



Supplementary Materials

Table S1. Illustrative literature evidence on photocatalytic coloring dye degradation.

Photocatalyst Utilized	Dye Pollutants	Light Source	Performance and Conclusions	Ref.
Anatase TiO ₂	Quinoline Yellow	6-Watt UV lamp	UV source irradiated to photoreactor containing the dye solution with a concentration of 8×10^{-5} M (150 ml) and 9 mg catalyst loading. The COD analysis affirms 100 % mineralization.	[80]
Benzoic acid/TiO ₂	Methyl orange, Rhodamine B, Methyl red, Tartrazine, Methyl violet, and Methyl Blue	High-pressure Xenon lamp (300 W, PLS-SXE300C)	Out of these, the photocatalytic efficiency of tartrazine in the DI water phase shows 99.08 % degradation, whereas the photodegradation capabilities of MO, MB, RhB, and MV confirm 13.32, 74.89, 64.36, and 87.88 % respectively, under a similar atmospheric nature.	[81]
Pt@TiO ₂	Methyl orange	300 W Xe Ozone-free Newport lamps (model no. 6258)	20 μ M aqueous solution of MO degraded 40 % within 60 min.	[82]
Immobilized TiO ₂	Acid Red 73	UV-A lamps (9 Watt, Philips 31250 - 25000 cm ⁻¹)	The degradation performance of Acid red 73 accessed 92.24% with various parameters such as initial dye concentration of 25 mg/L, pH=3, an anion solution concentration of 0.69 mg/L along with 0.5 mg/L of H ₂ O ₂ .	
Chitosan/TiO ₂	Reactive red 2 (RR), Methylene Blue (MB), and Rhodamine B (RhB)	Mercury Lamps (8W)	Chitosan/TiO ₂ was added in presence of UV photon illumination to achieve a successful photocatalytic degradation. The percentage of color dye depollution was recorded to be 80.2%, 94.8%, and 90.9% for RhB, RR, and MB dyes, respectively within 60 min.	[83]
TiO ₂ (Ti-HTS-40 - Ti-HTS-240)	Rhodamine B (RhB)	Xenon arc lamp (Newport 1000 W) through a Pyrex glass filter (cut off 420 nm)	Complete photodegradation of RhB (>97%) was analyzed under the illumination of visible photons utilizing TiO ₂ porous materials, and it was tracked down that the pace of degradation is reliant upon the explicit surface regions, pore sizes, and surface hydroxyl radicals of the materials. Bigger pore-measured materials favor powerful dissemination of RhB pollutants to the TiO ₂ dynamic active sites bringing about upgraded decomposition.	[84]
Ag & Au doped TiO ₂	Rhodamine (RhB and Rh 6G), Xanthene (Rose Bengal), and thiazine (methylene blue) dyes	Solar (85-95 mW /cm ² intensity) and Visible source	The photodegradation of azo dyes represented the accompanying order: P25 < mesoporous TiO ₂ < mesoporous Ag-TiO ₂ < mesoporous Au-TiO ₂ . Within 7h, 85% of TOC removal for every azo dye under irradiation of both direct solar and visible photons.	
TiO ₂ and Au-TiO ₂	Tartrazine (FD&C Yellow No. 5)	Solar light	The dye toxins degradation is frequently elevated due to ROS generation and electron carry enhanced by Au-TiO ₂ as well as alkaline reaction conditions.	[85]
(TiO ₂ /PW ₁₂) _n Nanocomposite	Methyl orange (MO)	300 W mercury lamp (medium-pressure, max = 365 nm) double-walled quartz glass tube equipped for water cooling.	Contrasted and (PAH/PW ₁₂) ₁₀ and (PSS/TiO ₂) ₁₀ , (TiO ₂ /PW ₁₂) ₁₀ multi-facet films depicted loftier photocatalytic performance owing to their synergistic impact among TiO ₂ and polyoxometalates. The photon-induced catalytic productivity of (TiO ₂ /PW ₁₂) _n composite exceptionally depends on thin film thickness. The 93.2% of degradation effectiveness within 1 hr of MO is at the 10 mg/L of initial concentration.	[86]
TiO ₂ /AC (Activated carbon)	Reactive Brilliant Red K-2BP	UV lamp (25 W, with the emission wavelength ranging from 228 to 400 nm)	The elevated photocatalytic decolorization proficiency of K-2BP utilizing TiO ₂ /AC photocatalyst materials in a bubbling fluidized bed photocatalytic reactor (BFBPR) was accomplished under UV photon	[87]

			brightening at a convergence of 3.75 mg/L inclusion to the optimum rate at a pH worth of 5.7.	
TiO ₂ on glass fiber cloth (TiO ₂ -GFC)	Methylene Blue (MB)	UV lamp	In the degradation assessment of MB, the photocatalytic action of the combined glass fiber on which zeolite was 1.9 times better apart from the glass fiber on which TiO ₂ was covered.	[88]
F-TiO ₂ (B)/CNT	Malachite green (MG)	Visible photon source	The synergistic impact of ultrasound and photo illumination and furthermore decrease of band energy owing to F-doping and hybrids of CNTs on TiO ₂ increment the mineralization productivity. From the evaluated data, it is seen that F-TiO ₂ (B)/SWCNT composite has a preferable photocatalytic and sonophotocatalytic performance over F-TiO ₂ (B)/MWCNT and F-TiO ₂ (B) under the illumination of visible photon for malachite green pollutant degradation.	[89]
Mo-Doped Titania	Orange II	Visible source “warm white” lamp and Narva fluorescent lamp with a light intensity of ~3.5 mWcm ⁻² , power =13 W and “Blacklight” (< 365 nm) for UV.	Mo-doped TiO ₂ photocatalytic investigation was dictated by the disintegration of the orange II pollutant under visible illumination at 400 and 365 nm. The titania catalyst with 1.38% Mo has the most noteworthy synergist movement at the photocatalyzed decolorization of orange II color pollutants in an aqueous solution in the visible and UV photon range.	[90]
N/Pd-codoped TiO ₂	Eosin Yellow	Visible source	The most elevated initial kinetic rate of 0.02238 min ⁻¹ was noticed for N/P TiO ₂ -Pd (0.8%). The outcomes exhibited that the N/Pd-co-doped TiO ₂ -Pd (0.6%)test could decompose eosin dye totally within 180 min, while the least effective dye degradation noted for TiO ₂ , (Degussa P25).	[91]
TiO ₂ /Pt	Sulforhodamine-B dye (SRB)	500 W halogen lamp	Degradation of SRB dye due to oneself photosensitized intervened using TiO ₂ /Pt examples is 3-overlap quicker than that of TiO ₂ alone under visible photon illumination and under leastwise, indistinguishable conditions by powers of the platinum dopant go about as an electron sink from which oxygen molecule scavengers the electrons to produce initially superoxide anions (O ₂ ^{•-}) radicals and afterward OH [•] radicals.	[92]
TiO ₂ (Anatase /rutile phases)	Methylene Blue (MB)	UV light (8 W 4 lamps)	The blended anatase/rutile-stage TiO ₂ nanoparticles calcined at 700 °C conveyed the most elevated photocatalytic execution, better than that of the commercially procured TiO ₂ (Degussa P25) photocatalyst, as a result of synergistic impacts of phase structure and crystallinity.	[93]
Carbon quantum dots (CQDs)/TiO ₂ (CT) composites	Methyl orange (MO)	UV lamp (3 W, 365 nm) and a xenon lamp (300 W)	Within 6 hr, CT-1 composite could mineralize 70.56 and 78.75% of MO pollutant (40 ppm) under the strong irradiation of 600 nm and 365 nm photons, respectively. CQDs assimilated photons and changed over them into UV light, which energized TiO ₂ to produce H ⁺ and OH [•] to MO degradation.	[94]
r-Graphene oxide (rGO)/ TiO ₂ nanowire	Methylene Blue (MB)	25 W, 254 nm medium pressure mercury lamps	Photocatalytic exercises of TiO ₂ samples composite were better than certain unadulterated TiO ₂ /GO/rGO individually. GO in addition to rGO illustrated various impacts on the photoreactivity, identified with semiconductor assistance.	[95]
Rutile TiO ₂	Reactive Orange 16	UV-A lamp (125 W; 12.7 mWcm ⁻¹ ; Philips)	The complete photocatalytic rate within 20 min, then such that basic reference TiO ₂ (P25) sample, found for the well-faceted nanorod PTA 1/100 came about because of the commitment of three components: proficient electron excitation, the morphology of nanoscale, and electron/hole partition.	[96]
S doped TiO ₂	Methylene Blue, Reactive black-5, Methyl Orange	UV lamps (λ-254 nm and power 25 Wcm ⁻²) and sunlight.	S doped TiO ₂ prompts the type of better surface territory, which impact robust color pollutants degradation was accomplished between 1-4 h under the light. Though utilization of a sunlight-based concentrator diminished the catalytic season of RB-5	[97]

			and MB to < 5 min, and within 20 min MO was turned colorless.																
Mesoporous TiO ₂	Methyl violet (MV), Gentian violet (GV), Reactive black-5 (RB) and methylthionine chloride (MC)	UV source (25 μW.cm ⁻²) and sunlight	<table><tr><th>Dye</th><th>Solar(%)</th><th>UV source(%)</th></tr><tr><td>GV</td><td>73.3</td><td>2.3</td></tr><tr><td>MC</td><td>85.4</td><td>4.9</td></tr><tr><td>MV</td><td>83.9</td><td>3.4</td></tr><tr><td>RB</td><td>98.9</td><td>5.4</td></tr></table>	Dye	Solar(%)	UV source(%)	GV	73.3	2.3	MC	85.4	4.9	MV	83.9	3.4	RB	98.9	5.4	[98]
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TiO ₂ /zeolite	Indigo dye	9-Watt Hg low-pressure lamp (UV)	The outcomes concluded that the photocatalytic performance of TiO ₂ /zeolite composite was superior as the level of photodegradation contrasted with the perfect TiO ₂ material attributable to synergistic cooperation between the TiO ₂ and the zeolite lattice. The catalytic efficacy 58.6 and 75.0 % were accomplished by utilizing TiO ₂ /zeolite in 10 mg/L and 20 mg/L respectively.	[99]															
Anatase TiO ₂ (325mesh)	Tartrazine	UV radiation of 10 mW/ cm ² and UV intensity can be varied from 8 to 16 mW/ cm ² in the reactor	The photocatalysis of the tartrazine color pollutants measures a pseudo-first-order rate. The optimal circumstances for the decolorization of color pollutants were 0.18 mg/L of catalyst loading, 6×10 ⁻⁵ M concentration of tartrazine solution, and pH of 11. To decide the nature of wastewater, Chemical Oxygen Demand (COD) estimations were completed.	[100]															
BaF ₂ - TiO ₂	Trypan Blue (TB)	Solar light	BaF ₂ - TiO ₂ is discovered to be more productive than bare TiO ₂ and TiO ₂ -P25 for the mineralization of TB under sun-powered light. The photocatalyst was discovered to be recyclable. COD estimations affirmed the 100% decolorization of TB pollutants in 60 min.	[101]															
S, Cu- codoped TiO ₂	Acid Orange 7	Visible light (>447 nm) is 18 W lamp	20 mg/L Acid orange 7 solutions with different weights of photocatalyst in acidic nature. In enhanced conditions, 60 % of the color pollutant was changed over in the aqueous solution.	[102]															
Rutile and Degussa P25 TiO ₂ (R and D)	Direct Fast Blue B2RL dye	UVA (15 W) light bulbs (2.74 mW/cm ²)	The primary photodegradation of B2RL happens at the surface of the catalyst and the rate consistent (k) diminishes in solid and fluid frameworks as follows: - in R the kinetic rate is pH 2 < pH 5.7 (neutral) < pH 12, while in D the request is pH 2 < pH 12 < pH 5.7. R and D forms had great execution after continued running in the photocatalytic mineralization system	[103]															
n-TiO ₂	Rhodamine 6G and Phenol red	Solar radiation (1050 Wm ⁻²)	The kinetics of photodegradation was assessed from the remaining fixation spectrophotometrically. Phenol red (95.2 %) showed superior decolorization than Rhodamine 6G (71.7 %) which can be credited to its sulfonic and hydroxyl mooring groups. The photodegradation affirmed pseudo-first-order kinetics.	[104]															
nano-TiO ₂ (A& B)	Black B dye	UV 254 nm (8 W) lamp.	The nano-TiO ₂ sintered at 600 °C (A-600) photocatalyst shows the most elevated performance. A-500, B-500 A-600, and A-700 shows degradation rate constant 0.121, 0.069, 0.734 and 1.000 h ⁻¹ , respectively within 4 hr.	[105]															
α-C ₃ N ₄ /TiO ₂	Reactive Red 4 (RR4)	20 W white color LED lamps (237 W cm ⁻²)	The photodegradation performance of RR4 for α-C ₃ N ₄ /TiO ₂ was decolorized totally under visible photons illumination within 60 min, roughly 5.3 times quicker than P25 – TiO ₂ . This is practically identical to their rate of electron-hole recombination dependent on PL force. The photocatalytic improvement is impacted by α-C ₃ N ₄ which can repress the electron-holes and injector recombination.	[106]															
TiO ₂ -Graphene (GR)	Acid Orange 7 (AO7)	Solar light	The TiO ₂ -GR which is in nanocomposite form has high photocatalytic action contrasted and the TiO ₂ on AO7 toxic mineralization under solar photons. The upgraded photocatalytic action may be credited to the GR enacted as an electron acceptor as well as carrier in the composite surface, which successfully stifled the recombination of charges and advanced the charge move inside the composites. The photodegradation level of AO7 for the four progressive cycles of TiO ₂ -	[107]															

			GR nanocomposites are 95.10%, 93.48%, 90.17%, and 88.12%.																
Au/N _x -TiO ₂	Direct blue 71 (DB71) and Reactive red 120 (RR120)	The UV irradiated light (λ <395 nm) was obturated using a UV filter film	The mineralization of RR120 and DB71 in milli-Q water adequacy is 86% and 91%, individually within the existence of permeable Au–N _x -TiO ₂ NPs with under 360 min of sun-based light illumination and in tap water 74% and 66% capability of mineralization are accomplished on account of RR120 and DB71, respectively.	[108]															
Polyaniline-coated TiO ₂ (PTO)	Eosin Yellow (EY) and Naphthol blue-black (NBB).	UV lamp	The optimal decolorization was discovered to be 99.74 % and 99.85 % for NBB and EY respectively. This optimum condition rate degradation was seen at a pollutant concentration of 15 mg/L, pH 3.0, and a catalyst dose of 1.0 g/L. The photocatalytic mechanism and degraded item are distinguished by LC-MS information.	[109]															
TiO ₂ – poly-dimethyl siloxane (PDMS)	Rhodamine B - RhB	1000 W xenon arc lamp	Upon openness to sunlight source, the color adsorbed on the outside of the TiO ₂ -PDMS wipe was photocatalytic performance, bringing about the further evacuation of the color pollutant from the arrangement (complete 80% removal). The amazing execution and the recyclability of this expense-effective TiO ₂ - PDMS wipes propose their promising applications	[110]															
TiO ₂ and Mg-TiO ₂	Congo red	150 W tungsten halogen lamp (≥400 nm): The intensity was 80,600 ±10 lux	Mg-TiO ₂ -P25 nanoparticles confirmed the most reduced PL power and the 98 % photocatalytic action of congo red might be owing to the negligible recombination of electron-hole pairs. The photodegraded items framed while photocatalytic oxidation is affirmed by GC–MS examination	[111]															
Metal (Ni, Zn, Co) doped TiO ₂	Methylene blue (MB) and Neutral red (NR)	UV source	<table><tr><th>Catalyst</th><th>MB (%)</th><th>NR (%)</th></tr><tr><td>TiO₂</td><td>86</td><td>76</td></tr><tr><td>TiO₂/Ni</td><td>95</td><td>90</td></tr><tr><td>TiO₂/Zn</td><td>93.5</td><td>87.5</td></tr><tr><td>TiO₂/Co</td><td>93.5</td><td>88.75</td></tr></table>	Catalyst	MB (%)	NR (%)	TiO ₂	86	76	TiO ₂ /Ni	95	90	TiO ₂ /Zn	93.5	87.5	TiO ₂ /Co	93.5	88.75	[112]
Catalyst	MB (%)	NR (%)																	
TiO ₂	86	76																	
TiO ₂ /Ni	95	90																	
TiO ₂ /Zn	93.5	87.5																	
TiO ₂ /Co	93.5	88.75																	
Micro-cellulose (MC) and TiO ₂ composites	Methylene Blue (MB), Acid violet (AV), and Methyl violet (MV)	Sunlight	The after-effects of the investigation showed that the consolidated hydrogen peroxide as an oxidant helped photocatalytic efficacy (TiO ₂ + MC + H ₂ O ₂) 99% of MB (200 mg/L) dye in 2.5 hr with 72% of COD decrease. While 6 and 7 hr response time was needed for the total decolorization of MV and AV color pollutants.	[113]															
TiO ₂ /Au NPs	Rhodamine B (RhB)	Xe lamps (300 Watt, 420 nm) with a UV-cut-off filter	The spiky TiO ₂ /Au nanoparticles improved the photocatalytic degradation efficacy of RhB which expanded by variables of 2.09 times, contrasted and those of commercial TiO ₂ under similar conditions.	[114]															
nano-sized TiO ₂	Methylene Blue (MB)	200 W tungsten lamp (Philips)	At ideal conditions, the kinetics of mineralization of MB for nano-sized and native TiO ₂ photocatalysts are 3.05×10 ⁻³ and 2.7×10 ⁻³ s ⁻¹ , respectively. During the photocatalytic measures, OH• radicals respond with color particles and decolorize them into non-toxic items like H ₂ O, CO ₂ , NO ₃ ⁻ particles, and so on.	[115]															
TiO ₂ /Zinc phthalocyanine (ZnPc)	Ponceau 4R (Acid red 18, C.I. 16255).	400W high-pressure mercury vapor lamp	The outcomes reveal that the TiO ₂ composite sample presents preferable execution over the other, coming to about half mineralization of the color pollutant reaction in 2 hr, around numerous times superior to that recorded under the activity of unadulterated TiO ₂ -P25, albeit this photocatalyst induces a quantum yield of OH• radical formation.	[116]															
TiO ₂ /novel axial substituted sub phthalocyanine H ₁₂ SubPcB-OPHCH ₂ COOH (SubPc-3)	Methyl orange (MO) and bromophenol blue (BB)	300 W Xe arc lamp (λ≥400 nm)	The photodegradation viability of BB and MO debasement with TiO ₂ /SubPc-3 is 99.5% and 97.8% respectively, which are around 1.41 and 5.26 times contrasted with unadulterated TiO ₂ , individually. In addition, the reusability examines that the photodecomposition proficiency of TiO ₂ /SubPc-3	[117]															

			(25:1) could be kept up around 90.1% after five flowing photocatalytic mineralization.	
TiO ₂ and Ag-TiO ₂	Rhodamine B (RhB)	4 UVC lamps (TUV Philips, 15 W, maximum intensity at 254 nm).	0.25% Ag: TiO ₂ spare film presented improved photocatalytic proficiency. The tests with a film of various thicknesses confirmed that for unadulterated TiO ₂ , the increment in film thickness was the just factor liable for enhancing the photocatalytic movement in the request 0.25% Ag: TiO ₂ > 0.5% Ag: TiO ₂ > 1.0% Ag: TiO ₂ > TiO ₂ > Ag > direct photolysis.	[118]
TiO ₂ , (Degussa P-25)	Procion yellow H-EXL	100-Watts's mercury lamp	The dye expulsion viability is contrarily relative to dye toxic concentration, the lower the color pollutant concentration, the higher the efficacy of dye evacuation. The productivity upsides of both photocatalytic mineralization and adsorption measures came to the greatest values of 100% and 46.4 %, respectively, with a color pollutant concentration of 10 mg/L.	[119]
TiO ₂ /palygorskite composite	Basic Blue 41 (BB41)	Four lamps with 4-Watt power each	The catalytic performance in 90 min affirmed above 80 % of the dye harmful was eliminated from the mixture in the optimized atmosphere of 2.5×10^{-5} M solution of BB41 solution (80 mL) with the dosage of 12 mg catalyst.	[120]
Fe-doped TiO ₂	Cibacron Yellow LS-R	UV irradiation with 8 Wm ⁻² (Philips Cleo sun Bed fluorescent tubes)	0.5% Fe-doped TiO ₂ depicts superior photocatalytic execution among Fe-doped examples, notwithstanding, it showed low photocatalytic performance in the Cibacron Yellow LS-R dye photodecomposition contrasted and Aeroxide TiO ₂ -P25.	[121]
TiO ₂	Basic Red 46	Three UV-A lamps (PL-L 24 W/10/4P PHILIPS)	The investigation affirmed that the anticipated efficiency of 57.63% mineralization and 100% decolorization could be accomplished within 360 min along with 99.94% and 99.97% certain intervals, respectively.	[122]
Mesoporous ZrO ₂ -TiO ₂	Naphthol Green B	16W/cm ² high-pressure mercury Lamp (254 nm)	20 ppm of aqueous dye solution (50 mL) and a variation amount of ZrO ₂ -TiO ₂ photocatalyst were added. In streamlined conditions, >99% of color could be extracted from the dye suspension.	[123]
I doped TiO ₂ (Ti _{1-x} I _x O ₂)	Direct Blue 199	UV tubes (8W, Philips TUV G8T5 Hg)	The Ti _{0.97} I _{0.03} O ₂ catalyst affirms the most elevated photodegradation performance of the blended undoped, and I doped TiO ₂ photocatalysts. The incorporated photocatalyst sample (Ti _{0.97} I _{0.03} O ₂) was additionally observed better correlated to the commercially accessible Aeroxide P-25 and can be recycled multiple times.	[124]
Carbon/TiO ₂ nanotubes	Rhodamine B	Two UV lamps (20 W)	25 mg of catalyst sample loading in the 20 ml of 5×10^{-5} M dye pollutant concentration shows more than 80 % of dye toxic degradation after 12 hr of reaction.	[125]
Brookite TiO ₂	Rose Bengal (RB) and Rhodamine B (RhB)	4 fluorescent lamps (15 W) 60 W, emitting in the range of 370 – 400 nm (λ_{max} =385 nm)	The dye pollutants photodegradation is altogether overestimated by considering the decolorization alone and continues in the order: mineralization < aromatic ring opening << decolorization.	[126]

Table S2. Literature verification on photodegradation of colorless hazardous organic toxin molecules and pharmaceutical contamination.

Photocatalyst	Colorless Pollutants	Light Source	Comments	Ref.
Integrated photocatalytic adsorbents (IPCA) based on TiO ₂ -activated carbon	Indomethacin (IND)	125 W medium pressure mercury lamp (TQ 150 Heraeus Noble light)	The 10% TiO ₂ IPCA displayed a low adsorption steady rate, K_{ads} of 1.1843 L/mg and the most elevated rate kinetics, k_{L-H} of 0.0846 mg/L/min. The extent of TiO ₂ assumed a huge part of the photoefficiency of the IPCAs. The photodegradation effectiveness of the TiO ₂ IPCA (10%) stayed more prominent than 70% after 5 cycles of utilization.	[153]
Pure anatase and Aeroxide TiO ₂ P25	Chlorhexidine digluconate (CHD)	UVA lamps (10 W)	The expulsion of chlorhexidine digluconate (CHD) was detected around 68.14% after 60 min at 25 °C with a pollutant-to-photocatalyst proportion is 2.5:1 at pH of 10.5 in presence of UV illumination of 50 $\mu\text{W}\cdot\text{cm}^{-2}$. The antimicrobial vulnerability analysis was additionally executed to evaluate the last harmfulness capability of the reaction items, which presents a negative reaction proposing an eco-friendly release to nature.	[154]
TiO ₂ NPs	Verapamil, Buspirone	UV LED Spot Curing plant NSC4 ($\lambda = 365$ nm, 650 mW/cm ² intensity at 4 cm distance).	Ultimately, a period settled laser ablation electrospray ionization mass spectroscopy (LASEI-MS) arrangement was created and introductory outcomes for verapamil revealed astounding stability of photocatalyzed oxidation responses in 1 hr.	[155]
Degussa type TiO ₂	Alprazolam (8-chloro-1-methyl-6-phenyl-4H-[1,2,4] triazolo[4,3-a][1,4]benzodiazepine, ALP)	UV (Heraeus TQ150) medium pressure mercury vapor lamps.	Effective photodecomposition was seen in the photocatalytic mineralization operation, with about 90% efficacy following 1.5 hr under advanced conditions. Benzophenone, triazolaminoquinoline, -hydroxy alprazolam, 5-chloro-(5-methyl-4H-1,2,4-triazol-4-yl) and triazolbenzophenone, were recognized as degradation by-products by HPLC-MS and fluorescence spectroscopy	[156]
TiO ₂	Acetaminophen (ACF) and Diclofenac (DFC)	(UVB, UVA and visible light) Six fluorescent tubes Repti Glo 5.0 (20 W), $\lambda = 290$ & 690 nm with maxima at 385 and 540 nm respectively	The most noteworthy acetaminophen with 71% photodegradation was gotten at 800 mg of photocatalyst stacking and 5% of catalyst-drug proportion and diclofenac all-out debasement was accomplished utilizing 100 mg/L of dosage of photocatalyst and 10% of the catalyst-drug proportion.	[157]
TiO ₂ NPs	Doxorubicin (DOX)	UV source (Black-Ray® B-100 AP/R lamps, 2.5 A, 100 W with 365 nm emission	Contrasted with the photocatalysis of non-adsorbed strains in suspension by portable hydroxyl (OH•) radicals, the adsorption-subordinate surface oxidation by UV-incited holes on TiO ₂ is highly proficient which is significant for photograph oxidative remediation of ecological natural toxins with amine or carbonyl functionalities that chemisorb on surfaces of titania.	[158]
TiO ₂	Pharmaceutics and personal care products (tetracycline hydrochloride, paracetamol, caffeine, and atenolol	UV (Jelosil HG500 lamp, power-30 mWcm ⁻²) and solar light (a halogen lamp from Lot Oriel, power- 1 mW cm ⁻² , $\lambda = 280$ to 400 nm and 14 mW cm ⁻² in the range 400–800 nm)	TiO ₂ sample photodegradation in ultrapure water: antibiotic medication expulsion happened on a more limited time scale (90% after 35 min), while paracetamol, caffeine, and atenolol disappeared up to 80–90% later 6 h with a slower rate. Besides, no impedance impacts diminished the effectiveness of the process on account of contamination blends, accomplishing 60% of mineralization later 6 h. The scrounger pretended by HCO ₃ ⁻ species gives off an impression of being prevailing in repressing the mineralization	[159]
TiO ₂ –SiO ₂ composites	Paracetamol	125 W medium pressure mercury lamp (model UV13F, Helios Italquartz, Italy)	The outcomes from photocatalytic mineralization of contamination compounds propose that xTiO ₂ –MSN photocatalyst give a decent combination of photocatalytic properties and potential adsorptive. In paracetamol mineralization, the adsorption of the objective atoms on TiO ₂ inside the pores of the	[160]

			mesoporous silica nanoparticles (MSN), support is restricted by the dissemination.	
TiO ₂ -BN nanofiber	Ibuprofen	Visible light (150-Watt halogen lamp)	A dynamic investigation of the photocatalysis of ibuprofen demonstrated the improved photocatalytic execution of TiO ₂ -BN catalysis with an elevated BN proportion in the nanocomposites. The reaction rate consistent with the TiO ₂ -10% BN catalysis was ten times greater than the unadulterated TiO ₂ nanofiber which is a powerful sunlight-based photocatalyst was shown by the recyclability of the wastewater approach.	[161]
TiO ₂	Amoxicillin trihydrate (AMT)	Solar and Visible light	51%, 69%, and 87%, mineralization was seen under immobilized sodium alginate balls, covered cemented beads, and shallow lake slurry reactor, respectively, at streamlined conditions. The TiO ₂ structure was discovered to be unblemished after the fifth reuse.	[162]
TiO ₂ -Ag sample	Ciprofloxacin	UV (254 nm) and visible (532 nm) light (laser)	Here, the evacuation effectiveness was 98.22% for color pollutants and 90.66% for antibiotics agents following 150 minutes of UV illumination. Photocatalytic tests under visible photons showed a decent proficiency (90%) following 18 hours in the ciprofloxacin removal.	[163]
N, S-CQDs /TiO ₂ nanocomposite	Diclofenac (DCF)	UV source (40 W) and visible light (12 W)	The 1.5 N, S-CQDs/ TiO ₂ layer showed the most noteworthy photodegradation execution among the films with 62.3% of DCF evacuation under visible photons while the 3.33% expulsion of contaminations by just unadulterated TiO ₂ film. Likewise, the 1.5 N, S-CQDs/ TiO ₂ layer showed improved hydrophilicity with the best penetrability of 277 L/m ² .hr.bar.	[164]
Polysulfone/alginate/TiO ₂ composite (PAT)	Triclosan (TCS) and Diclofenac (DCF)	UV lamp (15 W, emission at λ -254 nm)	With the surface adjustment, PAT-12 M revealed unrivaled photocatalytic action toward the drugs – diclofenac (DCF), triclosan (TCS), and dye methylene blue (MB) which were 100 % removal under 120, 40, and 50 min, respectively.	[165]
TiO ₂ film	Anthelmintic drug, praziquantel (PZQ),	15 W mercury UV lamps	The catalysis was multiple times quicker in the photocatalysis process where UV-C photons ($k = 0.2390 \text{ min}^{-1}$) were utilized than in UV-A ($k = 0.0201 \text{ min}^{-1}$). By correlating all outcomes, it tends to be inferred that the UV-C/TiO ₂ /H ₂ O ₂ provided the total mineralization of PZQ and the most elevated mineralization rate was gotten under 7 min.	[166]
Cu and S co-doped TiO ₂	Ciprofloxacin	UV light irradiation (280 nm)	The round-off removal of ciprofloxacin was acquired after 90 min with 0.4% Cu-0.5% S-TiO ₂ photocatalyst utilizing a visible source and in 120 min illuminating UV photon.	[167]
Novel TiO ₂ -Coconut Shell Powder (TCNSP) composite	Carbamazepine, Triclosan and Clofibric acid	UVC irradiation	The kinetics of the concentration decline pattern was as: UVA<UVC< UVA/TCNSP < UVC/TCNSP. Over the UVC/TCNSP mix, 99% evacuation was accomplished contrasted with TiO ₂ -30%. The removal efficacy diminished with the expansion of initial medical and personal-care products (PPCs) concentration.	[168]
TiO ₂ /CMK-3	Ibuprofen	125 W Hg lamp	The 1% TiO ₂ /CMK-3 catalyst displayed the pre-eminent photocatalytic execution, 100% efficacy just in 5 min, and COD and TOC data affirmed the ibuprofen mineralization.	[169]
Reduced-GO/TiO ₂ /Sodium alginate (RGOT/SA)	Ibuprofen and sulfamethoxazole	High-pressure 100 W mercury lamp	Over 99% expulsion of both the toxins was gotten inside 45 to 90 min with RGOT/SA aerogel under the illumination of UV-A photon. Maximum photocatalysis of sulfamethoxazole was seen at acidic to neutral pH and pH= 7 was observed as appropriate for the mineralization of ibuprofen.	[170]

N and S doped TiO ₂ coated over polycarbonate (NS-TiO ₂ @PC)	Ibuprofen and naproxen	UVC source (125 W, λ - 100 nm to 280 nm)	Advancement results conclude that more photodegradation efficacy of 100% and 83% were accomplished for naproxen and ibuprofen, respectively and the feasible intermediates were distinguished by LC-MS.	[171]
Degussa P25 TiO ₂	Fluoroquinolone (FQ) compounds (i.e. ofloxacin norfloxacin, ciprofloxacin & enrofloxacin)	800 W Xenon lamp (Visible source)	The photocatalytic response observed the pseudo-first-order system, with the reaction rate of (k) 0.026, 0.026, 0.022, and 0.027 min ⁻¹ for ofloxacin, enrofloxacin, ciprofloxacin, and norfloxacin, respectively after 90 min visible photon irradiation.	[172]
Mesoporous TiO ₂ with silver (Ag) and cerium (Ce) nanoparticles	Ibuprofen (IBP)	Visible light	Above 98% of IBP mineralization was accomplished around 4 h light for the photocatalyst fabricated by co-deposition precipitation with urea. The prevailed TOC transformation followed the diminishing request: AgCe/TiO ₂ [co-deposition precipitation with urea (Co-DPU)] > AgCe/TiO ₂ [co-impregnation (Co-IMP)] > TiO ₂ > P25.	[173]
(GO-TiO ₂) Graphene oxide-TiO ₂ composite	Microcystin-LR (MC-LR)	Four F15W/T8 black light tubes (71.7 mW at a distance of 25 cm) and 150 W Xe arc lamps (Visible)	UV-A light illumination Degussa TiO ₂ P25 was discovered to be the major product in the decomposition of all objective mixtures accompanied by ref-TiO ₂ , GO-TiO ₂ , and Kronos (commercial available TiO ₂), which revealed comparative photocatalytic execution of 2-methylisoborneol (MIB) and geosmin (GSM) though MC-LR Kronos was established to have the least movement.	[174]
ZnFe ₂ O ₄ -TiO ₂ heterojunction	Bisphenol-A (BPA)	A solar simulator (AM 1.5G filter, 300W Xenon lamps) and 8W visible lamps, UV light lamps(8 lamps) at 365 nm.	The photocatalytic corruption productivity and rate kinetics of BPA over ZnFe ₂ O ₄ - TiO ₂ under the illumination of various photon sources follow the sequence 365 nm UV light < sunlight-based test system < 465 nm visible light. The BPA photodegradation in any event 10 patterns of response with 0.191–0.218 min ⁻¹ rate kinetics denotes brilliant recycling and photostability.	[175]
Nanocellulose (NC)-supported TiO ₂ NPs	Mefenamic acid (MEF)	450W high-pressure mercury lamp (UV light)	The 10% TiO ₂ - Nanocellulose showed the most elevated clear reaction kinetics (K _{app}) and accomplished generally MEF expulsion of ca. 89% within 180 min. The 10% TiO ₂ NCT depicted its photocatalytic efficacy as over 85% after five consecutive cycles.	[176]
TiO ₂ /polyacrylonitrile (TiO ₂ /PAN) hybrid nanofibers	Phenol	UV sources (50 W, high-pressure mercury lamp, λ - 313 nm)	As revealed in the work, after UV photon illumination of about 50 min, the photodegradation proficiency of phenol was achieved at 98.7%, 97.3%, 95.8%, 94.8%, and 94.5% for the five consecutive cycles, respectively.	[177]
Al ₂ O ₃ -TiO ₂	p-Cresol and phenol	UV source (UVP Products) with a wavelength 254 nm and intensity of 4.4 mVcm ⁻²	The ATi15 photocatalysts are more productive in the mineralization of phenol and p-cresol, the example with the most noteworthy TiO ₂ fixation (15 Wt%) being the most dynamic in both reactions, with 84% and 57% TOC decrease, respectively.	[178]
PES/TiO ₂ nanofibers	Phenol	UV lamps (250 W, λ -360 nm)	The best phenol evacuation adequacy was 43.0 ± 0.3% and determined under enhanced circumstances of 8% of TiO ₂ , pH regarding 7, and 120 ppm of beginning phenol concentration.	[179]
TiO ₂ /ZnO	Bifonazole	UVA radiation (λ - 320 to 400 nm)	Comparative investigations affirmed that a mix of 1:1 ratio of TiO ₂ /ZnO was a highly viable photocatalyst than TiO ₂ or ZnO with efficacy of 67.57% under 24 hr of UV illumination.	[180]
Fe/TiO ₂	Di-isopropanol amine (DIPA)	500W halogen lamp as the visible source giving 980W/m ² intensity	Optimized states pH was discovered to be at 10 which is the genuine pH of DIPA aqueous solution at 1000 ppm, with 2 g/L of 0.2 wt% Fe/TiO ₂ photocatalyst measurement showed the greatest COD evacuation.	[181]
TiO ₂ @rGO	2,4,6-trichlorophenol (2,4,6 TCP)	6 UV sources (60 cm mercury lamps, 11 Watt)	The outcomes obtained a high decrease in TOC and COD upsides of production effluents extending to 85% and 82%, separately. The greatest	[182]

			photocatalysis proportion came up to 90% adequacy at the underlying TCP concentration of 50 mg/l when presented with UV illumination for 180 min at pH 6 along with a photocatalyst portion of 0.4 g/L.	
CuSO ₄ -doped TiO ₂	2-chlorophenol (2-CP)	Five LED, lamps (HR16 1W/110, λ -440 to 490 nm)	Optimization of parameters for complete evacuation of 2-CP has been acquired at a photocatalyst dose of 3 gdm ⁻¹ , and underlying 20 ppm of 2-CP at pH 5.5 mixture. Zero-point charge (pHzpc) exists at 3.5 for the undoped and 3.84 for CuSO ₄ -doped TiO ₂ were resolved.	[183]
Sulfur-TiO ₂ (S-TiO ₂) nanocomposite	Cyanide	Visible sources (150 W, Blue fluorescent lamp)	The 0.3 wt% S-TiO ₂ composite displayed the least bandgap and the total (100%) photocatalytic oxidation efficacy of cyanide in 30 min. The photocatalytic execution of 0.3 wt% S-TiO ₂ was steady, in spite of the fifth recycle for the cyanide oxidation.	[184]
TiO ₂	Fluoranthene (FLAN), Phenanthrene (PHE), and Benzo[a]pyrene (BaP)	UV lights (300 W high-pressure mercury lamp, λ > 320 nm, intensity-4.8 mW/cm ²)	The trial showed that P25-2.5% GR displayed improvement in both photodegradation and adsorption, around 80% of polycyclic aromatic hydrocarbons were eliminated after 120 min photodegradation.	[185]
TiO ₂	Insecticide (diazinon)	Four Blacklight-(Blue F15W/T8/BLB lamps, λ -300 to 400 nm)	The underlying oxidative mechanism of the mineralization of diazinon included the wreckage of sulfur by oxygen over the P=S bond, breakage of the ester bond of pyrimidine, and isopropyl group oxidation.	[186]
TiO ₂ -coated sponge biofilm	Chlorine dioxide bleaching wastewater	Visible source (LED lamp 65 W)	Nonetheless, the evacuation rate of dissolved organic carbon (DOC), adsorbable organic halides (AOX), and chemical oxygen demand (COD _{Cr}), in wastewater management by convention intimate coupling of visible-photon catalysis and biodegradation (ICPB) came to 86.7%, 80.3%, and 90.5% respectively.	[187]
TiO ₂	5-membered nitrogen heterocycles (pyrrole, imidazole and 1,2,4-triazole)	Solar light stimulator LS 1000W equipped with a xenon lamp and filters that reproduce solar UVB and UVA radiation (290–400 nm)	Photodegradation isn't noticed at very low pH, and at higher pH, the photocatalysis rates decline significantly. At pH 8, pyrrole, triazole and imidazole, all mineralization with half-lives < 2h.	[188]
Imprinted TiO ₂	The herbicide 2,4-dichlorophenoxyacetic acid (2,4D)	UV irradiation using a UWAVE led UV lamp system with emission at 365 nm, with an irradiance of 12 mW/cm ²	At the point when the light is turned on, a surprising upgrade of the rate of photocatalysis of 2,4D was gotten with the MI TiO ₂ /2,4D example which, degrades 75% of the underlying convergence of the herbicide after 4 hr, while unaltered TiO ₂ mineralize 45% of the pesticide.	[189]
(PMMA)/TiO ₂ nanocomposite	4-nitrophenol	Sun-light fluorescent lamp	The steady rate of the formation 4-Aminophenol by 4-Nitrophenol photoreduction was determined and the most extreme rate consistent was determined with the TiO ₂ -0.01 wt% dose in the photocatalyst and pH=7.5 of solution mixture.	[190]

Table S3. Literature verification on photodegradation of petroleum-based hydrocarbons pollutants

Type of Catalyst	Organic Pollutant	Light Source	Findings	References
TiO ₂ Degussa P-25	Petroleum wastewater	UVA-UVB	COD was reduced by 83% after 120 min	[196]
PEI/TiO ₂	PRW (COD)	UV	100% at 120 min (300 ppm)	[197]
TiO ₂	PRW (COD)	UVB-UVA	Optimum pH = 3; 72% at 90 min (200–220 ppm)	[198]
Degussa P-25 TiO ₂	Petroleum wastewater	Solar light	Optimum pH = 6.8; 76% reduction of COD.	[199]
TiO ₂ /ZnO	PRW(COD)	Artificial Solar	60% at 180 min (1075 ppm)	[200]