## **Supporting information**

Coupling of chromophores with exactly opposite-luminescence behaviours in mesostructured organosilicas for high-efficiency multicolour emission

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## **Experimental Section**

**Materials.** 3-Aminopropyltriethoxysilane (APTS, Sigma-Aldrich), tetraethoxysilane (TEOS, Beijing Beihua Chemical Co., Ltd.), tetrahydrofuran (THF, Tianjin Tiantai Fine Chemical Co., Ltd.), cetyltrimethylammonium bromide (CTAB, Shanghai Huishi Chemical Co., Ltd.). 1,2-Bis-[4-(bromomethyl)phenyl]-1,2-diphenylethene (BTPE) was prepared according to the reported procedures.<sup>S1</sup> All reagents and solvents for the syntheses were purchased from commercial sources and used as received except THF (chromatographic grade) was distilled from sodium with benzophenone as colour reagent.

**Synthesis of TPE-bridged organosilica.** To an anhydrous THF (7 mL) solution of BTPE (0.052 g, 0.1 mmol) and  $K_2CO_3$  (0.12 g, 8.7 mmol), APTS (0.12 mL, 0.4 mmol) was added dropwise. The mixture was then heated to reflux for 4 h under  $N_2$  atmosphere. After cooling to room temperature, the reaction mixture was filtered and washed with abundant THF. The solvent was removed under reduced pressure to yield the target organosilane precursor without further purification. The resulting material is denoted as TPE-Si. Because TPE-Si is very easy to hydrolysis, the reaction solution should be freshly prepared before the next step of preparation. MS data (m/z calcd for  $C_{40}H_{54}N_2O_6Si_2$ : 714.35 [M]; found: 714.90).

**Synthesis of TPE-bridged periodic mesoporous organosilicas.** 0.5 g of CTAB was dissolved in 120 mL of aqueous NaOH solution and stirred at 80 °C for 30 min. A mixture of 1.9 g of TEOS and 0.09 g of TPE-Si was then added under rapid stirring. After being stirred for another 4 h, the solution was cooled to room temperature. The product was collected by centrifugation and dried in a freezer dryer overnight. Finally,

the template CTAB was removed under reflux in methanol solution for 24 h. The resulting product is denoted as AIE-PMO1. Other materials such as AIE-PMO2 and AIE-PMO3 were prepared using a similar synthesis method, except with the addition of 0.12 and 0.15 g of TPE-Si, respectively. The TPE contents introduced in the materials, as determined by CHN elemental analysis, were approximately 0.12, 0.17 and 0.21 mmol  $g^{-1}$ , respectively.

**Procedure for encapsulating ACQ dyes in AIE-PMOs.** Powder samples of AIE-PMO2 (10 mg) were suspended in 5 mL of aqueous solutions containing appropriate concentration of RhB dyes (0–1.73 mol% ratios with respect to the amount of TPE unit) under stirring in 10 mL sealed centrifuge tubes. The mixtures were stirred for 24 h at room temperature away from light. The immersed samples were then removed and washed with copious amounts of water to remove residual RhB dyes on the surface and obtain RhB@AIE-PMO2 powder. The concentrations of the encapsulated RhB dyes in AIE-PMO2 were determined from their UV-Vis absorption spectra. When the concentration of TPE units in the TPE-PMO2 powder was 0.17 mmol g<sup>-1</sup>, the final contents of the powders were 0.04, 0.07, 0.12, 0.16, 0.36, 0.48, 1.22 and 1.71 mol% RhB with respect to TPE. The contents of encapsulated R6G dyes in AIE-PMO2 were measured via the same method, and the final content of R6G ranged from 0.02 to 0.68 mol% with respect to the amount of embedded TPE unit.

**Procedure for encapsulating RhB dyes in SBA-15.** AIE luminogen tetraphenylethene functionalized mesoporous silica SBA-15 was prepared via post-grafted method according to the reference.<sup>S2</sup> 20 mg of samples were suspended in 5 mL of aqueous solutions containing appropriate concentration of RhB dyes (0–1.73)

mol% ratios with respect to the amount of TPE unit) under stirring in 10 mL sealed centrifuge tubes. After 1 h, the PL spectra of the solutions were measured under excitation at 365 nm, as shown in Fig. S6. As the content of RhB increased, the emission intensity of AIE luminogen-functionalized SBA-15 gradually decreased, whereas a new emission peak of RhB at 574 nm steadily increased, accompanied by a small red-shift in the emission maxima. This result strongly suggests that the excitation energy of the AIE units in the SBA-15 can also be transferred to the RhB dyes. However, PMOs with homogenously distributed AIE units are a superior host compared to SBA-15 in which AIE units are post grafted.

The stability experiments of RhB@AIE-PMOs in aqueous solution. The timedependent emission spectra of RhB@AIE-PMO2 containing 0.36 mol% RhB was measured. 5 mg of RhB@AIE-PMO2 powder was first dispersed into 3 mL of aqueous solution, and then the PL spectra of the mixture solution were monitored during continuous irradiation with 365 nm UV light for 45 min. The RhB desorption from RhB@AIE-PMO2 in solution was investigated by UV-Vis spectroscopic measurement. 5 mg of RhB@AIE-PMO2 powder containing 0.36 mol% of RhB was dispersed into 3 mL of aqueous solution, and was then centrifuged after certain time. The separated solution was monitored by UV absorption.

**Procedure for preparation of multicolour ACQ@AIE-PMO films.** A surfactant solution was first prepared by dissolving 0.64 g of P123 in 8.0 mL of a 1:1 mixture of THF and ethanol (v/v). 0.15 g of TPE-Si was then added to the surfactant solution, followed by the addition of different amounts of RhB dyes (0-5 mol% ratios with respect to the amount of TPE units) in 0.44 mM ethanol solution. After the solution

was stirred at room temperature for 0.5 h, 0.8 g of TEOS was added; the resulting solution was subsequently drop-casted onto glass or quartz substrates and dried at room temperature for 24 h.

Characterization. Powder XRD patterns were recorded on an X-ray diffractometer (D/MAX 2500/PC, Rigaku) equipped with a Cu-K $\alpha$  radiation source ( $\lambda = 0.15405$ nm). Scanning electron microscopy (SEM) images were obtained using a fieldemission scanning electron microscope (JSM-6510) after the samples were sputtered with a thin layer of gold. TEM images were recorded using a Tecnai F20 electron microscope. N<sub>2</sub> adsorption-desorption isotherms were measured at 77 K on a Micromeritics ASAP 2010 M apparatus. Surface areas were estimated according to the Brunauer-Emmett-Teller (BET) method, and the pore size distributions were calculated via the Barrett-Joyner-Halenda (BJH) method on the basis of the adsorption branch of the isotherm. CHN elemental analyses were carried out on a varioMICRO elemental analyser. UV-Vis absorption spectra were obtained on a Shimadzu UV-2550 spectrophotometer. Photoluminescence emission spectra were obtained on a Shimadzu RF-5301PC spectrofluorometer. The emission lifetime was measured with the instrument of FLS920 under UV irradiation. The luminescent quantum efficiencies of the materials were measured on an Edinburgh FLS920 fluorescence spectrometer with an integration sphere attachment under excitation of 365 nm.



**Fig. S1** Fluorescence spectra of samples depending on the water fractions in THF. (a) The freshly prepared reaction solution of TPE-Si in THF; (b) The freshly prepared reaction solution of TPE-Si in THF/H<sub>2</sub>O (v/v=1:9); (c) BTPE; (d) BTPE in THF/H<sub>2</sub>O (v/v=1:9). Excitation wavelength: 365 nm. The photographs are taken under UV light illumination (365 nm).



**Fig. S2** SEM images of the mesostructured AIE-PMOs. (a) AIE-PMO1. (b) AIE-PMO2. (c) AIE-PMO3.



**Fig. S3** TEM images of the mesostructured AIE-PMOs at low magnification and high magnification. (a,b) AIE-PMO1. (c,d) AIE-PMO2. (e,f) AIE-PMO3.



Fig. S4 FT-IR spectra of AIE-PMOs and mesoporous silica.



**Fig. S5** Normalized fluorescence spectra (blue, green, magenta) of AIE-PMOs (AIE-PMO1, AIE-PMO2, AIE-PMO3) and UV-Vis absorption (orange), fluorescence (red) spectrum of RhB in water. Excitation wavelength: 365 nm.



**Fig. S6** Fluorescence spectra of AIE luminogen-functionalized SBA-15 in the aqueous solution with different concentrations of RhB. Excitation wavelength: 365 nm.



Fig. S7 Photostability of RhB@AIE-PMO2 in solid state as a function of light exposure time.



**Fig. S8** Photostability of RhB@AIE-PMO2 powder dispersed in aqueous solution as a function of light exposure time.



**Fig. S9** Time-dependent UV-Vis spectra of the dye desorbed from RhB@AIE-PMO2. 10<sup>-5</sup> M RhB was used as reference.



**Fig. S10** Schematic illustration of the fabrication of multicolour tunable emission ACQ@AIE-PMO films. ACQ@AIE-PMO films are prepared by sol-gel polycondensation via evaporation-induced self-assembly process. The emission colours of the films are tuned by doping different RhB contents.



Fig. S11 XRD pattern of the mesostructured AIE-PMO film.



Fig. S12 TEM image of the mesostructured AIE-PMO film.



**Fig. S13** Normalized fluorescence (green) spectrum of AIE-PMO2 and UV-Vis absorption (blue), fluorescence (red) spectrum of R6G in water. Excitation wavelength: 365 nm.



**Fig. S14** (a) Fluorescence spectra of R6G@AIE-PMO2 in the solid state with different concentrations of R6G. (b) Emission colours (marked by the dots) in the CIE 1931 chromaticity diagram calculated from the fluorescence spectra of (a).

Samples	$S_{BET}^{}(m^2 g^{-1})$	D <sub>BJH</sub> (nm)	V(cm <sup>3</sup> g <sup>-1</sup> )	TPE (mmol g <sup>-1</sup> )
AIE-PMO1	1064	2.5	0.78	0.12
AIE-PMO2	1009	2.4	0.70	0.17
AIE-PMO3	1007	2.3	0.61	0.21

 Table S1 Textural parameters of AIE-PMO samples.

Table S2 Luminescence lifetimes ( $\tau_i$ , ns) of TPE at 480 nm in RhB@AIE-PMO2.

RhB (mol%)	$\tau_1$	$\tau_1\%$	$\tau_2$	$\tau_2$ %	$\tau_3$	$\tau_3\%$	τ
0	1.12	19.18	3.92	62.61	10.79	18.21	4.63
0.36	1.06	29.09	3.72	57.42	10.32	13.49	3.84
1.71	0.80	67.16	3.27	28.31	9.90	4.53	1.91

**Table S3** Summary of the quantum yield  $(\Phi_F)$  of the reported white-emitting inorganic-organic materials.

Name	CIE	$\Phi_{\rm F}$	Reference number
Mn doped [Zn <sub>1.7</sub> Cd <sub>0.3</sub> S <sub>2</sub> (octylamine)]	(0.36, 0.36)	29.1%	6a
Ga <sub>2</sub> O <sub>3</sub> -RhB NCs	(0.33, 0.33)	30%	6b
[Ir(ppy) <sub>2</sub> (bpy)]@1	(0.31, 0.33)	20.4%	6c
F-1a/Rhd6G film	(0.32, 0.34)	43%	11d
RhB@AIE-PMO	(0.32, 0.33)	49.6%	this work
	Name Mn doped [Zn <sub>1.7</sub> Cd <sub>0.3</sub> S <sub>2</sub> (octylamine)] Ga <sub>2</sub> O <sub>3</sub> -RhB NCs [Ir(ppy) <sub>2</sub> (bpy)]@1 F-1a/Rhd6G film RhB@AIE-PMO	Name         CIE           Mn doped         (0.36, 0.36)           [Zn <sub>1.7</sub> Cd <sub>0.3</sub> S <sub>2</sub> (octylamine)]         (0.33, 0.33)           Ga <sub>2</sub> O <sub>3</sub> -RhB NCs         (0.33, 0.33)           [Ir(ppy) <sub>2</sub> (bpy)]@1         (0.31, 0.33)           F-1a/Rhd6G film         (0.32, 0.34)           RhB@AIE-PMO         (0.32, 0.33)	NameCIE $\Phi_{\rm F}$ Mn doped [Zn_{1.7}Cd_{0.3}S_2(octylamine)](0.36, 0.36)29.1%Ga_2O_3-RhB NCs(0.33, 0.33)30%[Ir(ppy)_2(bpy)]@1(0.31, 0.33)20.4%F-1a/Rhd6G film(0.32, 0.34)43%RhB@AIE-PMO(0.32, 0.33)49.6%

References

<sup>S1</sup> A. J. Qin, L. Tang, J. W. Y. Lam, C. K. W. Jim, Y. Yu, H. Zhao, J. Z. Sun and B. Z. Tang, *Adv. Funct. Mater.*, 2009, **19**, 1891–1900.

<sup>S2</sup> D. D. Li, J. H. Yu and R. R. Xu, Chem. Commun., 2011, 47, 11077–11079.