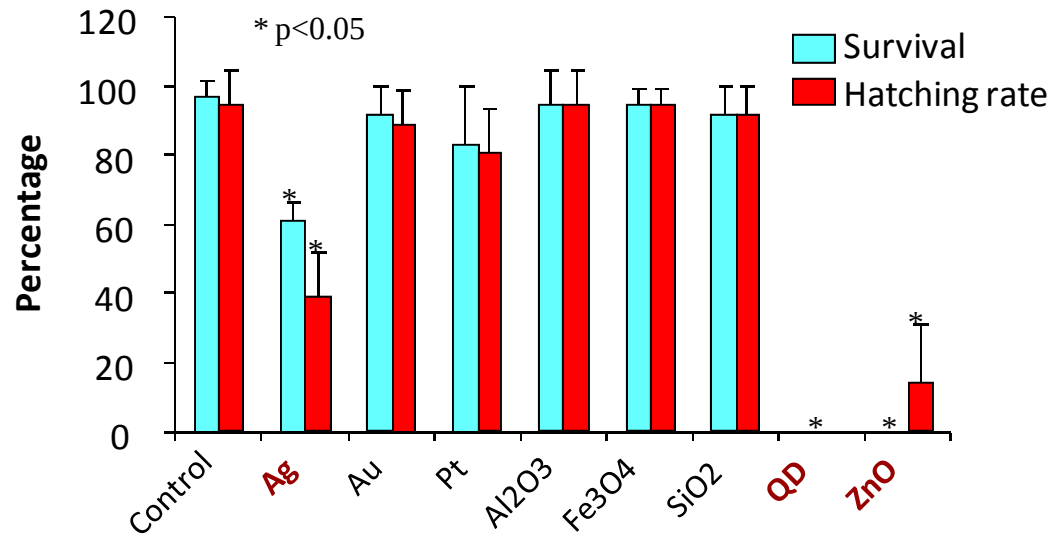


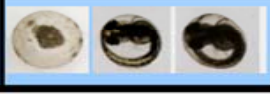
Improved dispersion and stability in the presence of alginate as the dispersing agent

S. George, T. Xia, and A. Nel et al. ACS Nano, 5(3), 2011, 1805-1817.

Toxicity Screening in Zebrafish

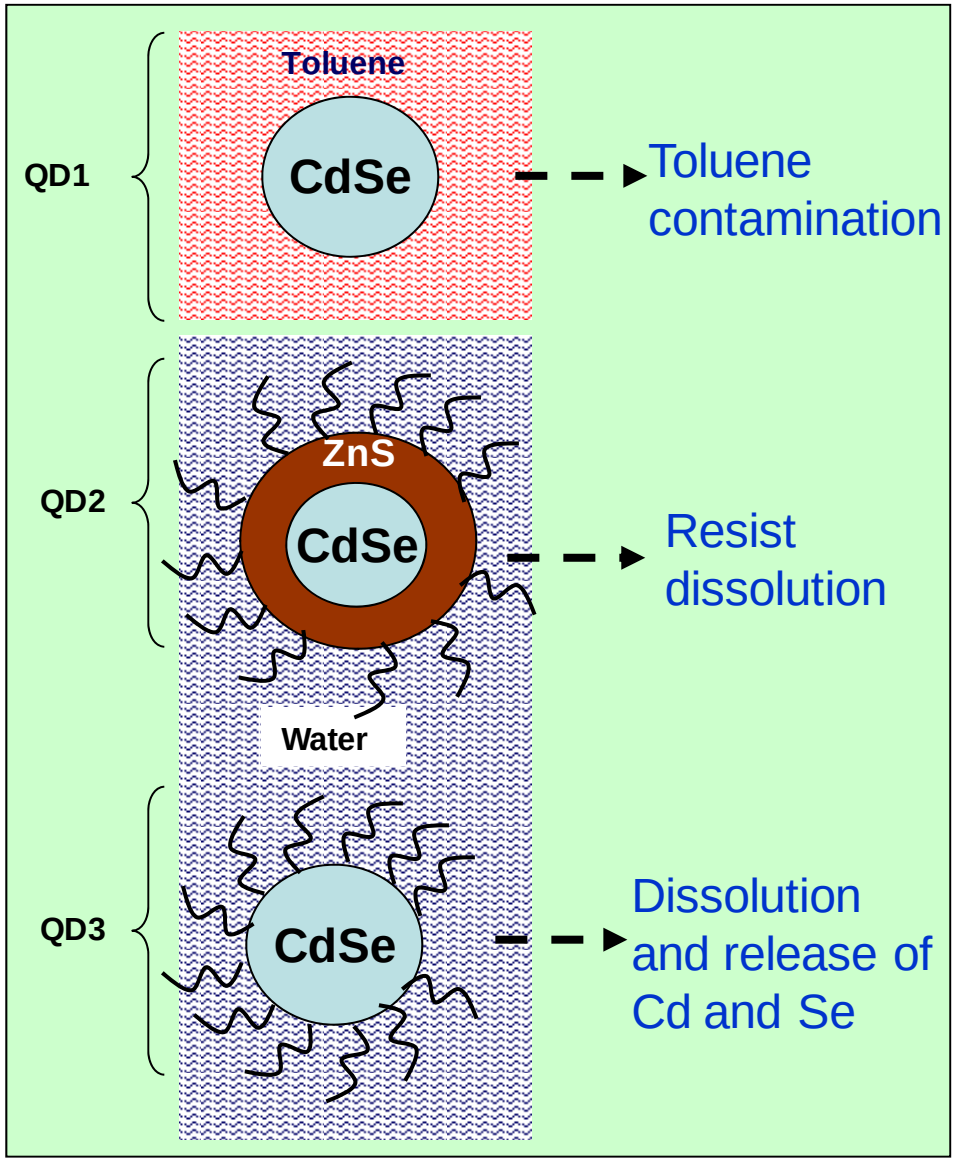


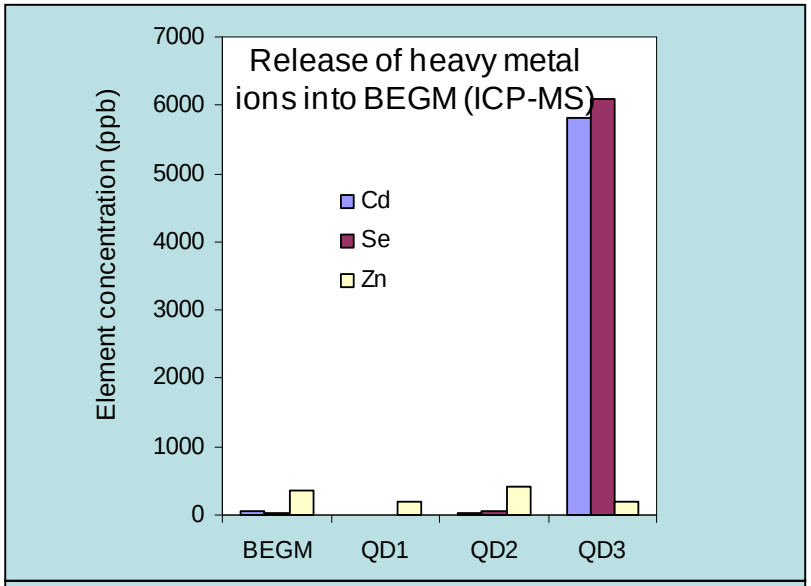


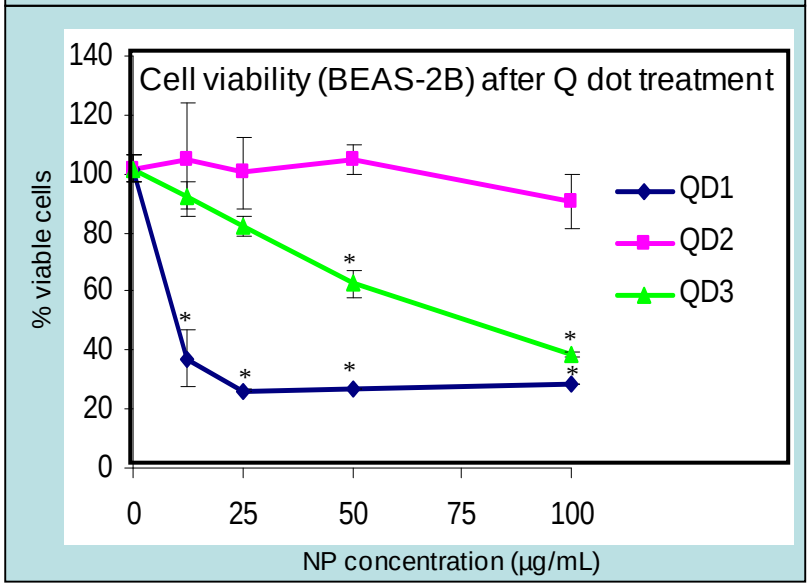
Ranking	NPs	Morphological defects	Physiological defects
0. No morphological or physiological defects	Au, Al_2O_3, Fe_3O_4, SiO_2		
1. Single morphological or physiological defect	-	-	-
2. Multiple morphological and physiological defects	Pt		Low heart beat
3. Severe multiple morphological and physiological defects	Ag		High mortality and reduced hatching rate and low heart beat
4. Embryo do not survive	ZnO, QD		Embryos do not survive or fail to hatch

S. George, T. Xia, and A. Nel et al. ACS Nano, 5(3), 2011, 1805-1817.

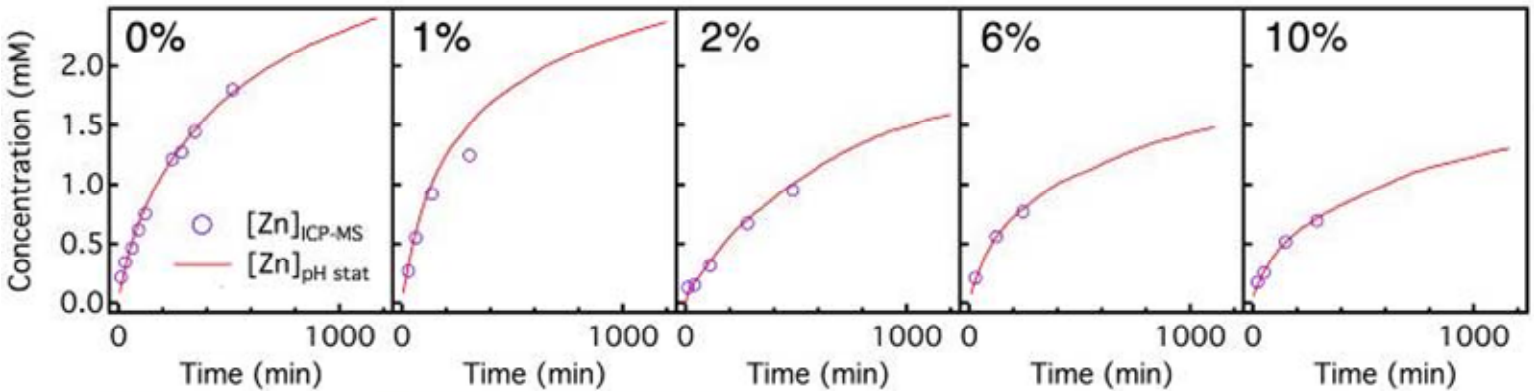
Quantum Dot Mediated Toxicity



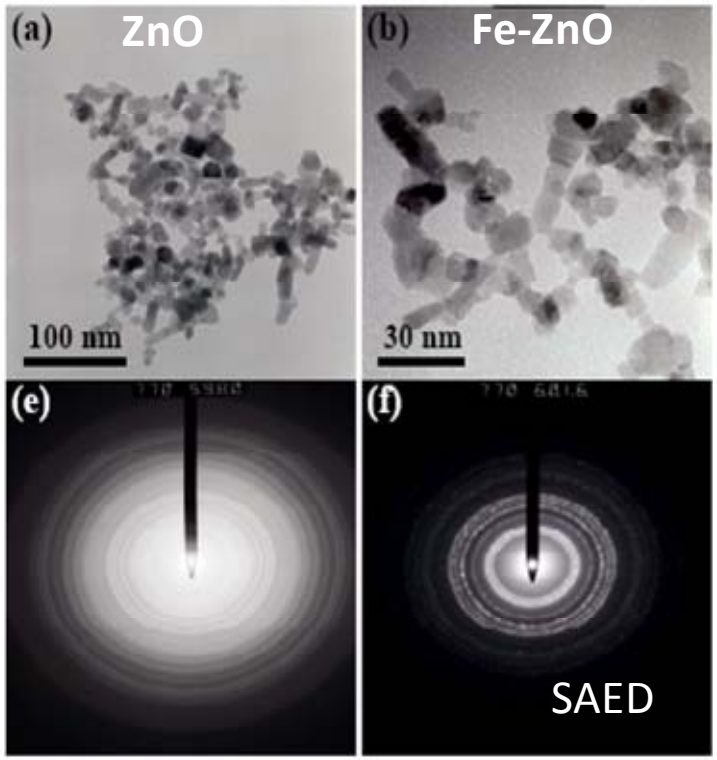


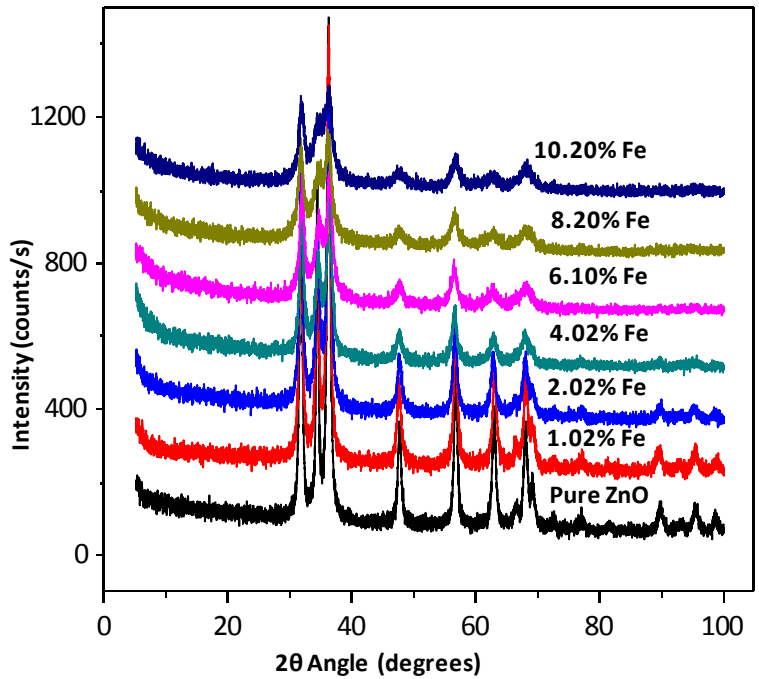


Dissolution Kinetics of ZnO and Fe-ZnO and Their Physical-Chemical Properties



ICP-MS

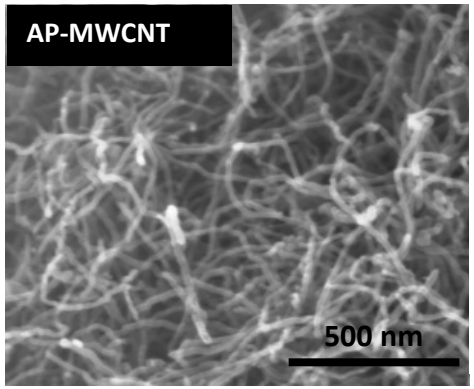


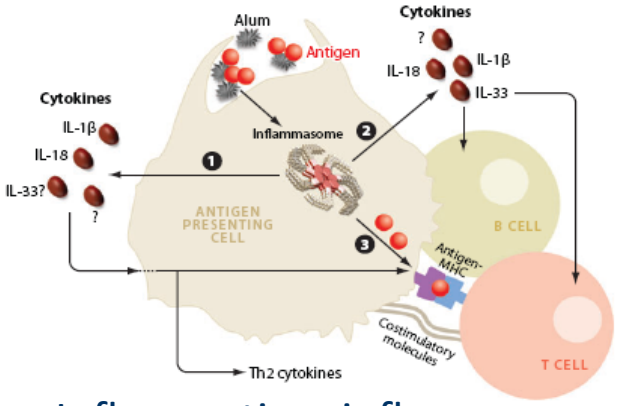


XRD

George, Pokhrel, Maedler et al. ACS Nano, 2010, 4, 15–29.

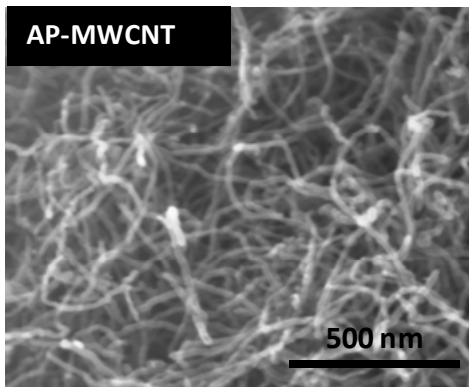
Case Study III – MWCNTs

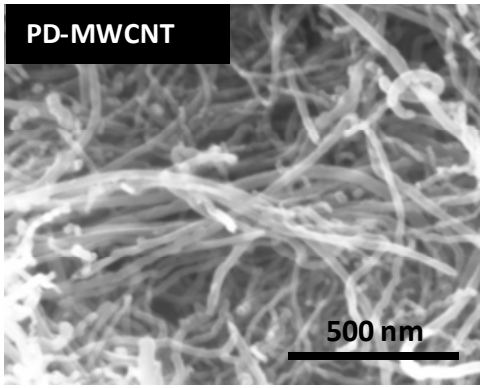


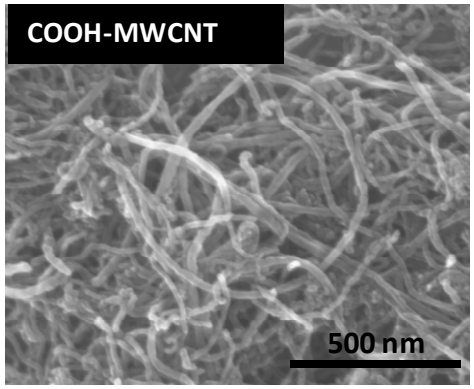


Inflammation, inflammasome

MWCNT Combinatorial Library







	AP MWCNTs	PD MWCNTs	MWCNT-COOH
Outer Diameter (nm)	20-30	20-30	20-30
Inner Diameter (nm)	5-10	5-10	5-10
Length (µm)	10-30	10-30	10-30
Purity	> 95 %	> 95 %	> 95 %
Elemental Composition (%weight)	4.49 % Ni, 0.76 % Fe	1.80 % Ni, 0.08 % Fe	0.18 % S

AP: as-prepared; PD: purified; -COOH: carboxylated.

X. Wang, T. Xia, and A.E. Nel et al. ACS Nano, 4(12), 7241-7252.

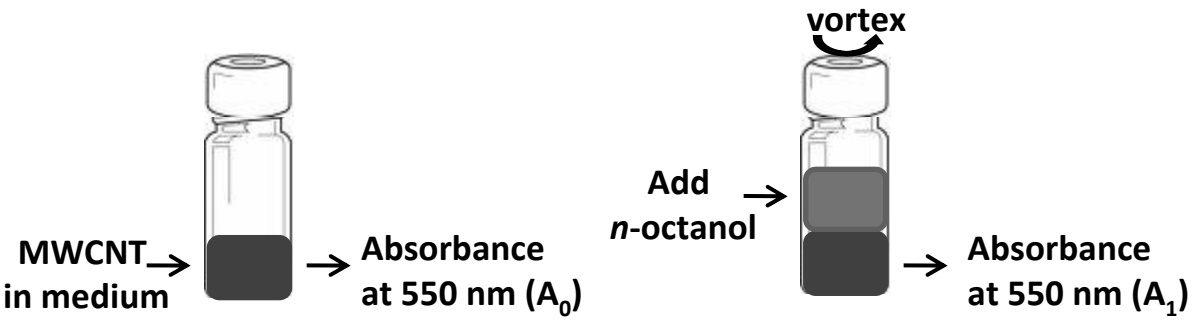
Zeta Potential & Size Analyses of MWNTs

	Medium	AP-MWCNT	PD-MWCNT	COOH-MWCNT
Zeta potential (mV)	H_2O	-14.50	-8.73	-50.30
	PBS	-14.08	-13.12	-13.08
	BEGM	-8.01	-7.42	-9.12
	DMEM	-12.85	-13.20	-13.45
Hydrodynamic size (nm)	H_2O	324	858	134
	PBS	713	718	1193
	BEGM	779	650	1062
	DMEM	1390	1492	1529

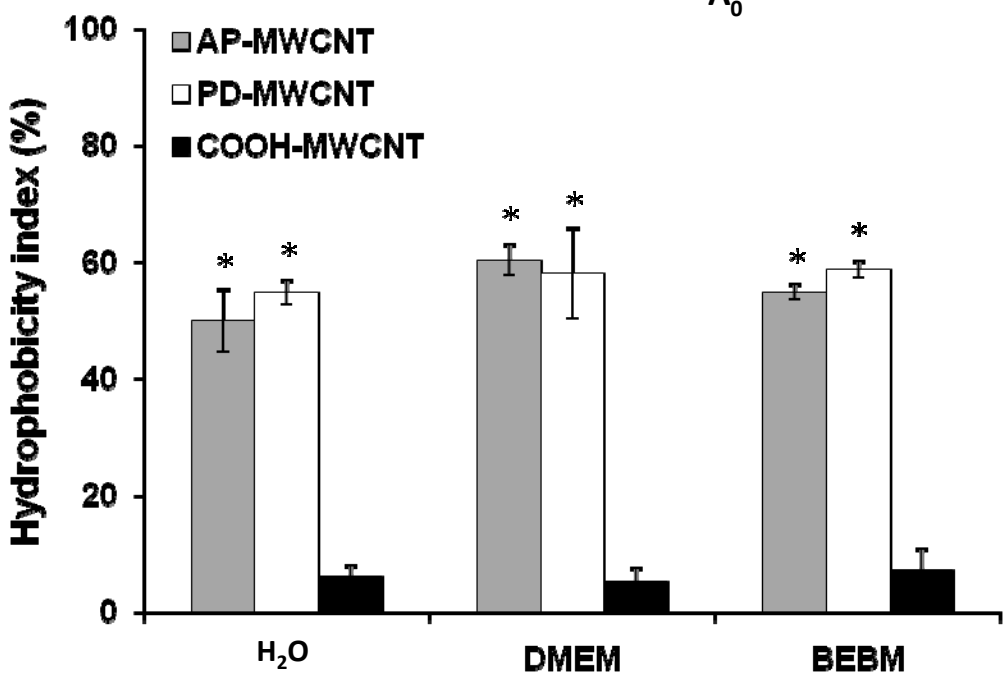
- In H_2O: Slightly negative zeta potentials for AP-MWCNT and PD-MWCNT and much higher zeta potential for COOH-MWCNT
- Similar zeta potentials in PBS, BEGM, and DMEM – DLVO theory fails at high ionic strength
- COOH-MWCNT was much better dispersed in H_2O compared to AP-MWCNT and PD-MWCNT, but not in PBS, BEGM, and DMEM

X. Wang, T. Xia, and A.E. Nel et al. ACS Nano, 4(12), 7241-7252.

n-Octanol/Water Partitioning by UV-vis



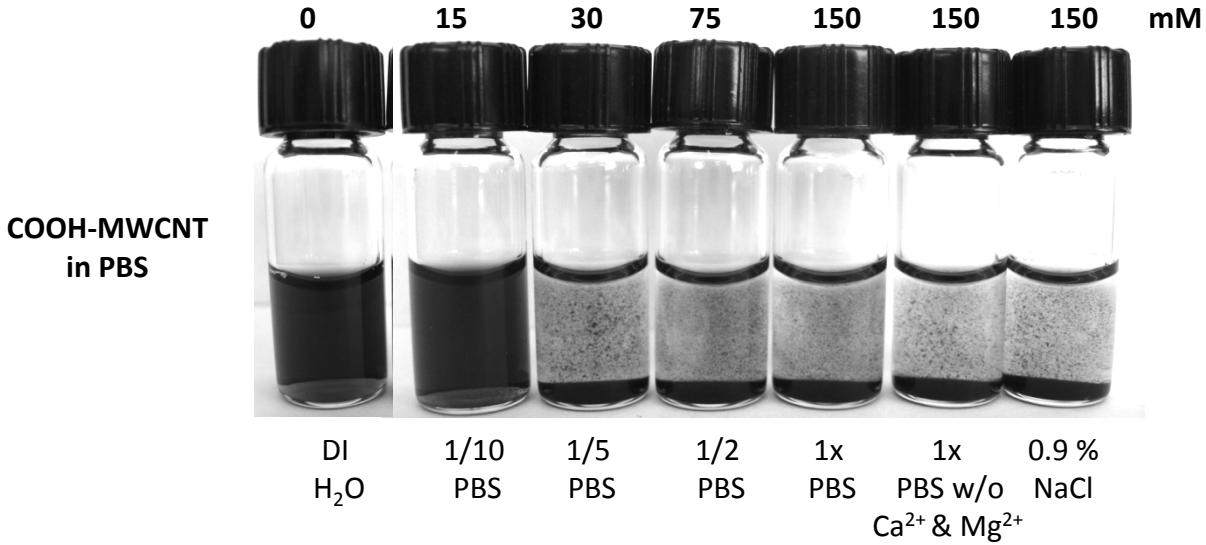
$$\text{Hydrophobicity index (\%)} = \frac{A_0 - A_1}{A_0} \times 100\ \%$$

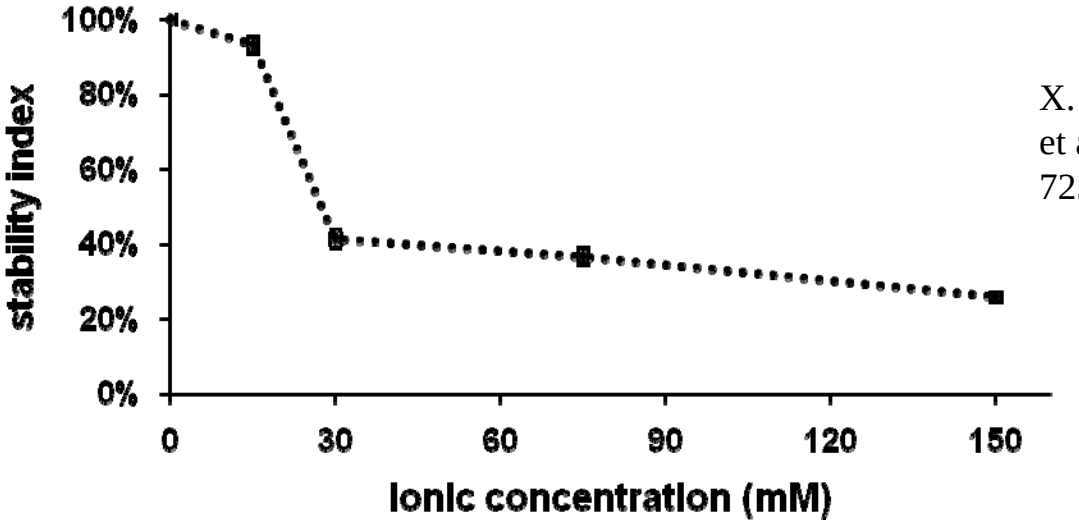


The relatively high hydrophobicity of AP-MWCNTs and PDMWCNTs is a major factor contributing to their poor dispersion, while the electrostatic repulsion by the carboxyl groups promotes COOH-MWCNT hydrophilicity and thus better dispersion.

X. Wang, T. Xia, and A.E. Nel et al. ACS Nano, 4(12), 7241-7252.

High Ionic Strength Contributes Tube Agglomeration



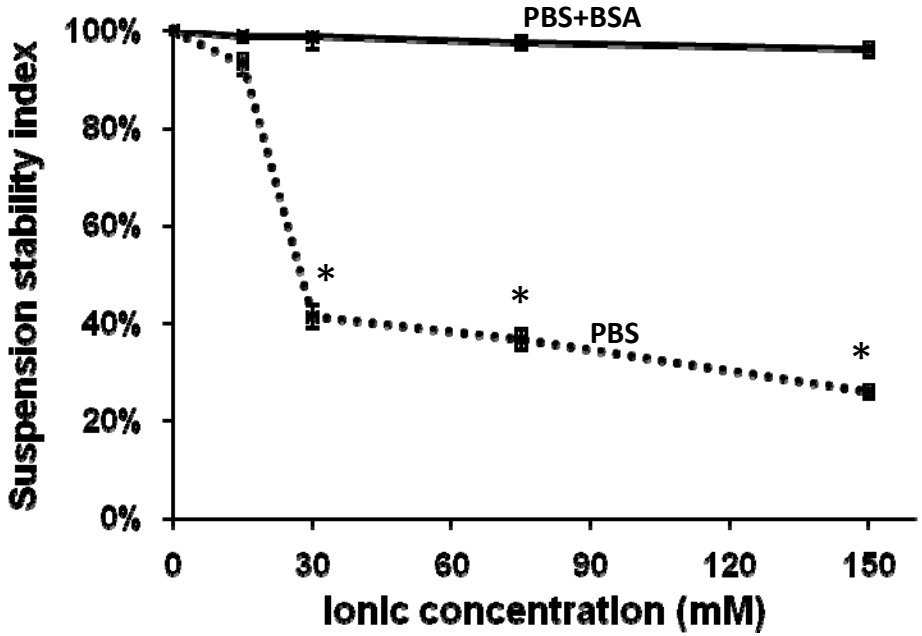


X. Wang, T. Xia, and A.E. Nel et al. ACS Nano, 4(12), 7241-7252.

Improved MWCNT Dispersion in PBS by BSA

COOH-MWCNT in PBS with BSA

DI H_2O	1/10 PBS	1/5 PBS	1/2 PBS	1x PBS	1x PBS w/o Ca^{2+} & Mg^{2+}	0.9 % NaCl



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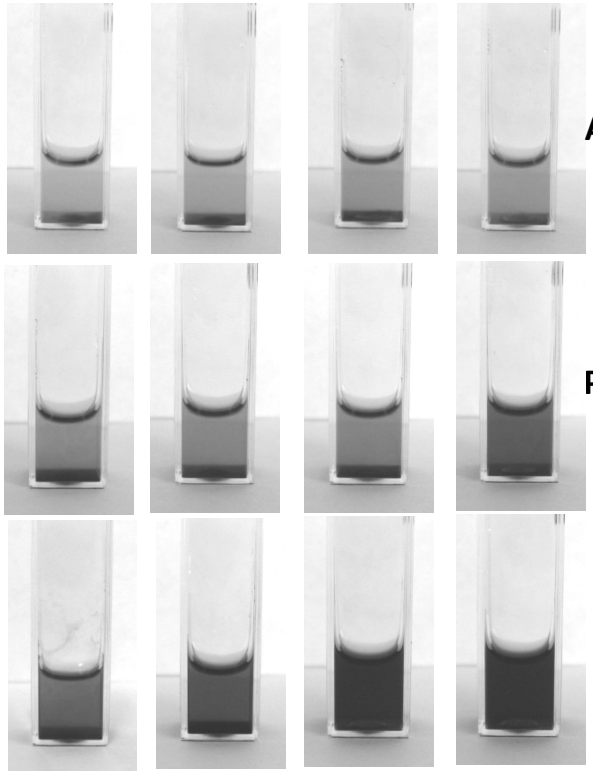
MWCNT Dispersion Characterization in BEGM

Relative hydrodynamic size

	Dose (µg/mL)	BEGM	BEGM+DPPC	BEGM +BSA	BEGM+ BSA+DPPC
AP-MWCNT	100	679	485	504	320
	50	495	370	339	239
	25	388	278	325	262
PD-MWCNT	100	349	792	591	342
	50	350	481	489	354
	25	403	475	425	443
COOH-MWCNT	100	1062	1616	367	412
	50	849	1241	314	364
	25	620	813	297	310

250 500 750 1000 1250 1500 1750 2000 2250 (nm)



AP-MWCNTs

PD-MWCNTs

MWCNT-COOH

BEGM BEGM+DPPC BEGM+BSA BEGM+BSA+DPPC

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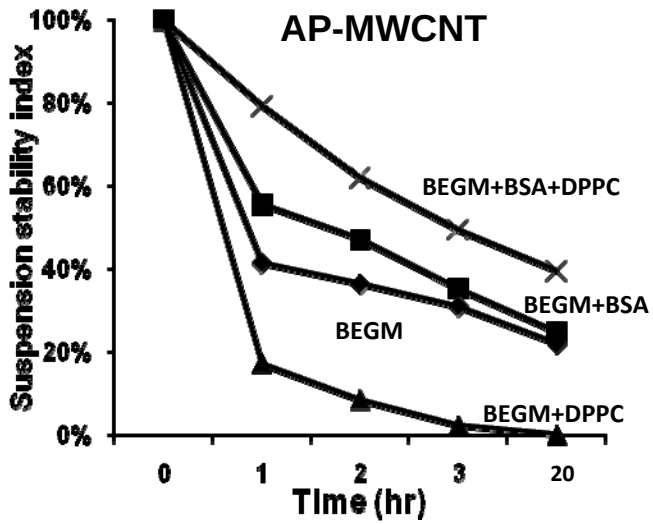
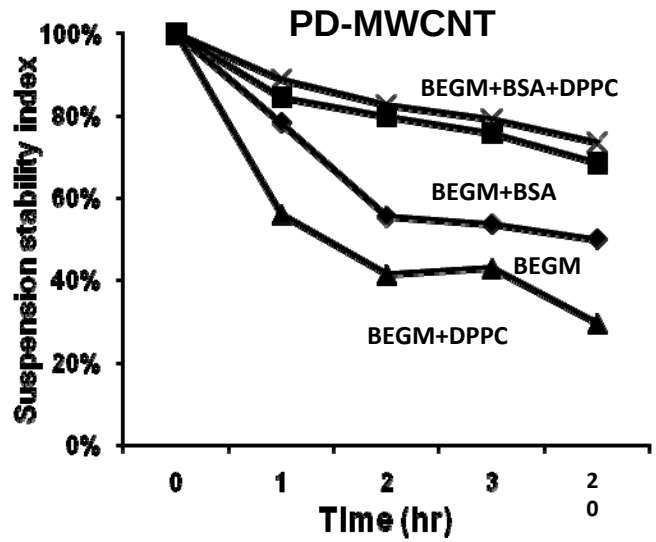
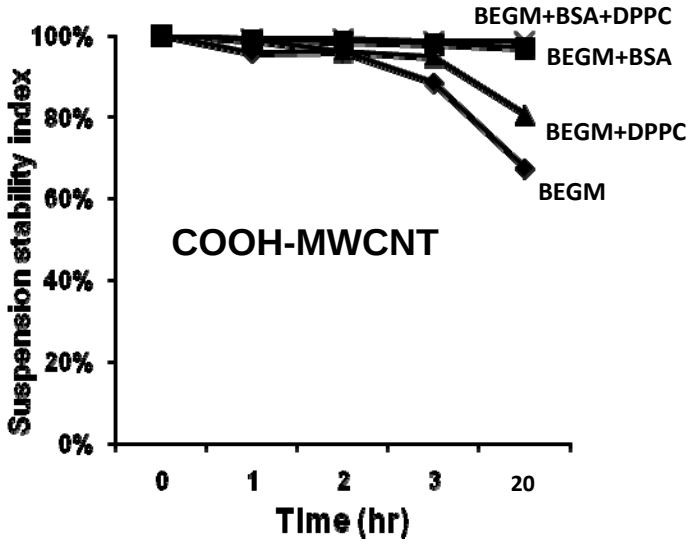
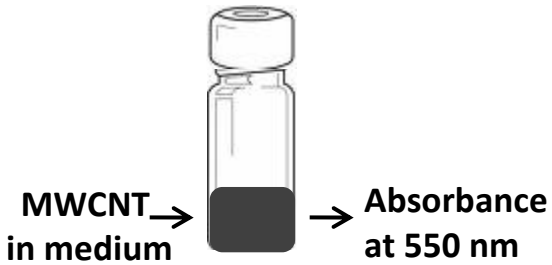
MWCNT Stability Measurement in BEGM









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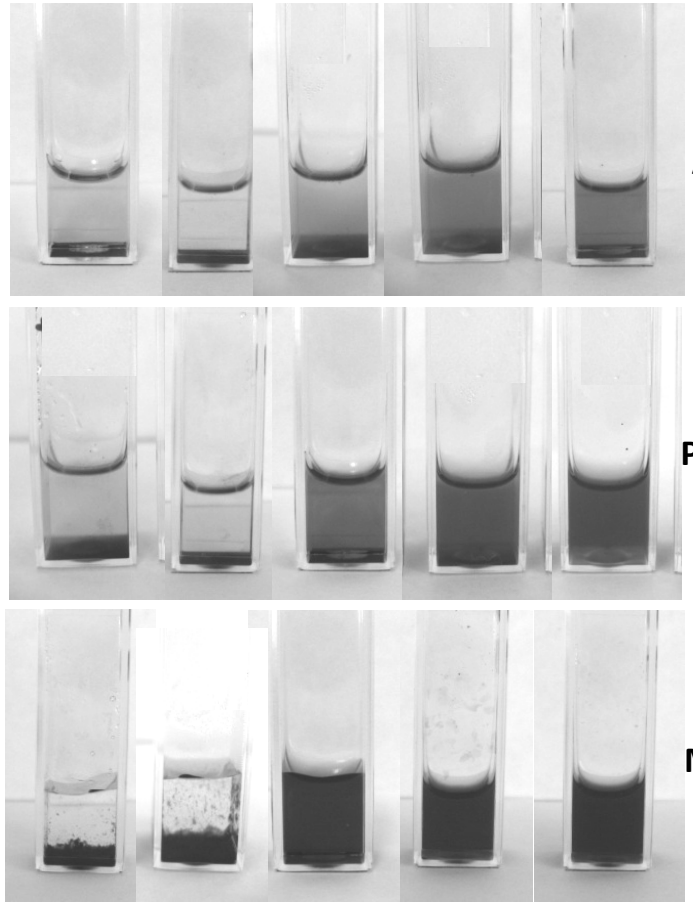
MWCNT Dispersion Characterization in DMEM

	Dose (µg/mL)	Relative hydrodynamic size				
		DMEM	DMEM+DPPC	cDMEM	DMEM +BSA	DMEM+ BSA+DPPC
AP-MWCNT	100	1144	1820	350	424	525
	50	1390	1630	395	417	420
	25	779	1543	362	372	348
PD-MWCNT	100	1492	1526	227	558	380
	50	1165	1497	246	517	375
	25	668	1766	208	344	295
COOH-MWCNT	100	1311	1685	376	326	238
	50	2248	1526	447	373	244
	25	1529	1976	371	385	230

250 500 750 1000 1250 1500 1750 2000 2250 (nm)



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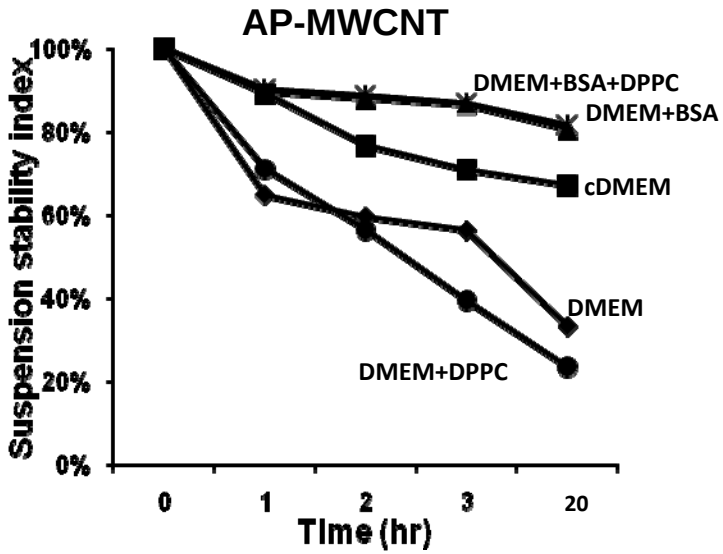
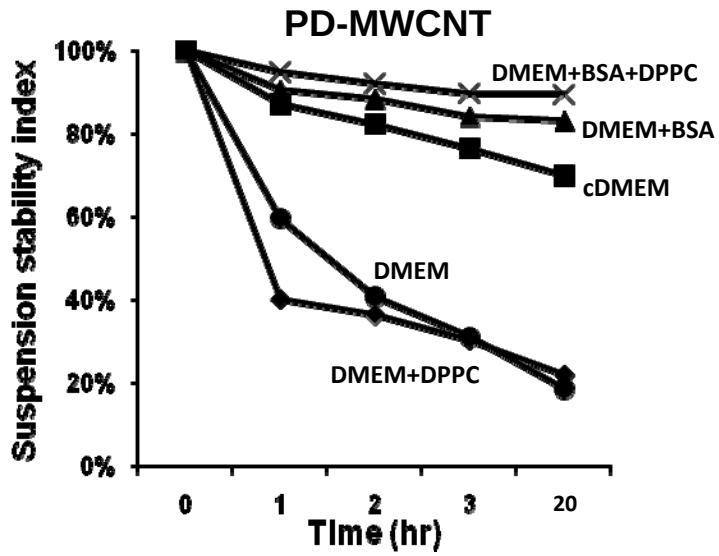
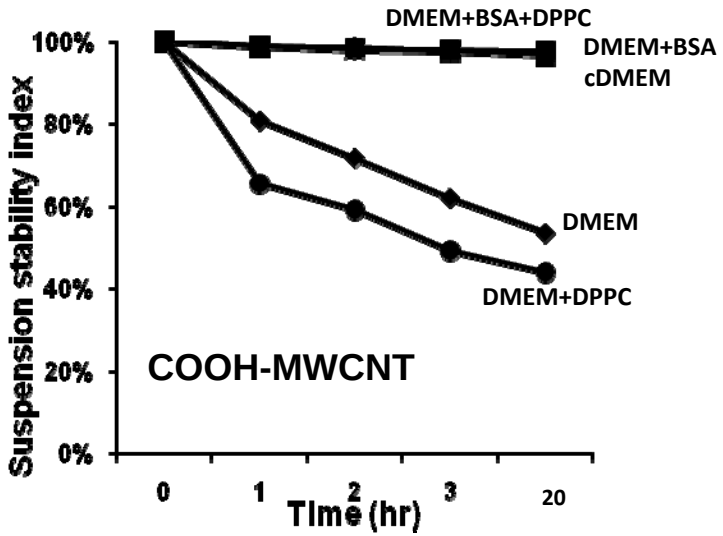
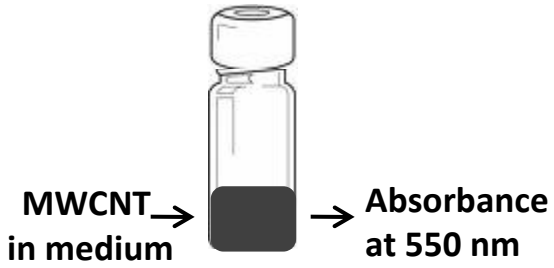
MWCNT Stability Measurement in DMEM









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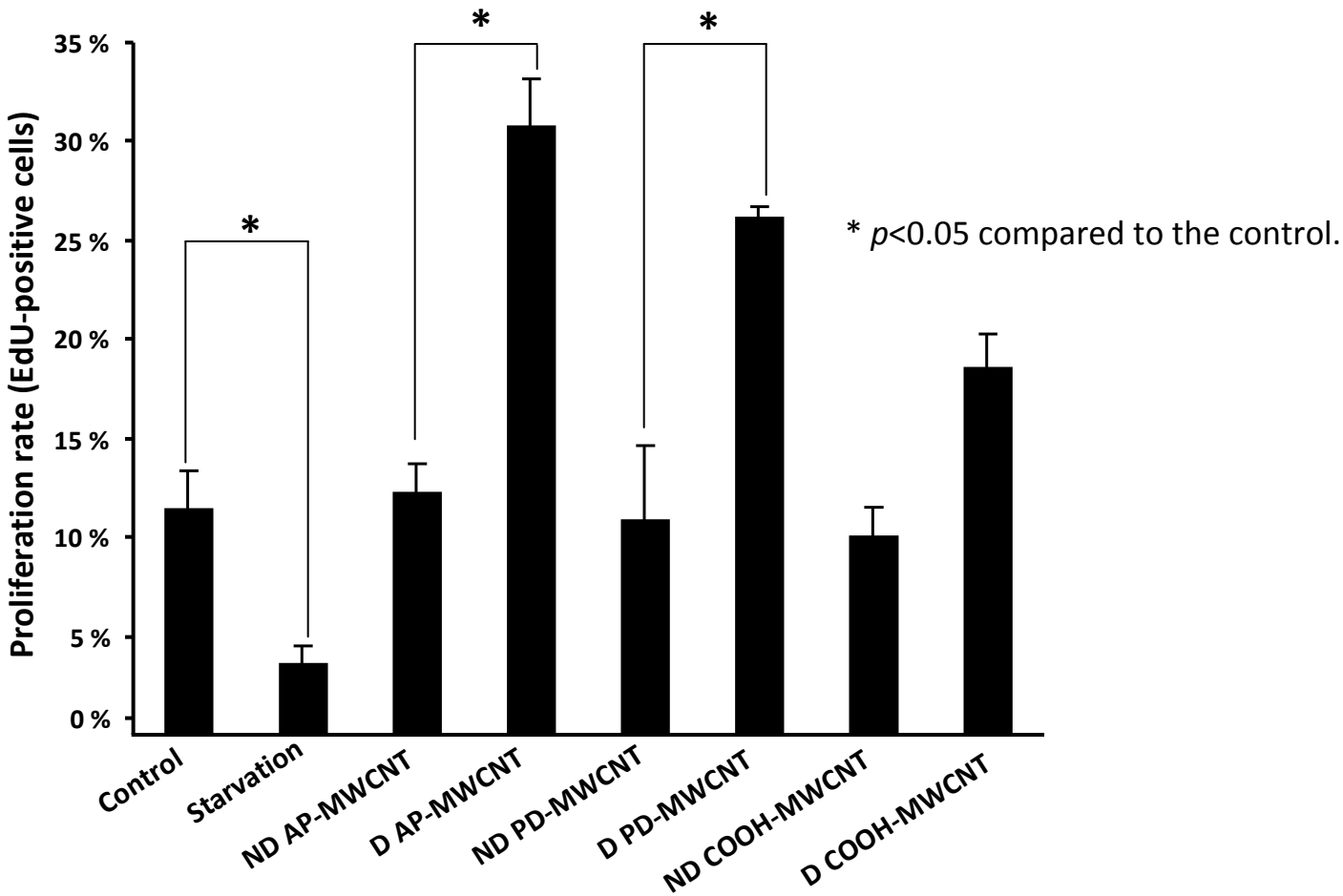
Dispersion Enhances Fibroblast Proliferation



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Summary

- Highly stable TiO_2 nanoparticle dispersions in different cell culture media were obtained by using FBS, BSA, or BSA&DPPC as dispersing agents
- A general dispersion method could be applied for many other metal or metal oxide nanoparticles
- Dissolution characterization is critical for nanomaterials such as ZnO and QDs
- Hydrophobicity and dispersion state play important roles in MWCNT toxicity studies

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