

Fig. S1 Normalized radiation patterns of UVC LED.

Supplemental Fig. S1

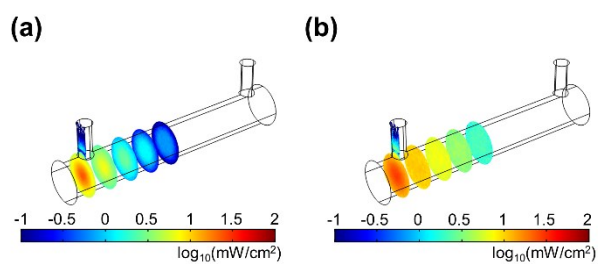


Fig. S2 (a) Fluence rate E' at 10, 20, 30, 40 and 50 mm transverse plane within reactor for water UVT = 50%/cm; (b) Fluence rate E' at 10, 20, 30, 40 and 50 mm transverse plane within reactor for water UVT = 90%/cm.

Supplemental Fig. S2

Supplemental Fig. S3

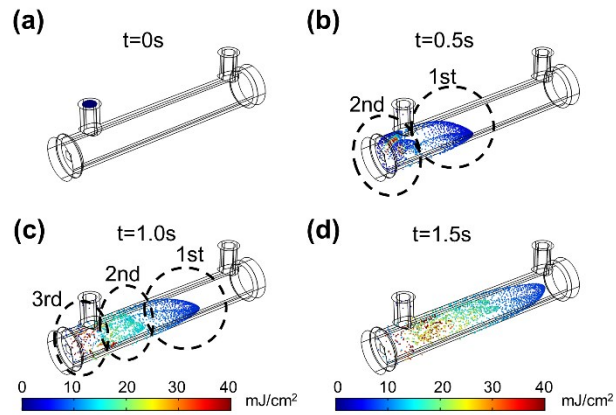


Fig. S3 Multiphysics modeling of particle tracing at time (a) $t = 0$, (b) $t = 0.5$ s, (c) $t = 1.0$ s, (d) $t = 1.5$ s with color representing UV fluence each particle received. Three particle populations behave distinctively are highlighted at $t = 0.5$ s and 1.0 s.

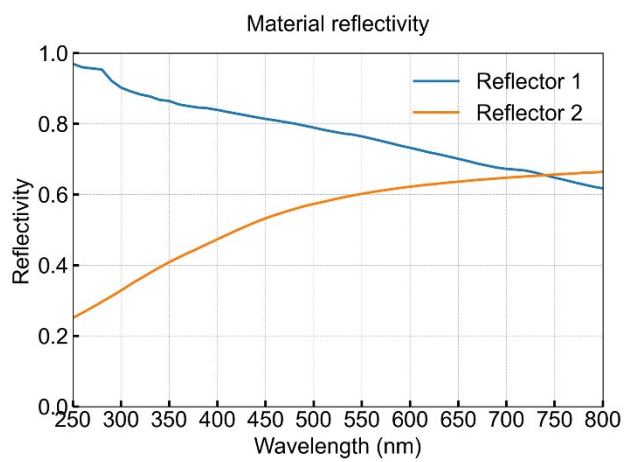


Fig. S4 Reflectivity measurement from 250nm to 800nm for diffuse (Reflector 1) and specular (Reflector 2) reflective materials.

Supplemental Fig. S4

Supplemental Fig. S5

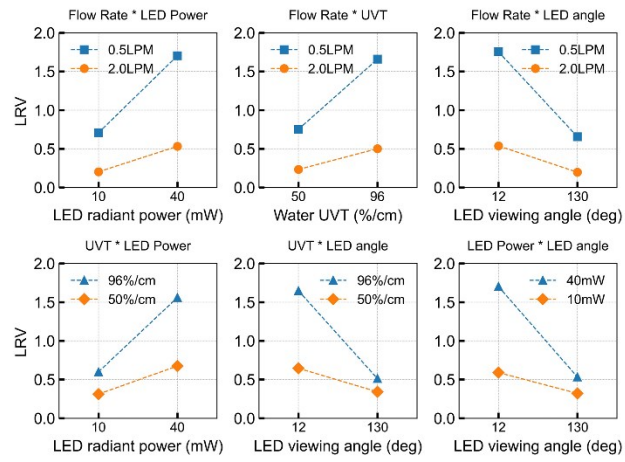


Fig. S5 Two-way interaction plots.

Supplemental Fig. S6

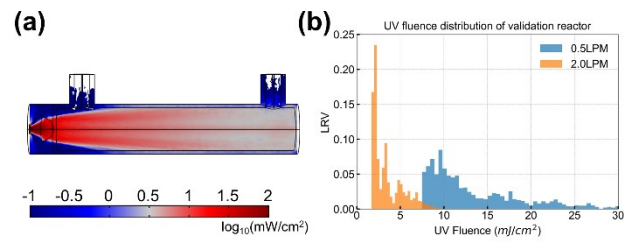


Fig. S6 (a) UV fluence rate of a validation reactor; (b) UV fluence of the validation reactor at flow rate of 0.5 and 2.0 LPM.

Supplemental Table S1

Table S1. Effect of UVC LED reactor design and operational variables and three-way interactions

Determinant	Symbol	Effect	Coefficient (α_i)	p-value
Flow rate	x_0	-0.8377	-3.36	< 0.001
UVT	x_1	0.5867	1.485	< 0.001
Reflector reflectivity	x_2	-0.1910	0.1784	0.002
LED radiant power	x_3	0.6624	-0.147	< 0.001
LED viewing angle	x_4	-0.7192	0.0115	< 0.001
LED wavelength	x_5	-0.2508	-0.0387	< 0.001
Flow rate × UVT	$x_{0,1}$	-0.3184	-0.991	< 0.001
Flow rate × LED radiant power	$x_{0,3}$	-0.3330	0.0058	< 0.001
Flow rate × LED viewing angle	$x_{0,4}$	0.3786	-0.0085	< 0.001
Flow rate × LED wavelength	$x_{0,5}$	0.1283	0.0143	0.033
UVT × Reflector reflectivity	$x_{1,2}$	-0.1726	-0.375	0.005
UVT × LED radiant power	$x_{1,3}$	0.2990	0.1220	< 0.001
UVT × LED viewing angle	$x_{1,4}$	-0.4158	-0.0151	< 0.001
LED radiant power × LED viewing angle	$x_{3,4}$	-0.4502	-0.00005	< 0.001
Flow rate × UVT × LED radiant power	$x_{0,1,3}$	-0.1545	-0.0299	0.011
Flow rate × UVT × LED viewing angle	$x_{0,1,4}$	0.2335	0.0115	< 0.001
Flow rate × LED radiant power × LED viewing angle	$x_{0,3,4}$	0.2348	0.000177	< 0.001
UVT × LED radiant power × LED viewing angle	$x_{1,3,4}$	-0.2371	-0.000582	< 0.001

UVT = Ultraviolet Transmittance,

$$LRV = 9.96 + \sum_{i=0}^5 \alpha_i x_i + \sum_{i=1,3,4,5} \alpha_{0,i} x_{0,i} + \sum_{i=2,3,4} \alpha_{1,i} x_{1,i} + \alpha_{3,4} x_{3,4} + \sum_{i=3,4} \alpha_{0,1,i} x_{0,1,i} + \sum_{i=0,1} \alpha_{i,3,4} x_{i,3,4}$$