Cytotoxicity Effects of Water-Soluble Multi-walled Carbon Nanotubes Decorated with Quaternized Hyperbranched Poly(ethyleneimine) Derivatives on Autotrophic and Heterotrophic Gram-negative Bacteria

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Supplementary Materials

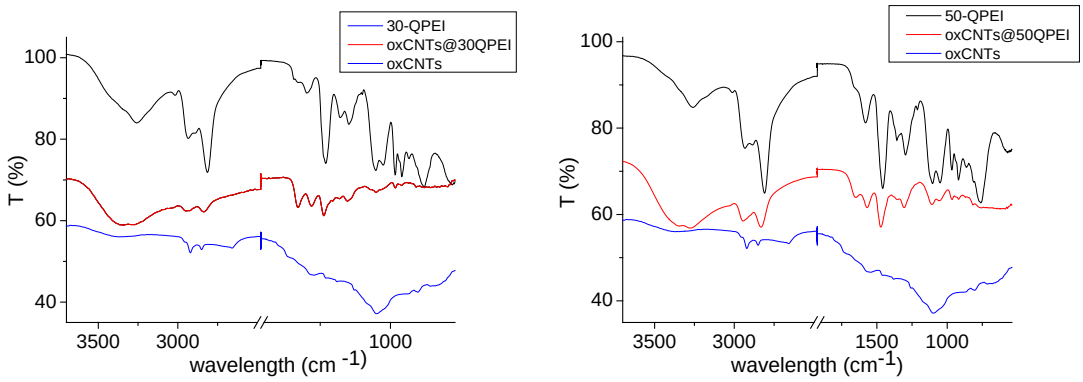


Figure S1. FTIR spectra of oxCNTs, 30-QPEI, oxCNTs@30-QPEI, 50-QPEI and oxCNTs@50-QPEI.

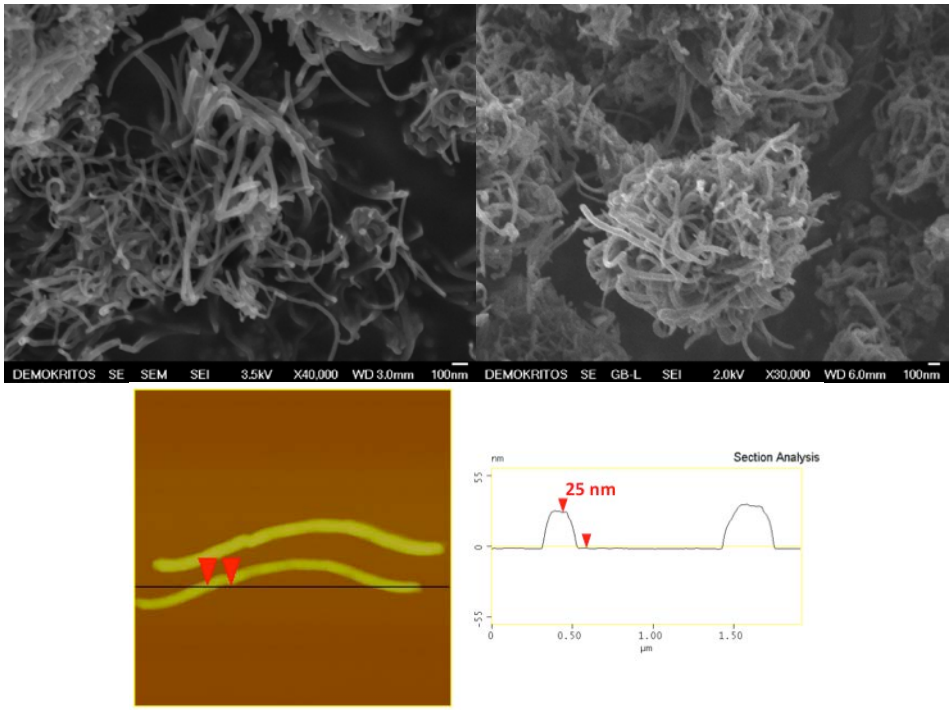


Figure S2. SEM images (upper part), AFM image and profile section (lower part) of oxCNTs.

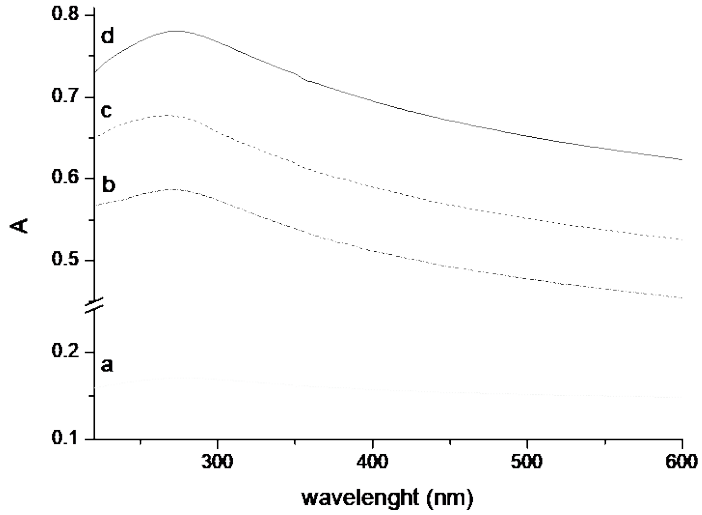


Figure S3. UV–vis absorption spectra of oxCNTs (a), oxCNTs@30-QPEI (b), oxCNTs@50-QPEI (c) and oxCNTs@80-QPEI (d) in aqueous solution (1 mg/mL).

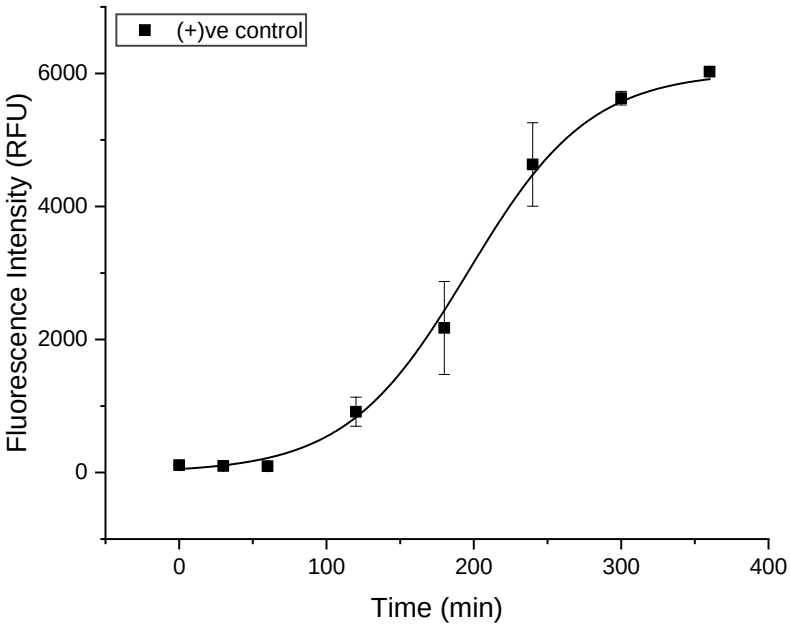


Figure S4. Fluorescence intensity change of RFP at 590 nm (excitation: 545 nm) upon *Escherichia* coli XL1-blue bacteria growth.

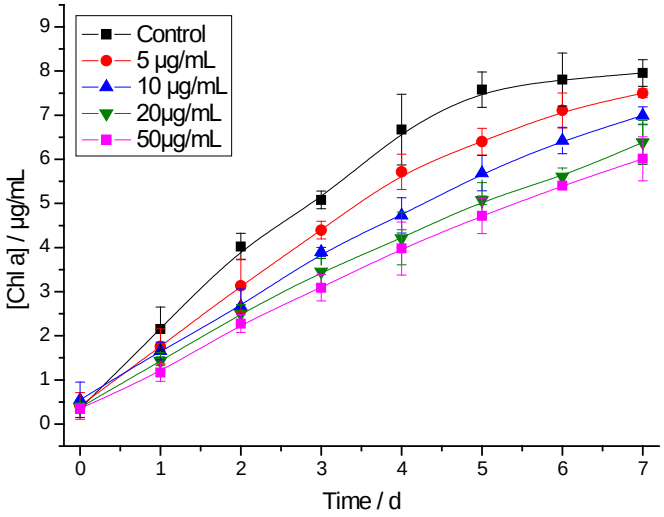
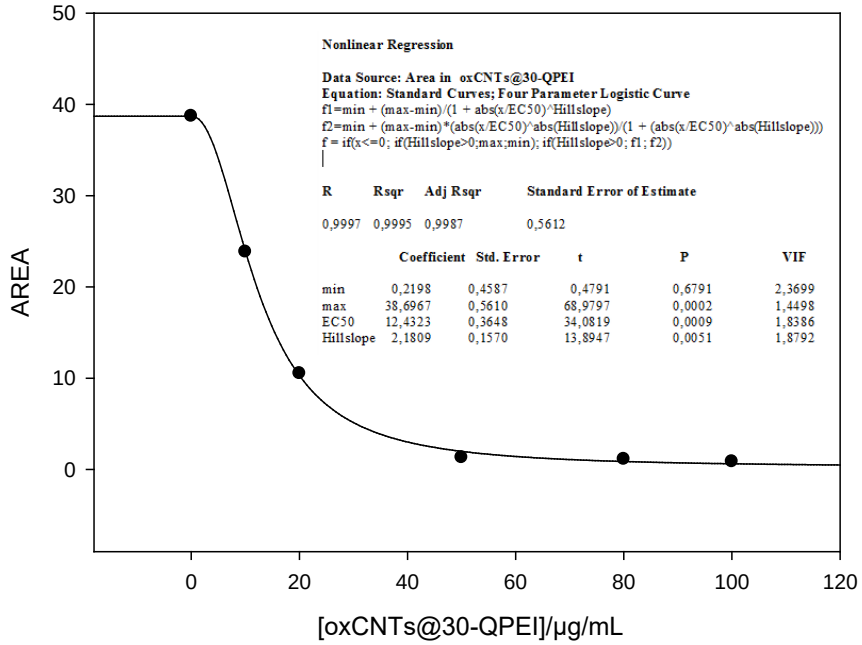


Figure S5. Effect of oxCNTs on cell proliferation of cyanobacteria Synechococcus sp. PCC 7942 in the presence of different concentrations. Error bars represent mean ± SD for at least three independent experiments.

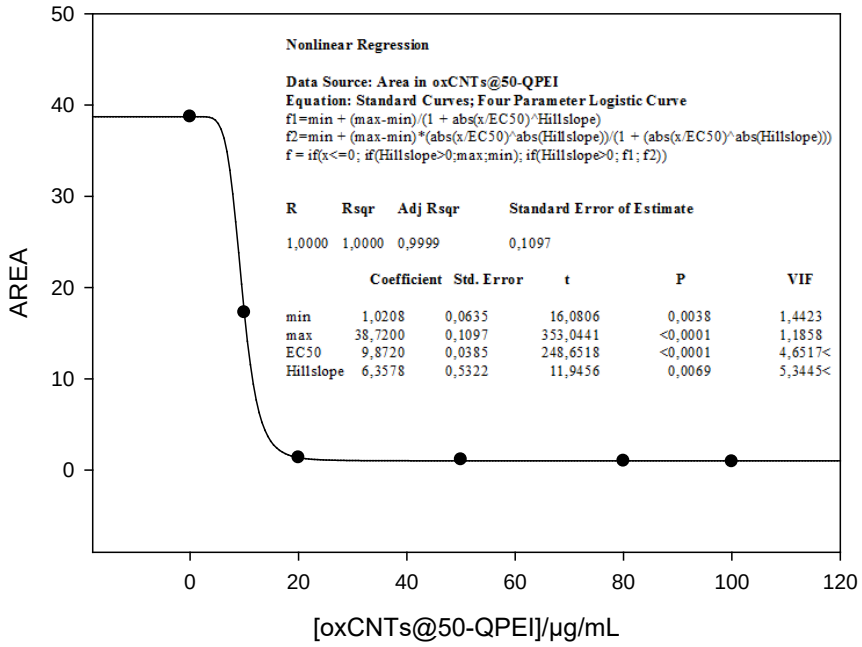


Nonlinear Regression

Data Source: Area in oxCNTs@30-QPEI
Equation: Standard Curves; Four Parameter Logistic Curve
f1=min + (max-min)/(1 + abs(x/EC50)^Hillslope)
f2=min + (max-min)*(abs(x/EC50)^abs(Hillslope))/(1 + (abs(x/EC50)^abs(Hillslope)))
f = if(x<=0; if(Hillslope>0;max;min); if(Hillslope>0; f1; f2))

R	Rsqr	Adj Rsqr	Standard Error of Estimate
0,9997	0,9995	0,9987	0,5612

	Coefficient	Std. Error	t	P	VIF
min	0,2198	0,4587	0,4791	0,6791	2,3699
max	38,6967	0,5610	68,9797	0,0002	1,4498
EC50	12,4323	0,3648	34,0819	0,0009	1,8386
Hillslope	2,1809	0,1570	13,8947	0,0051	1,8792



Nonlinear Regression

Data Source: Area in oxCNTs@50-QPEI
Equation: Standard Curves; Four Parameter Logistic Curve
f1=min + (max-min)/(1 + abs(x/EC50)^Hillslope)
f2=min + (max-min)*(abs(x/EC50)^abs(Hillslope))/(1 + (abs(x/EC50)^abs(Hillslope)))
f = if(x<=0; if(Hillslope>0;max;min); if(Hillslope>0; f1; f2))

R	Rsqr	Adj Rsqr	Standard Error of Estimate
1,0000	1,0000	0,9999	0,1097

	Coefficient	Std. Error	t	P	VIF
min	1,0208	0,0635	16,0806	0,0038	1,4423
max	38,7200	0,1097	353,0441	<0,0001	1,1858
EC50	9,8720	0,0385	248,6518	<0,0001	4,6517<
Hillslope	6,3578	0,5322	11,9456	0,0069	5,3445<

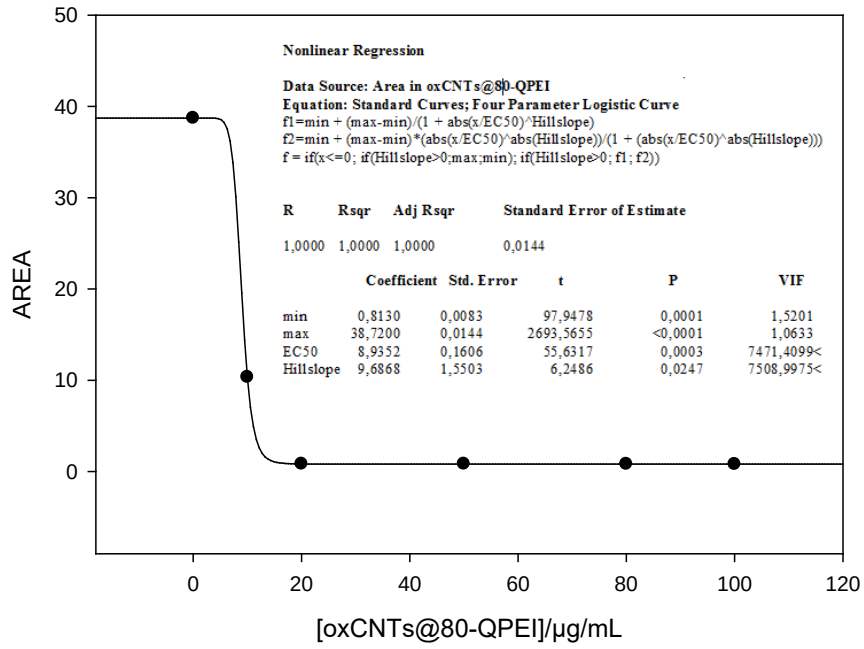


Figure S6. Plot of the area under the growth curves of Synechococcus sp. PCC 7942 cells for each concentration of oxCNTs@PEIs versus the corresponding concentration as well as the relevant IC-50 calculations. The IC-50 values were calculated as 12.4 µg/mL, 9.9 µg/mL and 8.9 µg/mL for oxCNTs@30-QPEI, oxCNTs@50-QPEI and oxCNTs@80-QPEI, respectively, using a non-linear regression of the 4-parameters logistic function.

Table S1. Elemental analysis results of ox-CNTs, QPEI and QPEI-functionalized ox-CNTs.

	Sample elemental composition (wt%)			
Sample	**C**	**H**	**N**	**QPEI (% w/w)**
ox-CNTs	94.48	0.44	0.18	
30-QPEI	51.62	11.06	23.54	
ox-CNTs@30-QPEI	80.38	1.96	3.93	16.05 %
50-QPEI	51.49	11.87	24.48	
ox-CNTs@50-QPEI	81.67	2.99	5.02	19.92 %
80-QPEI	50.98	12.74	25.57	
ox-CNTs@80-QPEI	82.19	3.23	6.08	23.23 %

Table S2. Photosystem II and I electron transport activities measured on *Synechococcus* sp. PCC 7942 permeaplasts in the presence of oxCNTs@80-QPEI.

	PSII activity (μmol O_2/mg Chl a * h)	**PSI activity (μmol O_2/mg Chl a * h)**
[oxCNTs] (μg/mL)		
0	119.9	317.0
20	119.6	175.1
25	119.3	152.2
100	98.6	88.8
200	78.0	-
250	74.8	13.7
[oxCNTs@80-QPEI] (μg/mL)		
0	210.1	420.1
20	170.0	10.1
25	164.9	9.5
80	149.9	9.0
200	100.1	8.2
250	96.9	8.0

Table S3. Effects of oxCNTs@80-QPEI on the steady state oxidation of P700 (ΔA820/A820) by FR light in Synechococcus sp. PCC 7942 cells.

[oxCNTs@80-QPEI] (mg/mL)	PSI ($P700^{+}$) ($\Delta A820/A820$) x (10^2)	PSI inhibition %
0	1.0502	-
10	0.6476	39
25	0.6387	40
50	0.3956	63
100	0.3003	72
150	0.2976	71
250	0.1951	82