

Supplementary Information

For

Impact of Chlorine and UV/H₂O₂ on Microplastics in Drinking Water

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Preparation of MP-free Water

A filtration apparatus consisting of a 1000 mL filtration flask, 500 mL funnel, and vacuum pump capable of providing approximately 15 psi (Welch, Mt. Prospect, IL, USA) was set up in a Class II laminar flow hood (Forma Scientific, Inc., Watertown, MA, USA). 2 L of Type 1 reagent-grade Milli-Q water (18.2 M Ω -cm) produced by a Milli-Q Integral water purification system (Merck-Millipore, Darmstadt, Germany) was collected into 2 L glass beakers that were covered with aluminum foil. 200 mL were subsequently filtered through a 47 mm diameter 0.2 μ m nylon filter (Supelco Analytical, PA, USA) and used to rinse the vacuum filter flask and a 2 L amber glass bottle. The remaining Milli-Q water was filtered and collected in the 2 L bottle.

Quantification of Microplastics

To determine the mean and standard deviation of the number of particles and their size distribution in the LDPE and HDPE stock suspensions, triplicate 150 μ L aliquots were filtered through a 16 mm opening onto a 47 mm diameter 0.2 μ m black PC filters. The stainless-steel disk placed directly on the filter was used to concentrate particles into a smaller area such that analysis time could be reduced. The size distributions of 150 μ L stock suspensions of LDPE and HDPE (in headspace-free vials containing 40 mL AFW with 10 mM pH 6 sodium phosphate buffer) were determined in triplicate to evaluate consistency (Figure S1a-b). Difference in particle concentrations of LDPE ($P = 0.5744$) and HPDE ($P = 0.4314$) in spikes were not deemed significant at the 95% confidence level.

Following filtration, filters were removed using forceps and placed in glass Petri dishes, then transferred to the microscope. Imaging was performed using a Nikon Eclipse E600 microscope (Nikon Canada, Inc, ON) equipped with a Y-FL-epi-fluorescence attachment and a Basler Ace monochrome camera (acA2440-35um Mono, Edmund Optics Inc., USA). The entire 16 mm filter area was captured by taking 255 images using a 10x objective with a DAPI filter to excite green LDPE particles and a BV-2A filter to excite red HDPE particles. In addition, the following settings were employed: exposure time = 3530, gain = 16.0, saturation = 1.0, contrast = 0.1, and brightness = -0.09. Images were subsequently stitched together using the Microscopy Image Stitching Tool (MIST) plug-in available in Fiji to create mosaics with a scale adjusted to 1524 pixels/mm. An auto-threshold was applied to each mosaic, as well as Analyze Particles tool was used to record major and minor dimensions of all particles.

Equivalent diameters of particles in each sample were calculated using the following equation (Waldschläger & Schüttrumpf, 2020):

$$\text{Equivalent Diameter} = \sqrt{\text{Major Dimension} \times \text{Minor Dimension}} \#(S1)$$

This data was used to determine the number of particles in specific bins (1 - 2, 2 - 3, 3 - 4, 4 - 5, 1 - 5, 5 - 10, 10 - 20, 20 - 30, 30 - 40, 40 - 50, 50 - 60, and 60 - 70 μm) using COUNTIF and COUNTIFS functions in Excel. Any particles present in the blank were subtracted from the triplicate samples, as well as the control. In addition, the mean concentration and standard deviation of LDPE and HDPE particle numbers in each size bin were determined for triplicate samples. Data was then expressed as number of MPs per liter and subsequently used to plot size distributions.

Preparation of Samples for Chlorine Trials

Chlorinated AFW was added to individual 40 mL amber vials containing both LDPE and HDPE particles such that they were headspace free. Controls and blanks were prepared by filling a 40 mL amber vial which contained LDPE and HDPE with unchlorinated AFW, as well as an additional 40 mL amber vial (containing no MPs) with chlorinated AFW, respectively. The same process was repeated for vials which contained MP pellets. All vials were inverted end over end at 35 rpm and 20 °C. LDPE and HDPE particles and pellets were separated from the aqueous phase following 1 h, 2 h, 1 week, and 2 week contact times.

At each time interval, particles were filtered as described earlier onto separate 47 mm diameter 0.2 μm black PC filters under approximately 15 psi of vacuum pressure. Vials were triple rinsed with 40 mL of MP-free Milli-Q containing 0.05% Tween 20, vortexed for 5 s, and the contents filtered following each rinse, in addition to the vacuum funnel being rinsed. Filters containing LDPE and HDPE particles were stored in labelled glass Petri dishes. Pellets were removed from vials using forceps and placed in 2 mL labelled vials. Residual free chlorine concentrations were determined using the *N,N*-diethyl-*p*-phenylenediamine (DPD) method.

Methods for Removal of Sample Matrices from Petri Dish

In preparation for trials involving UV, two methods for were evaluated: i) filtration of the entire sample volume, or 2) withdrawal of 1 mL aliquots (in triplicate). These trials were used to determine which method resulted in the lowest standard deviation of number of particles. The first method involved filtration of the contents of Petri dishes containing LDPE (769 ± 103 particles) and HDPE (973 ± 46 particles) in 25 mL of MP-free Milli-Q. The second method involved withdrawal of 1 mL aliquots of a continuously stirred 25 mL solution containing the same number of LDPE and HDPE particles and filtering the solution. It was determined that filtration of the entire sample provided less variation in particle counts (<11%) (Figure S1)).

Preparation of Polymer Samples for UV, H₂O₂, and UV/H₂O₂ Trials

To limit the loss of MPs and ensure that hydrogen peroxide was dosed consistently, aliquots of pH 7 MP-free AFW were removed from Petri dishes corresponding to required volumes of hydrogen peroxide and LDPE and HDPE stock suspensions prior to their addition. 1 cm stir bars and 25 mL of MP-free AFW buffered to pH 7 were added to 6 cm diameter Petri dishes placed on magnetic stirring plates. The volume of 5 g/L hydrogen peroxide stock solution required to achieve 5 mg/L H₂O₂ in 25 mL of pH 7 MP-free AFW (25 μ L) was confirmed in triplicate using a procedure described by Klassen et al. (1994). For all samples, 25 μ L aliquots were removed from 25 mL solutions a volumetric pipette such that hydrogen peroxide could be added without increasing the total solution volume. For samples containing particles, two 93.8 μ L aliquots were removed and replaced with the same volume of LDPE and HDPE stock suspension, resulting in 769 ± 103 and 973 ± 46 MP particles, respectively. For samples containing pellets, Petri dishes were prepared by the addition of 25 mL of pH 7 MP-free AFW along with seven 3 mm LDPE or HDPE pellets. An appropriate amount of hydrogen peroxide (25 μ L) was dosed to achieve a concentration of 5 mg/L. Immediately, 1 mL was removed and used to rinse a 1-cm quartz cuvette (Hewlett Packard, Mississauga, ON) which was filled with another 2.5 mL aliquot in order to measure UV absorbance at 254 nm (UV254) using an Agilent 8453 UV–VIS spectrophotometer (Agilent Technologies, Mississauga, Ontario, Canada).

With the exception of trials that incorporated H₂O₂, Petri dishes were placed under a collimated beam emitting UV at 254 nm and were magnetically stirred such that the surface of the water did not form a vortex. To prevent light from reflecting off the edges of the Petri dish, an opaque ring of equal inner diameter was placed to cover the walls. Following exposure times corresponding to UV fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm², the shutter was closed and Petri dishes carefully removed. For trials involving LDPE and HDPE particles, solutions in the Petri dishes were poured into a funnel and filtered through a 47 µm diameter 0.2 µm black PC filters. Petri dishes were triple-rinsed with 25 mL of MP-free Milli-Q which contained 0.05% Tween 20. Filters were stored in separate Petri dishes until analysis. For trials involving pellets, single LDPE or HDPE pellets were removed using forceps and placed into separate 2 mL vials following each sampling interval; Petri dishes were placed back under the collimated beam apparatus to continue the trials. All trials were conducted in triplicate; additional trials using UV alone and H₂O₂ alone were conducted under the same conditions. Contact times for trials involving peroxide were determined by taking the average time to reach a desired fluence. Blanks which contained no particles or pellets were subjected to the same conditions, in addition to triplicate control trials which did not involve UV or H₂O₂.

Table S1 Exposure required for pathogen inactivation in drinking water by free chlorine.

Disinfectant	Target	Inactivation or Removal	pH	Temp (° C)	Ct Value (min·mg/L)	C (mg/L)	t (min)
Free Chlorine	<i>Giardia lamblia</i>	3-log	8-9	10	149-292	0.04-5	10 - 120
				20	50-97		
			6-7.5	10	73-166		
	Viruses	4-log	10	5-10	45-60		
				15-20	22-30		
			6-9	5-10	6-8		
				15-20	3-4		

Note: Ct values obtained from (EPA, 2020).

Table S2 UV light dosage required for pathogen inactivation in drinking water.

Log Inactivation	<i>Cryptosporidium</i>	<i>Giardia lamblia</i>	Viruses
	mJ/cm ²		
1.0	2.5	2.1	58
2.0	5.8	5.2	100
3.0	12	11	143
4.0	22	22	186

Note: Values obtained from (EPA, 2020).

Table S3 Impact of chlorine and UV exposure on polymer related cytotoxicity.

Type	Disinfectant				Polymer				Cell Line	Effect on Cell Line	Physical & Chemical Impacts Observed	Reference	
	pH	Temp.	Dose	Exposure Time	Ct or UV Fluence	Type	Size (dia.)	Shape					Condition
Chlorine	6-7	NR	10, 100 mg/L	7, 14, 21 d	1.0×10 ⁵ , 2.0×10 ⁵ , 3.0×10 ⁵ , 1.0×10 ⁶ , 2.0×10 ⁶ , 3.0×10 ⁶ (min-mg/L)	PS	214 nm	Sphere	Virgin	GES-1	Decreased cell viability (100 mg/L Cl ₂), altered cell morphology (all conditions), cell membrane damage (all conditions), apoptosis (all conditions), inflammatory response (all conditions)	Surface cracks and pits (100 mg/L Cl ₂), C-Cl bonds (on samples ≥ 140 mg/min/L), increased ROS (all conditions)	(Qin et al., 2022)
UV	NR	25 °C	500 W (300 – 2500 nm)	0, 3, 6, 12 h	n/a	PS	1.0 – 1.9 μm	NR	Virgin	Caco-2	Decreased cell viability (at all conditions, but decreased with time), cell membrane damage (at all conditions, but increased with time)	Surface cracks and pits appeared after 12 h, carbonyl and hydroxyl groups appeared after 3 h	(Yu et al., 2021)
UV	NR	NR	UV-C (0.04 mW/cm ²)	800 h	1.2 ×10 ⁵	PS	1, 5 μm	Sphere	Virgin	A549	Cell membrane damage, altered cell morphology, wound healing reduction	Increase in roughness, no change in size, less round shape, greater increase in carboxyl group with particle size, increased oxygen content	(El Hayek et al., 2023)
UV	NR	NR	UV-A(2.16 mW/cm ²), UV-B(0.12 mW/cm ²), UV-C(0.014 mW/cm ²), (Exact wavelength NR/rotating photo-reactor)	1, 2 months	1.1×10 ⁷ , 6.3×10 ⁵ , 7.5×10 ⁴ , 5.7×10 ⁶ , 3.4×10 ⁵ , 3.7×10 ⁴ (mJ/cm ²)	PS	98 nm	Sphere	Virgin	A549	Decreased cell viability (all conditions), oxidative stress (all conditions), cell membrane damage (all conditions)	Non-uniform shape, fragmentation, negative surface charge, carboxyl group, increased oxygen content	(Shi et al., 2021)
UV	NR	25 °C	UV-A (11.3 mW/cm ²)	60 d	9.8×10 ⁵ mJ/cm ²	PS	22.3 μm	Frags	Virgin	Hepato cytes	Apoptosis, mitochondrial damage caused by increased ROS	Increase in fragments, serrated edges, cracks and roughness, increase in O-containing functional groups	(Wang et al., 2020)

Note: NR = not reported, PS = polystyrene, GES-1 = Human gastric epithelial, ROS = Reactive oxygen species, Caco-2 = Colon cancer cells, A549 = Airway epithelial cells

Table S4 Reported impacts to polymers subjected to chlorine under a range of conditions.

Study Objective	Matrix	pH	Temp	Dose (C)	Exposure Time (t)	Ct (min-mg/L)	Polymer			Reported Impacts	Analysis Method	Reference
							Type	Size	Source			
Assess impacts of MPs and chlorine on disinfection kinetics and microbial growth in drinking water.	Tap Water (China)	7.09 – 10.03	25 °C	0, 0.5, 1, 1.5 mg/L	0 to 14 d	0 – 2.8×10 ⁵	PE, PP, PET, PVC, PPR, HDPE	1 – 3 mm	Dongguan Qimei Plasticizing Co., Ltd (Guangdong, China)	Surface cracks	SEM	(Chen et al., 2022)
Identify mechanisms related to oxidative breakdown of HDPE under superchlorination conditions.	Reagent Water (Barnstead Nanopure® ultrapure)	6.5	37 °C	50, 250, 500 mg/L	160 d	1.1×10 ⁷ , 5.7×10 ⁷ , 1.2×10 ⁸	HDPE (Pipe)	Diam.= 19 mm, Thick.= 2.6 mm, Length = 2 cm	Commercial Source (Supplier not specified)	Carbonyl groups	ATR-FTIR	(Mitroka et al., 2013)
Evaluate degradation of commercially available polymers under typical municipal distribution system conditions.	Deionized Water (Preparation not specified)	6.8	40 °C	2, 5, 10 mg/L	1200 h	1.4×10 ⁵ , 3.6×10 ⁵ , 7.2×10 ⁵	HDPE, LDPE, UPVC, Hi-PVC (All Pipe)	15 cm x 8 cm	Commercial Source (Supplier not specified)	Carbonyl groups, CI increased for HDPE pipe material at 2, 5, 10 mg/L NaOCl, for LDPE, uPVC, and Hi-PVC	ATR-FTIR and XPS	(Afzal Khan et al., 2022)
Identify physical and chemical changes to PS following chlorine exposure; evaluate cytotoxicity using GES-1 cells.	Reagent Water (Type and preparation not specified)	6 – 7	NR	0, 10, 100 mg/L	7, 14, 21 d	0 – 3.0×10 ⁶	PS	213.7 ±8.2 nm	Baseline Chromtech Research Center (Tianjin, China)	C-Cl bonds, increased oxygen content, surface cracks and roughness, formation of ROS	FTIR, XPS, Optical microscope, DCFH-DA kit	(Qin et al., 2022)
Assess effect of chlorine conc. and temp. on LDPE properties.	Reagent Water (Type and preparation not specified)	NR	25 and 80 °C	50, 500, 5000 mg/L	500 h	1.5×10 ⁶ , 1.5×10 ⁷ , 1.5×10 ⁸	LDPE (Pipe)	NR	Reliance Petrochemicals (Mumbai)	Hydroxyl and carbonyl groups, surface cracks and roughness	FTIR and SEM	(Samarth & Mahanwar, 2017)
Examine oxidative damage to wastewater related MPs as result of chlorination.	Reagent Water (Type and preparation not specified)	6 – 7	NR	2.5 and 5 mg/L, Extreme Dose: 25000 mg/L	30 min, Extreme Dose: 1 d	75, 150, 3.6×10 ⁷	PS, PP, HDPE	< 5 mm	Plastic consumer products (PS, PP, HDPE) and weathered plastics obtained from a beach in east Asia (HDPE and PP). Size reduced using scissors.	HDPE developed new C-Cl bonds	Raman	(Kelkar et al., 2019)
Assess the degradation of nano-sized PS by ozonation and chlorination.	Reagent Water (Type and Preparation not specified)	6.43	NR)	2.5 mg/L	0 to 240 min	0 - 600	PS	8x10 ⁵ Da	Shanghai Huge Biotechnology Co. Ltd (China)	C-Cl bonds	ATR-FTIR, SEM, XPS	(Li et al., 2022)

Note: NR = Not reported, HDPE = High-density polyethylene, LDPE = Low-density polyethylene, CI = Carbonyl index, uPVC = Unplasticized poly-vinylidene chloride, Hi-PVC = High-impact polyvinylidene chloride, PS = Polystyrene, PP = Polypropylene, PVC = Polyvinyl Chloride, PET = Polyethylene terephthalate, PPR = Random co-polymer polypropylene, SEM = Scanning electron microscopy, ATR-FTIR = Attenuated Total Reflectance – Fourier Transform Infrared Spectrometer, XPS = X-ray photoelectron spectroscopy, DCFH-DA = 2,7-dichlorodihydro fluorescent diacetate

Table S5 Reported impacts to polymers subjected to UV under a range of conditions.

Study Objective	Matrix	pH	Temp	Wave length	Exposure Time	UV Fluence (mJ/cm ²)	Type	Polymer Size	Source	Reported Impacts	Analysis Method	Reference
Identify morphological and chemical variation of MPs from UV irradiation.	18.2 MΩ Ultrapure Water (Preparation not specified)	NR	NR	254 nm at 180 W	NR	3600	PS, PE, PET, PVC	250 μm, 150 μm, 300 μm, 230 μm, respectively	Goodfellow Cambridge Limited (UK)	Surface flakes and roughness, PS/PVC/PE developed carboxyl groups, increased oxygen content, CI increased	Raman, XPS, FTIR	(Lin et al., 2020)
Evaluate impact of UV on PS MP and resulting toxicity.	Ultrapure Water (Preparation and type not specified)	NR	25 °C	300-2500 nm	0, 3, 6, 12 h	n/a ¹	PS	1.0-1.9 μm	McLean Reagent Co., Ltd. (Shanghai, China)	Surface cracks and pits, carbonyl groups, increased oxygen content	FTIR, XPS	(Yu et al., 2021)
Assess impact of UV irradiation on PVC MPs.	Pure Water (Preparation and type not specified)	NR	35 °C	UVA, UVB, UVC (dose NR)	4, 8, 12, 16 d	n/a ¹	PVC	NR	Dongguan Jingtian Raw Materials of Plastics Co., Ltd. (China)	Cracks and flakes, increased oxygen content	SEM, XPS, FTIR	(Ouyang et al., 2021)
Assess degradation of polymers exposed to UV.	Ultrapure Water (Type and preparation not specified)	NR	NR	UVA 340 nm	3 months	n/a ¹	PE, PP, PS	Pellets (Actual size NR)	DuPont Engineering Polymers (US)	Surface roughness, hydroxyl, and carbonyl groups	SEM, FTIR	(Cai et al., 2018)
Evaluate impact of ozone and UV on MPs.	Milli-Q ultrapure water	NR	NR	254 nm (15 W)	60 min	n/a ¹	LDPE, PET, uPVC	509 μm, 161 μm, 159 μm, respectively	Goodfellow (UK)	CI increase	ATR-FTIR,	(Miranda et al., 2021)
Characterize physical and chemical properties of PS exposed to UV.	Atmosphere (in a custom made aging chamber)	NR	NR	254 nm	96 h	n/a ¹	PS	125 – 250 μm	Goodfellow Cambridge Ltd. (Huntingdon, UK).	Surface cracks, carbonyl and hydroxyl groups, increase in CI	SEM, FTIR	(Hüffer et al., 2018)
Evaluate formation of environmentally free persistent radicals on polymers exposed to UV.	Atmosphere (Petri Dish)	NR	Room temp. (Actual temp not specified)	300 nm	15 d	n/a ¹	PS, PF, PVC, PE	95.0±5.0, 66.5±6.2, 115.0±5.0, and 110.0±10.0μm, respectively	Sigma-Aldrich Reagent Company (China)	Formation of oxygen containing functional groups on PS and PF	FTIR	(Zhu et al., 2019)
Assess photochemical reactions on the surface of PVC/PMMA mixtures.	Atmosphere (Petri Dish)	NR	NR	254 nm, 1.99 mW/cm ²	12 h	86x10 ³	PVC, PMMA	Molecular Weight = 97000 and 120000, respectively	Sigma-Aldrich Reagent Company (China)	Hydroxyl group, carbonyl groups, surface roughness	AFM, FTIR	(Kowalonek, 2016)

¹UV Fluence was not provided because either it was not reported or the required parameters to calculate it were not provided by the respective authors.

Note: NR = Not reported, HDPE = High-density polyethylene, LDPE = Low-density polyethylene, CI = Carbonyl index, PS = Polystyrene, PP = Polypropylene, PE = Polyethylene, PVC = Polyvinyl Chloride, PET = Polyethylene terephthalate, PMMA = Polymethyl methacrylate, PF = Phenol formaldehyde resin, SEM = Scanning electron microscopy, spICP-MS = single particle inductively coupled mass spectrometer, FTIR = Fourier Transform Infrared Spectrometer, XPS = X-ray photoelectron spectroscopy, AFM = Atomic force microscopy.

Table S6 Loss of chlorine during filtration of 40 mL of AFW containing 10 mM pH 6 sodium phosphate buffer using a 47 mm diameter 0.2 μm PC filter. Initial chlorine concentration = 6.0 ± 0.0 mg/L Cl_2 .

Replicate	Free Chlorine (mg/L Cl_2)		Free Chlorine Loss (mg/L Cl_2)
	<i>Unfiltered Sample</i>	<i>Filtered Sample</i>	
1	6.0	5.1	0.9
2	6.0	5.1	0.9
3	6.0	5.1	0.9
Avg.	6.0 ± 0.0	5.1 ± 0.0	0.9 ± 0.0

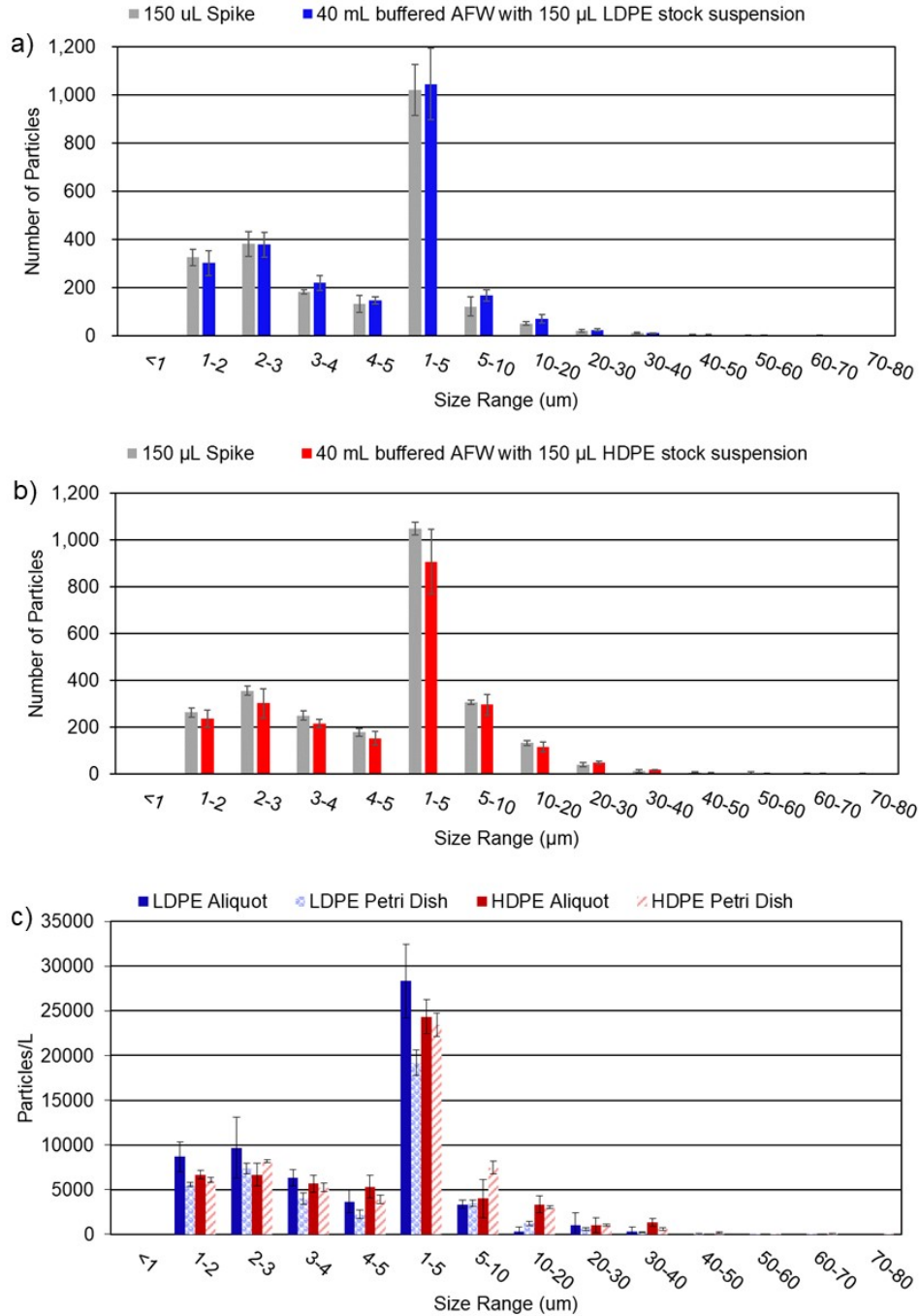


Figure S1 Comparison of size distributions of: a) triplicate 150 µl spikes of 2 - 125 µm LDPE stock suspension and triplicate 40 ml vials containing 150 µl of 2 - 125 µm LDPE stock suspension in ph 6 AFW, b) triplicate 150 µl spikes of 2 - 125 µm HDPE stock suspension and triplicate 40 ml vials containing 150 µl of 2 - 125 µm HDPE stock suspension in ph 6, and c) LDPE and HDPE MPs removed from a 25 mL Petri dish by filtering triplicate 1 mL aliquots or triplicate 25 mL volumes. Vertical bars represent \pm one standard deviation ($n=3$).

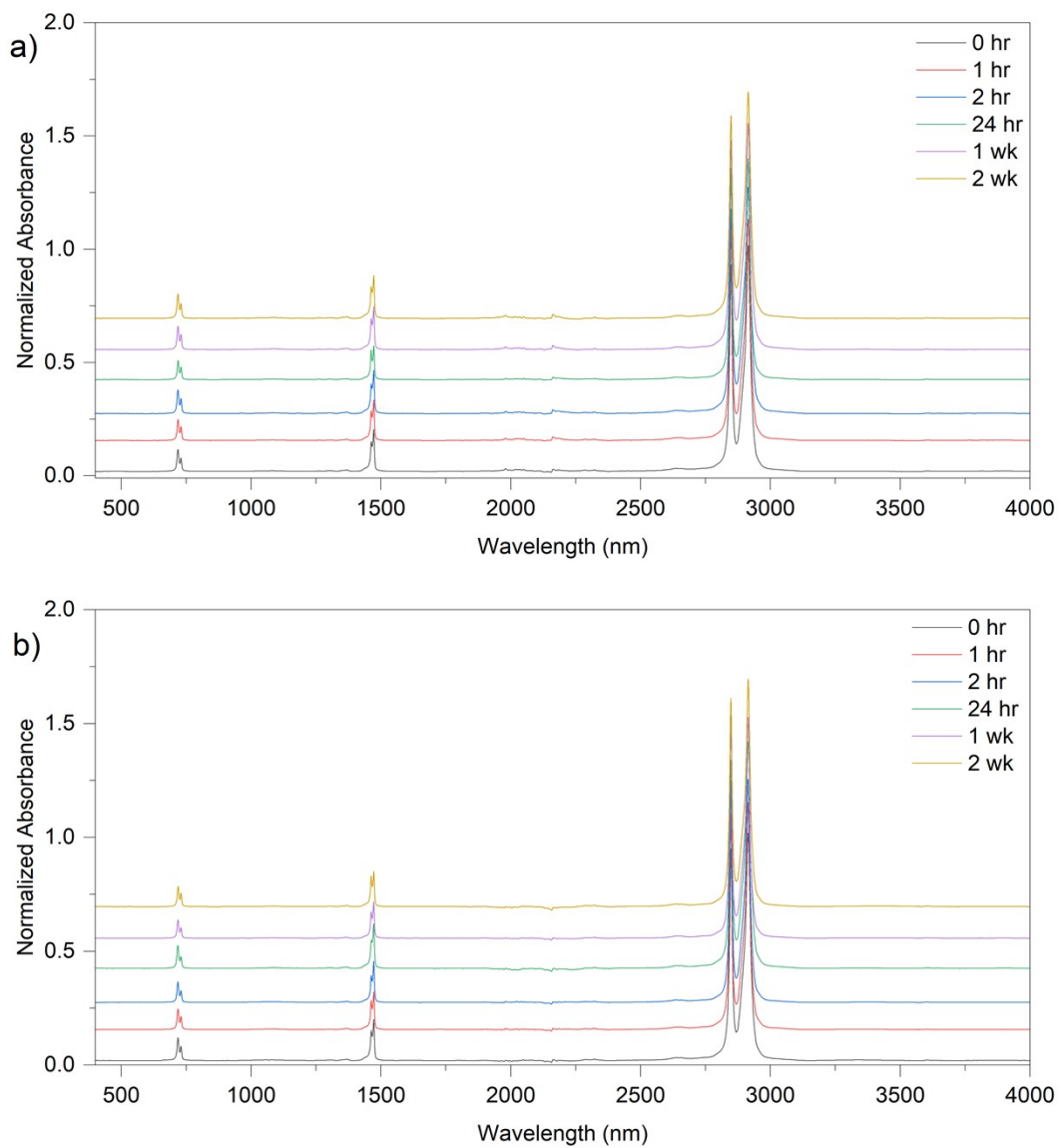


Figure S2 FTIR spectra of HDPE following exposure to 6 mg/L free chlorine at a) pH 6 and b) pH 8.

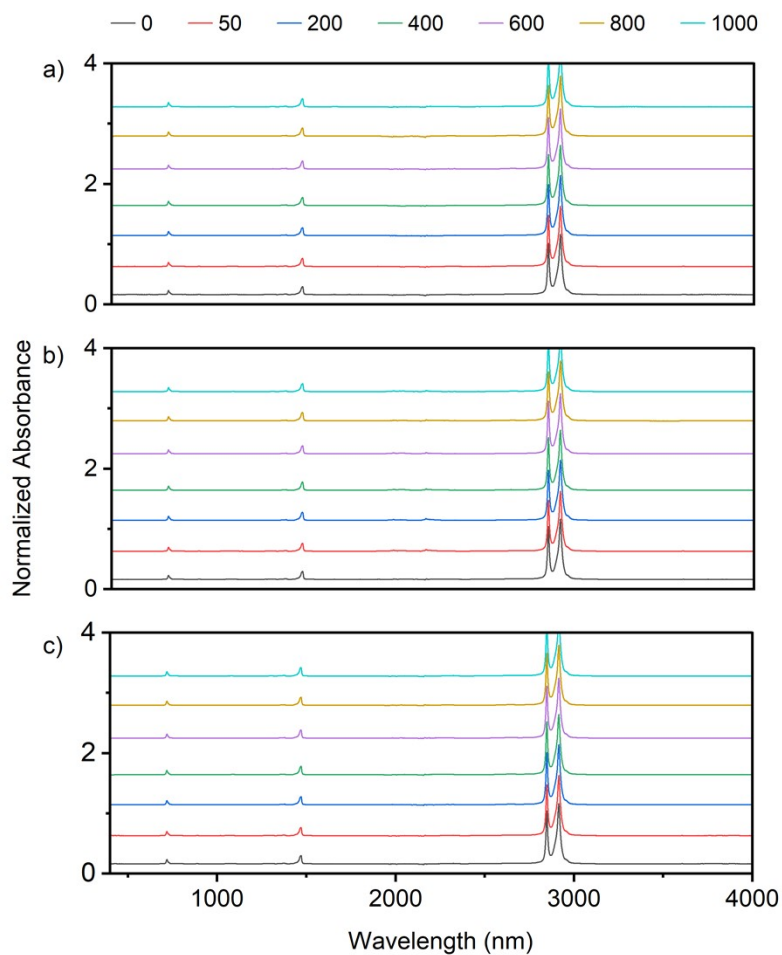


Figure S3 FTIR spectra of LDPE following exposure to a) UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2 , b) 5 mg/L of H_2O_2 at times corresponding to fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2 , and c) 5 mg/L of H_2O_2 with UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2

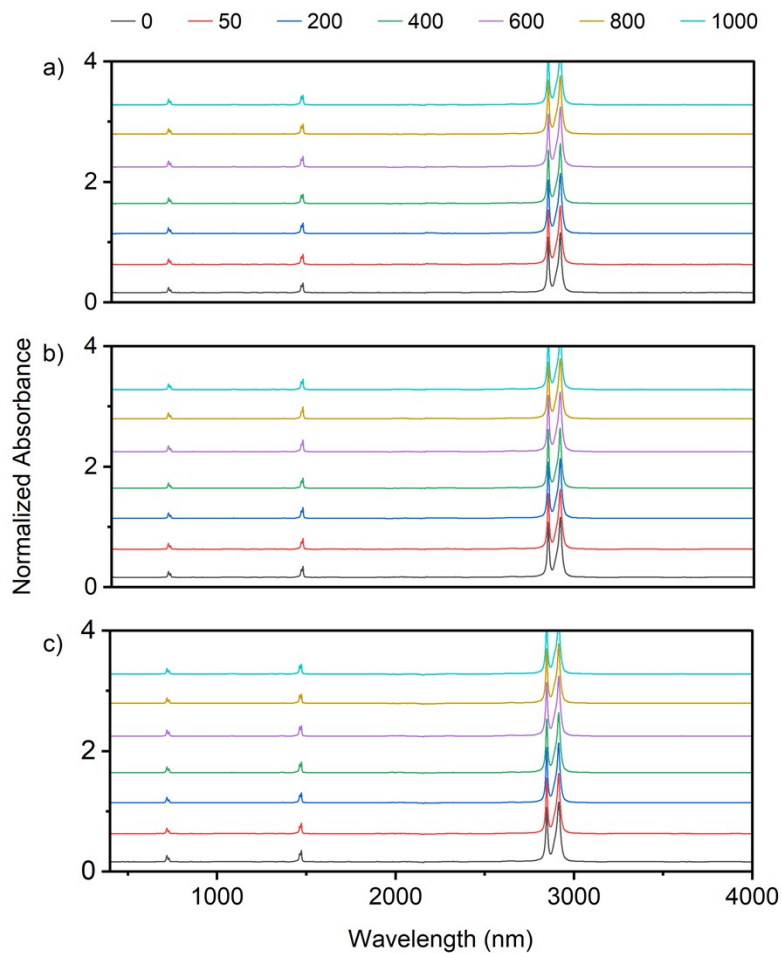


Figure S4 FTIR spectra of HDPE following exposure to a) UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2 , b) 5 mg/L of H_2O_2 at times corresponding to fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2 , and c) 5 mg/L of H_2O_2 with UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2

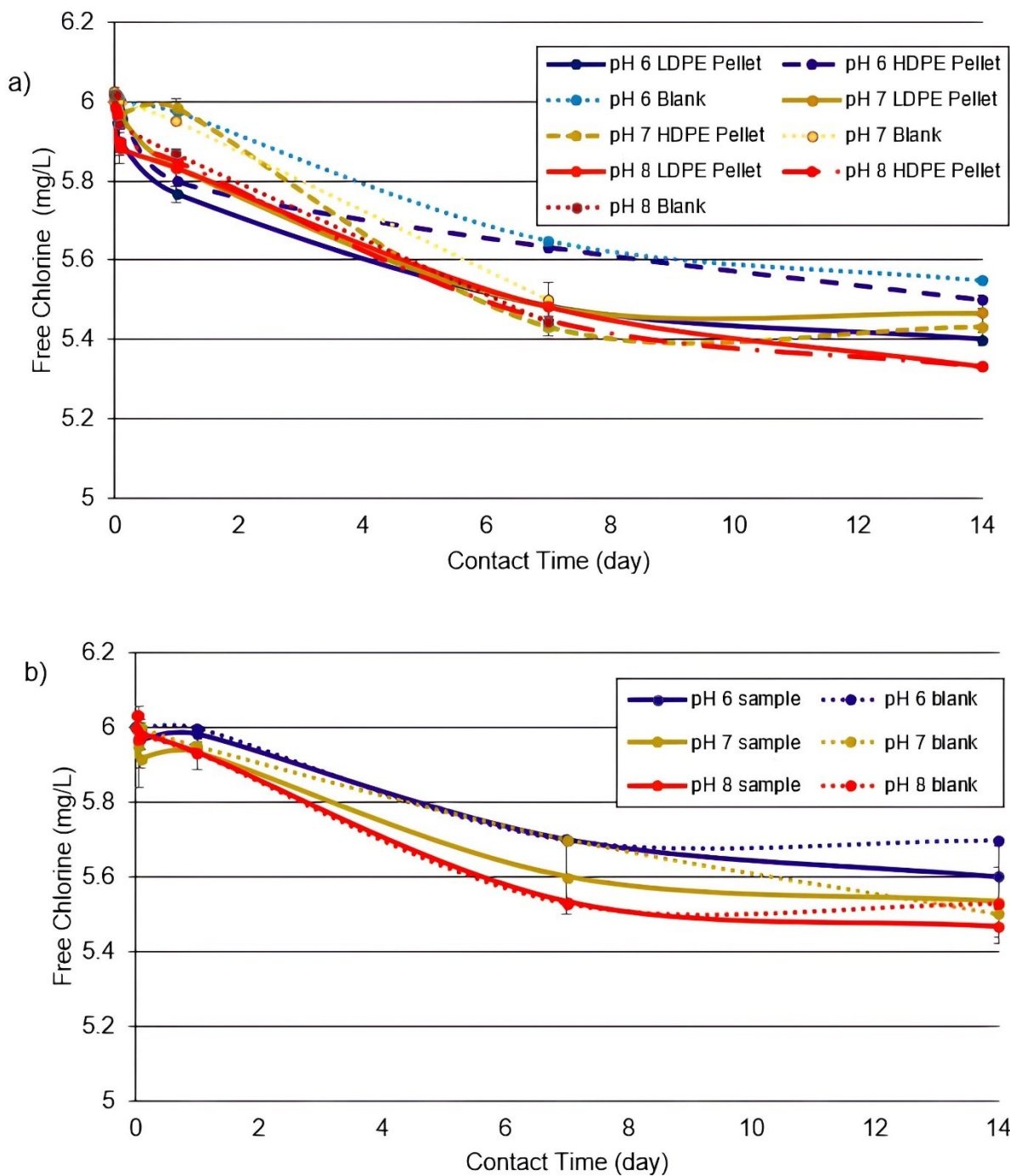


Figure S5 Chlorine decay in 40 mL vials containing AFW with 10 mM pH 6, 7, and 8 sodium phosphate buffer with a) either LDPE or HDPE pellets, as indicated, or b) 150 μ L HDPE stock suspension and 150 μ L LDPE stock suspension. Vertical bars represent \pm one standard deviation ($n=3$).

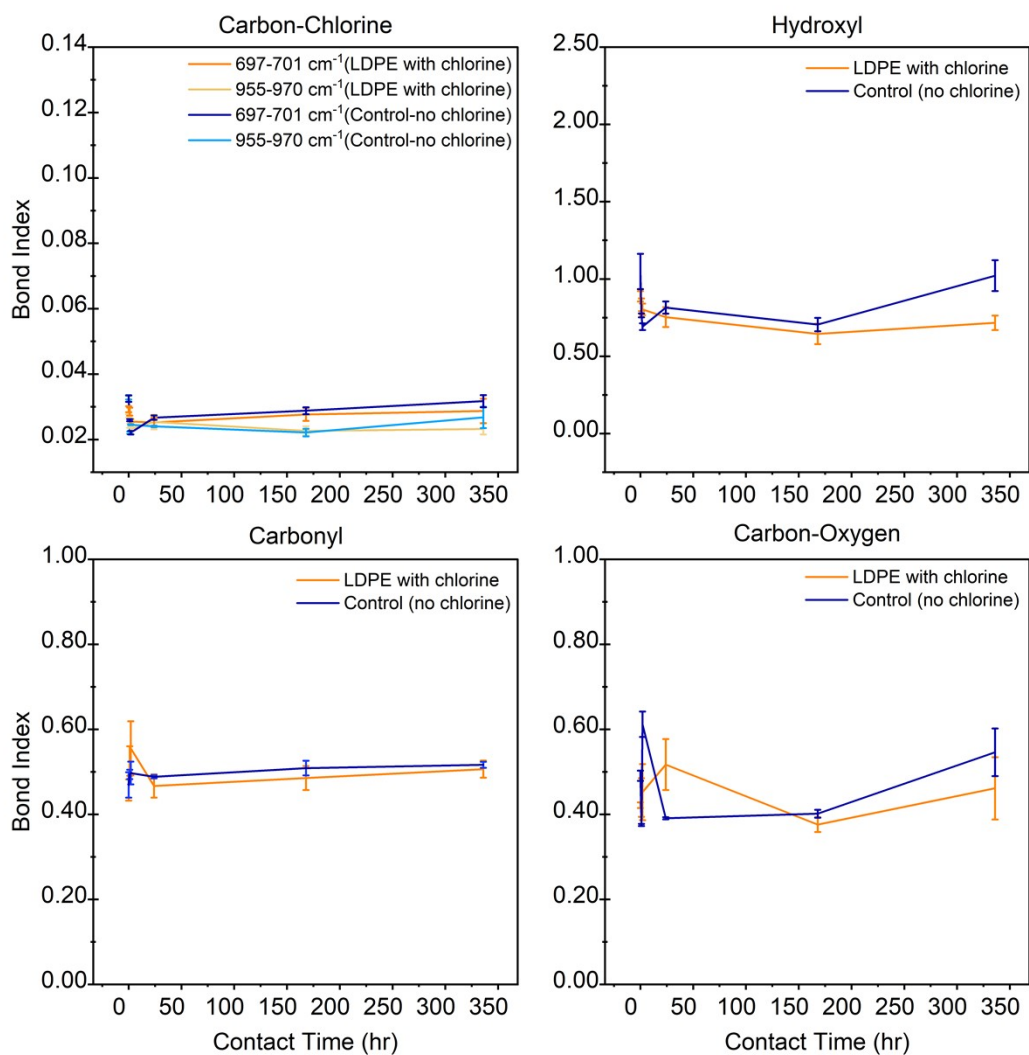


Figure S6 Bond indices of LDPE following exposure to 6 mg/L free chlorine (pH 8). Vertical bars represent ± one standard deviation (n=3).

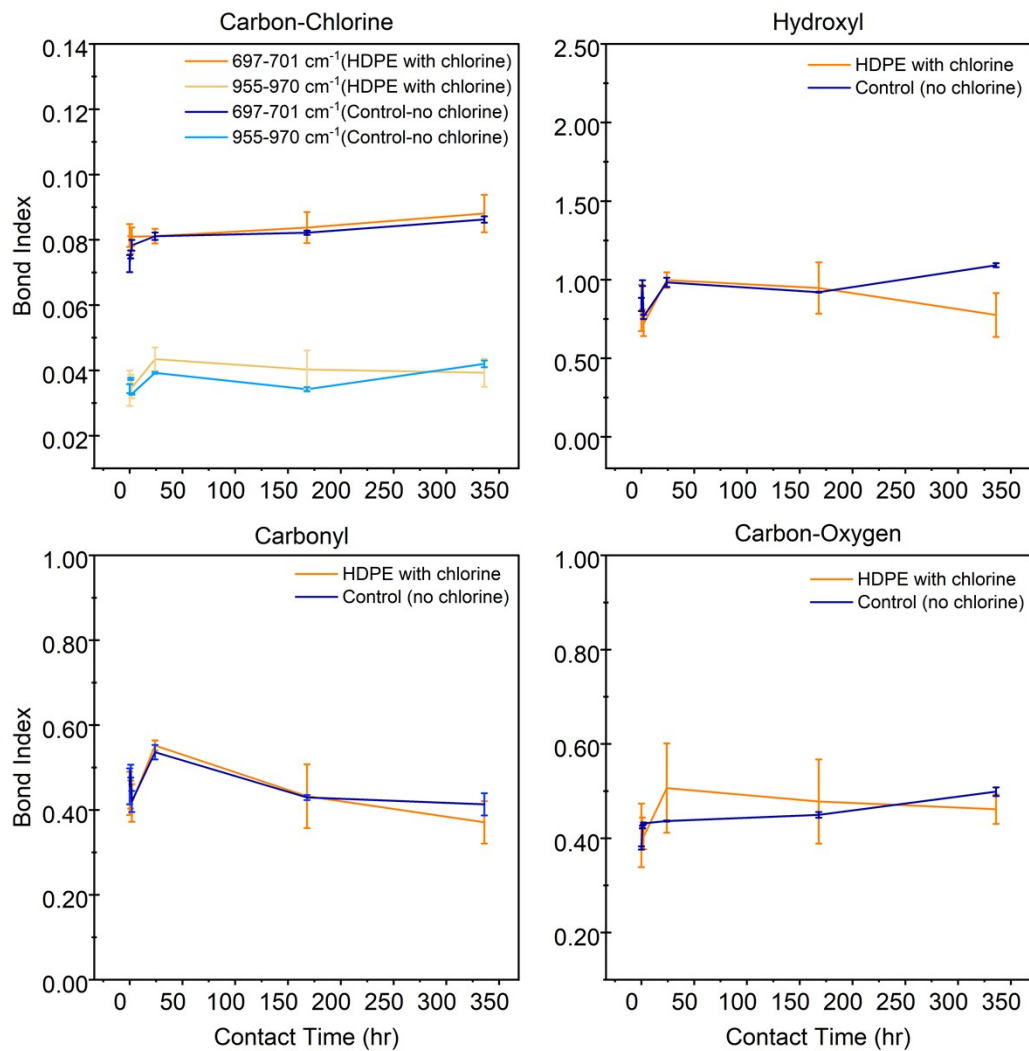


Figure S7 Bond indices of HDPE following exposure to 6 mg/L free chlorine (pH 6). Vertical bars represent ± one standard deviation (n=3).

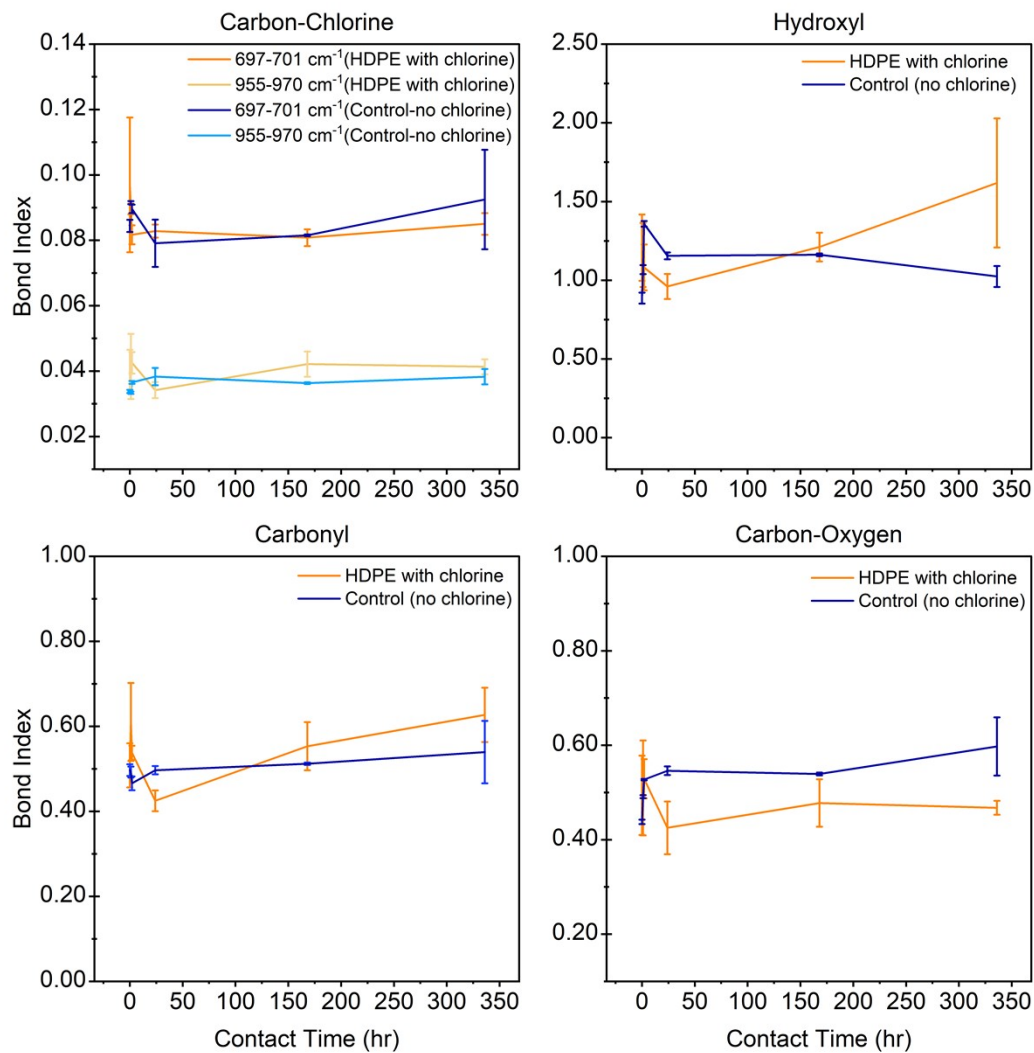


Figure S8 Bond indices of HDPE following exposure to 6 mg/L free chlorine (pH 8). Vertical bars represent \pm one standard deviation (n=3).

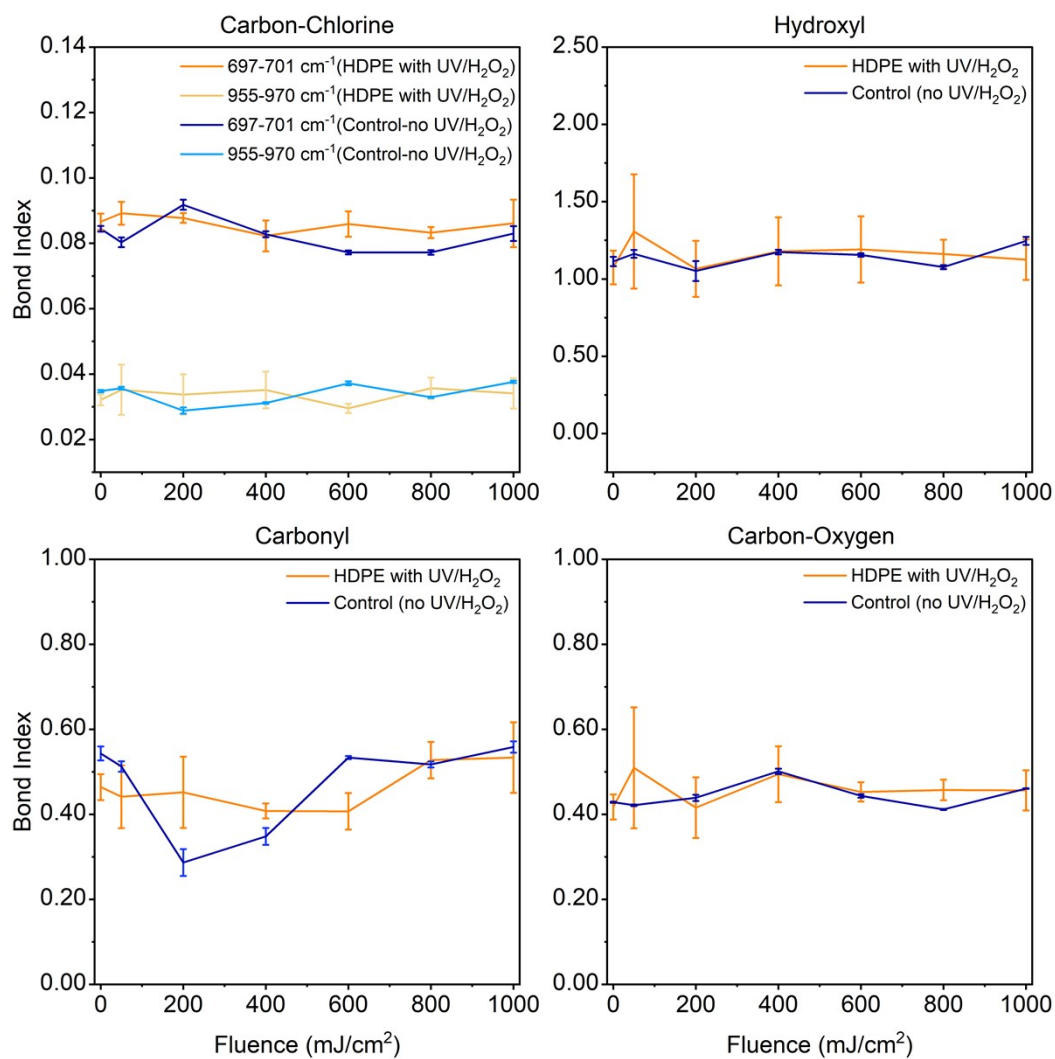


Figure S9 Bond indices of HDPE following exposure to 5 mg/L of H₂O₂ with UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm². Vertical bars represent ± one standard deviation (n=3).

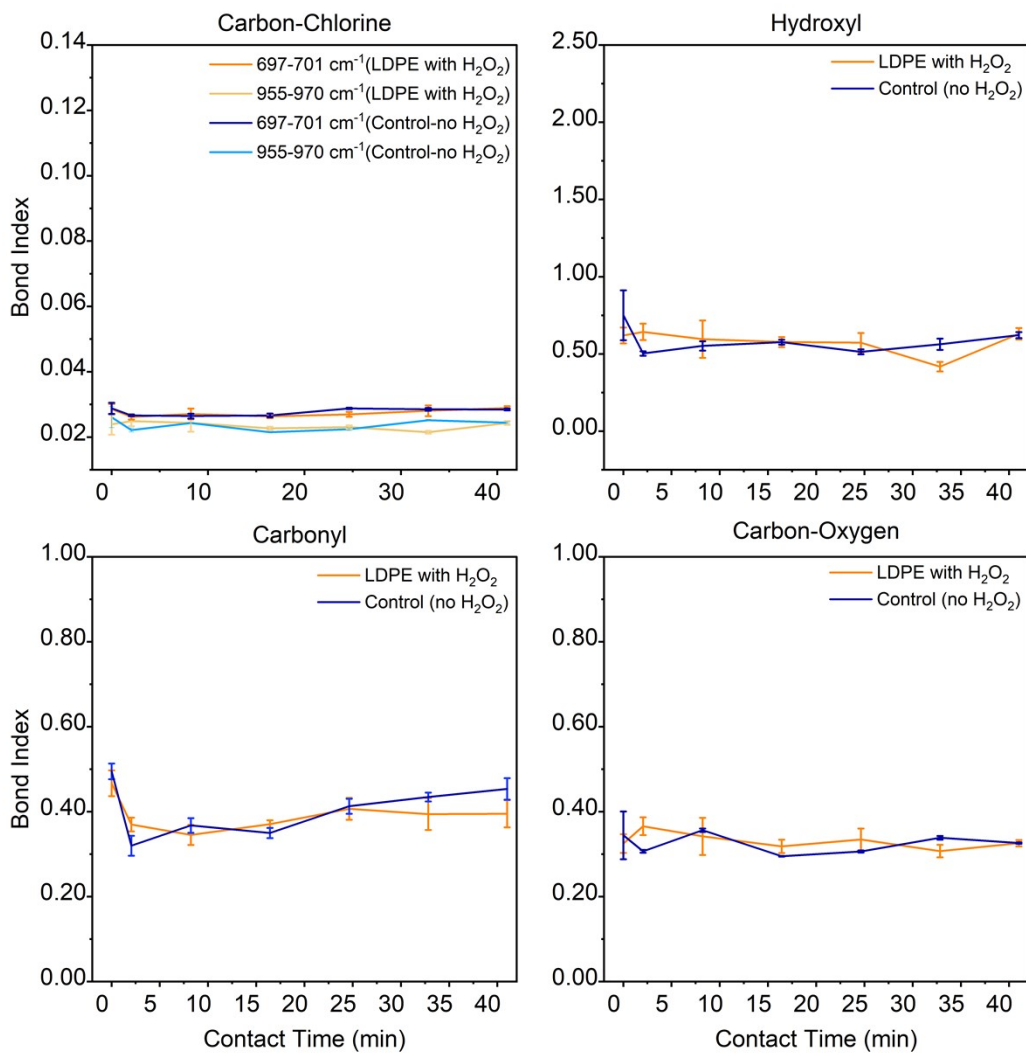


Figure S10 Bond indices of LDPE following exposure to 5 mg/L of H₂O₂ for 0, 2, 8, 16, 25, 32, and 41 minutes. Vertical bars represent ± one standard deviation (n=3).

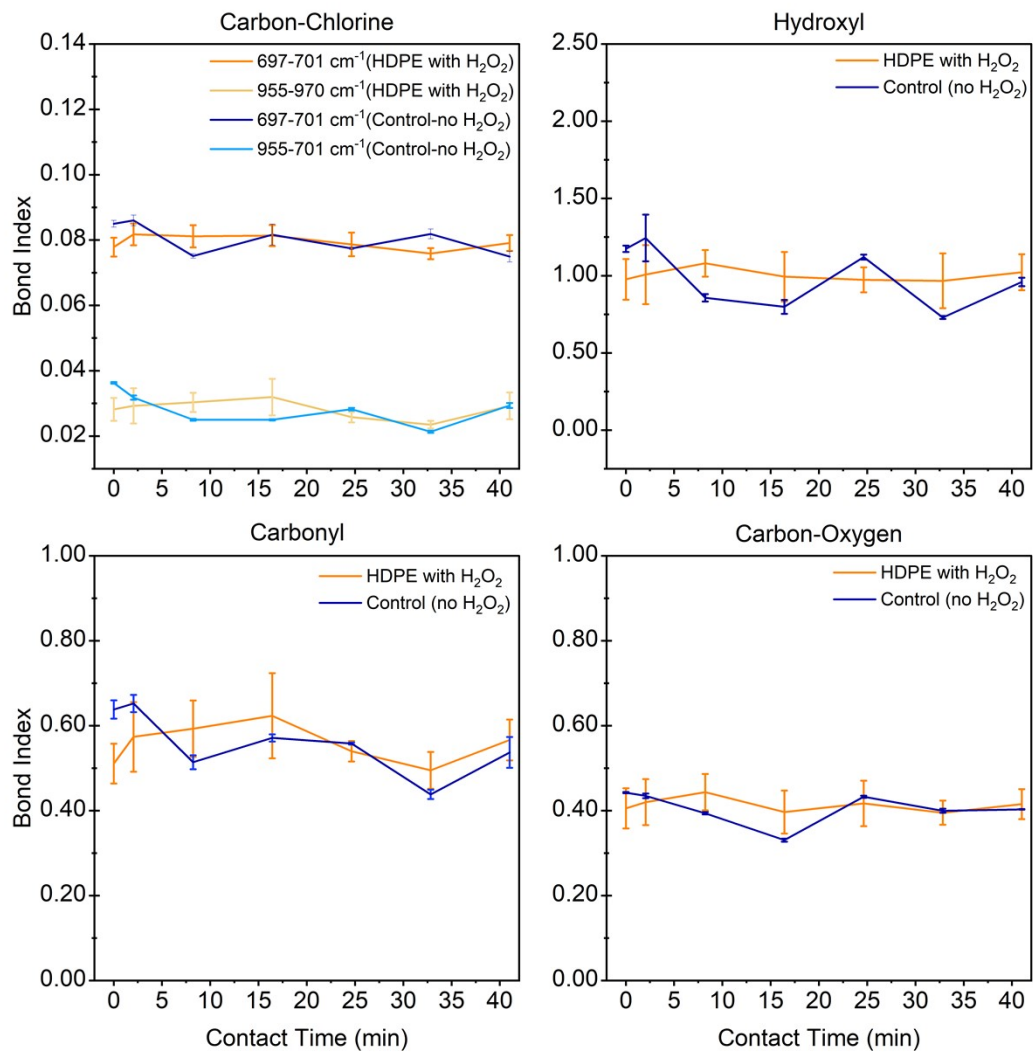


Figure S11 Bond indices of HDPE following exposure to 5 mg/L of H_2O_2 for 0, 2, 8, 16, 25, 32, and 41 minutes. Vertical bars represent \pm one standard deviation (n=3).

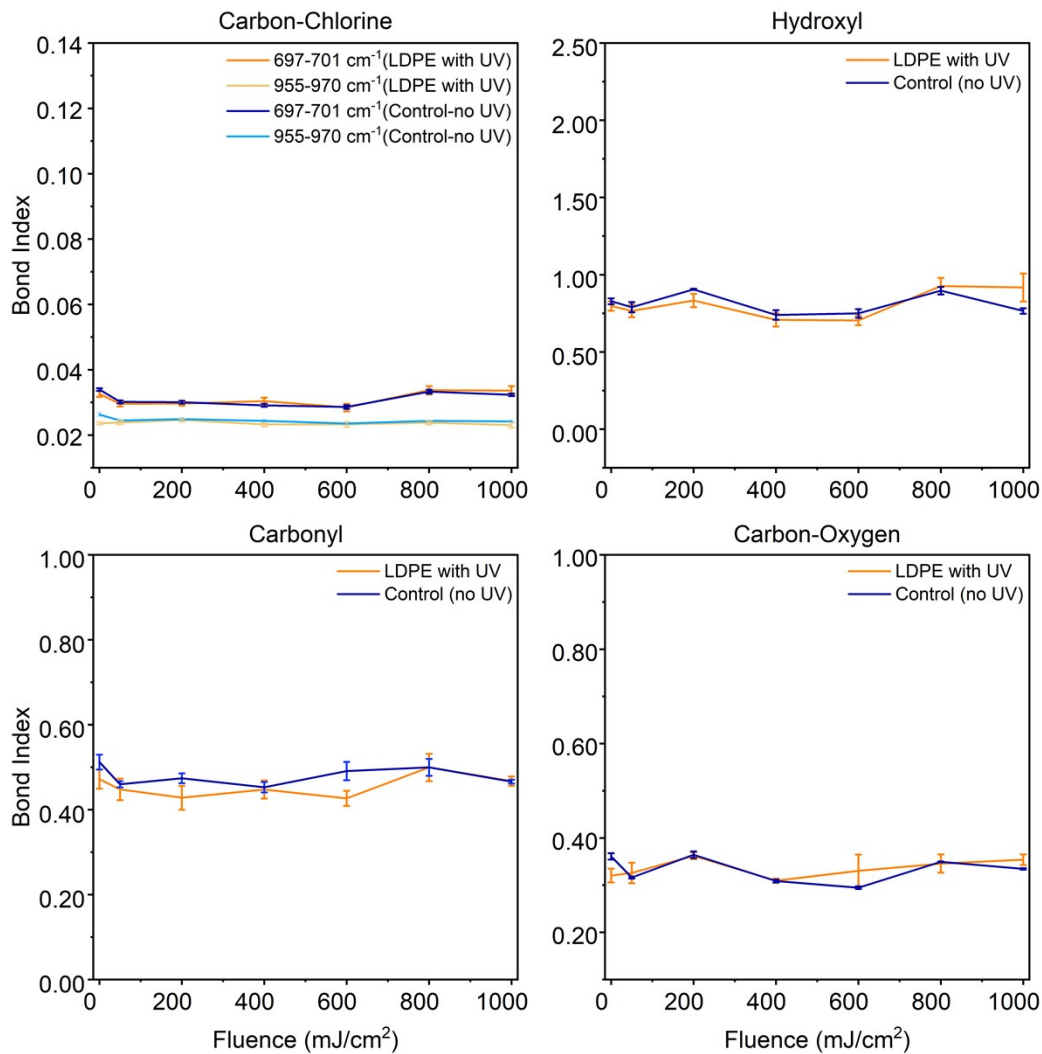


Figure S12 Bond indices of LDPE following exposure UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm². Vertical bars represent \pm one standard deviation (n=3).

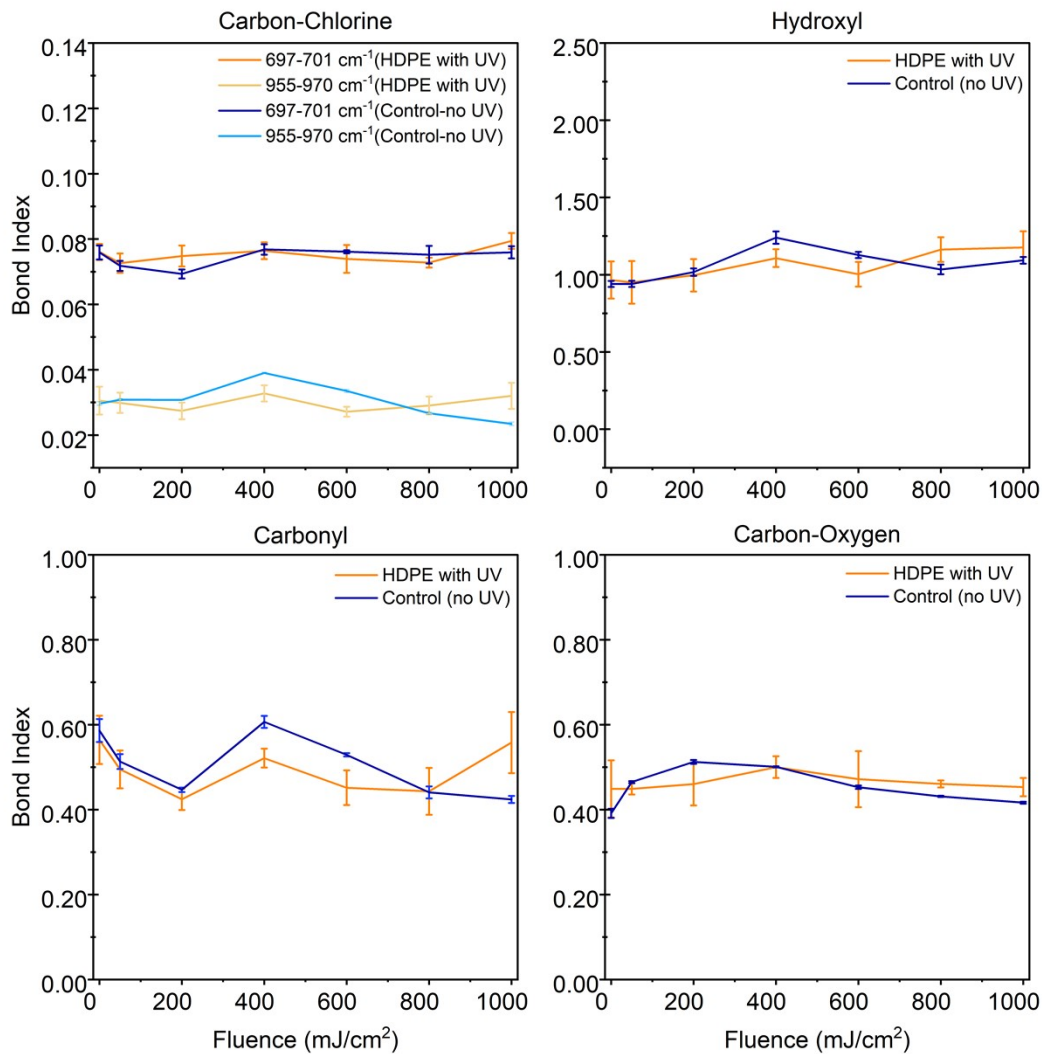


Figure S13 Bond indices of HDPE following exposure UV at fluences of 0, 50, 200, 400, 600, 800, and 1000 mJ/cm². Vertical bars represent \pm one standard deviation (n=3).

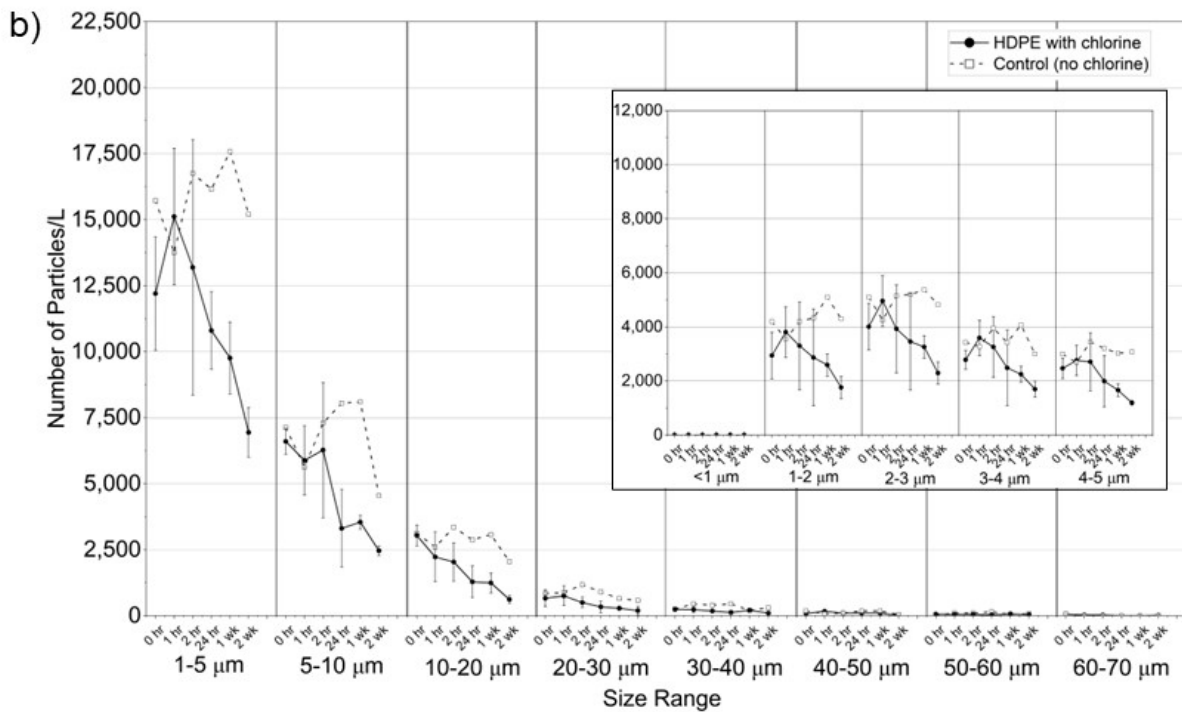
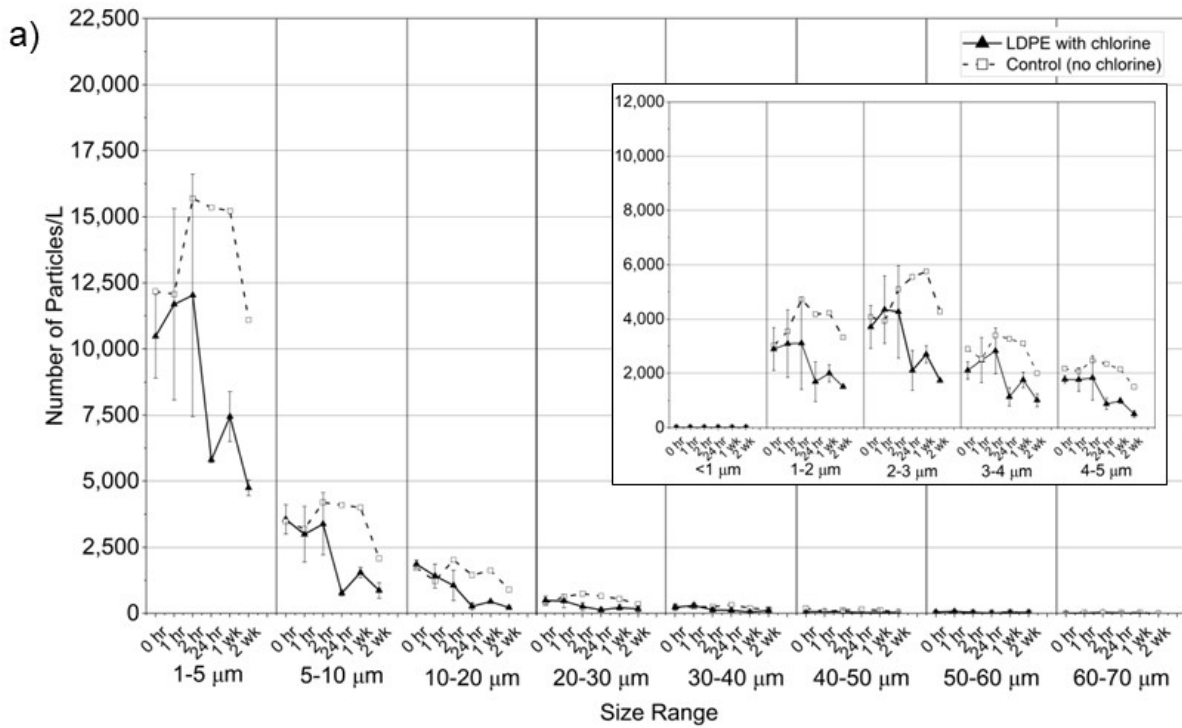


Figure S14 Impact of chlorine contact time (0 hr, 1 hr, 2 hr, 24 hr, 1wk, and 2 wk) on size distribution of a) LDPE, and b) HDPE particles in pH 8 AFW with 6 mg/L Cl₂. Vertical bars represent ± one standard deviation (n=3).

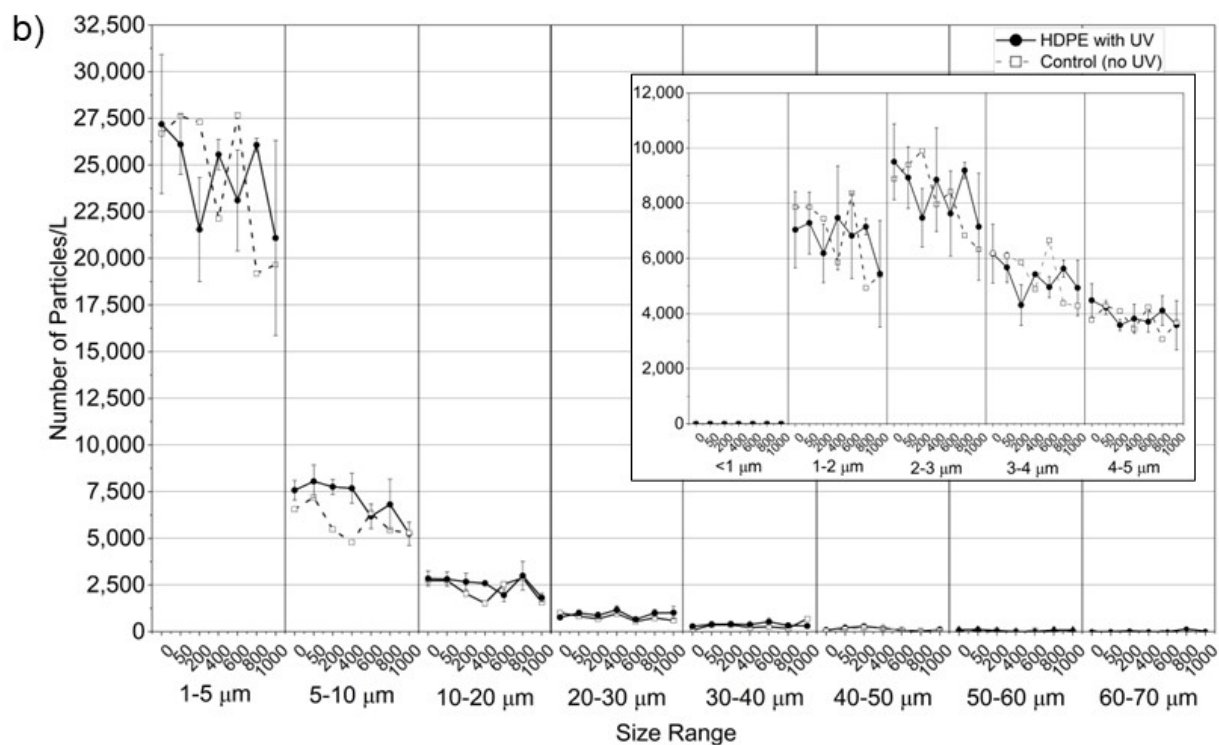
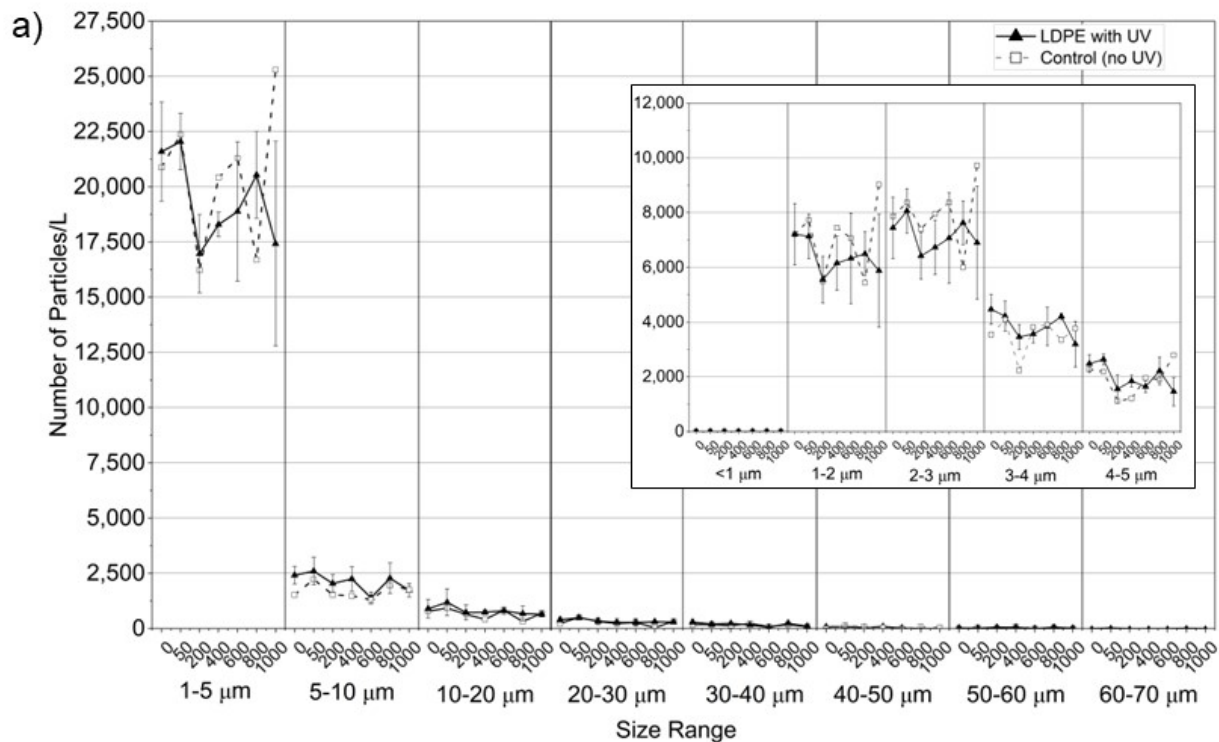


Figure S15 Impact of UV fluence (0, 50, 200, 400, 600, 800, and 1000 mJ/cm^2) on size distribution of a) LDPE, and b) HDPE particles in pH 7. Vertical bars represent \pm one standard deviation ($n=3$).

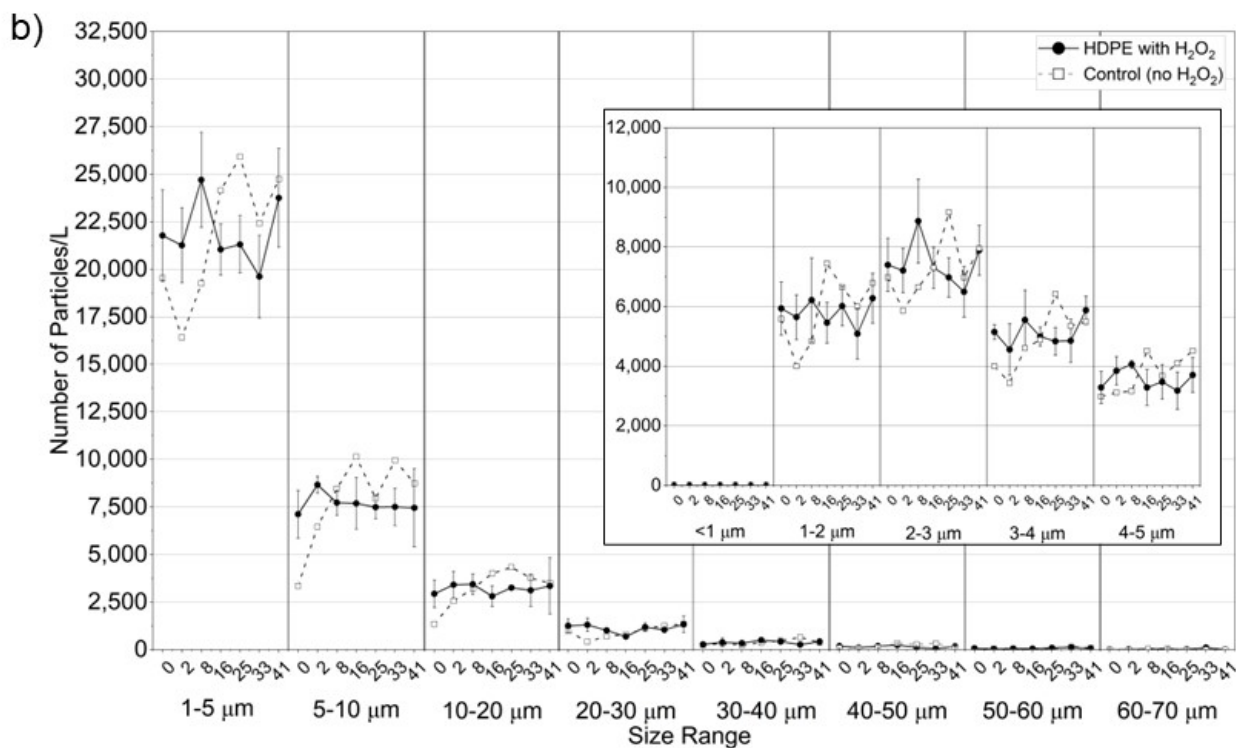
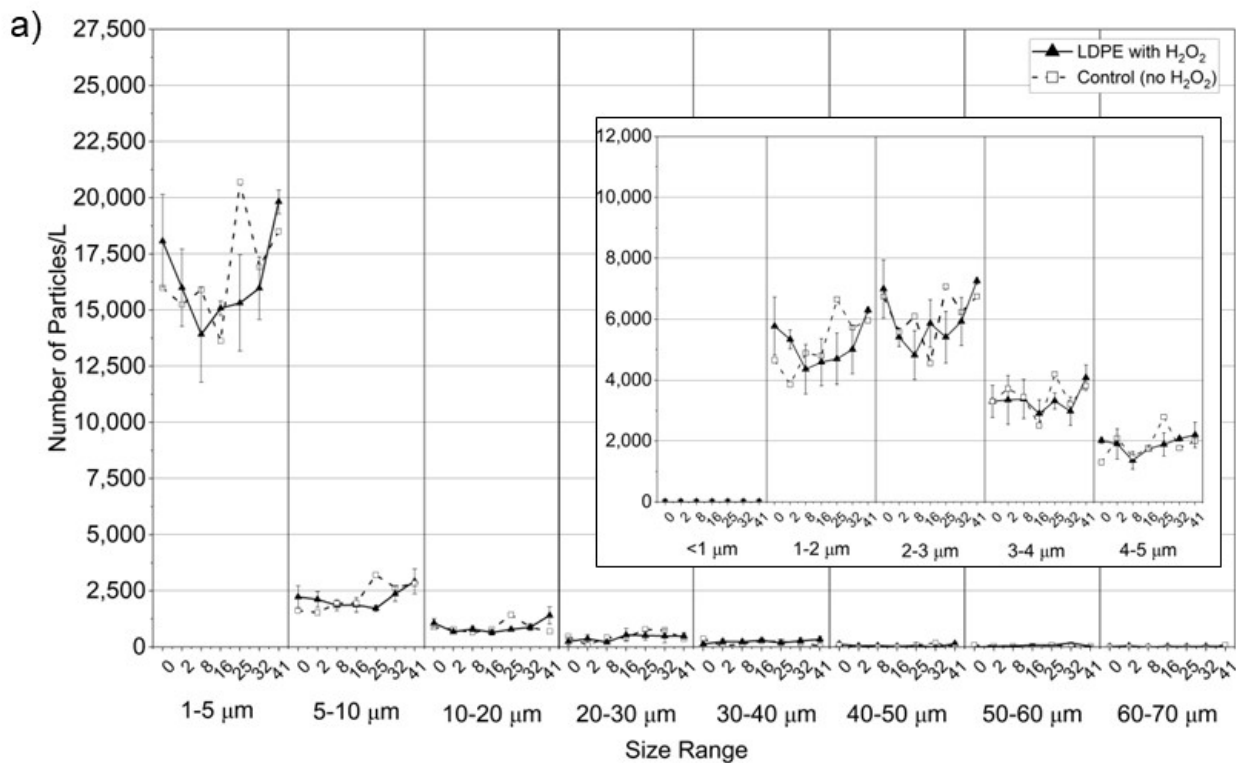


Figure S16 Impact of contact time (0, 2, 8, 16, 25, 32, and 41 min.) on size distribution of a) LDPE, and b) HDPE particles in pH 7 AFW with exposure to 5 mg/L of H₂O₂. Vertical bars represent ± one standard deviation (n=3).