Supporting Information

Fabrication of closed-cell inverse opal photonic crystal pigments with angle-independent and stable structural colors

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Table S1. Recipes for preparing monodisperse PS spheres with various diameters

Sample	SDS (mg)	Size (nm)	PDI	Zeta potential (mV)
(a)	45	305	0.045	- 62.6
(b)	60	260	0.057	- 65.8
(c)	75	230	0.033	- 64.8
(d)	90	220	0.046	- 64.1
(e)	100	205	0.042	- 59.7
(f)	110	185	0.038	- 63.8
(g)	120	170	0.031	- 66.4

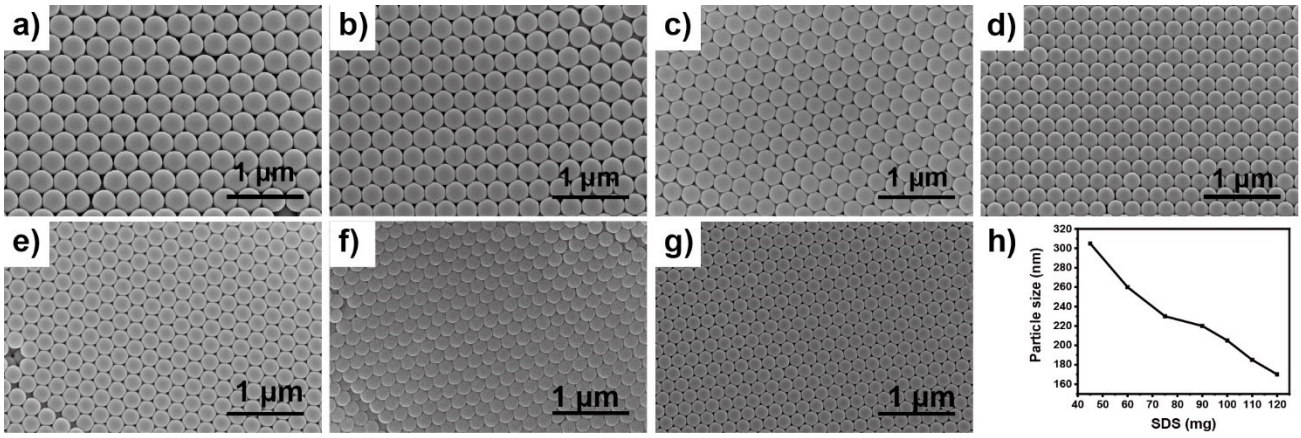

Figure S1. SEM images of monodisperse PS spheres with different diameters: (a) 305 nm; (b) 260 nm; (c) 230 nm; (d) 220 nm; (e) 205 nm; (f) 185 nm; (g) 170 nm; (h) plot showing the relationship between sphere diameter of PS spheres and the amount of emulsifier

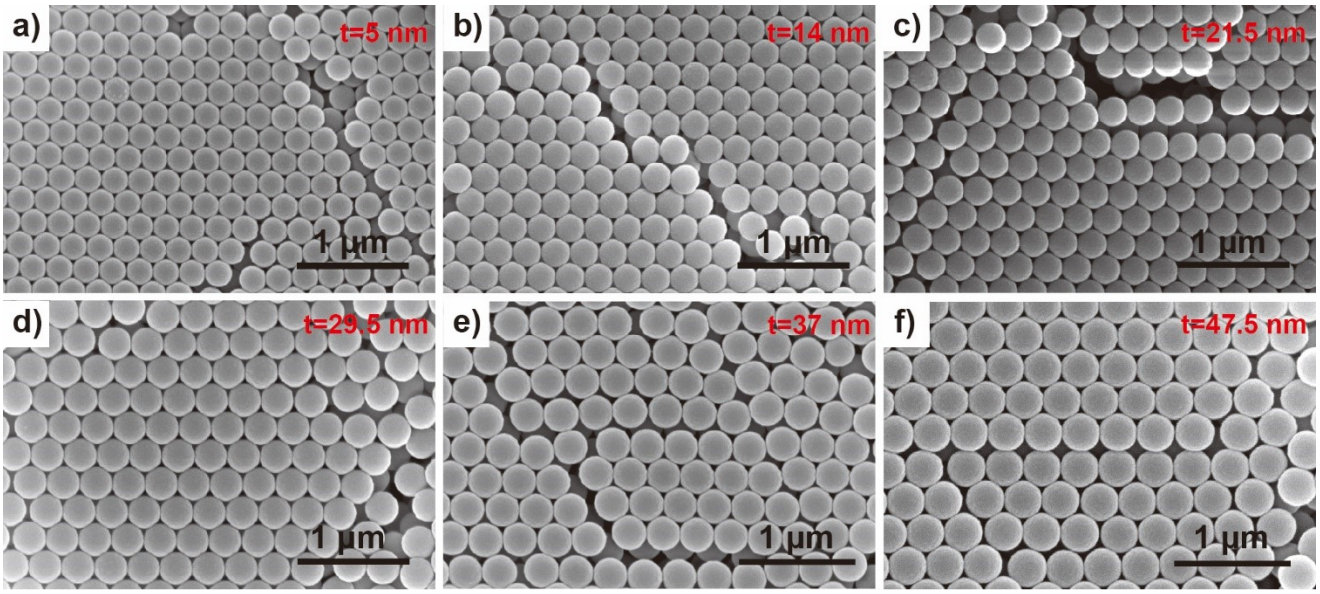

Figure S2. SEM images PS@SiO_2 core-shell spheres with 220 nm PS spheres as cores and various shell thickness: (a) 230 nm spheres with 5 nm shell; (b) 248 nm spheres with 14 nm shell; (c) 263 nm spheres with 21.5 nm shell; (d) 279 nm spheres with 29.5 nm shell; (e) 294 nm spheres with 37 nm shell; (f) 315 nm spheres with 47.5 nm shell;

Table S2. Recipes for preparing PS@SiO_2 spheres with various diameters and shell thickness

Sample	VTMS (mL)	Size (nm)	Shell thickness (nm)
(a)	1	230	5
(b)	2	248	14
(c)	3	263	21.5
(d)	4	279	29.5
(e)	5	294	37
(f)	6	315	47.5

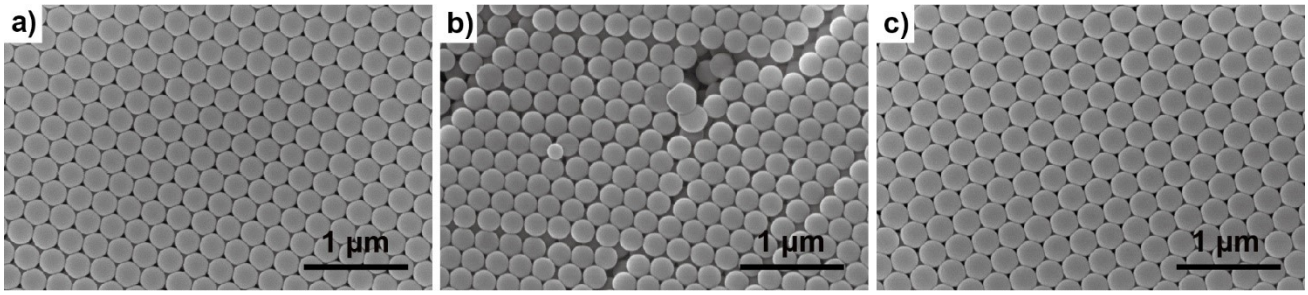

Figure S3. SEM images of (a) 220 nm PS spheres as cores; products of sol-gel reaction with various precursors: (b) TEOS; (c) VTMS

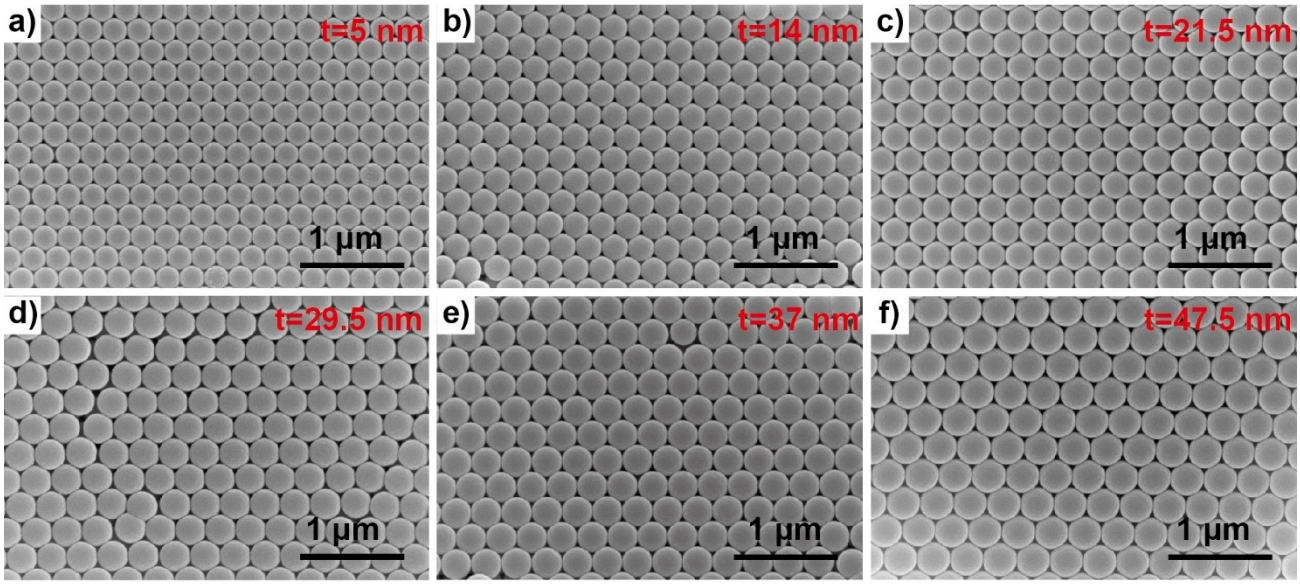

Figure S4. SEM images of PCs fabricated with PS@SiO_2 spheres bearing identical 220 nm PS spheres as cores and various shell thickness: (a) 230 nm spheres with 5 nm shell; (b) 248 nm spheres with 14 nm shell; (c) 263 nm spheres with 21.5 nm shell; (d) 279 nm spheres with 29.5 nm shell; (e) 294 nm spheres with 37 nm shell; (f) 315 nm spheres with 47.5 nm shell;

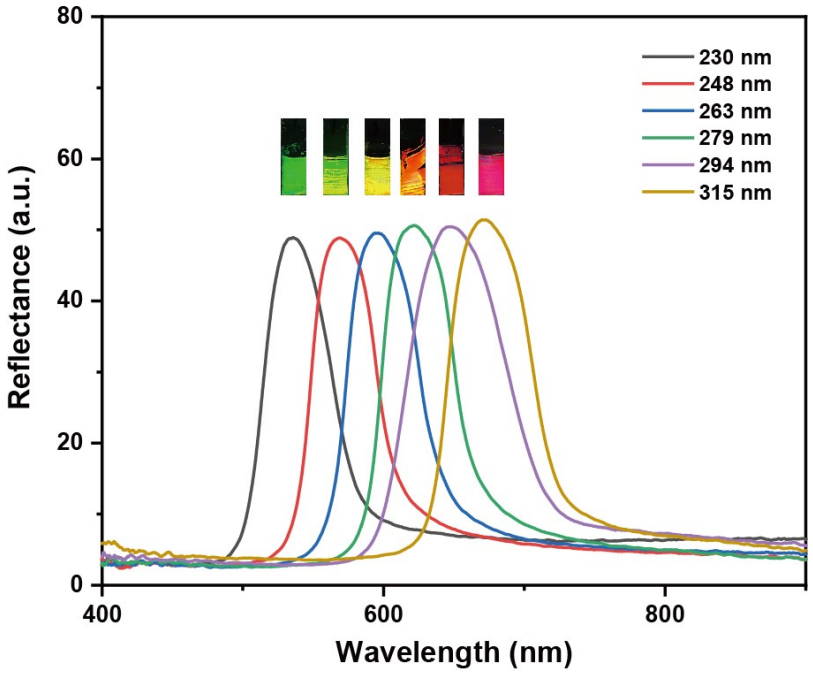

Figure S5. Reflectance spectra of PC films fabricated using PS@SiO_2 core-shell spheres with various shell thickness as building blocks

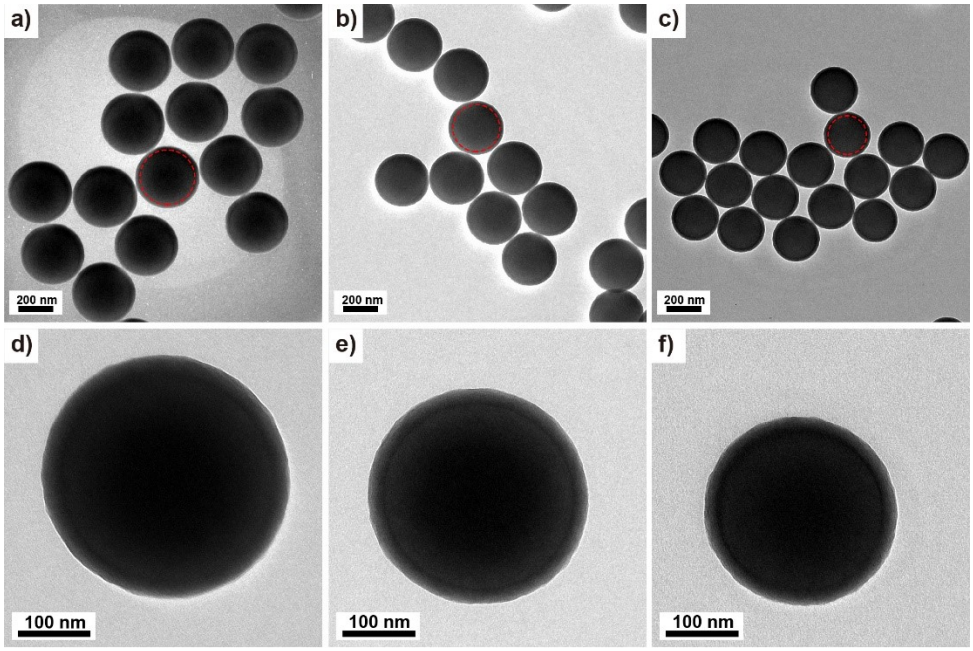

Figure S6. TEM images of PS@SiO_2 spheres with various diameters and nearly identical 23 nm shell thickness: (a,d) 352 nm; (b,e) 305 nm; (c,f) 268 nm; (d-f) are TEM images with higher magnification times of samples a, b and c, respectively.

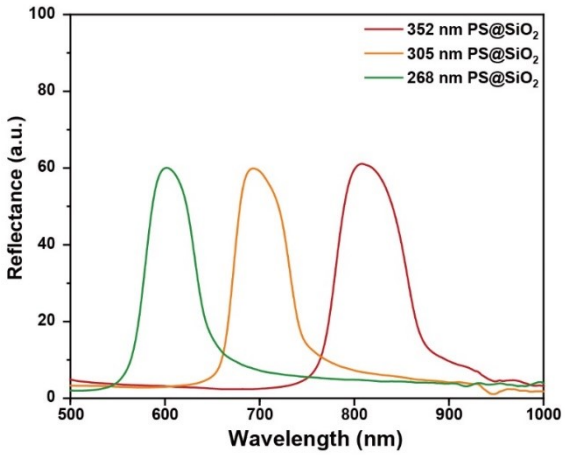

Figure S7. Reflectance spectra of opal PC templates fabricated using PS@SiO_2 spheres with different diameters

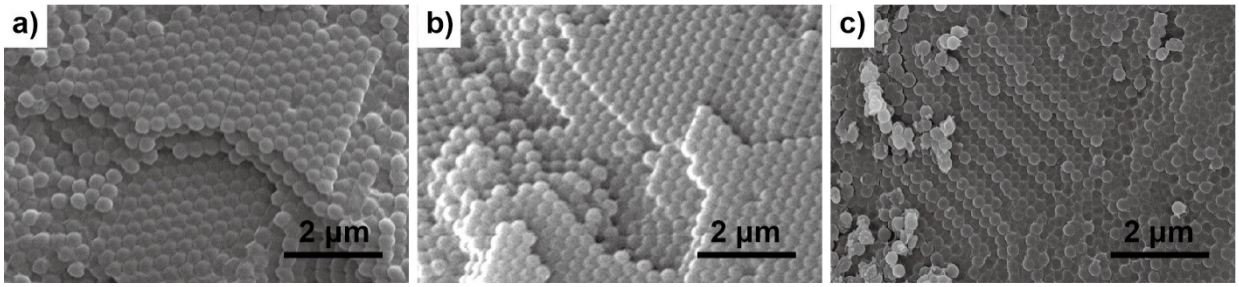

Figure S8. SEM images of PS@SiO_2 composite opal template films using different PS@SiO_2 core-shell spheres as building blocks with interstices between adjacent spheres filled with SiO_2: (a) 352 nm; (b) 305 nm; (c) 268 nm.

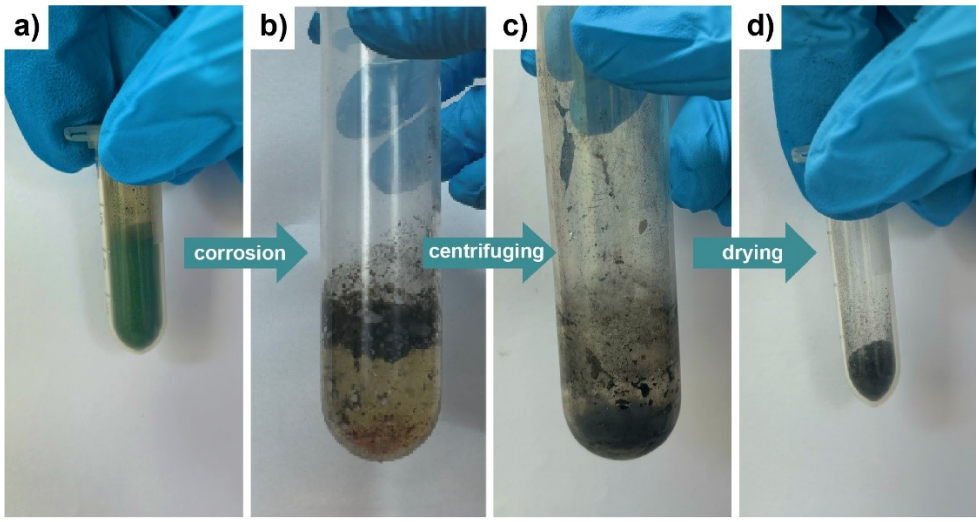

Figure S9. Digital photographs showing the whole harvesting process of carbon black

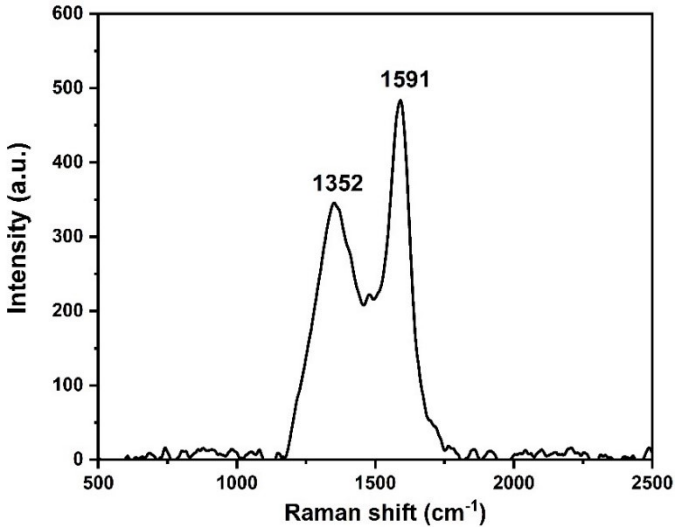

Figure S10. Raman spectrum of harvested products from etched green PC pigment powders

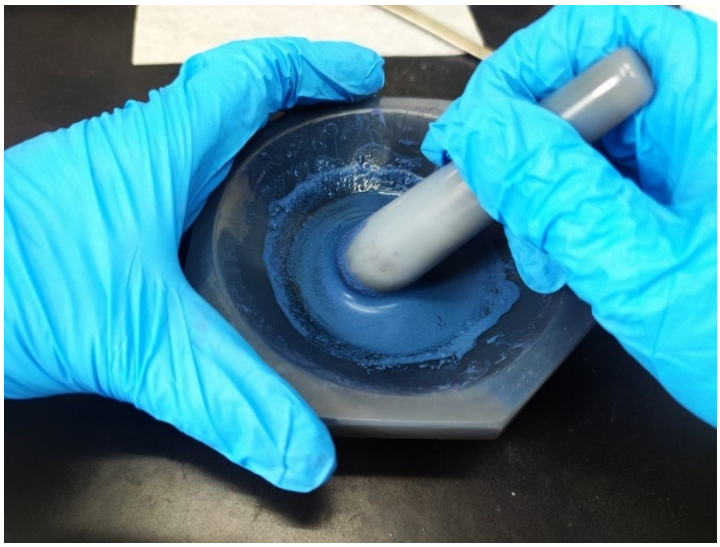

Figure S11. Digital photographs demonstrating the water grinding method

Figure S12. Digital photographs of butterfly patterns drawn with different PC pigments obtained at various calcination temperatures: the pigments for first row and second row are at 500 ºC and 600 ºC, respectively.

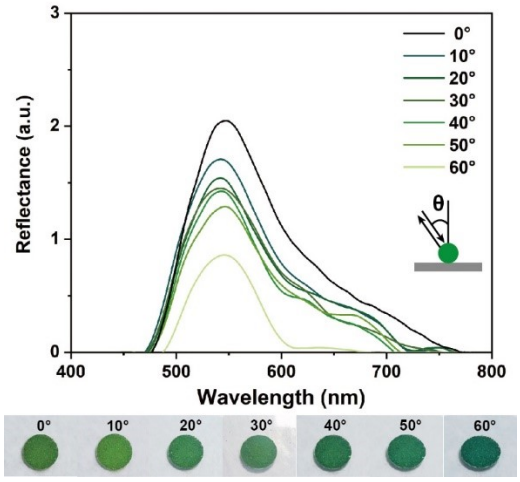

Figure S13. Reflectance spectra of green PC pigments at various incident and viewing angles

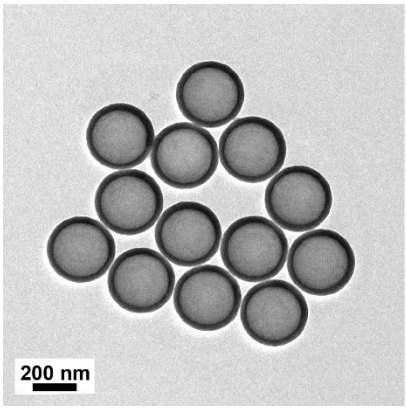

Figure S14. TEM image of calcined PS@SiO_2 spheres

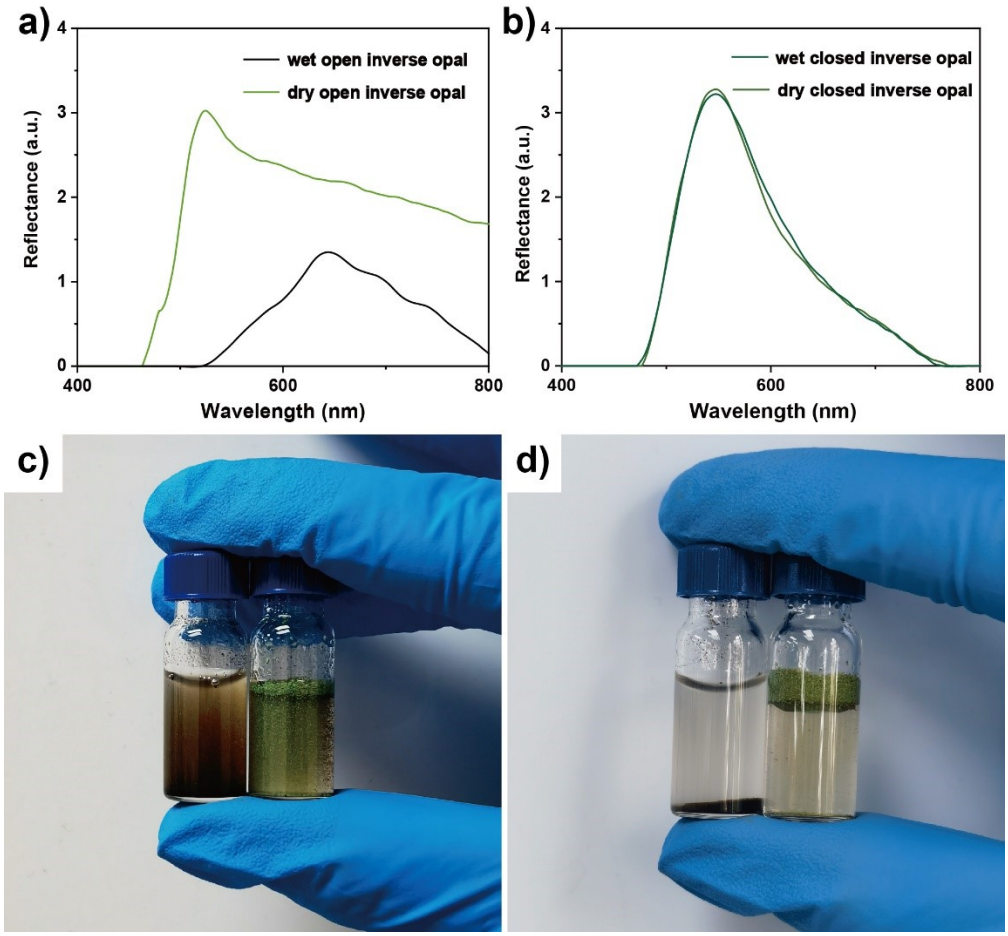

Figure S15. Reflectance spectra of SiO_2 PC pigments with different structures before and after immersion into water: (a) open-cell; (b) closed-cell structures; Digital photographs of SiO_2 inverse photonic crystals with through-hole and closed-hole structures after water infiltration: (c) right after shaking; (d) standing for 2 min

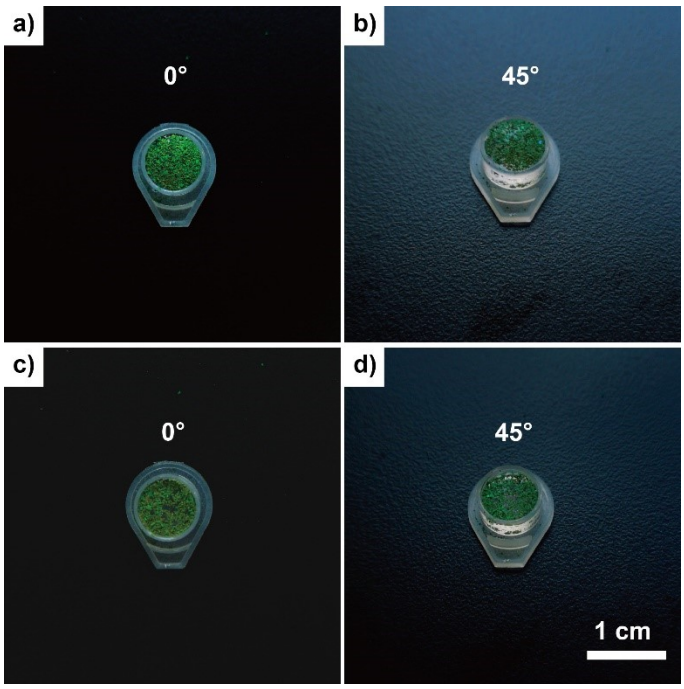

Figure S16. Digital photographs of SiO_2 closed-cell IOPC toner immersed into various solvents at different viewing angles: (a,b) water; (c,d) ethanol; (a,c) the viewing angle is 0°; (b,d) the viewing angle is 45°.