

## Supporting Information

### Effects of Weathering and Simulated Gastric Fluid Exposure on Cellular Responses to Polystyrene Particles

Liyuan Gong<sup>1</sup>, Animesh Pan<sup>2</sup>, Takeshi Matsuo<sup>3</sup>, Hemalatha Kanniyappan<sup>4</sup>, Irene Andreu<sup>2</sup>, Alan Rothman<sup>5</sup>, Geoffrey D. Bothun<sup>2</sup>, Mathew Mathew<sup>4</sup>, and Yang Lin<sup>\*a 1</sup>

<sup>1</sup>Department of Mechanical, Industrial and Systems Engineering, University of Rhode Island, Kingston, RI, 02881, USA

<sup>2</sup>Department of Chemical Engineering, University of Rhode Island, Kingston, RI, 02881, USA

<sup>4</sup>Department of Mechanical and Systems Engineering, Okayama University, Okayama, 700-8530, Japan

<sup>3</sup>Department of Department of Biomedical Sciences, University of Illinois Chicago, Chicago, IL, 60607, USA

<sup>5</sup>Department of Cell and Molecular Biology, University of Rhode Island, Kingston, RI, 02881, USA

#### Summary

Number of pages: 10

Number of Figures: 7

Number of Tables: 6

## Contents

**Fig S1.** Accelerated weathering setup in the UV chamber. (a). Q-Lab UV weathering chamber (b) glass beakers in the chamber. (c) closeup look at the beakers containing particles. (d). UVA340nm irradiance distribution.

**Fig S2.** A. Raman spectrum of non-treated particles and SGF-treated particles. (a) Full Raman spectrum, (b) Spectrum for wavenumber range 800 – 2000  $\text{cm}^{-1}$ , (c) spectrum for wavenumber range 2700- 3500  $\text{cm}^{-1}$ ; (d). FTIR spectrum for range 3000  $\text{cm}^{-1}$  – 3500  $\text{cm}^{-1}$ .

**Fig. S3.** EDS images showing nitrogen and oxygen atomic % and distribution on particle surfaces

**Fig. S4.** XPS survey for all particles. (a) non-treated pristine particles, (b) non-treated DI water weathered particles, (c) non-treated seawater weathered particles, (d) SGF-treated pristine particles, (e) SGF-treated DI water weathered particles, (f) SGF-treated seawater weathered particles.

**Fig S5.** ROS production of RAW264.7 cells.

**Fig. S6.** TNF $\alpha$  standard curve

**Fig. S7.** Particles in Caco-2 cells Z-stack 3D images.

**Table S1.** XPS survey element composition of non-treated pristine polystyrene particles

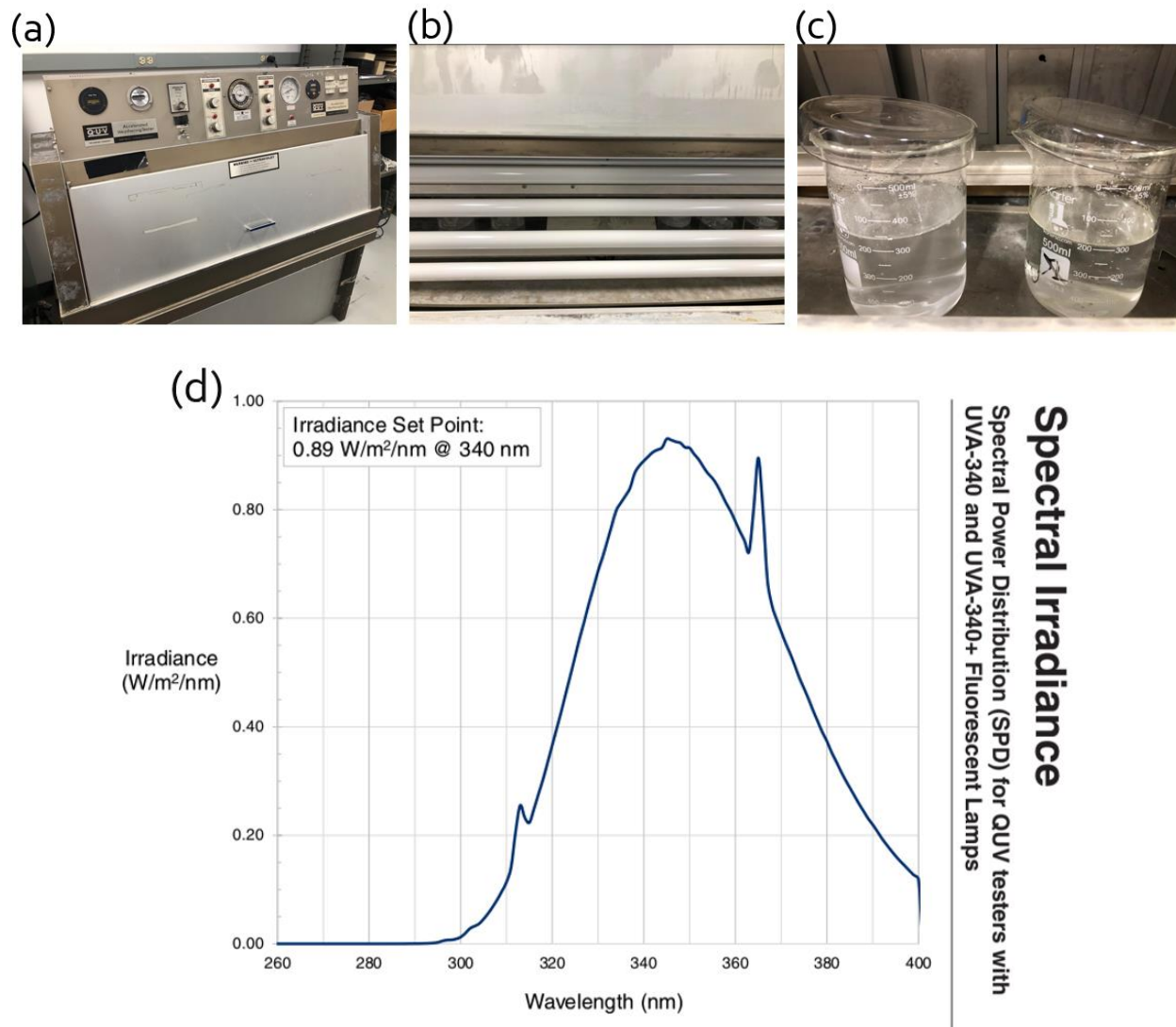
**Table S2.** XPS survey element composition of non-treated DI water weathered pristine polystyrene particles

**Table S3.** XPS survey element composition of non-treated seawater-weathered polystyrene particles

**Table S4.** XPS survey element composition of SGF-treated pristine polystyrene particles

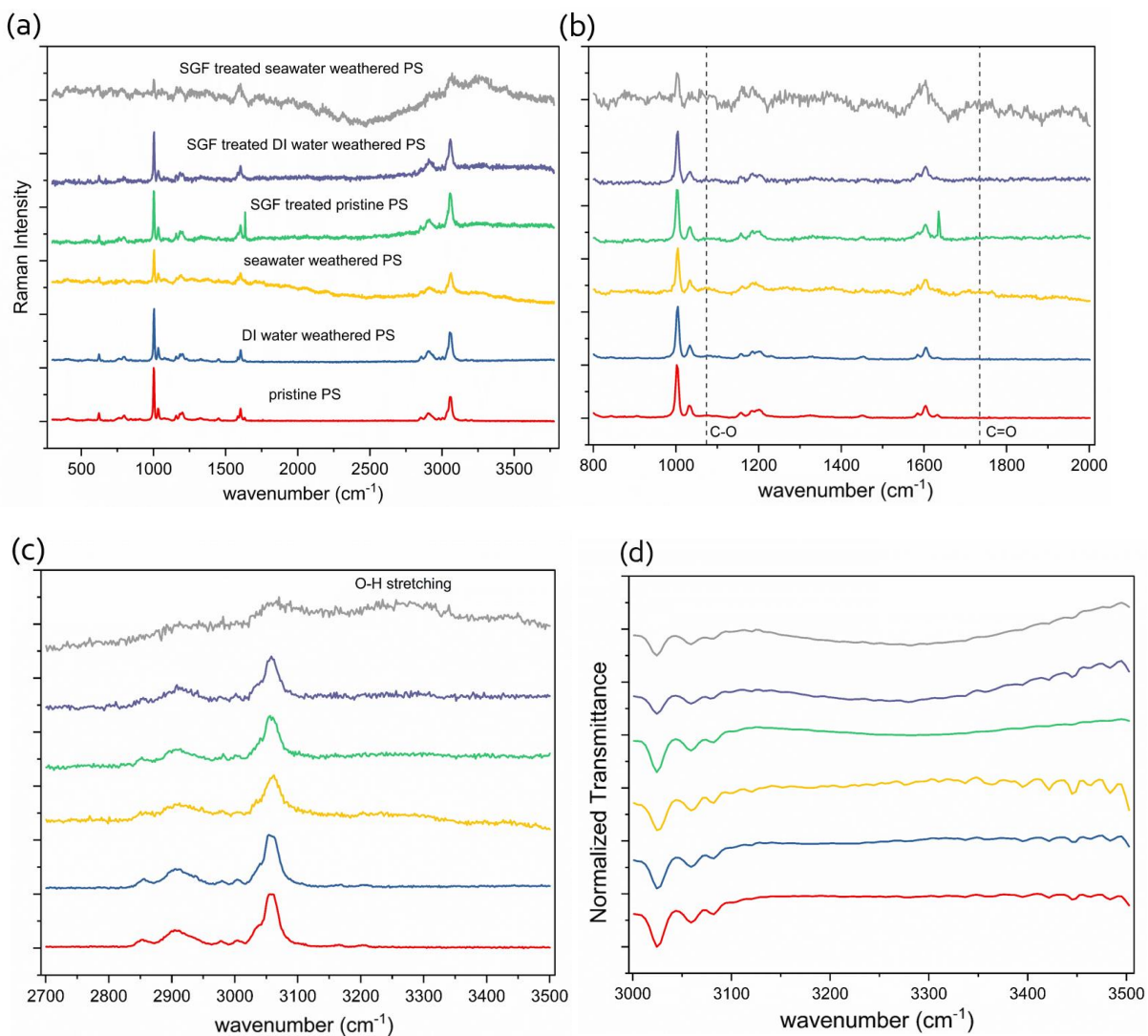
**Table S5.** XPS survey element composition of SGF-treated DI water-weathered polystyrene particles

**Table S6.** XPS survey element composition of SGF-treated seawater-weathered polystyrene particles

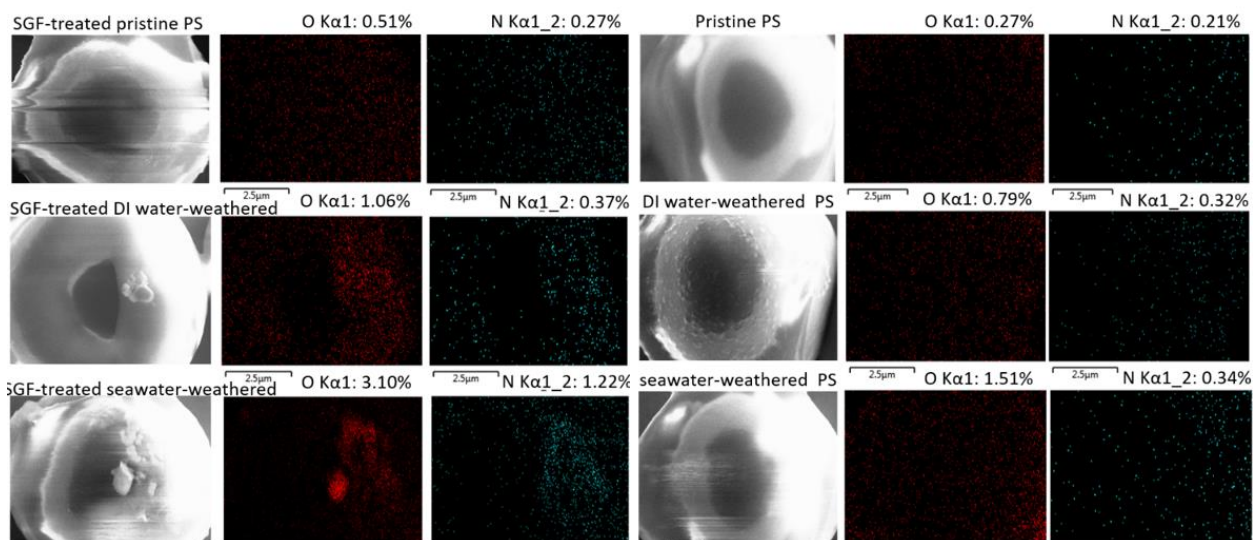


**Fig. S1.** Accelerated weathering setup in the UV chamber. (a). Q-Lab UV weathering chamber (b) glass beakers in the chamber. (c) closeup look at the beakers containing particles. (d). UVA340nm irradiance distribution.

**Weathering process:** The chamber was maintained at an average room temperature. Water levels were consistently replenished to sustain a volume of 300 mL throughout the experiment. After UV weathering, the particles were stored at 4°C for further experiments.

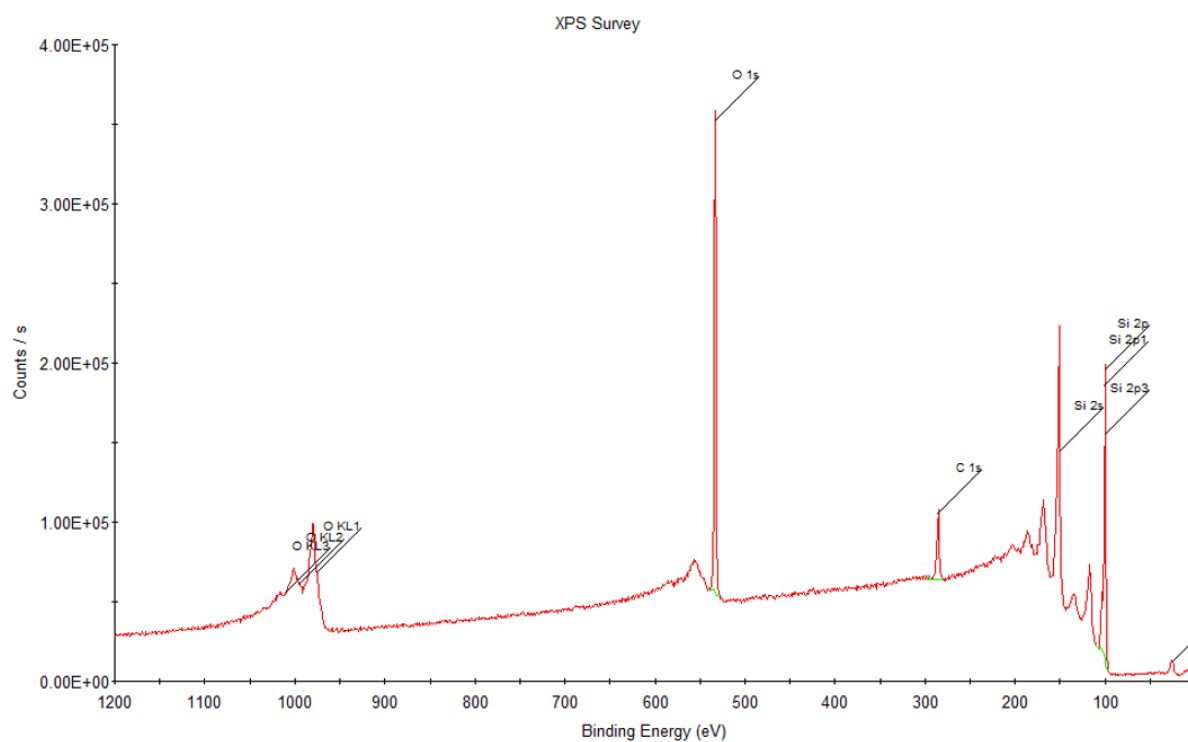


**Fig S2. A.** Raman spectrum of non-treated particles and SGF-treated particles. (a) Full Raman spectrum, (b) Spectrum for wavenumber range 800 – 2000 cm<sup>-1</sup>, (c) spectrum for wavenumber range 2700- 3500 cm<sup>-1</sup>; (d). FTIR spectrum for range 3000 cm<sup>-1</sup> – 3500 cm<sup>-1</sup>.

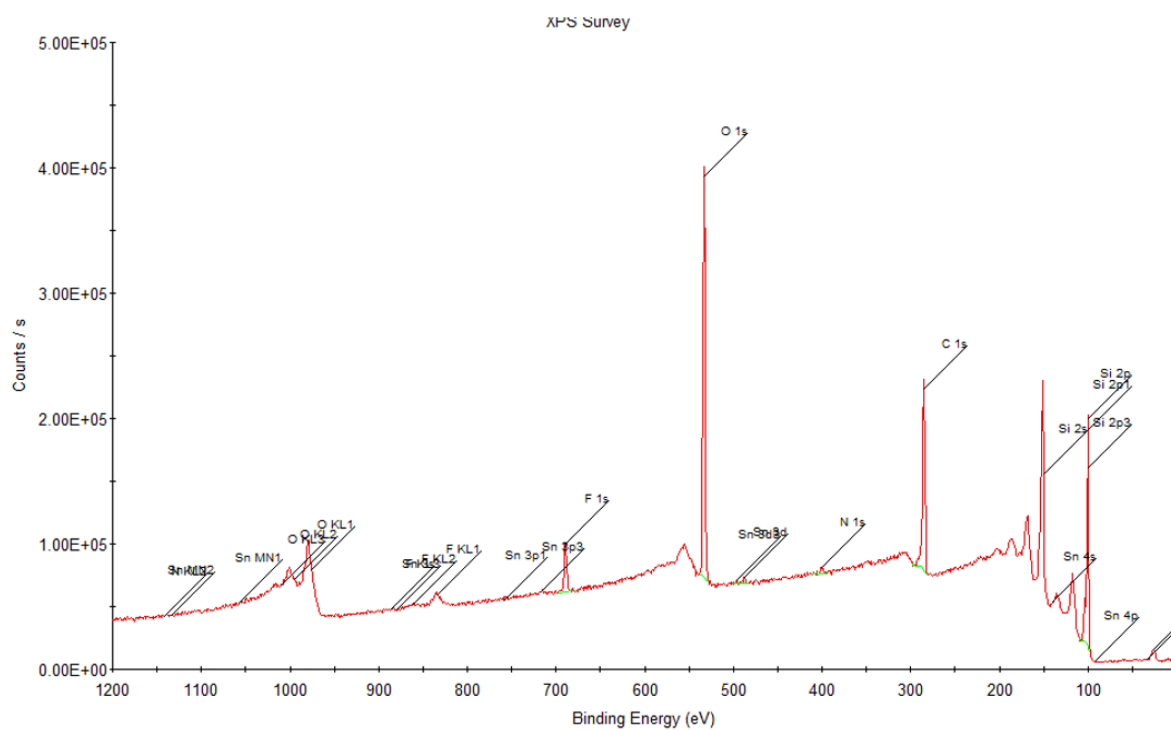


**Fig. S3.** EDS images showing nitrogen and oxygen atomic % and distribution on particle surfaces.

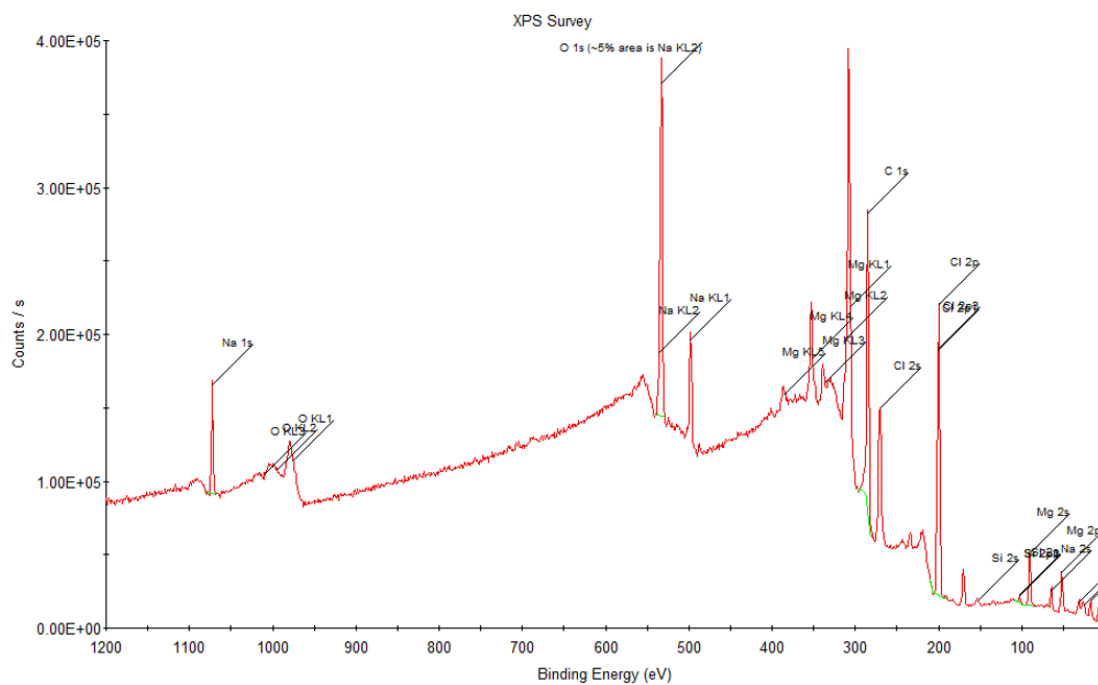
(a)



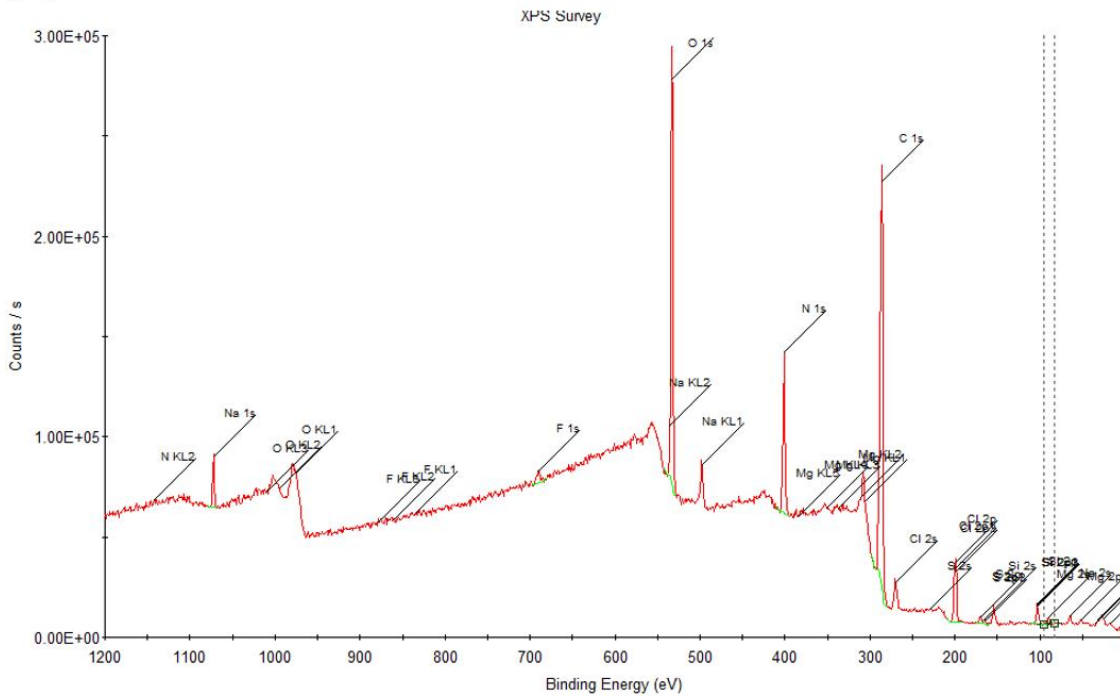
(b)



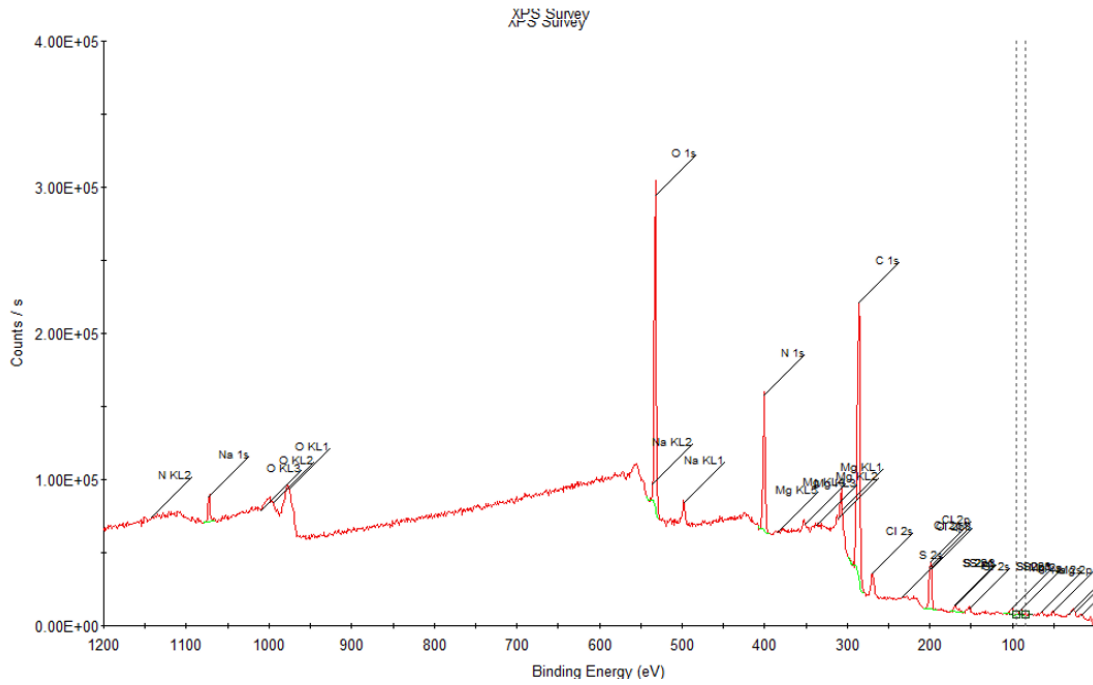
(c)



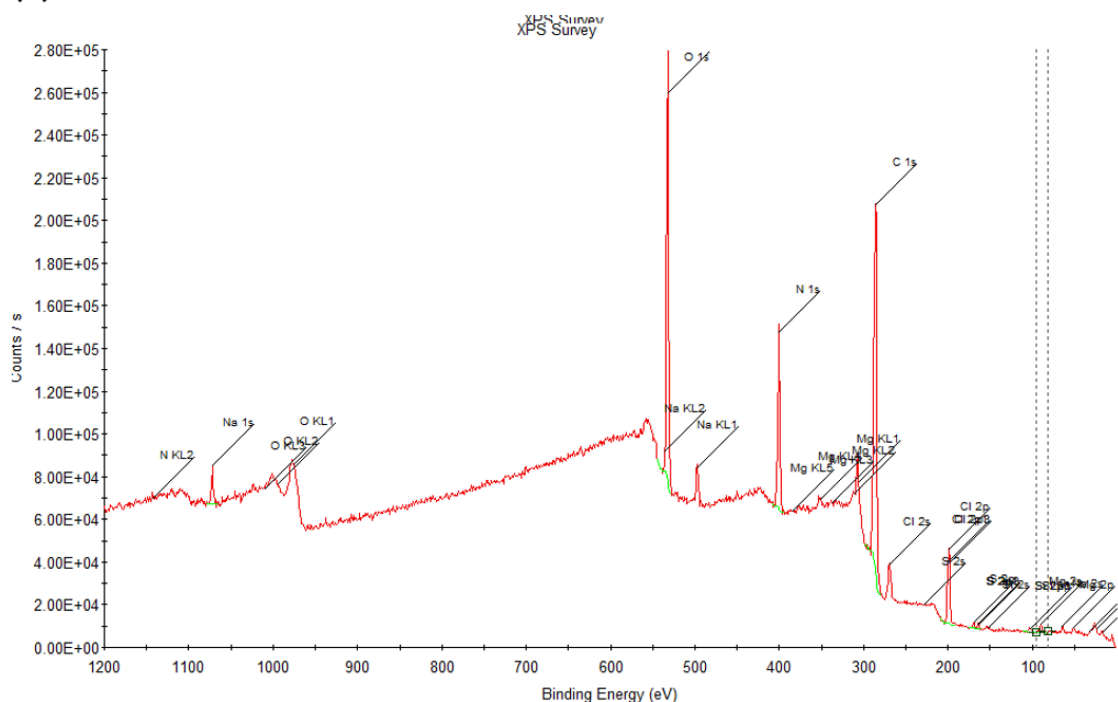
(d)



(e)



(f)



**Fig. S4.** XPS survey for all particles. (a) non-treated pristine particles, (b) non-treated DI water weathered particles, (c) non-treated seawater weathered particles, (d) SGF-treated pristine particles, (e) SGF-treated DI water weathered particles, (f) SGF-treated seawater weathered particles.

**Table S1.** XPS survey element composition of non-treated pristine polystyrene particles

Name	Peak BE	Height CPS	FWHM eV	Area (P) CPS.eV	Atomic %	Q
O1s	533.12	263209.81	2.77	815552.19	34.19	1
Si2p	100.11	149157.64	2.44	511536.78	51.52	1
C1s	285.31	38895.79	2.91	141098.44	14.29	1

**Table S2.** XPS survey element composition of non-treated DI water weathered pristine polystyrene particles

Name	Peak BE	Height CPS	FWHM eV	Area (P) CPS.eV	Atomic %	Q
Si 2p	98.37	136135	2.71	491663.6	35.5	1
C 1s	283.85	123399.5	3.31	470106.9	34.14	1
N 1s	398.77	4098.5	3.46	16159.31	0.76	1
Sn 3d	486.08	4210.58	2.67	22061.1	0.05	1
O 1s	531.28	265596.9	3	871634.4	26.19	1
F 1s	687.98	36409.93	3.3	140051.6	3.37	1

**Table S3.** XPS survey element composition of non-treated seawater-weathered polystyrene particles



Name	Peak BE	Height CPS	FWHM eV	Area (P) CPS.eV	Atomic %	Q
Mg 2s	90.81	33037.54	2.91	109383.5	9.57	1
Si 2p	102.13	4179.12	2.33	13598.31	1.01	1
Cl 2p	200.06	193284.4	3.26	672544.7	17.31	1
C 1s	285.11	178283.3	2.83	607996.9	45.22	1
O 1s (~5% area is Na KL2)	533.02	224822.8	3.01	778195.4	23.96	1
Na 1s	1072.35	66622.75	1.6	191541.5	2.93	1

**Table S4.** XPS survey element composition of SGF-treated pristine polystyrene particles

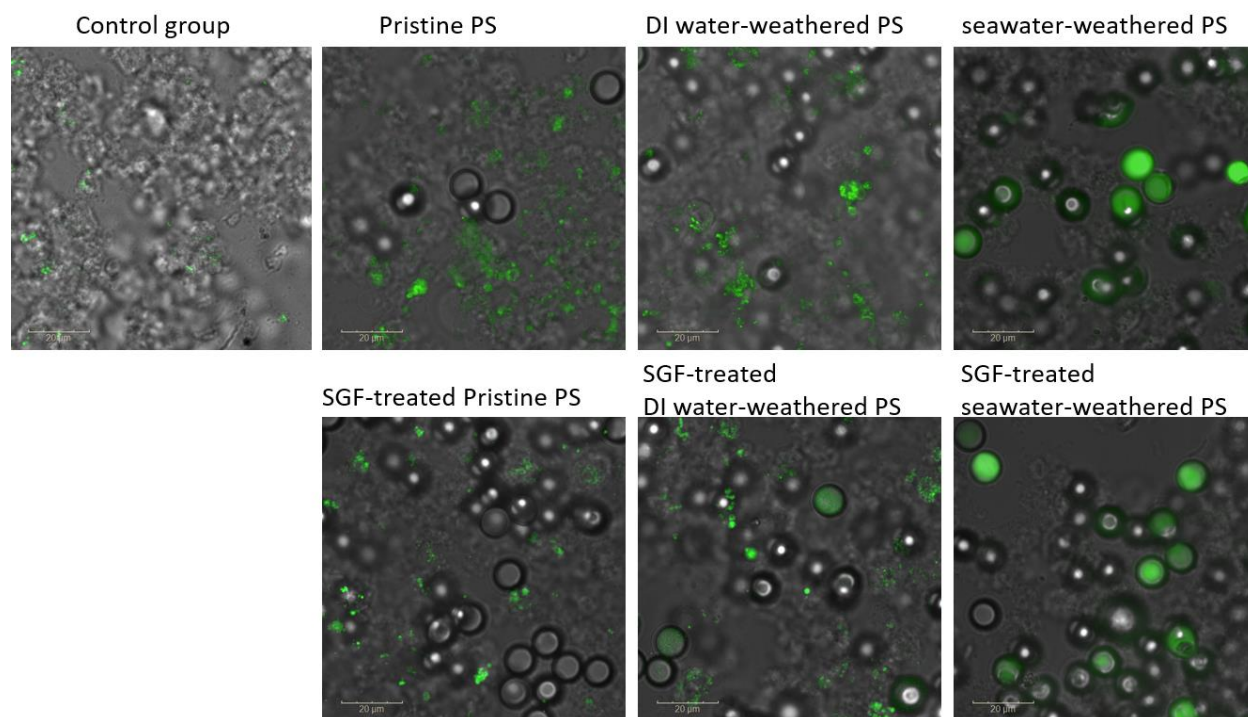
Name	Peak BE	Height CPS	FWHM eV	Area (P) CPS.eV	Atomic %	Q
Mg 2s	90.17	3074.12	2.73	10390.95	0.91	1
Si 2p	103.04	9175.44	3.01	33083.38	2.44	1
S 2p	169.98	2765.52	2.71	16142.58	0.59	1
Cl 2p	199.42	29845.84	3.44	109531.2	2.81	1
C 1s	286.27	199528.9	3.59	810859.3	60.13	1
N 1s	401.07	72104.07	2.85	227896.6	10.89	1
O 1s	532.96	204820	3	667104.8	20.46	1
F 1s	690.23	5729.16	3.99	31091.1	0.76	1
Na 1s	1072.23	22805.54	2.62	66077.25	1.01	1

**Table S5.** XPS survey element composition of SGF-treated DI water-weathered polystyrene particles

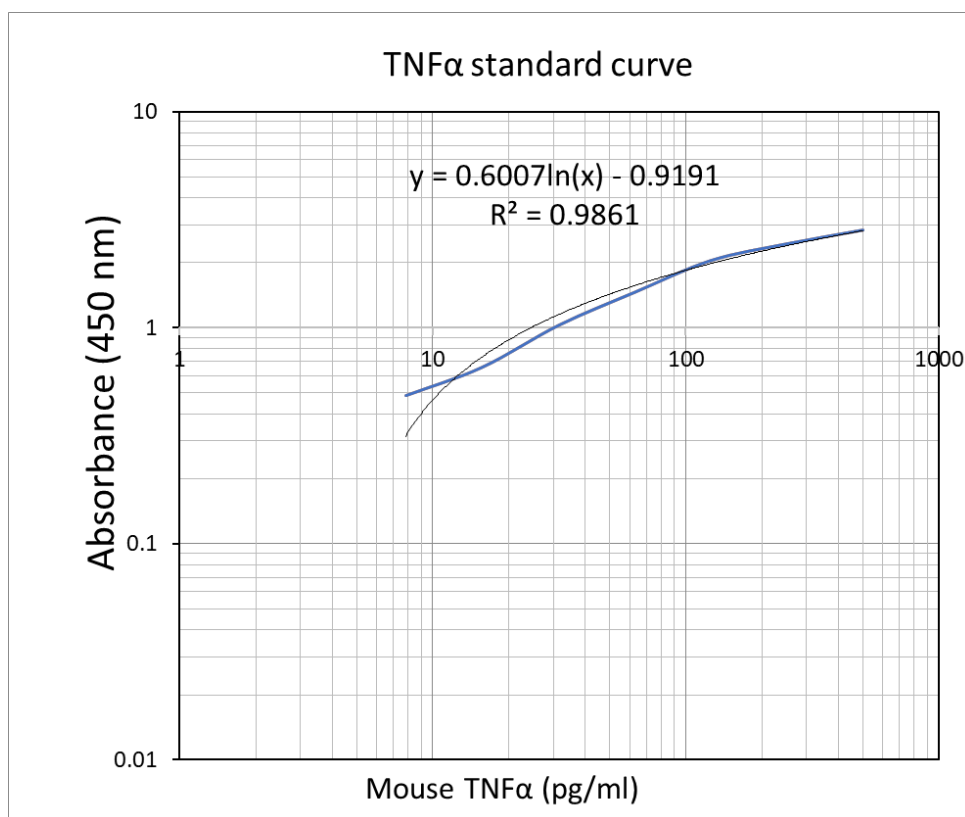
Name	Peak BE	Height CPS	FWHM eV	Area (P) CPS.eV	Atomic %	Q
Mg 2s	90	3586.04	3.05	11516.91	1.03	1
Si 2p	101.19	4014.64	3.01	14896.36	1.13	1
S 2p	169.28	4180.1	2.04	20498.76	0.77	1
Cl 2p	199.12	31759.44	3.54	116592.2	3.07	1
C 1s	286.09	181920.3	3.9	769513.5	58.7	1
N 1s	400.47	86949.6	1.68	277478.1	13.63	1
O 1s	532.28	203520.3	2.97	656197.6	20.7	1
Na 1s	1072.5	15981.03	1.82	61245.96	0.96	1

**Table S6.** XPS survey element composition of SGF-treated seawater-weathered polystyrene particle

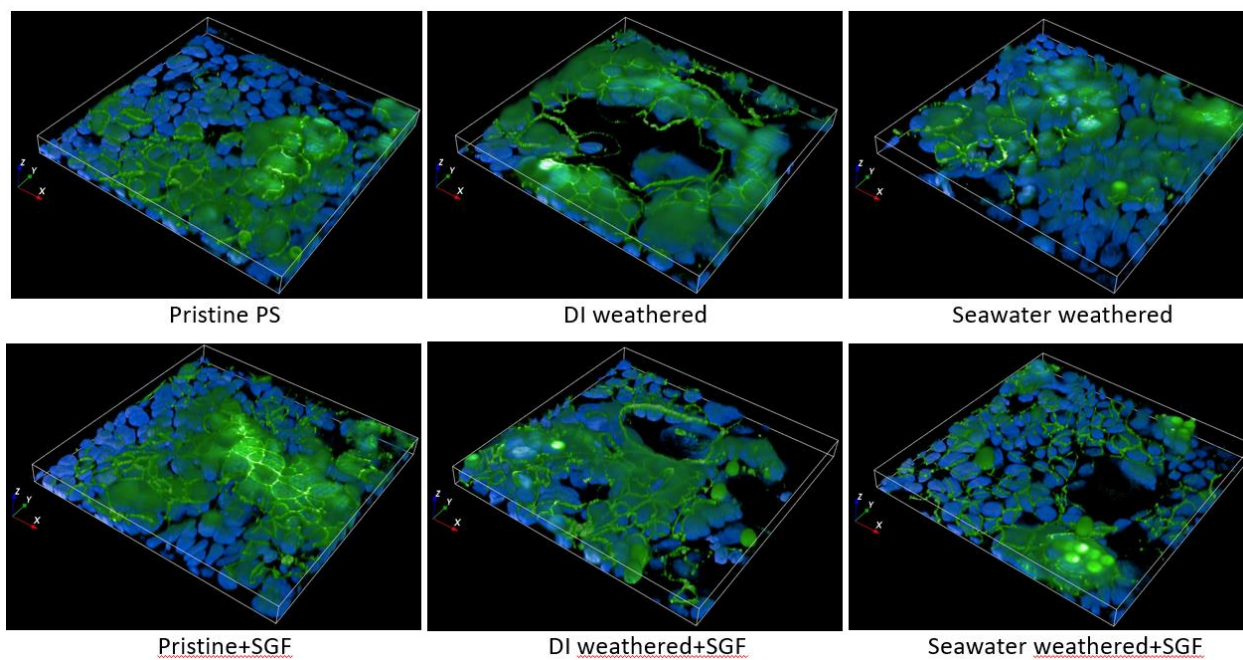
Name	Peak BE	Height CPS	FWHM eV	Area (P) CPS.eV	Atomic %	Q
Mg 2s	90.05	2954.64	2.01	8634.46	0.85	1
Si 2p	102.18	1737.9	5.54	9193.3	0.76	1
S 2p	169.16	2765.53	2.68	14881.47	0.61	1
Cl 2p	199	33217.55	3.3	122511.2	3.53	1
C 1s	286.03	169365.6	3.85	714604	59.65	1
N 1s	400.4	77682.12	1.81	247347.7	13.3	1
O 1s	532.27	182613.3	2.98	590586.4	20.38	1
Na 1s	1072.05	15088.74	2.54	53071.46	0.91	1



**Fig. S5** ROS production of RAW264.7. Brightfield and FITC channel. Images showing weathered particles, and SGF-treated weathered particles are conjugated with Alexa Fluor 488.



**Fig. S6** TNF $\alpha$  standard curve



**Fig. S7.** Z-stack 3D images of particles in Caco-2 cells