Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

“The Phactalysts”: Carbon Nanotube/TiO_2 Composites as Phototropic Actuators for Wireless Remote Triggering of Chemical Reactions and Catalysis

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S1. Supplementary Movie: Real-time video showing the typical actuation of a phactalyst under illumination with the halogen lamp (file uploaded separately).

S2. Average maximum bending angle as a function of different SWNT:TiO_2 weight ratios.

Suspension concentration	average maximum bending angle	
TiO_2 0.5 mg/mL	0 °	
SWNT 0.025 mg/mL+ TiO_2 0.5 mg/mL	0°	
SWNT 0.25 mg/mL+ TiO_2 0.5 mg/mL	10°	
SWNT 0.5 mg/mL+ TiO_2 0.25 mg/mL	30°	
SWNT 0.5 mg/mL	60°	
SWNT 0.5 mg/mL+ TiO_2 0.5 mg/mL	90°	
SWNT 0.5 mg/mL+ TiO_2 1 mg/mL	90°	

Table S2.

S3. Study of the photocatalytic activity of PC/SWNT+TiO_2 bimorph system as a function of the SWNT:TiO_2 weight ratios.

The photocatalythic activity of bimorphs obtained filtering on PC filters suspensions containing different SWNT:TiO_2 weight ratio was evaluated during the photodegradation of 15 mL of Methylene Blue (MB) 10^{-5} M bulk solution. The effect of different SWNT:TiO_2 ratio on dye absorption capability was also investigated by measuring the percentage of adsorbed dye on the solid system maintained for 1h in dark (**Fig. S3a**), and the photodegradation efficiency was tested under UV illumination (**Fig. S3b**).

Systems containing a higher relative amount of SWNT are characterized by higher absorption capability. In particular, an absorption capability higher than 50% is achieved in the case of bimorph systems prepared with suspension containing 0.5 mg/mL TiO_2 + 0.5 mg/mL SWNT and 0.25 mg/mL TiO_2 + 0.5 mg/mL SWNT.

From the catalytic viewpoint, faster MB degradation can be achieved under UV irradiation in the case of 0.25 mg/mL TiO_2 + 0.5 mg/mL SWNT, 1 mg/mL TiO_2 + 0.5 mg/mL SWNT and 0.5 mg/mL TiO_2 + 0.5 mg/mL SWNT suspensions.

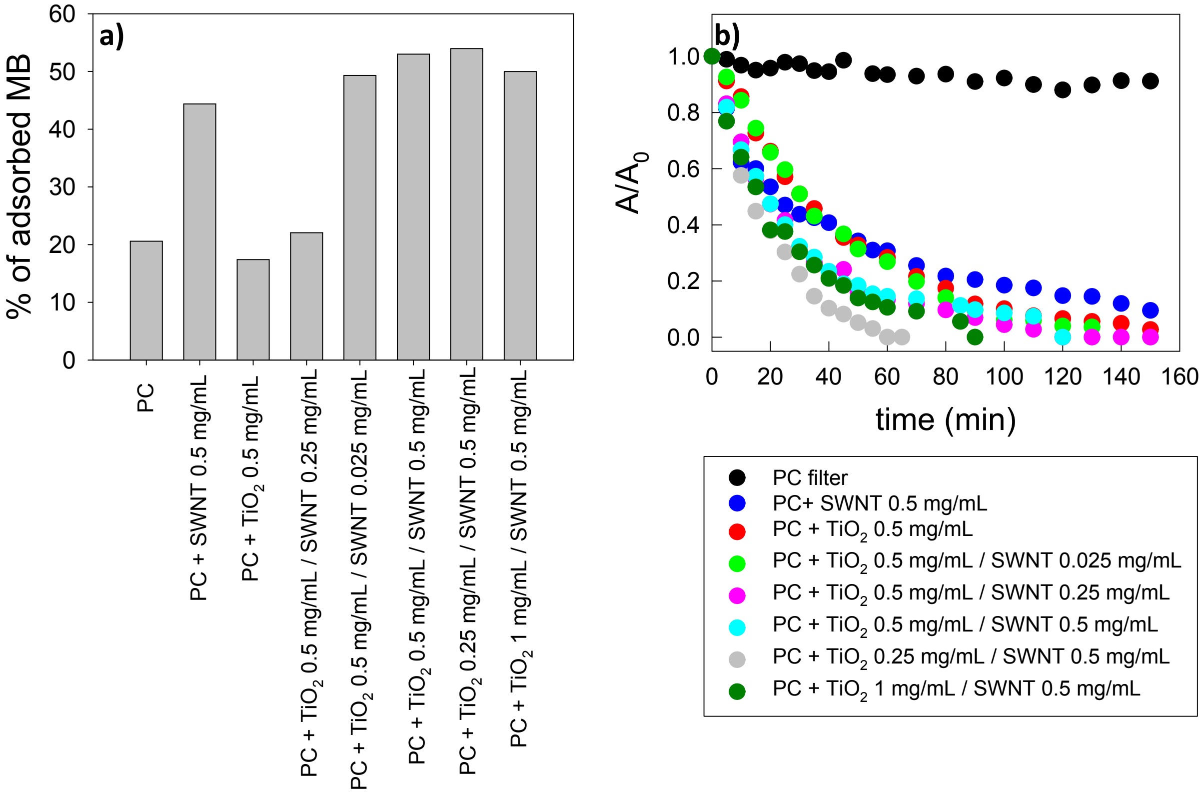

Figure S3. Photodegradation activity of bimorph systems during the degradation of MB 10^{-5} M solutions. a) percentage of adsorbed dye on the solid substrate after 1h in dark; b) photocatalytic degradation of MB solutions as a function of time, under UV irradiation.

S4. Supplementary Movie: Real-time video showing the typical setup and the typical employment of a phactalyst for the triggering of a generic chemical reactions (file uploaded separately).

S5. Supplementary Movie: Real-time video illustrating the use of a phactalyst for the triggering of the redox reaction between glycerol and potassium permanganate (file uploaded separately).

S6. TiO_2-catalysed photopolymerization of pyrrole

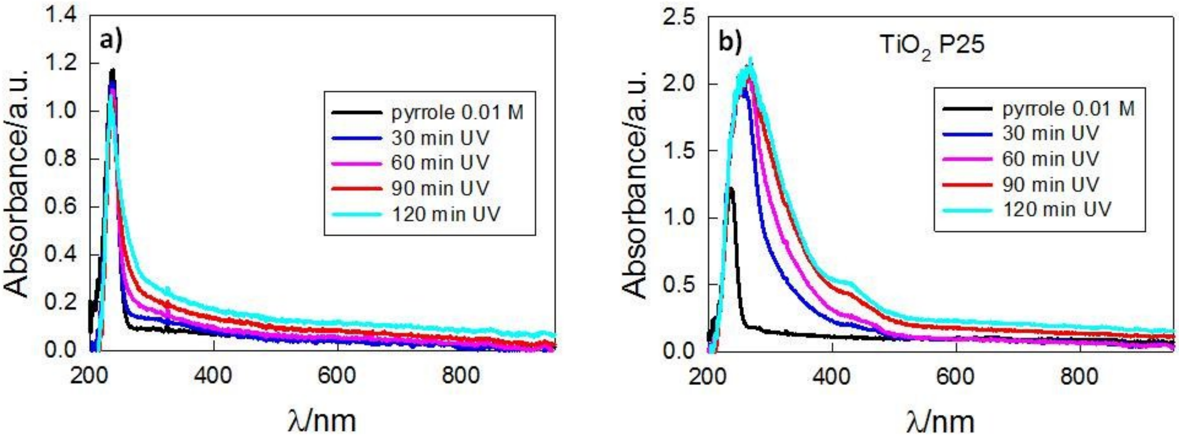

Figure S6. Study of the photo-polymerization of pyrrole in the absence (a) and in the presence (b) of TiO_2 P-25 NPs (0.8 mg/mL). a.) UV-Vis spectra of a pyrrole solution 0.01 M during 120 min of UV illumination in the absence of TiO_2 NPs. Over the time, no modifications can be detected; b) UV-Vis spectra of a pyrrole solution 0.01 M during 120 min. of UV illumination. Over the time, the pyrrole absorption peak moves from λ_{max} =206 nm to λ_{max} =250 nm and a broad band appears at λ~460 nm, indicating the formation of poly-pyrrole units (*see* Ref [55] in the main text).

S7. Supplementary Movie: Video illustrating the use of a phactalyst for triggering of the photo-polymerization of pyrrole (file uploaded separately).

S8. The phactalyst under UV illumination

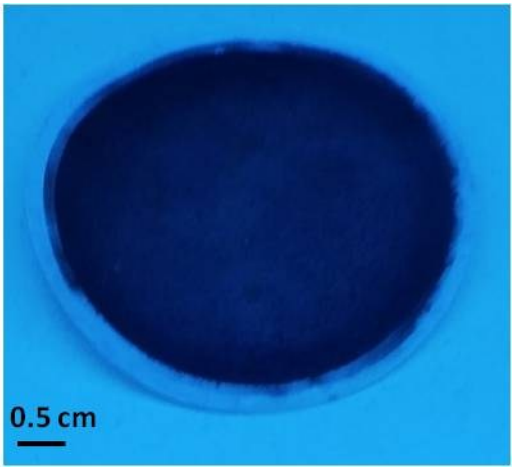

Figure S8. Optical image of a phactalyst under UV illumination: the sample remains flat.

S9. Degradation of methylene blue

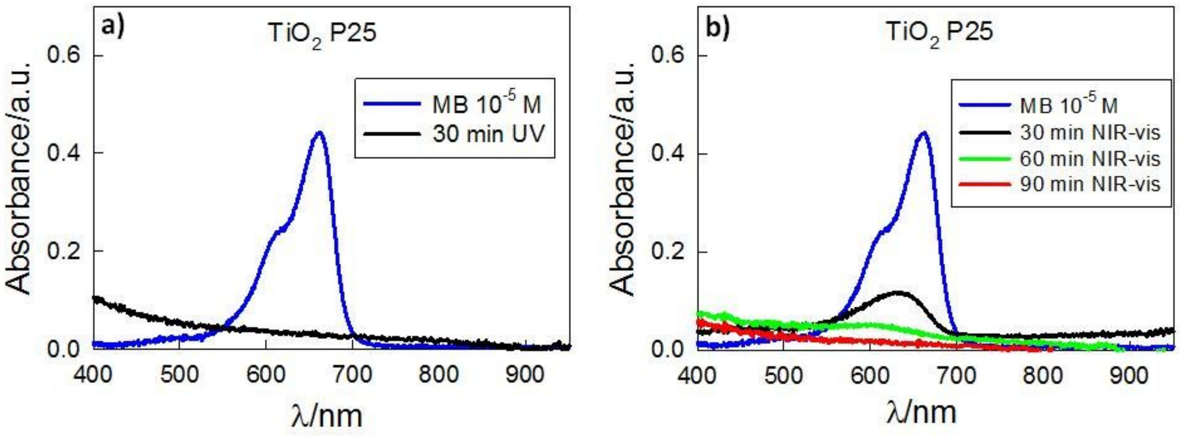

Figure S9. Study of the photodegradation reaction of methylene blue (MB) in the presence of TiO_2 P-25 NPs (0.5 mg/mL) under UV (a) or Vis/NIR illumination (b). a) UV-Vis spectra of methylene blue solution 10^{-5} M before and after 30 min of UV illumination. Within 30 min., the MB is completely degraded, as demonstrated by the disappearance of the MB absorption peaks at λ 600-700 nm; b) UV-Vis spectra of methylene blue solution 10^{-5} M before and after 90 min of Vis-NIR illumination. Each spectrum is recorded every 30 min. The self-degradation is complete after 90 min.

S10. Fields of application of photoactuators: synoptic review

Application	Type of photoactuator	Reference
Weight displacement	CNT-paraffin wax/polyimide	2
	(1,2-bis(5-methyl-2-phenyl-4-thiazolyl)perfluoro-cyclopentene	16, 17
	1,2-bis(2-methyl-5-(1-naphthyl)-3-thienyl)perfluorocyclopentene • perfluoronaphtalene	18
	HNAN/PVD/HFP	29
	graphene-chitosan/polyethene	45
Self-movement	Liquid crystal elastomer	3
	PC/SWNT	34
	Polydopamine-modified rGO	39
	rGO-ELP	41
	rGO-CNT/PDMS	42
	graphene-chitosan/polyethene	45
	graphene nanoplatelets-PDMS/PDMS	47
Self-folding origami	GO/PVD-HFP	40
	rGO-CNT/PDMS	42
	SWNT/pNIPAm	43
	Black ink/Shrinky Dinky polystyrene	44
Valves for microfluidics	spiropyran functionalized hydrogel	24

Table S10.

S11. Photoactuators obtained by combining graphene suspension, polycarbonate filters and TiO_2 NPs.

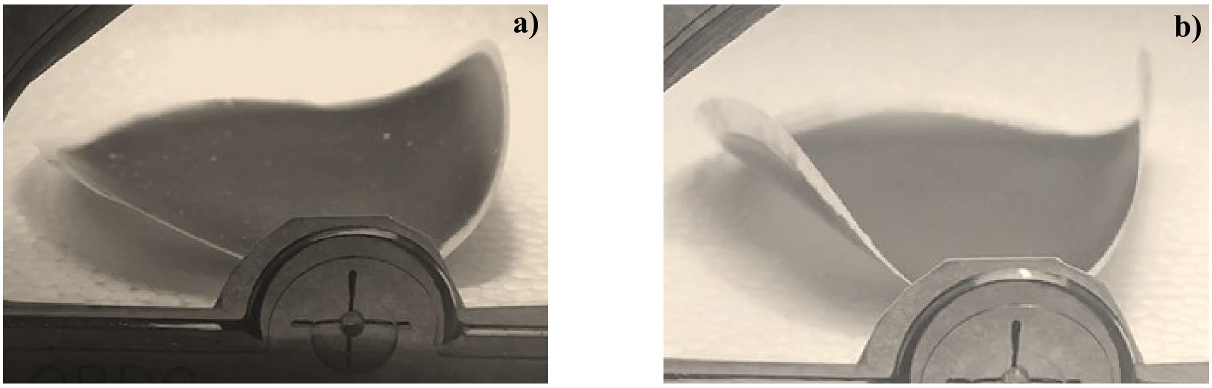

Figure S11. a) optical image of a photoactuator obtained by filtering commercial graphene suspension on PC filters under Vis/NIR illumination; b) optical image of a photoactuator obtained by filtering graphene/TiO_2 suspension on PC filters under Vis/NIR illumination.