Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts.

SUPPORTING INFORMATION

Determining Wavelength-Dependent Quantum Yields of Photodegradation: Importance of Experimental Setup and Reference Values for Actinometers

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Text S1. Solutions preparation and sample collection during experiments.
Atrazine, p-nitroanisole (PNA), and diclofenac solutions (10 μM) were prepared in ultrapure water (≥18.2 MΩ cm, Millipore Direct-Q 3 UV). Sulfamethoxazole solutions (10 μM) were prepared with 0.5 mM phosphate buffer at pH 7.2 or 8. Uridine solutions (5 μM) were prepared with 1 mM phosphate buffer at pH 7 from a 7.4 mM uridine stock solution prepared in ultrapure water. Phosphate buffer stock solutions (0.5 M) were prepared by adding sodium phosphate dibasic heptahydrate (Na_2HPO_4 x 7 H_2O, 9.8 g, 0.37 M) and potassium phosphate monobasic (KH_2PO_4, 1.8 g, 0.13 M) to 100 mL of ultrapure water. pH changes were negligible during the experiments (<0.2 pH units). Ferrioxalate solutions were prepared at 0.02 M of ferrioxalate in 0.05 M H_2SO_4 as previously described.[1] Briefly, stock solutions of 0.2 M ferric sulfate were prepared by dissolving iron(III) sulfate pentahydrate (Thermo Scientific, 97% purity) in 1 M sulfuric acid made from concentrated sulfuric acid (Fisher, Certified ACS Plus) and ultrapure water. Stock potassium oxalate solutions were made at 0.6 M concentration by dissolving potassium oxalate monohydrate (Alfa Aesar, 98.5+% purity) in ultrapure water. Ferrioxalate was prepared by diluting 2.5 mL of each stock solution into 50 mL of ultrapure water.

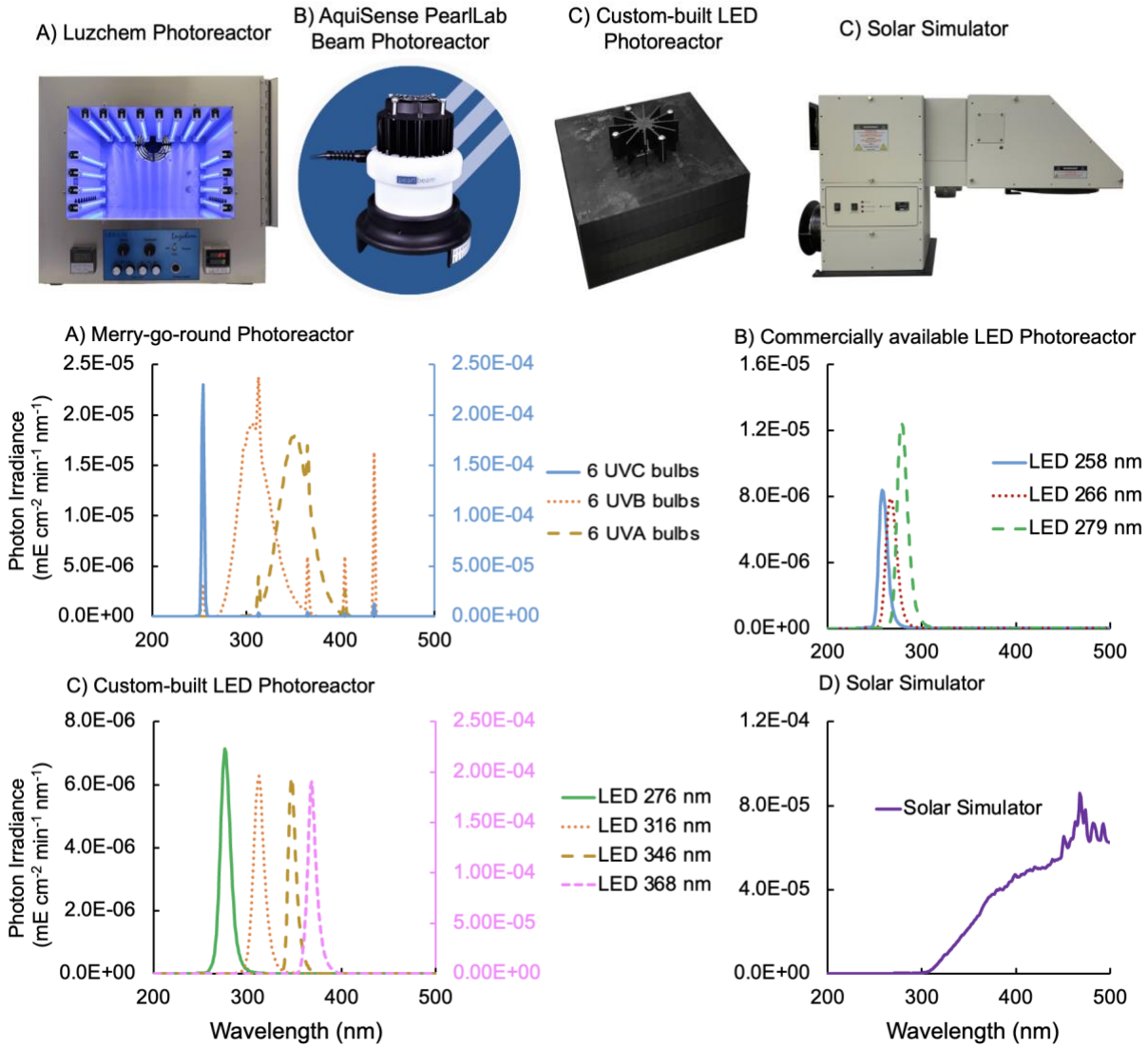


Figure S1. Images of the photoreactors used herein: (A) merry-go-round photoreactor (Luzchem), (B) commercially available LED photoreactor (AquiSense PearlLab Beam), (C) custom-built LED photoreactor, and (D) solar simulator (Newport). The irradiance spectra of the light sources in photon irradiance units (mE cm^{-2} min^{-1} nm^{-1}) are also provided.

Text S2. Spectroradiometer Setup and Calibration.
The spectroradiometer (Black Comet, StellarNet) was connected through an F600 UVVIS-SR fiber optic cable to a ¼" diameter UV-VIS-NIR cosine receptor (CR2, StellarNet). The integration window was set from 200-500 nm, and the integration time was selected as the highest value that allowed for the spectra to be fully captured in scope mode leveled up to the maximum number of counts (65,536 counts). An additional aperture with 9.5% transmittance (CR2-AP) was added on top of the cosine receptor to enable spectral measurements of light sources with intense irradiances (i.e. when saturation was observed for the minimum integration time of 30 ms). A dark spectrum was taken with the light sources turned off before all measurements. Irradiance measurements were obtained by placing the spectroradiometer sensor at the center of the light sources in the same position where the solution container was placed.

The spectroradiometer was calibrated in October 2022 (Certificate of Irradiance Calibration # 17092132-UV-CR2 and 17092131-UVVIS-CR2). Calibration was performed in the UV region (200-600 nm) using a StellarNet spectral UV irradiance lamp (model# SL3, serial# 17011917) and in the UV-vis region (300-1100 nm) using a LI-COR spectral irradiance lamp (model# 1800-02L, serial# ORL1027L). The accuracy of the equipment used is traceable to the US National Institute of Standards and Testing (NIST) by LI-COR Certificate of Calibration.

Text S3. Spectral Irradiance to Spectral Photon Irradiance Conversion.
The spectral irradiance (W; in power units of W m^{-2} nm^{-1}) obtained from the spectroradiometer readings was converted to spectral photon irradiances (E; in mE cm^{-2} min^{-1} nm^{-1}) following Equation S1:

$$E = 6 \times 10^{-9} \times \frac{\lambda \times W}{h \times c \times N_A} \quad \text{(S1)}$$

where λ is the wavelength in nm, h is the Planck constant (6.626×10^{-34} J s), c is the speed of light (2.998×10^{8} m s^{-1}), and N_A is the Avogadro constant (6.022×10^{23} mol^{-1}).

Text S4. Quantification of Ferrioxalate Transformation and Irradiance Spectral Photon Irradiance Calculation Using Ferrioxalate as Actinometer
Ferrioxalate transformation was quantified by measuring the absorbance of the iron(II)-phenanthroline complex at 510 nm using an Agilent Cary 60 UV-vis spectrophotometer. Irradiated samples (100 µL) were added to 3.2 mL of a phenanthroline colorimetric reagent. The mixture was set aside for 45 min before analysis. The colorimetric reagent was prepared by mixing equal amounts of a 0.2 M acetate buffer stock solution (pH=5.4), made from sodium acetate trihydrate (Alfa Aesar, 99% purity) and concentrated sulfuric acid, and a 0.2% phenanthroline stock solution, prepared using 1,10-phenanthroline (Sigma Aldrich, >99% purity) and ultrapure water.

Ferrioxalate absorbs all light below 400 nm (Figure S2). The rate of ferrioxalate degradation was used to calculate spectral irradiance as follows. First, the total irradiance of the light source (I_{total}) was calculated using Equation S2, where $\Delta A_{510}/\Delta t$ is the change in absorption of the iron(II)-phenanthroline complex over time, determined from a linear regression plot of the measured UV absorbance of the iron(II)-phenanthroline complex at 510 nm at each time point, d is the dilution factor of the sample in the phenanthroline colorimetric reagent, l is the optical path length, $\Phi_{\lambda,Fe(II)}$ is the ferrioxalate quantum yield, and ε_{510} is the iron(II)-phenanthroline complex molar absorptivity

at 510 nm (11,100 M^{-1} cm^{-1}). The spectral irradiance (I_λ) was then calculated using Equations S3-S5, where γ is a wavelength-independent scaling factor, and $I_{\lambda,normalized}$ is the normalized irradiance at a given wavelength.

$$I_{total} = \frac{(\Delta A_{510}/\Delta t) d\ l}{1000\ \Phi_{\lambda,Fe(II)} \varepsilon_{510}} \quad \text{(S2)}$$

$$I_\lambda = \gamma \times I_{\lambda,normalized} \quad \text{(S3)}$$

$$I_{\lambda,normalized} = \frac{I_{\lambda,spectroradiometer}}{\sum_\lambda I_{\lambda,spectroradiometer}} \quad \text{(S4)}$$

$$\gamma = \frac{I_{total}}{\sum_\lambda I_{\lambda,normalized}} \quad \text{(S5)}$$

The molar absorption coefficient of the iron(II)-phenanthroline complex at 510 nm (ε_{510}) was previously published.[2] Ferrioxalate quantum yields have been previously validated in the 205-365 nm region.[3] The following previously published quantum yields were used in Equation S2: 1.4 for experiments in the merry-go-round photoreactor with UVC bulbs (254±1.5 nm), and 1.25 for experiments in the merry-go-round photoreactor with UVB (291-324 nm), UVA bulbs (333-371 nm), and the solar simulator (304-680 nm).

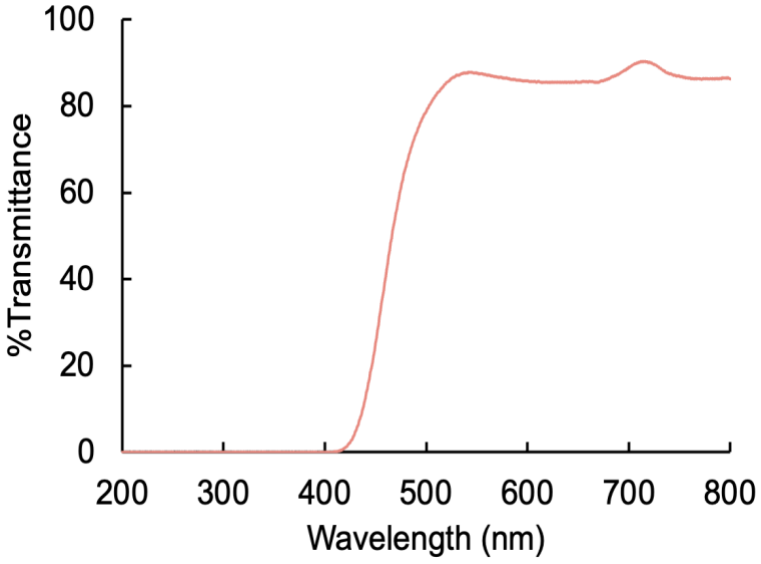


Figure S2. Transmittance spectra of 0.02 M ferrioxalate. The ferrioxalate solution is optically opaque at wavelengths <400 nm.

Text S5. Petri factor calculations.
Petri factors were calculated following a published protocol.[4] Briefly, all points in a grid with a unit cell size of 0.5 cm were measured from the center to 3 cm in the x, -x, y, and -y directions. The petri dish used in all experiments had a 50 mm internal diameter and 18 mm depth. The volume and solution depth for experiments were 10 mL and 0.8 cm, respectively.

Petri factors calculated with the light sources used in the merry-go-round photoreactor, commercially available LED photoreactor, and custom-built LED photoreactor are in Table S1.

Table S1. Petri factors calculated with the light sources used in the merry-go-round photoreactor, commercially available LED photoreactor, and custom-built LED photoreactor. More information on how calculations were performed is available on Text S2.

Photoreactor System	
Merry-go-round	**Petri Factor**
Number and type of bulbs	
6 UVA	0.9733
4 UVA	0.9611
2 UVA	0.9412
6 UVB	1.0217
4 UVB	0.9986
2 UVB	0.9711
6 UVC	1.0043
4 UVC	1.0020
2 UVC	0.9826
Commercially available LED	
Light source	
LED 258 nm	0.9223
LED 266 nm	0.9382
LED 279 nm	0.9313
Custom-built LED	
Light source	
LED 276 nm	0.9554
LED 316 nm	0.9515
LED 346 nm	0.9556
LED 368 nm	0.9679

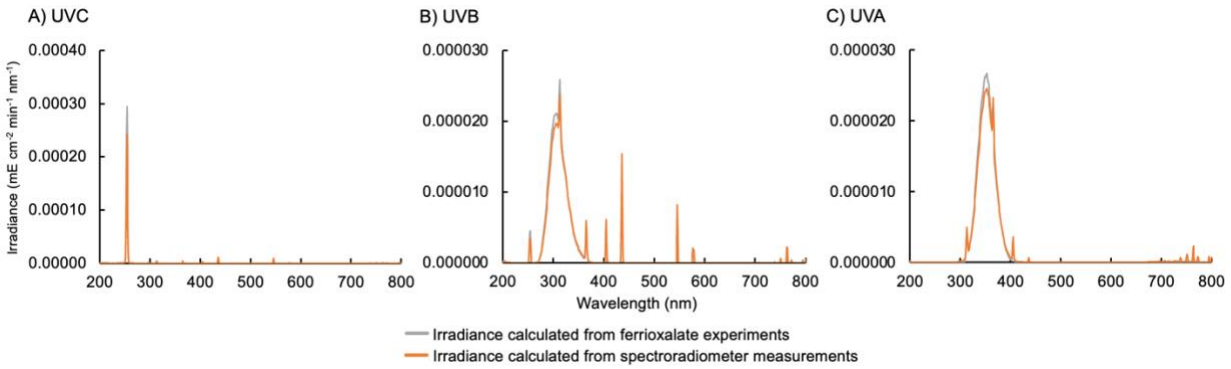


Figure S3. Photon irradiance spectrum obtained from spectroradiometer measurements (orange) and ferrioxalate actinometry (grey) for (A) UVC, (B) UVB, and (C) UVA bulbs in the merry-go-round photoreactor. Irradiances obtained from ferrioxalate actinometry were calculated according to Text S5 and Equations S2-S5. Experiments were performed with six bulbs placed on the ceiling of the photoreactor and using the black petri dish. Change in absorbance at 510 nm over time plots for experiments using ferrioxalate actinometry are in Figure S4.

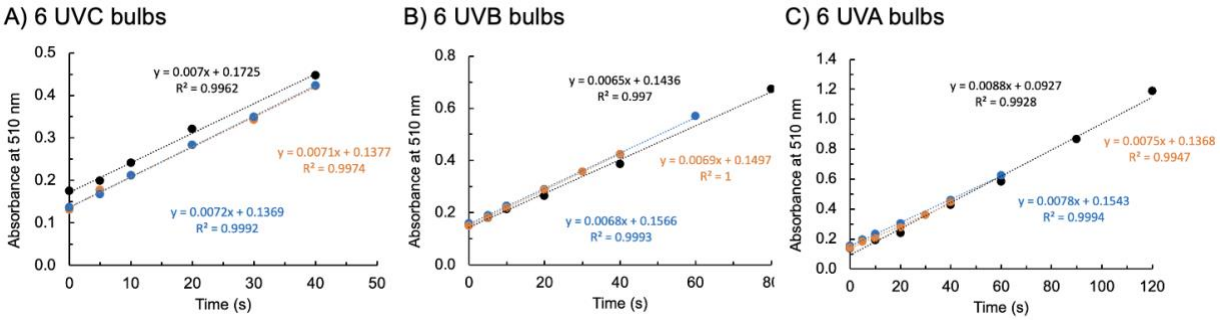


Figure S4. Change in absorbance at 510 nm over time for experiments using ferrioxalate actinometry with six (A) UVC, (B) UVB, and (C) UVA bulbs in the merry-go-round photoreactor. Each of the experiments was done in triplicate. The slope of the curve was used to determine the photon irradiance of each light source. Each color represents the results from a replicate experiment.

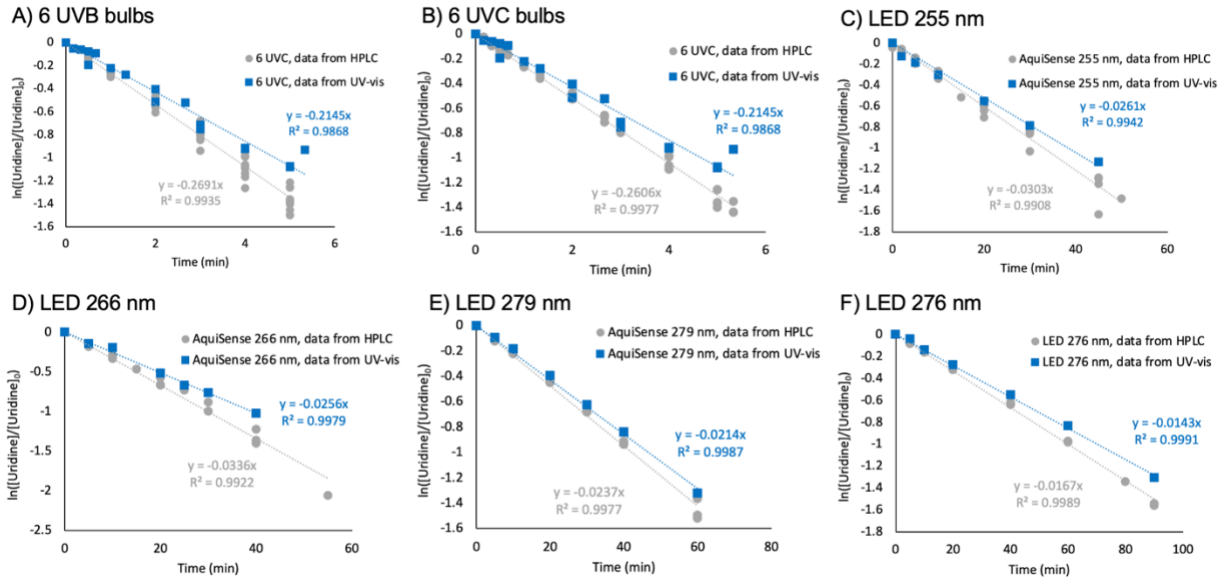


Figure S5. Data obtained for the uridine degradation over time using either HPLC-DAD analysis (triplicates, grey) or UV-vis spectrophotometry at 262 nm with a 1 cm cuvette (blue) in experiments with six (A) UVB and (B) UVC bulbs in the merry-go-round photoreactor, the (C) LED 258 nm, (D) LED 266 nm (E), and LED 279 nm light sources in the commercially available LED photoreactor, and the (F) LED 276 nm light source in the custom-built LED photoreactor.

Text S6. High-performance Liquid Chromatography Methods to Analyze Optically Transparent Chemicals.

Uridine, atrazine, PNA, sulfamethoxazole, and diclofenac concentrations in samples collected during experiments were measured using high-performance liquid chromatography with a diode array detector (HPLC-DAD, Agilent 1260) with a 3.0x150 mm 4 micron HPH-C18 column. Samples were eluted with acetonitrile (eluent A), ultrapure water with 10% acetonitrile (eluent B), or 10 mM pH 3 phosphate buffer with 10% acetonitrile (eluent C) at a flow rate of 0.6 mL/min. Uridine was eluted with B and detected at λ=262 nm. Atrazine was eluted with 50:50 A:B and detected at λ=264 nm. PNA was eluted with 50:50 A:B and detected at λ=316 nm. Sulfamethoxazole was eluted with 25:75 A:C and detected at λ=266 nm. Diclofenac was eluted with 60:40 A:C and detected at λ=220 nm.

Text S7. Pseudo-first-order Rate Constants Calculation for Uridine, Atrazine, PNA, Sulfamethoxazole, and Diclofenac

To determine first-order decay rate constants of direct photolysis (k^i, Equation S6) of each optically transparent chemical *i* (i.e., uridine, atrazine, PNA, sulfamethoxazole, and diclofenac), the chemical degradation was monitored using HPLC-DAD (methods described in Text S6). For each replicate sample collected at time *t*, the HPLC peak areas ($Area_t^i$) were determined by automatic integration in the chromatograms. To calculate k^i, replicate -ln($Area_t^i/Area_0^i$) for each time point were pooled and plotted versus time; k^i was calculated as the slope of the best-fit line, determined by linear regression.

$$-ln\left(\frac{Area_t^i}{Area_0^i}\right) = k^i t \quad \text{(S6)}$$

Text S8. Determining Molar Absorptivities of Uridine, Atrazine, PNA, Sulfamethoxazole, and Diclofenac

Absorbance measurements were collected using the UV-vis spectroradiometer at varying solution concentrations in water or the previously indicated buffer and using two quartz cuvettes (i.e., 1 cm and 10 cm). These data were then used to calculate the molar absorptivities of uridine, atrazine, PNA, sulfamethoxazole, and diclofenac according to Equation S7, where A_λ is the absorbance measured at each wavelength, *C* is the chemical concentration in water, and *l* is the cuvette pathlength:

$$\varepsilon_\lambda = \frac{A_\lambda}{C \times l} \qquad \text{(S7)}$$

The molar absorptivity curves obtained were then fitted with a series of Gaussian curves in MATLAB following Equation S8. The fitting values are reported in Table S2 and can be used to reconstruct the molar absorptivity spectra of the chemicals (Figure S6).

$$\varepsilon_\lambda = \sum_{i=1}^{n} (Peak\ height)_i\ e^{\left[-\left(\frac{\lambda - (Peak\ position)_i}{(Peak\ width)_i}\right)^2\right]} \qquad \text{(S8)}$$

Table S2. Peak height, peak position, and peak width values for the series of Gaussian curves plotted in MATLAB that reconstruct (Equation S8) the molar absorptivity spectra of uridine, atrazine, PNA, sulfamethoxazole at pH 7.2 and 8, and diclofenac. The curves are a result of interpolating multiple measurements of the molar absorptivity of the chemicals. Table continued on the next page.

Uridine				
Curve #	curve #1	curve #2	curve #3	curve #4
Peak Height (M^{-1} cm^{-1})	100784	9298.89	5343.32	7187.17
Peak Position (nm)	168.50	208.91	269.36	255.02
Peak Width (nm)	18.81	15.34	13.52	18.06

Atrazine			
Curve #	curve #1	curve #2	curve #3
Peak Height (M^{-1} cm^{-1})	19672.0	20513.9	3633.09
Peak Position (nm)	223.91	219.69	263.84
Peak Width (nm)	10.03	18.91	16.79

p-Nitroanisole (PNA)								
Curve #	curve #1	curve #2	curve #3	curve #4	curve #5	curve #6	curve #7	curve #8
Peak Height (M^{-1} cm^{-1})	4327.24	6231.67	6292.47	1513.60	2653.78	512.93	1066.41	7592.86
Peak Position (nm)	198.21	203.27	221.89	230.56	322.01	317.39	241.07	315.35
Peak Width (nm)	3.31	6.37	17.48	6.17	33.13	19.35	7.16	42.02

Sulfamethoxazole, pH 7.2				
Curve #	curve #1	curve #2	curve #3	curve #4
Peak Height (M^{-1} cm^{-1})	38208.56	6450.14	18457.37	1913.26
Peak Position (nm)	197.90	232.29	257.03	288.04
Peak Width (nm)	18.47	11.92	19.18	15.56

Sulfamethoxazole, pH 8				
Curve #	curve #1	curve #2	curve #3	curve #4
Peak Height (M^{-1} cm^{-1})	49302.20	6532.17	5982.39	13589.00
Peak Position (nm)	186.09	208.48	260.12	249.66
Peak Width (nm)	22.35	7.67	12.27	31.56

Table S2. Continued.

Diclofenac			
Curve #	curve #1	curve #2	curve #3
Peak Height (M^{-1} cm^{-1})	11915.37	31330.86	9889.50
Peak Position (nm)	199.55	198.75	276.77
Peak Width (nm)	7.78	31.11	24.35

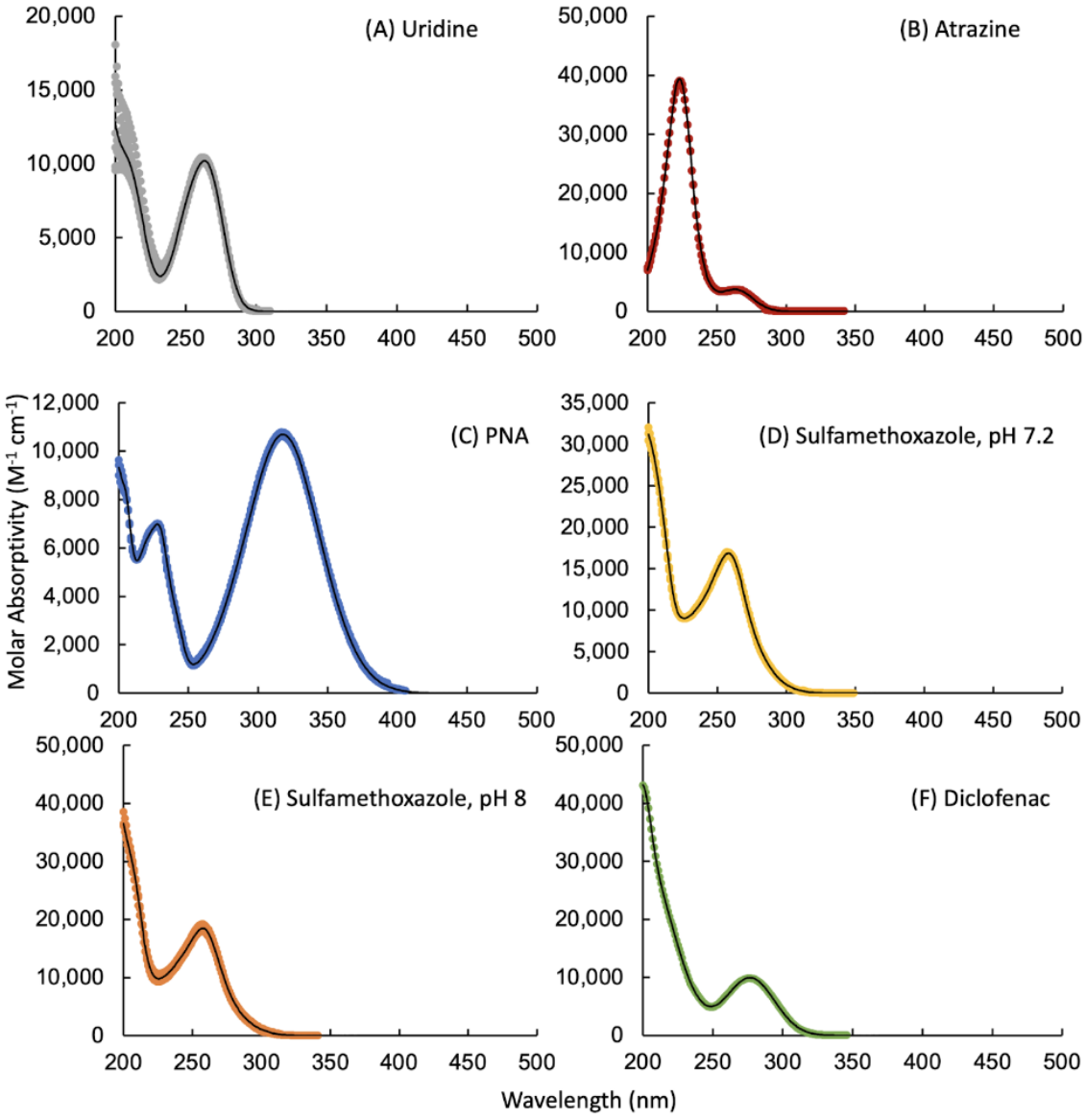


Figure S6. Molar absorptivity curves obtained from different measurements by varying the chemical concentration for (A) uridine, (B) atrazine, (C) PNA, (D) sulfamethoxazole pH 7.2, (E) sulfamethoxazole pH 8, and (F) diclofenac as colorful dots. The black lines correspond to the fitted curves from MATLAB results (Equation S8, Table S2, Figure S7).

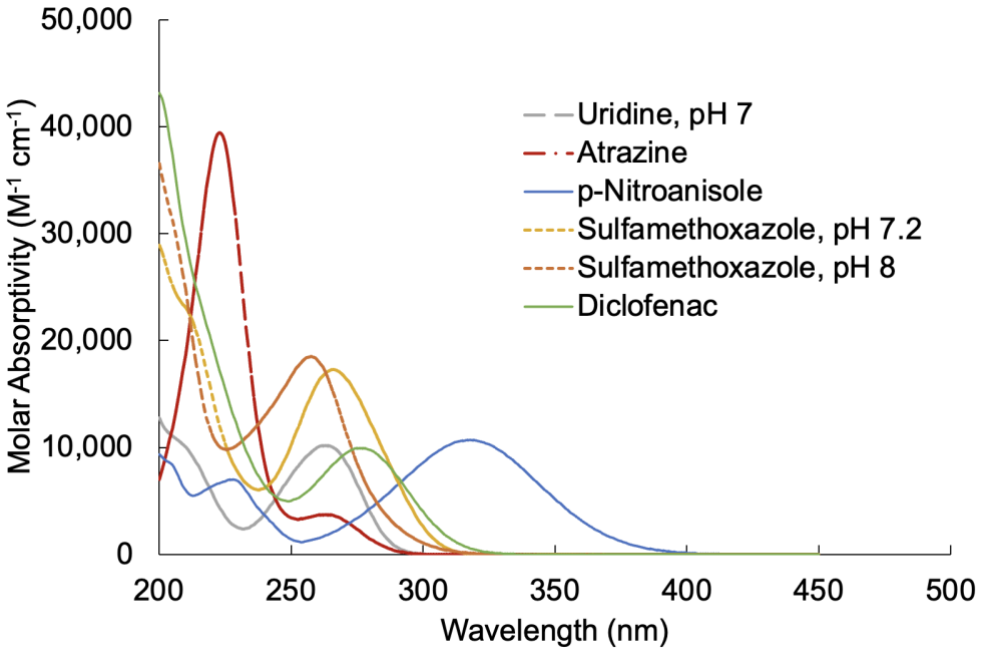


Figure S7. Molar absorptivity spectrum of uridine, atrazine, PNA, sulfamethoxazole at pH 7.2 and pH 8, and diclofenac in solutions made in water. These curves were obtained from fitting a series of Gaussian curves in MATLAB with values reported in Table S2.

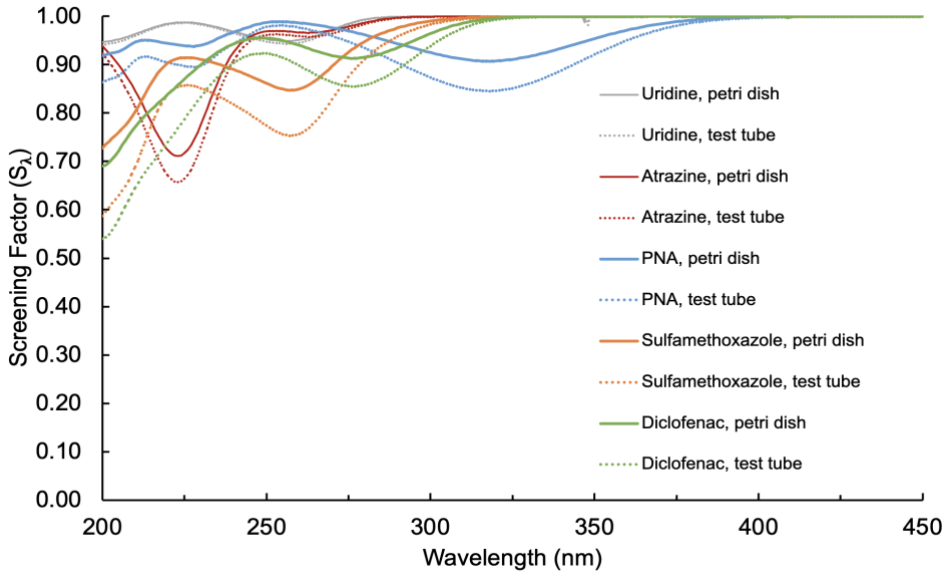


Figure S8. Screening factors (200-450 nm) calculated according to Equations 1-2 (main text) for uridine, atrazine, PNA, sulfamethoxazole pH 8, and diclofenac. Molar absorptivity values used in the calculations are reported in Table S2 and displayed in Figure S7. The solution concentration was 10 μM for all chemicals, except uridine (5 μM). The optical path length was 0.8 cm when using the petri dish and 1 cm with the test tubes. The differences in optical path length which varied based on the sample container chosen influenced the differences in screening factors observed for each chemical.

Table S3. UV total irradiances ($\sum_{\lambda} I_{250-400\,nm}$) obtained from spectroradiometer measurements. Six UVB bulbs were placed on the ceiling of the photoreactor. Irradiance measurements were taken by positioning the spectroradiometer sensor in the center or either 3 cm or 6 cm to the right, left, front, and back directions from the center, representing the edges of the aluminum surface where the petri dish sat (Figure 1A in the main text).

Position of the Sensor	Measured Total UV Irradiance (250-400 nm, W/m^2)
Center	52.71
3 cm from center to the front	57.43
6 cm from center to the front	56.56
3 cm from center to the back	45.80
6 cm from center to the back	37.26
3 cm from center to the right	52.50
6 cm from center to the right	44.77
3 cm from center to the left	51.67
6 cm from center to the left	45.48

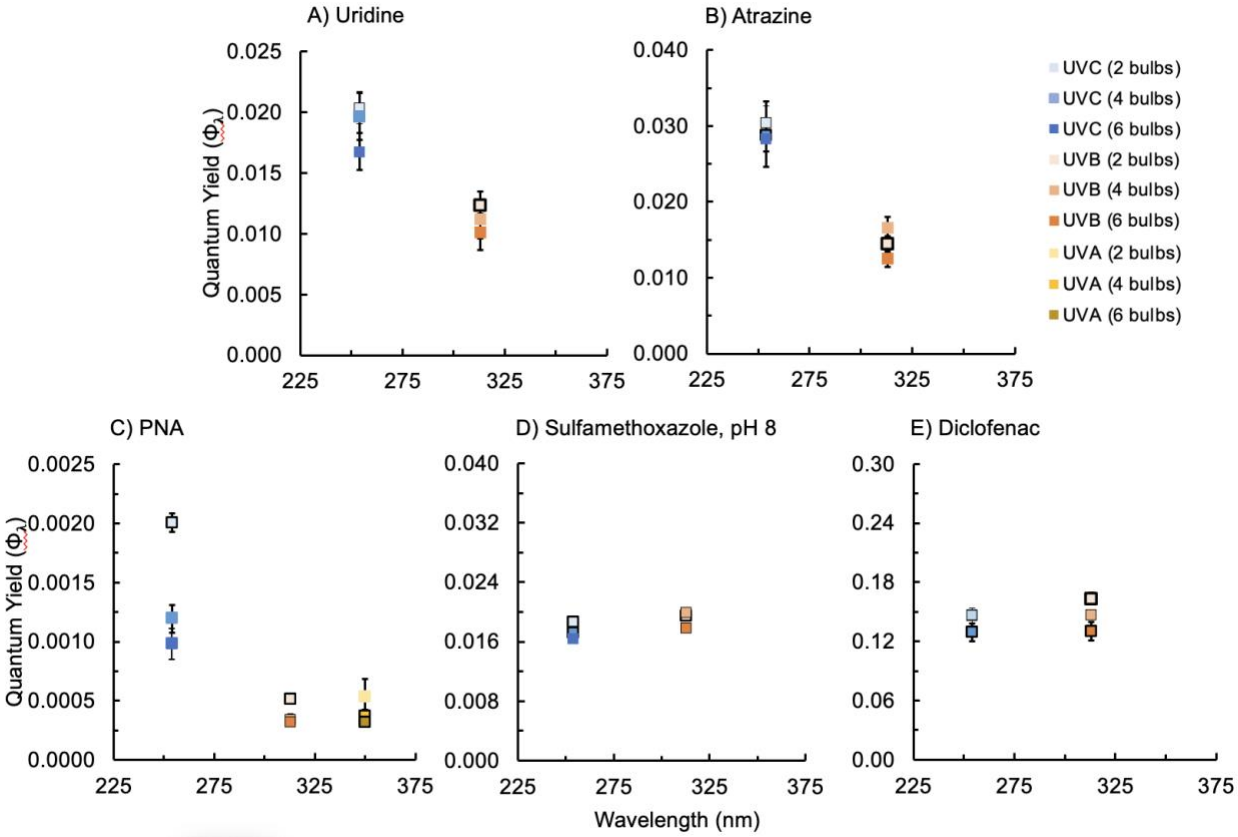


Figure S9. Apparent Φλ calculated for (A) uridine, (B), atrazine, (C) PNA, (D) sulfamethoxazole pH 8, and (E) diclofenac in experiments using two, four, or six bulbs placed on the ceiling of the merry-go-round photoreactor. Experiments with UVC, UVB, and UVA bulbs were performed. The black petri dish was used as sample container in all experiments and the photon irradiances were using the spectroradiometer. Error bars represent the standard deviation of at least three independent experiments, and error bars that are not visible are smaller than the symbol. Numerical results and t-test comparisons are available in Tables S4-S5. Chemical degradation over time plots for each of the experiments are displayed in Figure S10.

Table S4. Apparent Φ_λ and standard deviations (SD) calculated for uridine, atrazine, PNA, sulfamethoxazole pH 8, and diclofenac in experiments using two, four, or six bulbs placed on the ceiling of the merry-go-round photoreactor. Experiments with UVC, UVB, and UVA bulbs were performed. The UV total photon irradiances summed over the 200-500 nm region and obtained with the spectroradiometer are reported. The black petri dish was used as the solution container in all experiments. T-test results are available in Table S5 and the chemical degradation over time plots for each of the experimental setups are displayed in Figure S10.

Experimental Setup	Number of Bulbs	Quantum Yield (Φ_λ) ± SD	Measured Total UV Photon Irradiance (mE cm^{-2} min^{-1})
Uridine			
UVC experiments	2 bulbs	0.0204±0.0013	0.00031±0.00006
	4 bulbs	0.0197±0.0019	0.00061±0.00002
	6 bulbs	0.0168±0.0015	0.00089±0.00007
UVB experiments	2 bulbs	0.0124±0.0011	0.00034±0.00005
	4 bulbs	0.0112±0.0016	0.00059±0.00008
	6 bulbs	0.0101±0.0015	0.00092±0.00006
Atrazine			
UVC experiments	2 bulbs	0.0305±0.0021	0.00031±0.00001
	4 bulbs	0.0289±0.0043	0.00063±0.00005
	6 bulbs	0.0283±0.0017	0.00080±0.00001
UVB experiments	2 bulbs	0.0145±0.0010	0.00035±0.00004
	4 bulbs	0.0166±0.0014	0.00075±0.00007
	6 bulbs	0.0126±0.0011	0.00099±0.00006
PNA			
UVC experiments	2 bulbs	0.00201±0.00008	0.00032±0.00007
	4 bulbs	0.00120±0.00012	0.00055±0.00007
	6 bulbs	0.00098±0.00013	0.00092±0.00006
UVB experiments	2 bulbs	0.00051±0.00001	0.00033±0.00004
	4 bulbs	0.00034±0.00005	0.00060±0.00010
	6 bulbs	0.00032±0.00002	0.00091±0.00006
UVA experiments	2 bulbs	0.00054±0.00014	0.00036±0.00003
	4 bulbs	0.00037±0.00005	0.00068±0.00010
	6 bulbs	0.00031±0.00002	0.00078±0.00004
Sulfamethoxazole, pH 8			
UVC experiments	2 bulbs	0.0187±0.0003	0.00031±0.00004
	4 bulbs	0.0172±0.0003	0.00066±0.00002
	6 bulbs	0.0164±0.0004	0.00096±0.00004
UVB experiments	2 bulbs	0.0195±0.0004	0.00032±0.00006
	4 bulbs	0.0199±0.0005	0.00066±0.00005
	6 bulbs	0.0178±0.0006	0.00088±0.00002
Diclofenac			
UVC experiments	2 bulbs	0.146±0.008	0.00030±0.00001
	4 bulbs	0.147±0.002	0.00056±0.00005
	6 bulbs	0.129±0.009	0.00074±0.00004
UVB experiments	2 bulbs	0.164±0.006	0.00030±0.00001
	4 bulbs	0.147±0.003	0.00062±0.00008
	6 bulbs	0.130±0.010	0.00083±0.00002

Table S5. T-test p-values obtained by comparing the uridine, atrazine, PNA, sulfamethoxazole pH 8, and diclofenac Φ_λ from experiments with two, four, or six bulbs. Quantum yield averages and standard deviations are reported in Table S4. Experiments were performed with UVC, UVB, and UVA bulbs placed on the ceiling of the merry-go-round photoreactor, with black petri dishes as sample containers.

Experimental Setup	p-value (2 vs. 4 bulbs)	p-value (2 vs. 6 bulbs)	p-value (4 vs. 6 bulbs)
Uridine			
UVC experiments	0.65	0.09	0.34
UVB experiments	0.28	0.10	0.40
Atrazine			
UVC experiments	0.61	0.30	0.97
UVB experiments	0.10	0.10	0.02
PNA			
UVC experiments	0.001	0.0007	0.10
UVB experiments	0.03	0.003	0.57
UVA experiments	0.05	0.02	0.02
Sulfamethoxazole, pH 8			
UVC experiments	0.002	<0.0001	0.02
UVB experiments	0.40	0.02	0.01
Diclofenac			
UVC experiments	0.93	0.07	0.07
UVB experiments	0.02	0.01	0.09

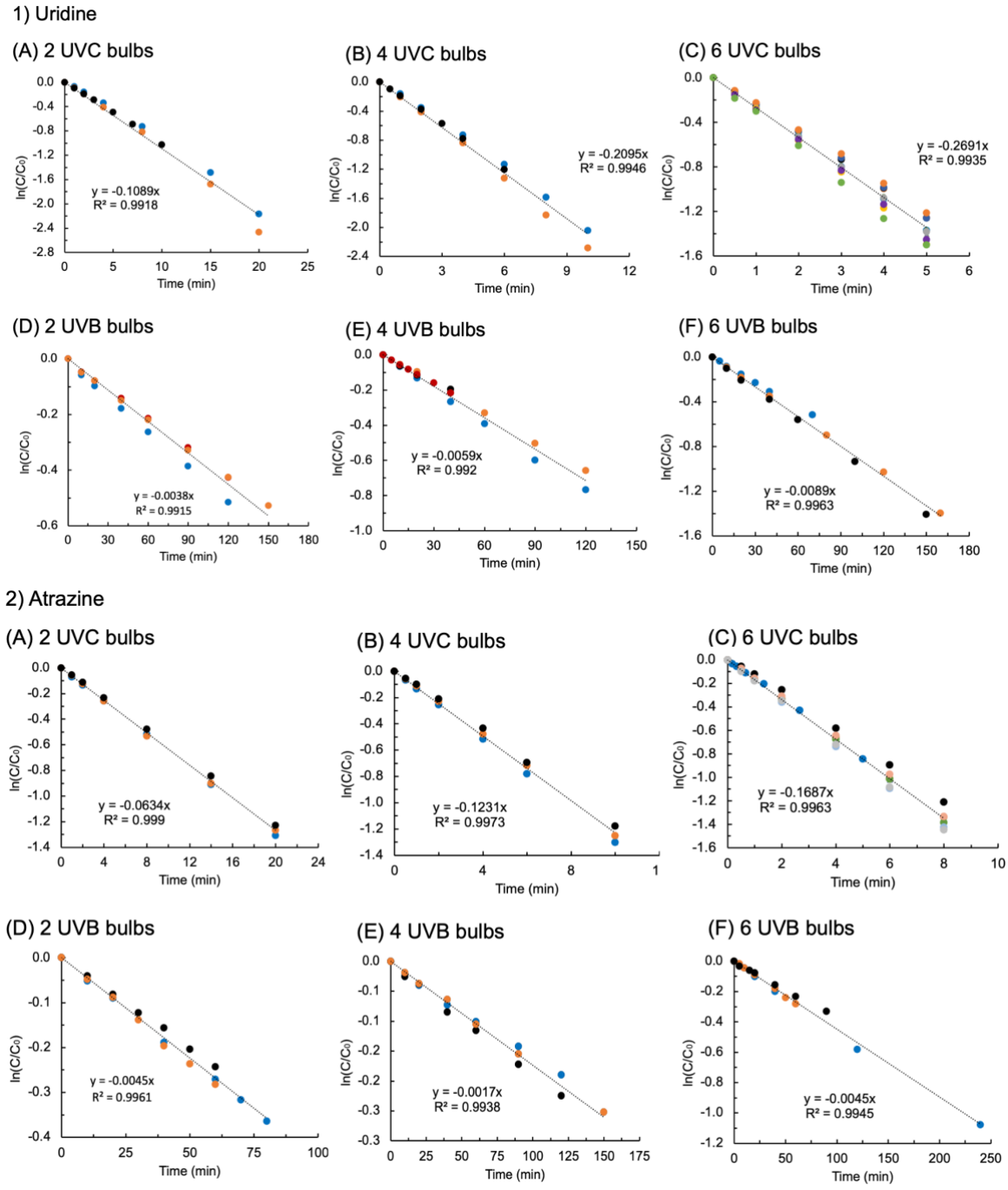
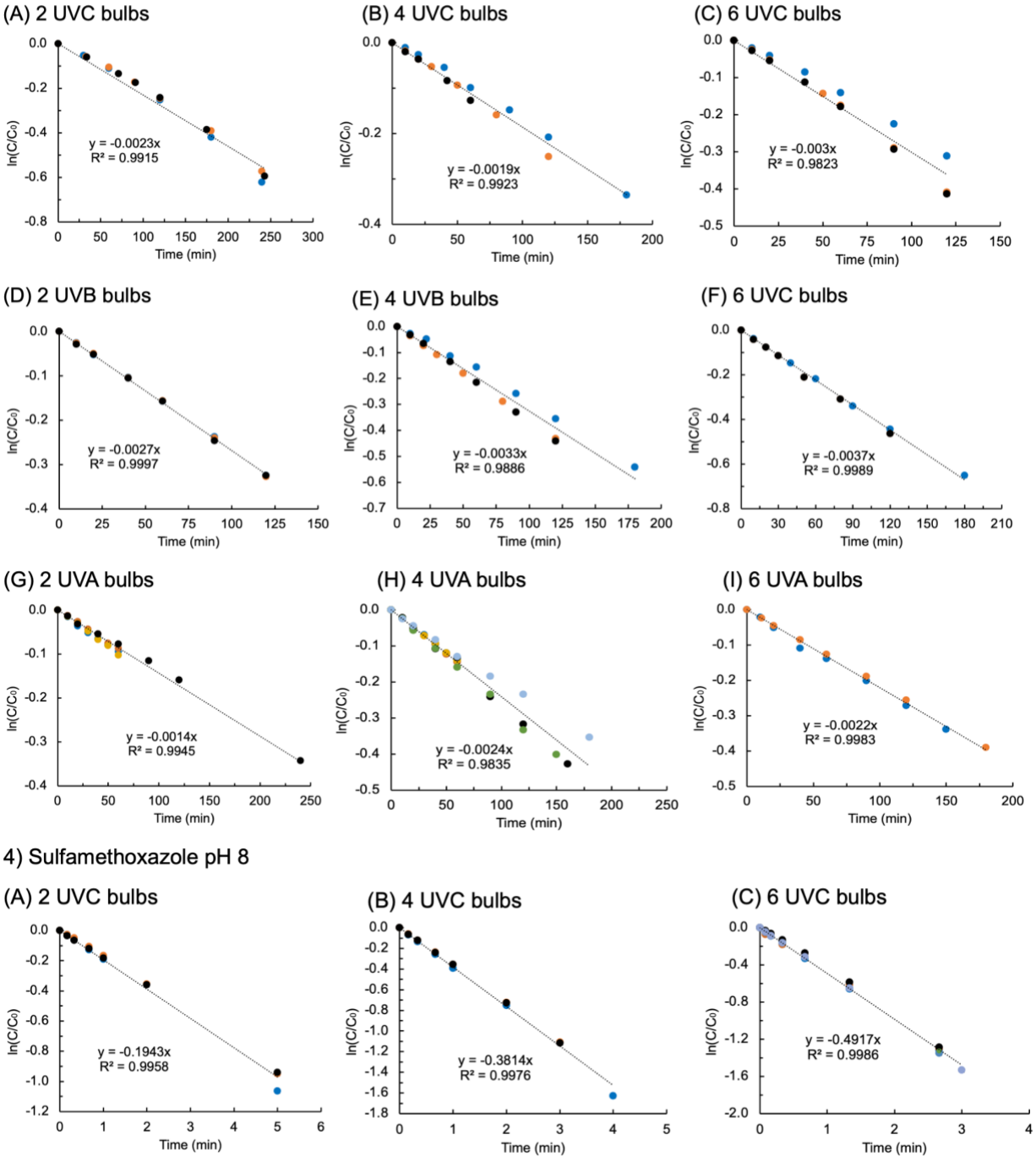


Figure S10. Chemical degradation over time for experiments with (1) uridine, (2) atrazine, (3) PNA, (4) sulfamethoxazole pH 8, and (5) diclofenac and (A) two UVC, (B) four UVC, (C) six UVC bulbs, (D) two UVB, (E) four UVB, (F) six UVB bulbs, (G) two UVA, (H) four UVA, and (I) six UVA bulbs in the merry-go-round photoreactor. Bulbs were placed on the ceiling of the photoreactor and the black petri dish was used in all experiments. Each of the experiments was done in triplicate at a minimum. The slope of the curve was used to determine the apparent Φ of each chemical in each experimental setup. Each color represents the results from a replicate experiment. Figure continued on the next pages.

Figure S10. Continued.

3) PNA



4) Sulfamethoxazole pH 8

Figure S10. Continued. 4) Sulfamethoxazole pH 8

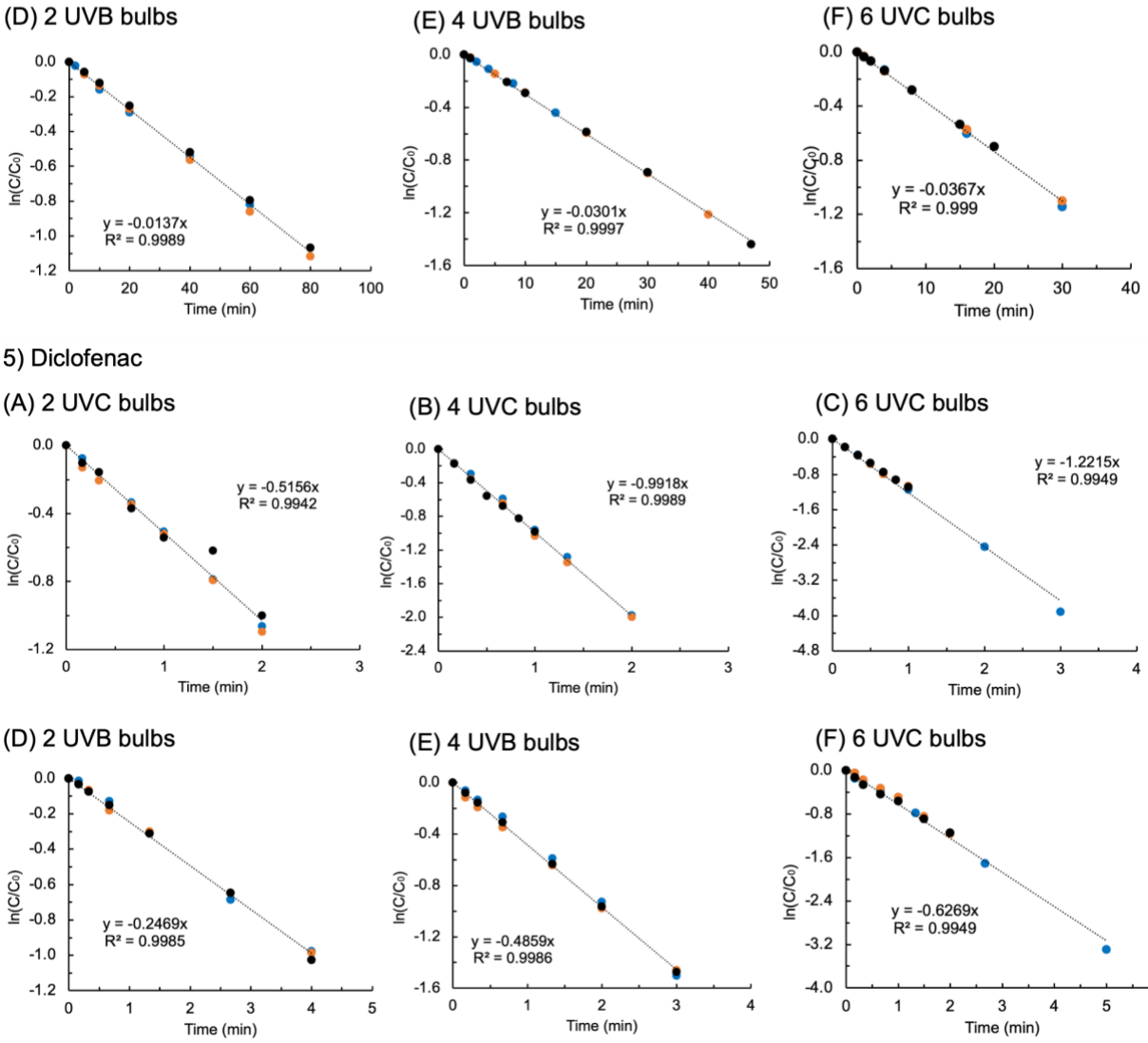


Table S6. UV total irradiance obtained when placing UVB bulbs on the ceiling of the merry-go-round photoreactor. The number and position of the UVB bulbs inside the photoreactor were varied. Total irradiance was obtained using the spectroradiometer, and the spectroradiometer sensor was positioned at the center of the photoreactor, pointing towards the ceiling where the bulbs were located, and at the same distance as the solutions were placed for the Φ_λ calculations with the black petri dish. The total irradiances were normalized by the number of bulbs for comparison. Bulb positions are shown in Figure S11.

Number of Bulbs and Position	**Measured Total UV Irradiance (250-400 nm, W/m^2)**	**Total Irradiance Normalized by Number of Bulbs**
1 UVB, position 3	7.55	7.55
1 UVB, position 4	7.54	7.54
2 UVB, positions 3-4	15.15	7.57
3 UVB, positions 2-4	26.07	8.69
3 UVB, positions 3-5	25.80	8.60
4 UVB, positions 2-5	36.30	9.07
5 UVB, positions 1-5	43.55	8.71
5 UVB, positions 2-6	42.58	8.52
6 UVB, positions 1-6	48.98	8.16

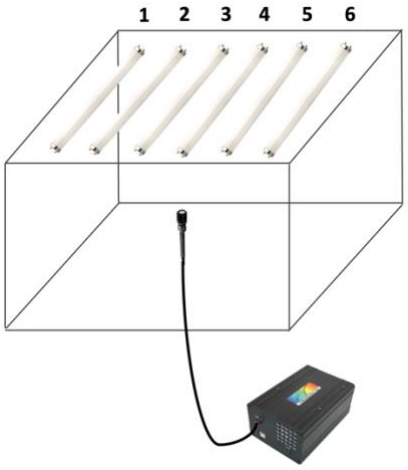


Figure S11. Schematic of placement and position numbers of the bulbs in the merry-go-round photoreactor. Total irradiances obtained by varying the number of bulbs and their position inside the photoreactor are available in Tables S6.

Table S7. UV total irradiances obtained with the spectroradiometer when placing each of the 14 UVB bulbs at a time on the ceiling of the merry-go-round photoreactor. All bulbs were placed in position 3 shown in Figure S11.

UVB Bulb #	Measured Total UV Irradiance (250-400 nm, W/m^2)
Bulb #1	8.04
Bulb #2	8.54
Bulb #3	9.39
Bulb #4	9.75
Bulb #5	8.71
Bulb #6	8.74
Bulb #7	9.07
Bulb #8	9.57
Bulb #9	9.88
Bulb #10	8.61
Bulb #11	8.52
Bulb #12	8.65
Bulb #13	9.47
Bulb #14	8.67

Table S8. Recalculated atrazine Φ_{254} based on the reported values by Hessler et al. (1993)[5] and by correcting each Φ_{254} reported at different concentrations by the screening factor (Equation 2 in the main text) derived from the absorbance of each solution and the quartz test tube path length of 1 cm. Both the absorbances and optical path length were reported in that study.

Concentration (μM)[5]	Absorbance at 254 nm[5]	Screening Factor	Reported Φ_{254}[5]	Corrected Φ_{254}
3	0.012	0.986	0.047±0.006	0.048
6	0.023	0.974	0.046±0.004	0.047
17	0.061	0.933	0.042±0.004	0.045
23	0.078	0.915	0.037±0.003	0.04
33	0.116	0.877	0.038±0.003	0.043
41	0.144	0.851	0.033±0.003	0.039
66	0.232	0.775	0.034±0.003	0.044
78	0.274	0.741	0.031±0.003	0.042
110	0.388	0.661	0.029±0.003	0.044
160	0.567	0.558	0.028±0.003	0.05
			Average	**0.044**
			Standard Deviation	**0.003**

Table S9. Measured average Φ_λ, their standard deviation, and the number of replicate experiments conducted (n) for sulfamethoxazole at pH 7.2 determined using multiple light sources. Chemical degradation over time plots for all experiments are available in Figure S12.

Experimental Setup	*n*	Quantum Yield
Sulfamethoxazole pH 7.2		
Merry-go-round UVC (max. 254 nm)	3	0.0177 ± 0.0005
Commercially-available LED 258 nm	3	0.0212 ± 0.0005
Commercially-available LED 266 nm	3	0.0208 ± 0.0013
Custom-built LED 276 nm	3	0.0222 ± 0.0003
Commercially-available LED 279 nm	3	0.0277 ± 0.0006
Merry-go-round UVB (max. 313 nm)	3	0.0329 ± 0.0027

Table S10. Linear regression statistics results for (A) uridine, (B) atrazine, (C) PNA, (D) sulfamethoxazole pH 7.2, (E) sulfamethoxazole pH 8, and (F) diclofenac with the wavelengths as the x-variables and the corresponding Φ_λ as the y-variables. Table continued on the next pages.

(A) Uridine

Regression Statistics	
Multiple R	0.9801693
R Square	0.96073187
Adjusted R Square	0.95091483
Standard Error	0.00053157
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.7653E-05	2.7653E-05	97.8637651	0.00058599
Residual	4	1.1303E-06	2.8257E-07		
Total	5	2.8784E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.0449	0.0031	14.63	0.0001	0.0364	0.0534
X Variable 1	-1.10E-04	1.12E-05	-9.9	0.0006	-1.41E-04	-7.94E-05

(B) Atrazine

Regression Statistics	
Multiple R	0.95590395
R Square	0.91375237
Adjusted R Square	0.89219046
Standard Error	0.00168666
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.2056E-05	1.2056E-05	42.3780859	0.00287382
Residual	4	1.1379E-05	2.8448E-06		
Total	5	0.00013194			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.0843	0.0097	8.6617	0.0010	0.0573	0.1114
X Variable 1	-2.30E-04	3.54E-05	-6.5098	0.0029	-3.29E-04	-1.32E-05

Table S10. Continued. (C) PNA

Regression Statistics	
Multiple R	0.85003778
R Square	0.72256423
Adjusted R Square	0.69173803
Standard Error	0.00019088
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	8.5403E-07	8.5403E-07	23.4399407	0.00091913
Residual	9	3.2791E-07	3.6435E-08		
Total	10	1.1819E-06			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.0027	0.0004	5.9900	0.0002	0.0017	0.0037
X Variable 1	-7.08E-06	1.46E-06	-4.8415	0.0009	-1.04E-05	-3.77E-06

(D) Sulfamethoxazole pH 7.2

Regression Statistics	
Multiple R	0.94766877
R Square	0.8980761
Adjusted R Square	0.87259512
Standard Error	0.00197844
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.00013796	0.00013796	35.2449645	0.00403618
Residual	4	1.5657E-05	3.9142E-06		
Total	5	0.00015361			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.0439	0.0114	-3.841	0.0184	-0.0756	-0.0121
X Variable 1	0.0002	4.15E-05	5.937	0.0040	0.0001	0.0004

Table S10. Continued. (E) Sulfamethoxazole pH 8

Regression Statistics	
Multiple R	0.73217881
R Square	0.53608581
Adjusted R Square	0.42010727
Standard Error	0.00099151
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.5441E-06	4.5441E-06	4.62228429	0.09798712
Residual	4	3.9323E-06	9.8309E-07		
Total	5	8.4764E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.0036	0.0057	0.6367	0.5589	-0.01225	0.0153
X Variable 1	4.47E-05	2.08E-05	2.1499	0.0980	-1.304E-05	0.0001

(F) Diclofenac

Regression Statistics	
Multiple R	0.16383602
R Square	0.02684224
Adjusted R Square	-0.2164472
Standard Error	0.00937866
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	9.7046E-06	9.7046E-06	0.11033048	0.75644484
Residual	4	0.00035184	8.7959E-05		
Total	5	0.00036154			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.1568	0.0541	2.8957	0.0443	0.0065	0.3071
X Variable 1	-6.53E-05	0.0002	-0.3322	0.7564	-0.0006	0.0005

Table S11. Brown-Forsythe and Welch ANOVA tests and Dunnett's T3 multiple comparisons test results for (A) uridine, (B) atrazine, (C) PNA, (D) sulfamethoxazole pH 7.2, (E) sulfamethoxazole pH 8, and (F) diclofenac with Φ_λ from individual experimental runs for each of the light sources as input data. *UVC, UVB, and UVA* refer to experiments performed in the merry-go-round photoreactor, *AquiSense* refers to experiments performed in the commercially available LED photoreactor, *LED* refers to experiments performed in the custom-built LED photoreactor. Table continued the on next pages.

(A) Uridine

Brown-Forsythe ANOVA test		**Welch's ANOVA test**	
F* (DFn, DFd)	18.89 (5.000, 12.11)	W (DFn, DFd)	14.38 (5.000, 7.357)
P value	<0.0001	P value	0.0012

Dunnett's T3 multiple comparisons test	**Mean Diff.**	**95% CI of diff.**	**Adjusted P Value**
6 UVC vs. AquiSense 258 nm	0.0017	-0.0022 to 0.0057	0.6863
6 UVC vs. AquiSense 266 nm	0.0035	-0.0028 to 0.0098	0.2187
6 UVC vs. LED 276 nm	0.0033	0.0016 to 0.0049	0.0002
6 UVC vs. AquiSense 279 nm	0.0038	0.0020 to 0.0056	0.0001
6 UVC vs. 6 UVB	0.0081	0.0021 to 0.0141	0.0212
AquiSense 258 nm vs. AquiSense 266 nm	0.0018	-0.0026 to 0.0071	0.8720
AquiSense 258 nm vs. LED 276 nm	0.0015	-0.0026 to 0.0056	0.7280
AquiSense 258 nm vs. AquiSense 279 nm	0.0021	-0.0018 to 0.0060	0.4335
AquiSense 258 nm vs. 6 UVB	0.0064	-0.0012 to 0.0116	0.0194
AquiSense 266 nm vs. LED 276 nm	-0.0002	-0.0089 to 0.0083	>0.9999
AquiSense 266 nm vs. AquiSense 279 nm	0.0003	-0.0086 to 0.0091	>0.9999
AquiSense 266 nm vs. 6 UVB	0.0046	-0.0018 to 0.0110	0.1425
LED 276 nm vs. AquiSense 279 nm	0.0006	-0.0011 to 0.0023	0.7284
LED 276 nm vs. 6 UVB	0.0049	-0.0033 to 0.0131	0.1319
AquiSense 279 nm vs. 6 UVB	0.0043	-0.0040 to 0.0127	0.1705

(B) Atrazine

Brown-Forsythe ANOVA test		**Welch's ANOVA test**	
F* (DFn, DFd)	74.28 (5.000, 19.61)	W (DFn, DFd)	50.39 (5.000, 8.259)
P value	<0.0001	P value	<0.0001

Table S11. Continued. (B) Atrazine.

Dunnett's T3 multiple comparisons test	Mean Diff.	95% CI of diff.	Adjusted P Value
6 UVC vs. AquiSense 258 nm	0.0051	0.0020 to 0.0083	0.0014
6 UVC vs. AquiSense 266 nm	0.0065	0.0029 to 0.0101	0.0027
6 UVC vs. LED 276 nm	0.0071	0.0045 to 0.0097	<0.0001
6 UVC vs. AquiSense 279 nm	0.0088	0.0051 to 0.0125	0.0003
6 UVC vs. 6 UVB	0.0157	0.0120 to 0.0195	<0.0001
AquiSense 258 nm vs. AquiSense 266 nm	0.0014	-0.0024 to 0.0051	0.8004
AquiSense 258 nm vs. LED 276 nm	0.0020	-0.0009 to 0.0048	0.2700
AquiSense 258 nm vs. AquiSense 279 nm	0.0037	-0.0002 to 0.0075	0.0616
AquiSense 258 nm vs. 6 UVB	0.0159	0.0067 to 0.0115	0.0003
AquiSense 266 nm vs. LED 276 nm	0.0006	-0.0031 to 0.0043	0.9937
AquiSense 266 nm vs. AquiSense 279 nm	0.0023	-0.0019 to 0.0066	0.3654
AquiSense 266 nm vs. 6 UVB	0.0092	0.0047 to 0.0138	0.0038
LED 276 nm vs. AquiSense 279 nm	0.0017	-0.0020 to 0.0054	0.25048
LED 276 nm vs. 6 UVB	0.0086	0.0039 to 0.0134	0.0089
AquiSense 279 nm vs. 6 UVB	0.0069	0.0025 to 0.0113	0.0072

(C) PNA

Brown-Forsythe ANOVA test		Welch's ANOVA test	
F* (DFn, DFd)	129.8 (10.00, 5.908)	W (DFn, DFd)	219.6 (10.00, 9.172)
P value	<0.0001	P value	<0.0001

Dunnett's T3 multiple comparisons test	Mean Diff.	95% CI of diff.	Adjusted P Value
6 UVC vs. AquiSense 258 nm	-0.00018	-0.0008675 to 0.0005009	0.7776
6 UVC vs. LED 279 nm	0.00053	-0.0003717 to 0.001433	0.1371
6 UVC vs. AquiSense 279 nm	0.00047	-0.0001386 to 0.001080	0.1002
6 UVC vs. AquiSense 266 nm	-2.48e-05	-0.0008965 to 0.0008469	>0.9999
6 UVC vs. 6 UVB	0.00066	-0.0002060 to 0.001532	0.0842
6 UVC vs. LED 316 nm	0.00065	-0.0002221 to 0.001519	0.0881
6 UVC vs. 6 UVA	0.00067	-0.0001984 to 0.001532	0.0826
6 UVC vs. LED 346 nm	0.00064	-0.0002608 to 0.001542	0.0963
6 UVC vs. LED 368 nm	0.00081	-5.418e-005 to 0.001668	0.0567
6 UVC vs. Solar Simulator	0.00070	-0.0001671 to 0.001559	0.0757
AquiSense 258 nm vs. LED 276 nm	0.00071	0.0002969 to 0.001131	0.0108
AquiSense 258 nm vs. AquiSense 279 nm	0.00065	0.0002275 to 0.001081	0.0149
AquiSense 258 nm vs. AquiSense 266 nm	0.00016	-0.0004207 to 0.0007378	0.4837
AquiSense 258 nm vs. 6 UVB	0.00085	0.0002711 to 0.001422	0.0235
AquiSense 258 nm vs. LED 316 nm	0.00083	0.0002543 to 0.001409	0.0245
AquiSense 258 nm vs. 6 UVA	0.00085	0.0002807 to 0.001419	0.0228
AquiSense 258 nm vs. LED 346 nm	0.00082	0.0004077 to 0.001241	0.0071
AquiSense 258 nm vs. LED 368 nm	0.00099	0.0004270 to 0.001554	0.0165
AquiSense 258 nm vs. Solar Simulator	0.00088	0.0003130 to 0.001446	0.0211

Table S11. Continued. (C) PNA

Dunnett's T3 multiple comparisons test	Mean Diff.	95% CI of diff.	Adjusted P Value
LED 276 nm vs. AquiSense 279 nm	-5.972e-005	-0.0002875 to 0.0001681	0.9243
LED 276 nm vs. AquiSense 266 nm	-0.0005554	-0.0007673 to -0.0003435	0.0031
LED 276 nm vs. 6 UVB	0.0001325	-7.459e-005 to 0.0003396	0.1618
LED 276 nm vs. LED 316 nm	0.0001179	-9.198e-005 to 0.0003278	0.2208
LED 276 nm vs. 6 UVA	0.0001361	-6.352e-005 to 0.0003357	0.1382
LED 276 nm vs. LED 346 nm	0.0001102	-0.0001044 to 0.0003248	0.3652
LED 276 nm vs. LED 368 nm	0.0002764	-1.080e-005 to 0.0005637	0.0539
LED 276 nm vs. Solar Simulator	0.0001654	-0.0001275 to 0.0004583	0.1478
AquiSense 280nm vs. AquiSense 266 nm	-0.0004957	-0.0007260 to -0.0002653	0.0055
AquiSense 279 nm vs. 6 UVB	0.0001922	-3.371e-005 to 0.0004182	0.0776
AquiSense 279 nm vs. LED 316 nm	0.0001776	-5.087e-005 to 0.0004061	0.0986
AquiSense 279 nm vs. 6 UVA	0.0001958	-0.0001322 to 0.0005238	0.1334
AquiSense 279 nm vs. LED 346 nm	0.0001699	-5.708e-005 to 0.0003969	0.1299
AquiSense 279 nm vs. LED 368 nm	0.0003362	1.869e-005 to 0.0006536	0.0447
AquiSense 279 nm vs. Solar Simulator	0.0002251	-9.751e-005 to 0.0005477	0.0997
AquiSense 266 nm vs. 6 UVB	0.0006879	0.0005759 to 0.0007999	<0.0001
AquiSense 266 nm vs. LED 316 nm	0.0006733	0.0005579 to 0.0007886	<0.0001
AquiSense 266 nm vs. 6 UVA	0.0006915	0.0005890 to 0.0007939	<0.0001
AquiSense 266 nm vs. LED 346 nm	0.0006656	0.0004549 to 0.0008762	0.0018
AquiSense 266 nm vs. LED 368 nm	0.0008318	0.0007196 to 0.0009441	0.0001
AquiSense 266 nm vs. Solar Simulator	0.0007208	0.0006236 to 0.0008180	<0.0001
6 UVB vs. LED 316 nm	-1.462e-005	-0.0001239 to 9.469e-005	>0.9999
6 UVB vs. 6 UVA	3.595e-006	-	>0.9999
6 UVB vs. LED 346 nm	-2.231e-005	-0.0002281 to 0.0001835	0.9998
6 UVB vs. LED 368 nm	0.0001439	4.109e-005 to 0.0002468	0.0193
6 UVB vs. Solar Simulator	3.288e-005	-5.706e-005 to 0.0001228	0.6868
LED 316 nm vs. 6 UVA	1.822e-005	-8.132e-005 to 0.0001178	0.9956
LED 316 nm vs. LED 346 nm	-7.688e-006	-	>0.9999
LED 316 nm vs. LED 368nm	0.0001586	5.026e-005 to 0.0002668	0.0170
LED 316 nm vs. Solar Simulator	4.750e-005	-4.663e-005 to 0.0001416	0.3802
6 UVA vs. LED 346 nm	-2.591e-005	-0.0002242 to 0.0001724	0.9980
6 UVA vs. LED 368 nm	0.0001403	5.352e-005 to 0.0002271	0.0127
6 UVA vs. Solar Simulator	2.928e-005	-3.970e-005 to 9.826e-005	0.6551
LED 346 nm vs. LED 368 nm	0.0001662	-0.0001189 to 0.0004514	0.1393
LED 346 nm vs. Solar Simulator	5.519e-005	-0.0002357 to 0.0003460	0.7348
LED 368 nm vs. Solar Simulator	-0.0001111	-0.00016 to -6.423e-005	0.0002

Table S11. Continued. (D) Sulfamethoxazole pH 7.2

Brown-Forsythe ANOVA test		Welch's ANOVA test	
F* (DFn, DFd)	46.32 (5.000, 4.196)	W (DFn, DFd)	41.45 (5.000, 5.264)
P value	0.0010	P value	0.0003

Dunnett's T3 multiple comparisons test	Mean Diff.	95% CI of diff.	Adjusted P Value
6 UVC vs. AquiSense 258 nm	-0.003575	-0.006585 to -0.00057	0.0274
6 UVC vs. AquiSense 266 nm	-0.003153	-0.009515 to 0.003210	0.2833
6 UVC vs. LED 276 nm	-0.004577	-0.007658 to -0.0015	0.0164
6 UVC vs. AquiSense 279 nm	-0.009996	-0.01325 to -0.006745	0.0007
6 UVC vs. 6 UVB	-0.01526	-0.03083 to 0.0003145	0.0520
AquiSense 258 nm vs. AquiSense 266 nm	0.0004226	-0.005676 to 0.006521	>0.9999
AquiSense 258 nm vs. LED 276 nm	-0.001002	-0.003492 to 0.001489	0.4238
AquiSense 258 nm vs. AquiSense 279 nm	-0.006421	-0.009308 to -0.0035	0.0026
AquiSense 258 nm vs. 6 UVB	-0.01168	-0.02702 to 0.003656	0.0843
AquiSense 266 nm vs. LED 276 nm	-0.001424	-0.009993 to 0.007144	0.7913
AquiSense 266 nm vs. AquiSense 279 nm	-0.006844	-0.01312 to -0.00057	0.0394
AquiSense 266 nm vs. 6 UVB	-0.01210	-0.02369 to -0.00052	0.0443
LED 276 nm vs. AquiSense 279 nm	-0.005420	-0.008322 to -0.0025	0.0085
LED 276 nm vs. 6 UVB	-0.01068	-0.02574 to 0.004383	0.0965
AquiSense 279 nm vs. 6 UVB	-0.005260	-0.02076 to 0.01024	0.3469

(E) Sulfamethoxazole pH 8

Brown-Forsythe ANOVA test		Welch's ANOVA test	
F* (DFn, DFd)	9.158 (5.000, 7.504)	W (DFn, DFd)	10.90 (5.000, 5.966)
P value	0.0045	P value	0.0058

Dunnett's T3 multiple comparisons test	Mean Diff.	95% CI of diff.	Adjusted P Value
6 UVC vs. AquiSense 258 nm	0.002034	0.0006973 to 0.0034	0.0065
6 UVC vs. AquiSense 266 nm	0.001911	-0.004234 to 0.0081	0.3953
6 UVC vs. LED 276 nm	2.057e-006	-	>0.9999
6 UVC vs. AquiSense 279nm	0.0004003	-0.001921 to 0.0027	0.9529
6 UVC vs. 6 UVB	-0.001403	-0.003823 to 0.0010	0.2004
AquiSense 258 nm vs. AquiSense 266 nm	-0.0001227	-0.004429 to 0.0042	>0.9999
AquiSense 258 nm vs. LED 276 nm	-0.002032	-0.006459 to 0.0024	0.3312
AquiSense 258 nm vs. AquiSense 279 nm	-0.001634	-0.003780 to 0.00051	0.1208
AquiSense 258 nm vs. 6 UVB	-0.003437	-0.005656 to -0.0012	0.0104
AquiSense 266 nm vs. LED 276 nm	-0.001909	-0.006647 to 0.0028	0.5531
AquiSense 266 nm vs. AquiSense 279 nm	-0.001511	-0.005995 to 0.0030	0.5619
AquiSense 266 nm vs. 6 UVB	-0.003314	-0.007850 to 0.0012	0.1145
LED 276 nm vs. AquiSense 279 nm	0.0003983	-0.004202 to 0.005	0.9997
LED 276 nm vs. 6 UVB	-0.001405	-0.006056 to 0.0032	0.6487
AquiSense 279 nm vs. 6 UVB	-0.001804	-0.004250 to 0.00064	0.1330

Table S11. Continued. (F) Diclofenac

Brown-Forsythe ANOVA test		Welch's ANOVA test	
F* (DFn, DFd)	3.001 (5.000, 8.535)	W (DFn, DFd)	1.555 (5.000, 5.145)
P value	0.0762	P value	0.3168

Dunnett's T3 multiple comparisons test	Mean Diff.	95.00% CI of diff.	Adjusted P Value
6 UVC vs. AquiSense 258 nm	-0.01455	-0.05875 to 0.02966	0.7287
6 UVC vs. AquiSense 266nm	-0.009129	-0.05851 to 0.04025	0.7283
6 UVC vs. LED 276 nm	-0.01004	-0.04642 to 0.02634	0.7177
6 UVC vs. AquiSense 279 nm	-0.02273	-0.06210 to 0.01665	0.2612
6 UVC vs. 6 UVB	-0.001097	-0.04055 to 0.03835	>0.9999
AquiSense 258 nm vs. AquiSense 266 nm	0.005417	-0.05886 to 0.06969	0.9893
AquiSense 258 nm vs. LED 276 nm	0.004505	-0.04126 to 0.05026	0.9991
AquiSense 258 nm vs. AquiSense 279 nm	-0.008181	-0.05373 to 0.03737	0.9849
AquiSense 258 nm vs. 6 UVB	0.01345	-0.03217 to 0.05907	0.8099
AquiSense 266 nm vs. LED 276 nm	-0.0009120	-0.01920 to 0.01738	>0.9999
AquiSense 266 nm vs. AquiSense 279 nm	-0.01360	-0.06677 to 0.03958	0.5160
AquiSense 266 nm vs. 6 UVB	0.008032	-0.04532 to 0.06139	0.8433
LED 276 nm vs. AquiSense 279 nm	-0.01269	-0.05142 to 0.02605	0.5848
LED 276 nm vs. 6 UVB	0.008944	-0.02991 to 0.04780	0.8371
AquiSense 279 nm vs. 6 UVB	0.02163	-0.01932 to 0.06258	0.3237

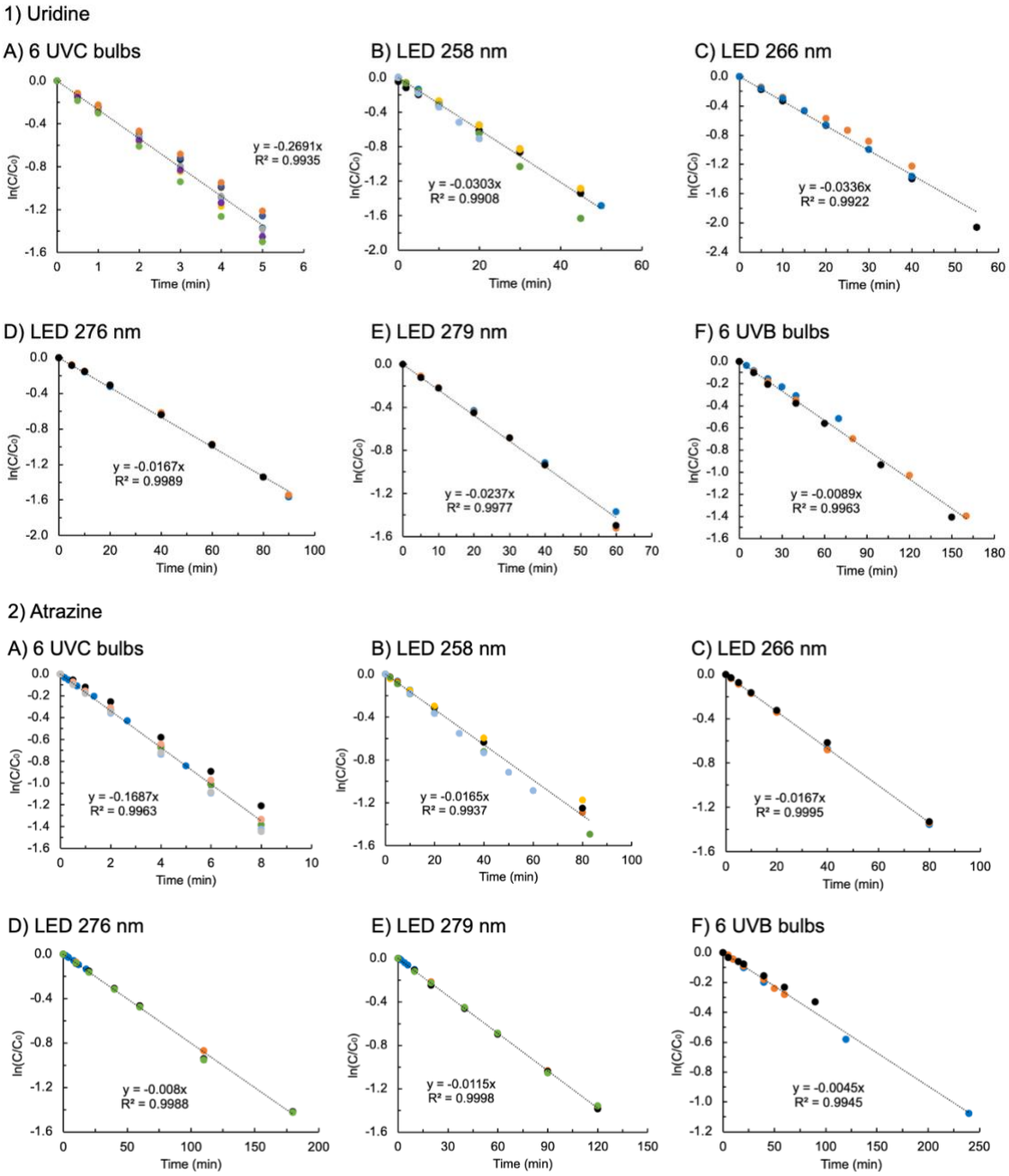


Figure S12. Chemical degradation over time for experiments with (1) uridine, (2) atrazine, (3) PNA, (4) diclofenac, (5) sulfamethoxazole pH 7.2, and (6) sulfamethoxazole pH 8 using (A) six UVC bulbs, (B) commercially available LED 258 nm, (C) commercially available LED 266 nm, (D) custom-built LED 276 nm, (E) commercially available LED 279 nm, (F) six UVB bulbs, (G) custom-built LED 313 nm, (H) six UVA bulbs, (I) custom-built LED 346 nm, (J) custom-built LED 368 nm, and (K) solar simulator. Bulbs were placed on the ceiling of the merry-go-round photoreactor, and the black petri dish was used in all experiments. Each of the experiments was done in triplicate at a minimum. The slope of the curve was used to determine the Φ_λ of each chemical for each light source. Each color represents the results from a replicate experiment. Figure continues on the next pages.

Figure S12. Continued.

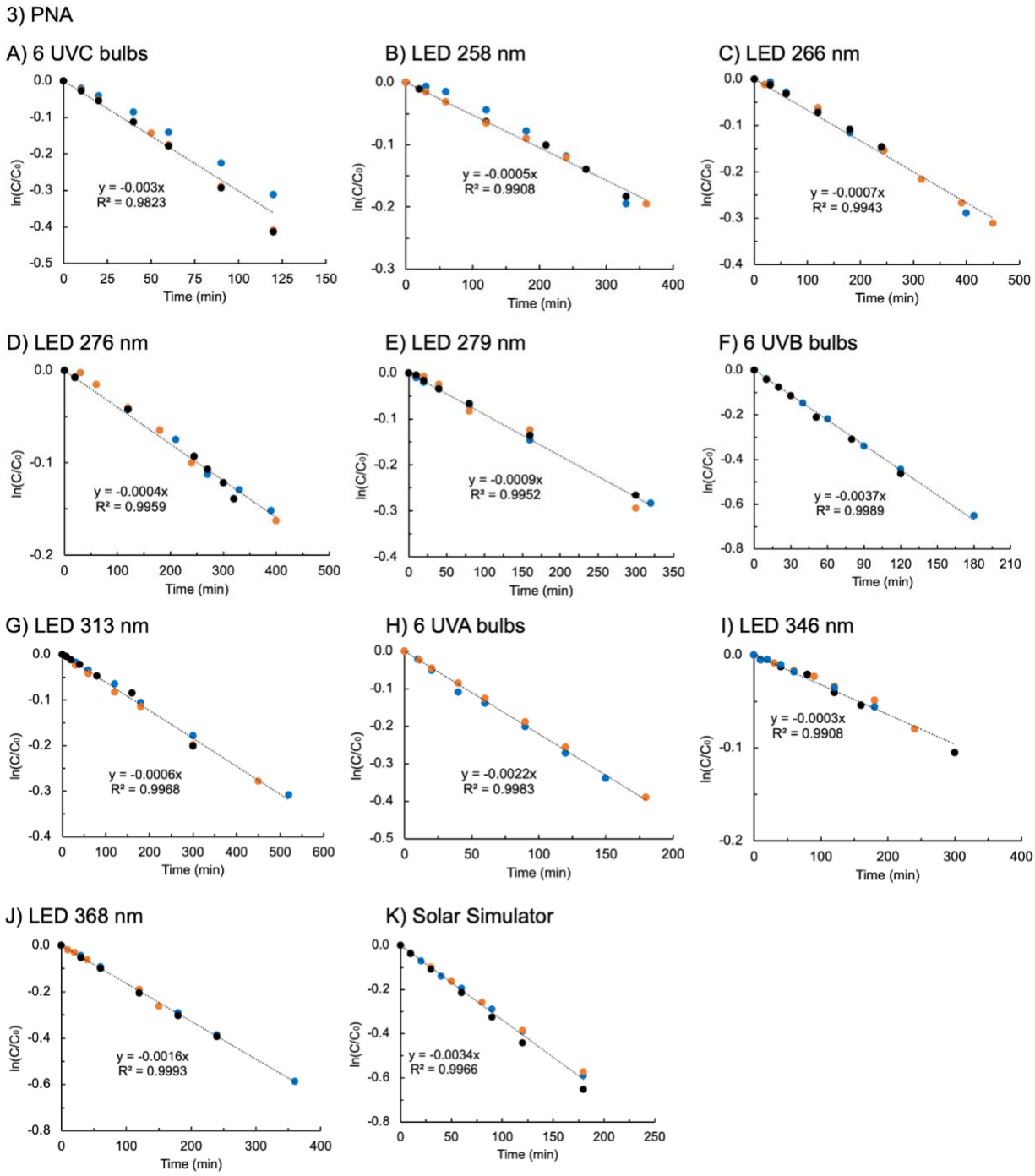
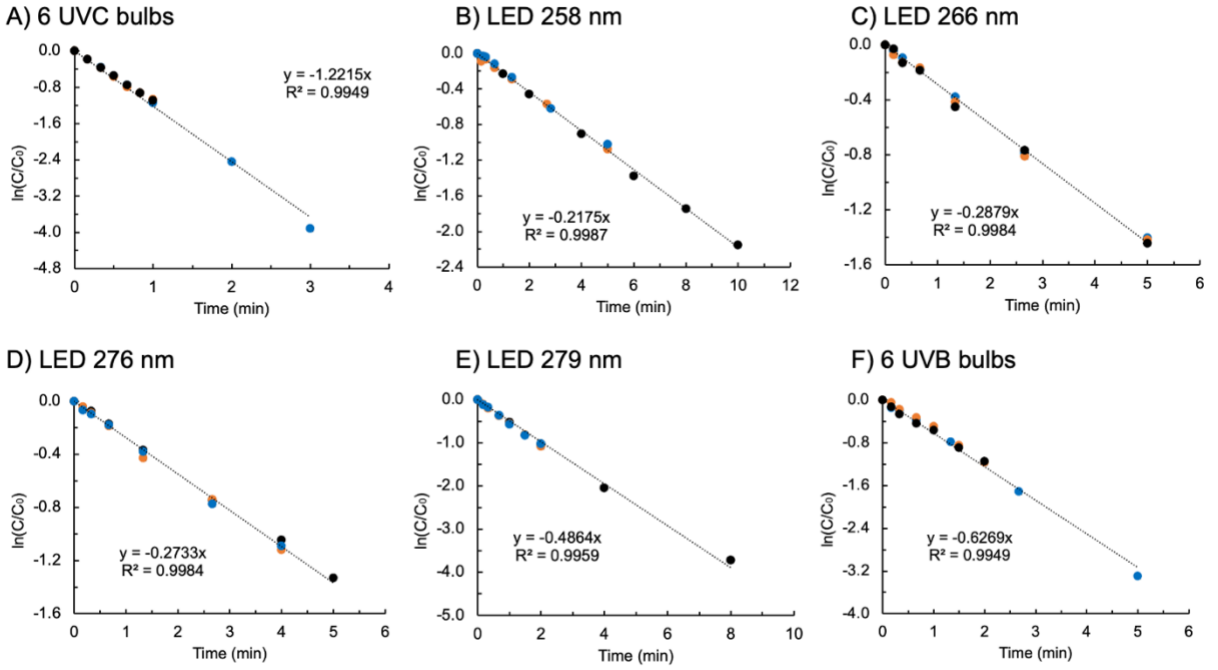
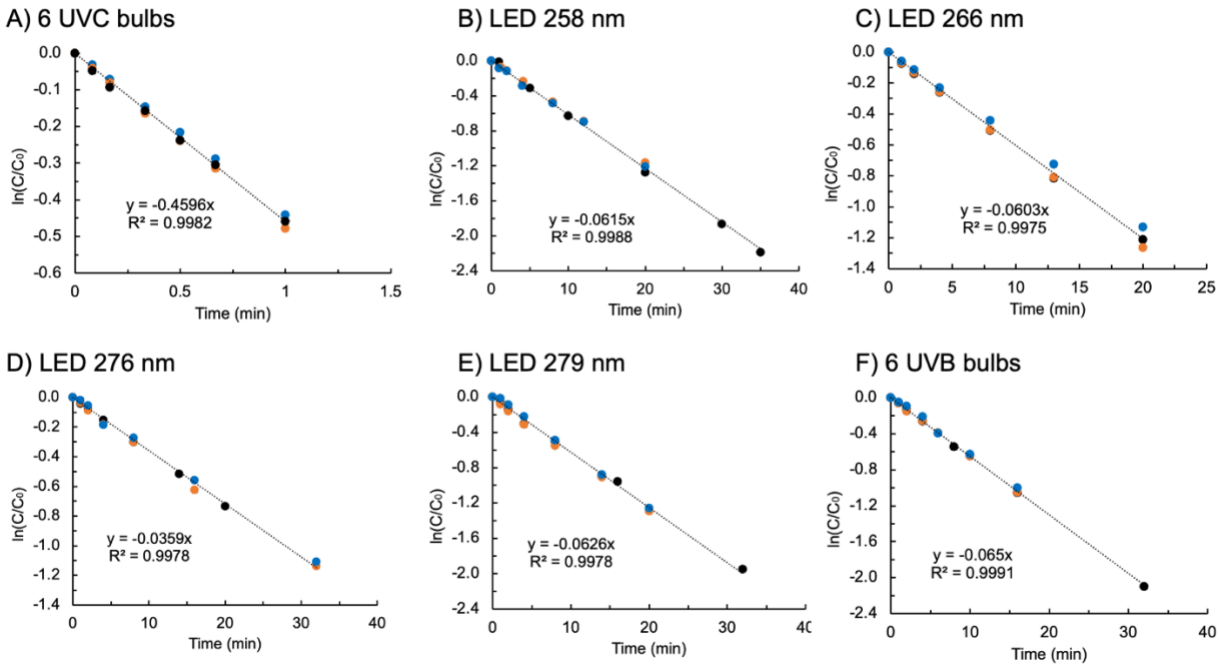


Figure S12. Continued.

4) Diclofenac



5) Sulfamethoxazole pH 7.2



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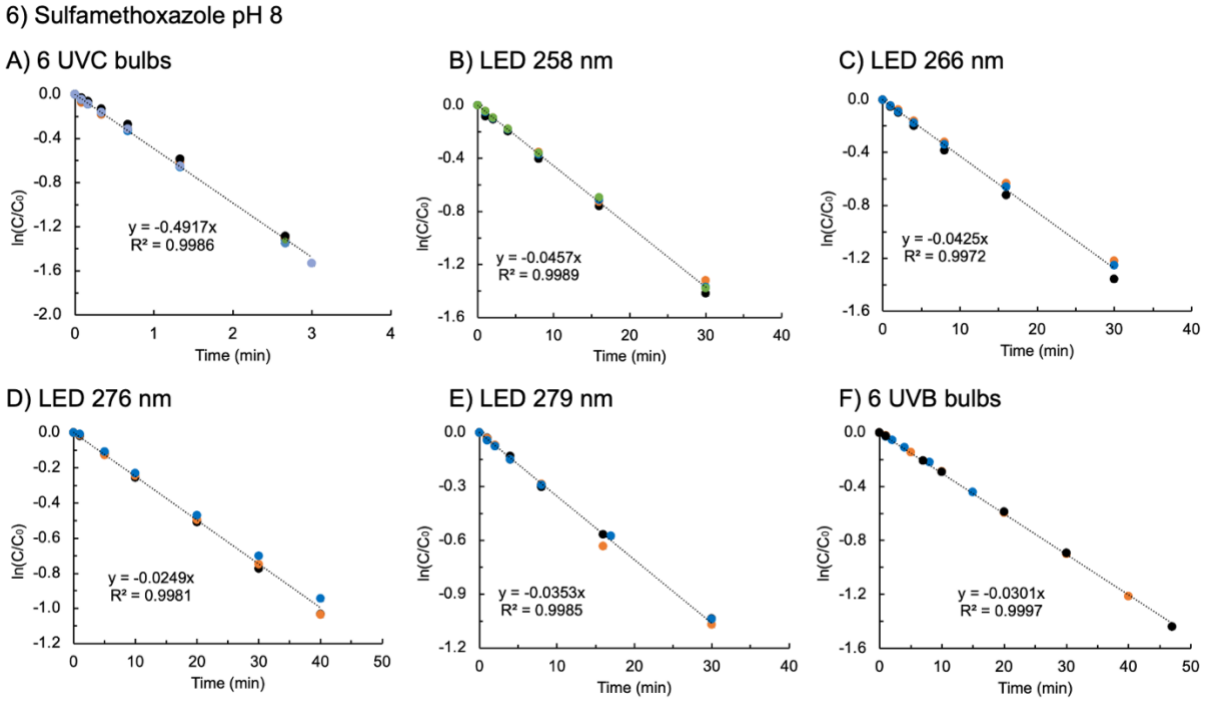


Table S12. Quantum yields and their standard deviations calculated for uridine, atrazine, PNA, sulfamethoxazole pH 8, and diclofenac obtained from experiments performed using different photoreactor systems. Three types of photoreactors were used: merry-go-round photoreactor with six UVC, UVB, or UVA bulbs installed on the ceiling, commercially available LED photoreactor with light sources emitting light centered at 258 nm and 279 nm, and the custom-built LED photoreactor with light centered at 276 nm, 316 nm, and 346 nm (see Figure 1 in the main text for the setups). The percent differences between the Φ_λ and the p-values obtained from performing t-tests are also reported. The black petri dish was used as the sample container in all experiments. Chemical degradation over time plots for each of the experiments are shown in Figure S13.

Photoreactor	**Quantum Yield (Φ_λ) ± SD**				
	Uridine	**Atrazine**	**PNA**	**Sulfamethoxazole, pH 8**	**Diclofenac**
Merry-go-round photoreactor, 6 UVC bulbs at the top	0.0168 ± 0.0015	0.0283 ± 0.0017	0.00098 ± 0.00013	0.0164 ± 0.0004	0.129 ± 0.009
Commercially available LED, 258 nm	0.0165 ± 0.0021	0.0232 ± 0.0014	0.00116 ± 0.00009	0.0144 ± 0.0005	0.144 ± 0.012
% difference	1%	20%	17%	13%	11%
p-value	0.12	<0.0001	0.12	0.0008	0.17
Commercially available LED, 279 nm	0.0145 ± 0.0005	0.0195 ± 0.0014	0.00051 ± 0.00005	0.0160 ± 0.0006	0.152 ± 0.010
Custom-built LED, 276 nm	0.0150 ± 0.0003	0.0212 ± 0.0008	0.00045 ± 0.00004	0.0164 ± 0.0011	0.139 ± 0.005
% difference	4%	8%	12%	2%	9%
p-value	0.17	0.09	0.18	0.63	0.14
Merry-go-round photoreactor, 6 UVB bulbs at the top	n.a.	n.a.	0.00032 ± 0.00002	n.a.	n.a.
Custom-built LED, 316 nm			0.00033 ± 0.00002		
% difference	n.a.	n.a.	4%	n.a.	n.a.
p-value			0.45		
Merry-go-round photoreactor, 6 UVA bulbs at the top	n.a.	n.a.	0.00031 ± 0.00002	n.a.	n.a.
Custom-built LED, 346 nm			0.00034 ± 0.00004		
% difference	n.a.	n.a.	8%	n.a.	n.a.
p-value			0.65		

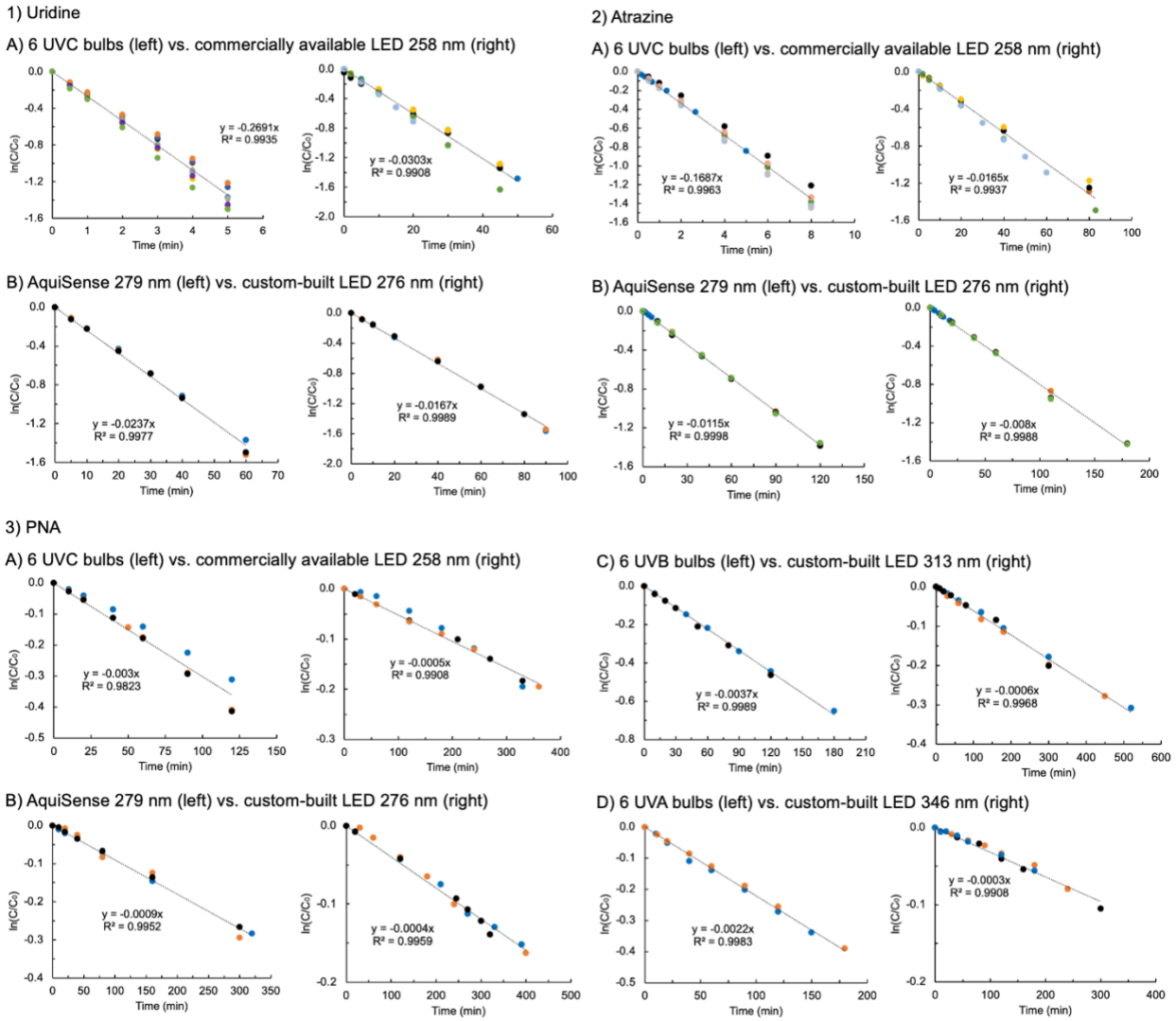


Figure S13. Chemical degradation over time for experiments with (1) uridine, (2) atrazine, (3) PNA, (4) sulfamethoxazole pH 8, and (5) diclofenac for comparisons between (A) six UVC bulbs vs. commercially available LED 258 nm, (B) commercially available LED 279 nm vs. custom-built LED 276 nm, (C) six UVB bulbs vs. custom-built LED 313 nm, and (D) six UVA bulbs vs. custom-built LED 346 nm. Bulbs were placed on the ceiling of the merry-go-round photoreactor, and the black petri dish was used in all experiments. Each of the experiments was done in triplicate at a minimum. The slopes of the curves were used to determine the Φ_λ of each chemical for each light source. Each color represents the results from a replicate experiment. Figure continued on the next page.

Figure S13. Continued.

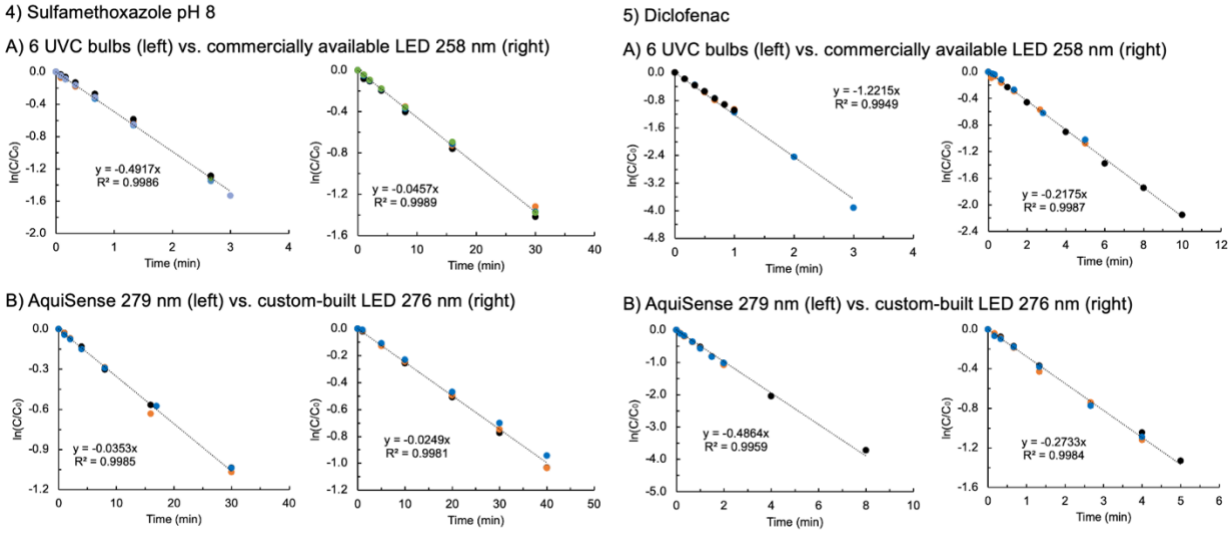


Table S13. Average apparent photon irradiances and their standard deviations (SD) obtained from experiments using either UVC or UVB bulbs in the merry-go-round photoreactor. Irradiances were calculated using Equations 1-2 (main text) for uridine, atrazine, PNA, sulfamethoxazole, and diclofenac, and using Equation S2 for ferrioxalate. The results from these experiments are also shown in Figure 3 (main text). P-values obtained from performing t-tests are also reported. In these experiments, eight bulbs were placed on the sides of the photoreactor (setup in Figure 1A in the main text), and the chemical solutions were added to either quartz or pyrex test tubes that were rotating in the merry-go-round. For one complete rotation of the tubes in the merry-go-round, the time needed was eight seconds. All chemicals were simultaneously present in the experiments to mitigate the effects of light fluctuations in the calculated apparent photon irradiances, with variable time points selected based on the chemical reactivity to light. The Φ_λ measured in this work and presented in Table 3 (main text) were used to calculate the total apparent photon irradiances measured by uridine, atrazine, PNA, sulfamethoxazole, and diclofenac. Ferrioxalate Φ_λ values were from the literature.[3] Chemical degradation over time plots for each of the experiments are available in Figure S14.

	Average Photon Irradiance (mE cm^{-2} min^{-1}) ± SD		
	UVC Experiments (Quartz test tubes)	**UVB Experiments (Quartz test tubes)**	**UVB Experiments (Pyrex test tubes)**
Ferrioxalate	0.00086±0.00010	0.00088±0.00006	0.00090±0.00003
Uridine	0.00175±0.00007	0.00370±0.00037	0.00177±0.00006
Atrazine	0.00164±0.00010	0.00433±0.00038	0.00172±0.00009
PNA	0.00139±0.00010	0.00195±0.00018	0.00150±0.00005
Sulfamethoxazole (SFM), pH 8	0.00157±0.00009	0.00206±0.00013	0.00141±0.00006
Diclofenac (DCF)	0.00149±0.00009	0.00186±0.00032	0.00140±0.00004
Correlations		***p-value***	
Ferrioxalate-uridine	<0.0001	<0.0001	<0.0001
Ferrioxalate-atrazine	0.0005	<0.0001	<0.0001
Ferrioxalate-PNA	<0.0001	<0.0001	0.0002
Ferrioxalate-SFM	<0.0001	<0.0001	<0.0001
Ferrioxalate-DCF	<0.0001	0.0001	0.0001
Uridine-Atrazine	0.20	0.018	0.406
Uridine-PNA	0.0004	0.0002	0.001
Uridine-SFM	0.0065	0.0003	0.0002
Uridine-DCF	0.0009	<0.0001	0.0002
Atrazine-PNA	0.025	<0.0001	0.010
Atrazine-SFM	0.365	<0.0001	0.002
Atrazine-DCF	0.103	<0.0001	0.002
PNA-SFM	0.013	0.160	0.096
PNA-DCF	0.123	0.498	0.062
SFM-DCF	0.158	0.155	0.826

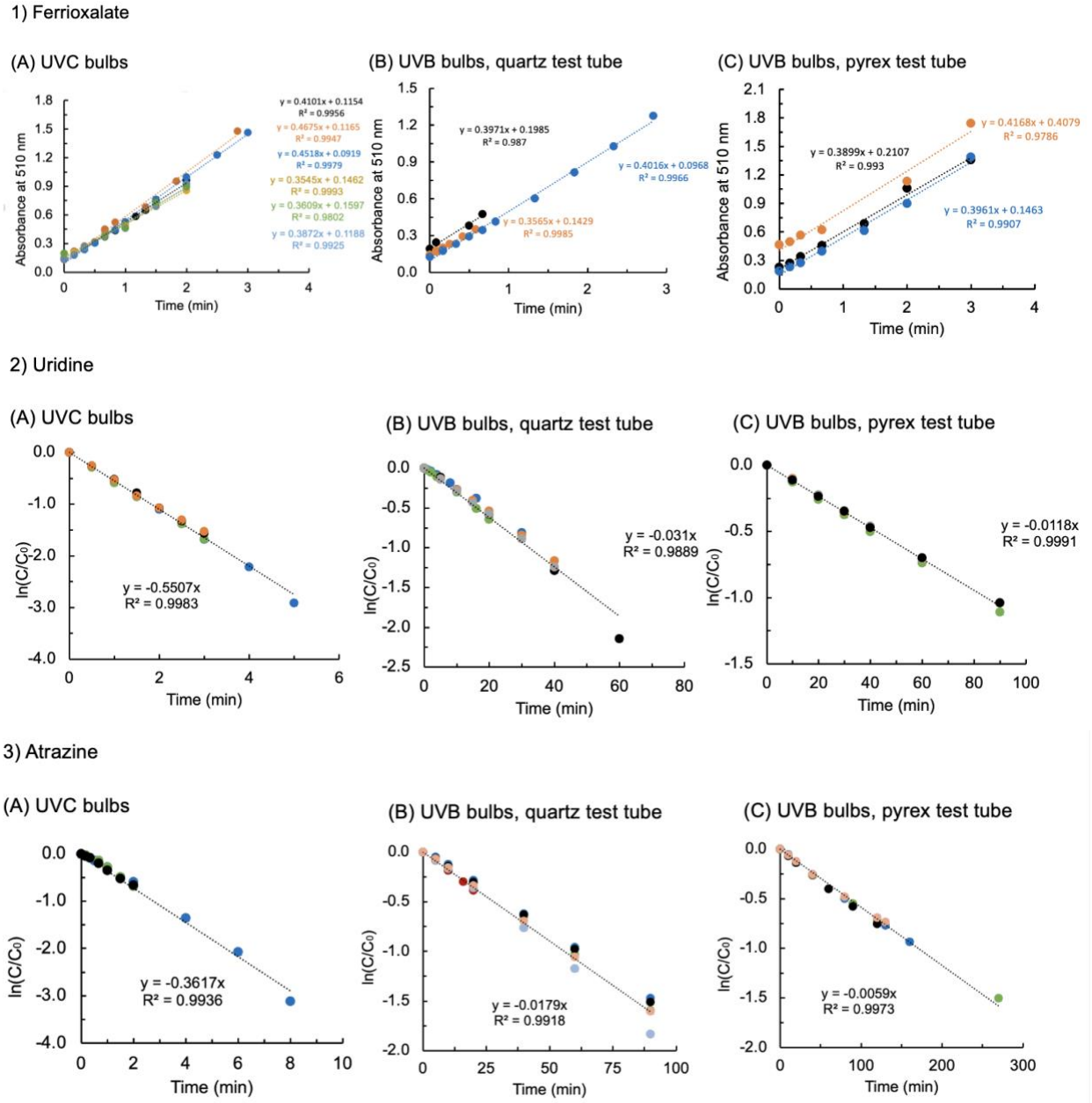
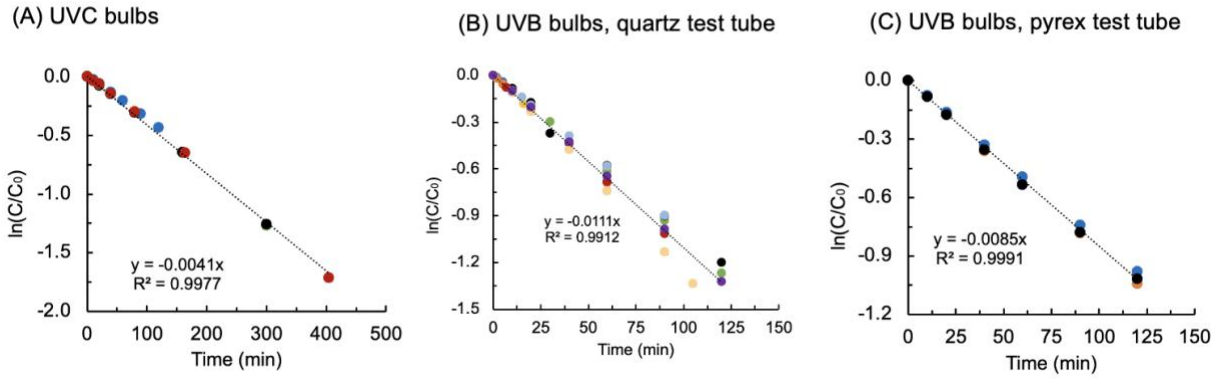


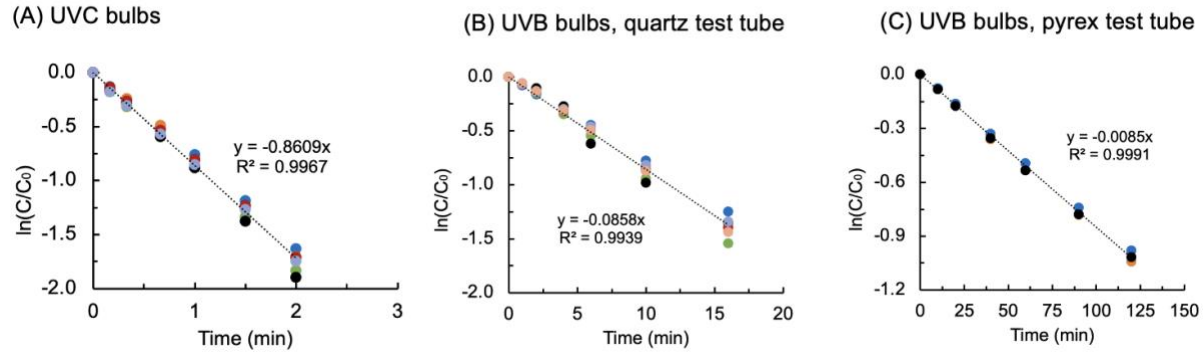
Figure S14. Change in absorbance over time for experiments with (1) ferrioxalate, and chemical degradation over time for experiments with (2) uridine, (3) atrazine, (4) PNA, (5) sulfamethoxazole pH 8, and (6) diclofenac using (A) 8 UVC bulbs, and (B and C) 8 UVB bulbs. Bulbs were placed on both sides of the merry-go-round photoreactor, and either (B) quartz test tubes or (C) pyrex test tubes were used in the experiments. Each of the experiments was done in triplicate at a minimum. The slope of the curve was used to determine total apparent photon irradiances. Each color represents the results from a replicate experiment. Figure continues on the next page.

Figure S14. Continued.

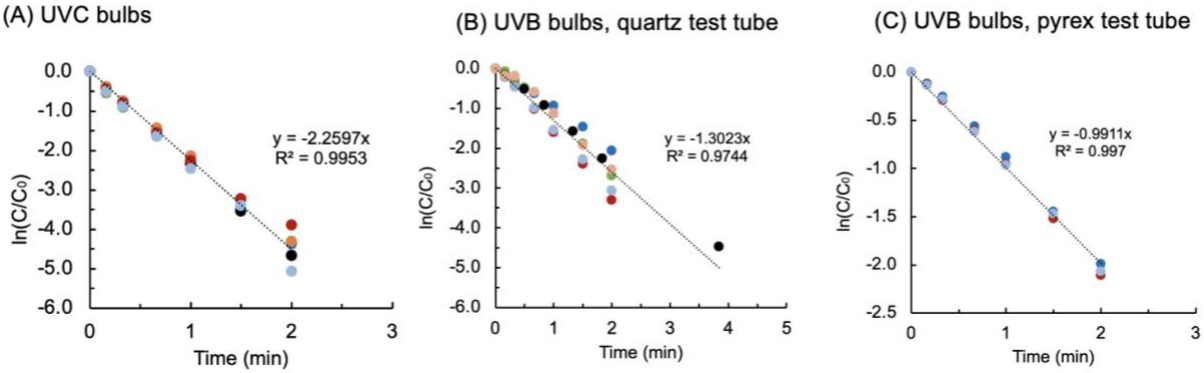
4) PNA



5) Sulfamethoxazole pH 8



6) Diclofenac



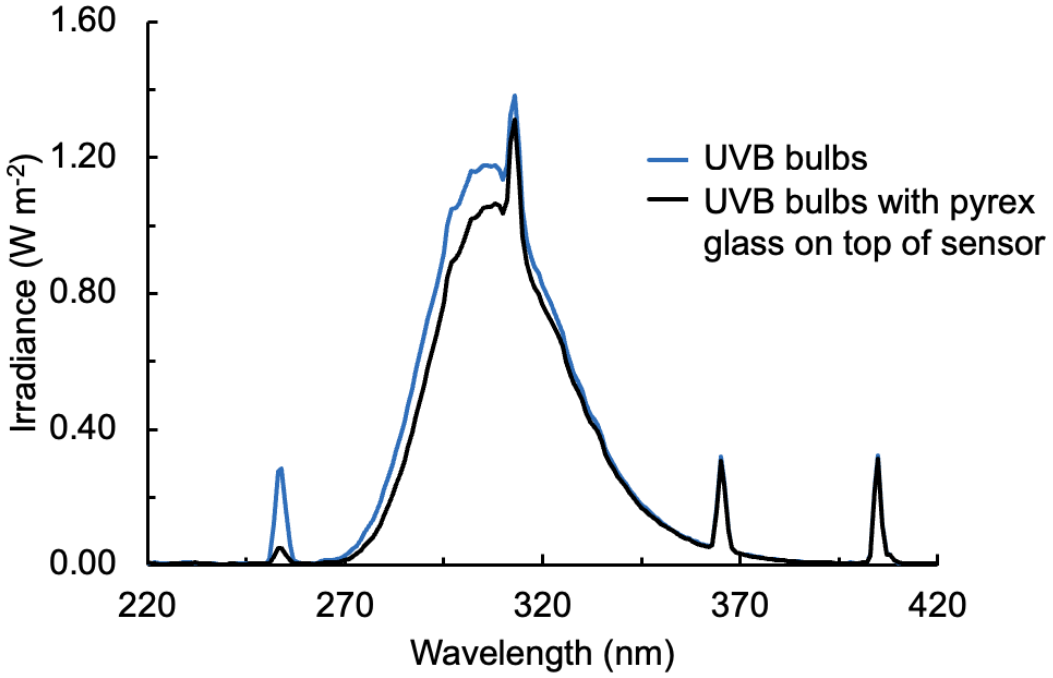


Figure S15. Irradiance spectra obtained with the spectroradiometer with six UVB bulbs placed at on ceiling of the photoreactor in blue, and also six UVB bulbs but with the pyrex glass placed on top of the spectroradiometer sensor in black.

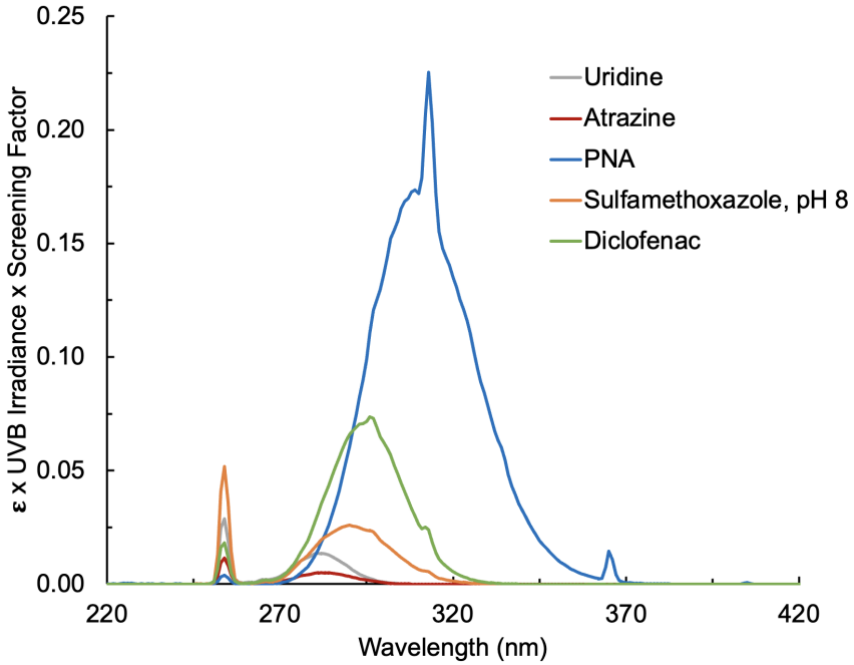


Figure S16. Spectra of the product of the molar absorptivity, the UVB irradiance, and the screening factors for uridine, atrazine, PNA, sulfamethoxazole pH 8, and diclofenac. These curves show the susceptibility of the chemical to absorb light in the wavelength ranges emitted by the UVB bulbs.

REFERENCES

1. J. R. Laszakovits, S. M. Berg, B. G. Anderson, J. E. O'Brien, K. H. Wammer and C. M. Sharpless, p-Nitroanisole/Pyridine and p-Nitroacetophenone/Pyridine Actinometers Revisited: Quantum Yield in Comparison to Ferrioxalate, *Environmental Science & Technology Letters*, 2017, **4**, 11-14.
2. M. Monalti, A. Credi, L. Prodi and M. T. Gandolfi, *Handbook of Photochemistry*, Taylor & Francis Group, Boca Raton, 3rd Edition edn., 2006.
3. S. Goldstein and J. Rabani, The ferrioxalate and iodide–iodate actinometers in the UV region, *Journal of Photochemistry and Photobiology A: Chemistry*, 2008, **193**, 50-55.
4. J. R. Bolton, S. Beck and K. G. Linden, Protocol for the determination of fluence (UV dose) using a low-pressure or low-pressure high-output UV lamp in benchscale collimated beam ultraviolet experiments, *International Ultraviolet Association*, 2003.
5. D. P. Hessler, V. Gorenflo and F. H. Frimmel, Degradation of Aqueous Atrazine and Metazachlor Solutions by UV and UV/H2O2 — Influence of pH and Herbicide Concentration Abbau von Atrazin und Metazachlor in wäßriger Lösung durch UV und UV/H2O2 — Einfluß von pH und Herbizid-Konzentration, *Acta hydrochimica et hydrobiologica*, 2006, **21**, 209-214.