# Rationally designed functional Macroporous materials as new adsorbents for efficient phosphorus adsorption

**Jie Yang,** [a] **Pei Yuan,**[b] **Hsin-Yi Chen,** [a] **Jin Zou,** [c] **Zhiguo Yuan** [d] **and Chengzhong Yu***[a]

*a ARC Centre of Excellence for Functional Nanomaterials and Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, Brisbane, QLD 4072, Australia. Fax: (+61) 7-334 63973; E-mail: c.yu@uq.edu.au*

*b State Key Laboratory of Heavy Oil Processing, China University of Petroleum,No. 18 Fuxue Rd., Beijing 102249, China*

*c Materials Engineering and Centre for Microscopy and Microanalysis, The University of Queensland, Brisbane, QLD 4072, Australia*

*d Advanced Water Management Centre, Gehrmann Building, Research Road, The University of Queensland, Brisbane, QLD 4072, Australia*

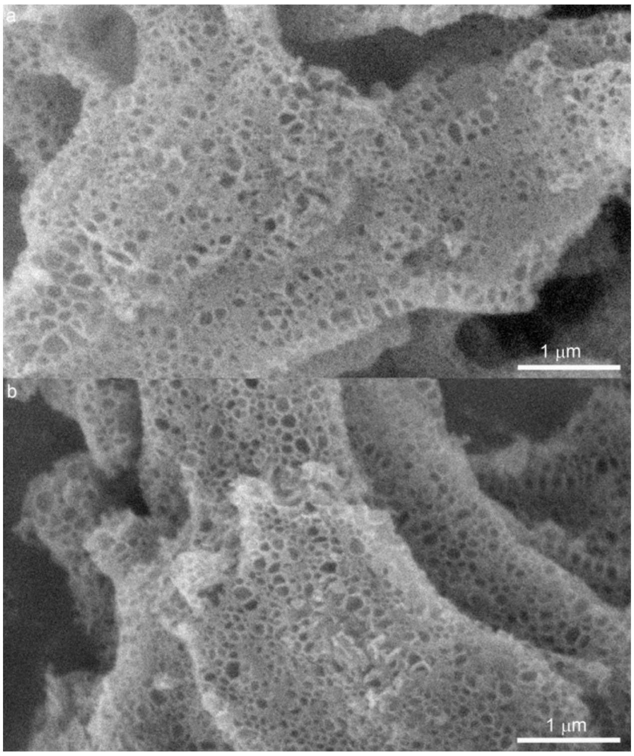


**Fig. S1.** (a) SEM images of MOSF and (b) $La_{200}$MOSF.

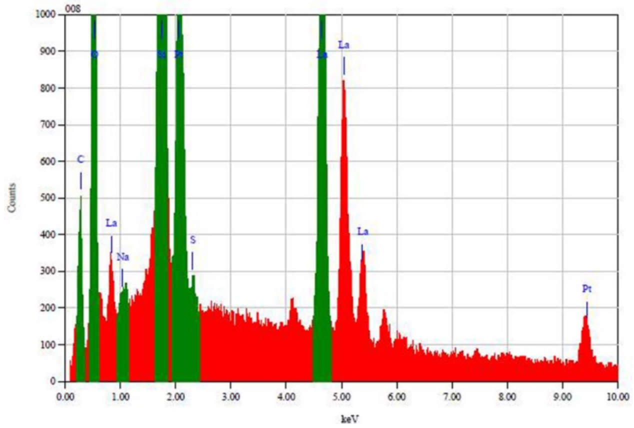


**Fig. S2.** The energy-dispersive X-ray spectrum of $La_{200}$MOSF.

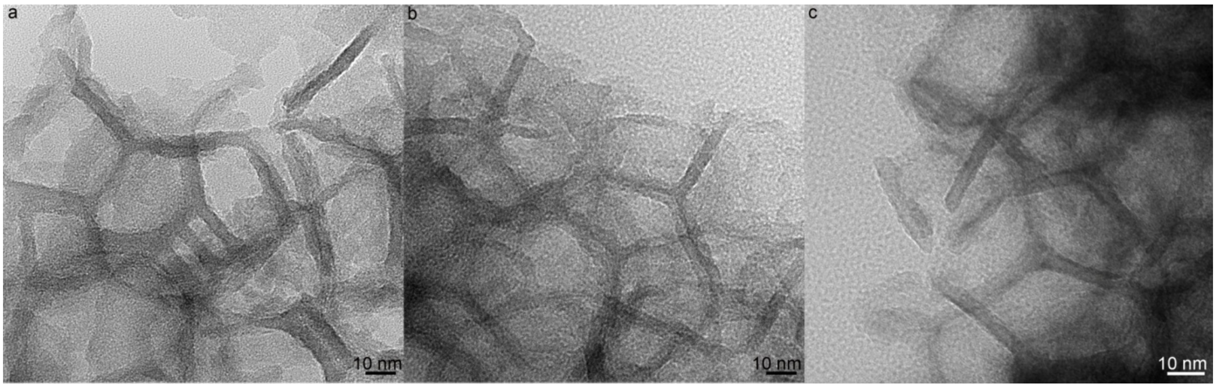


**Fig. S3.** (a) - (c) TEM images of $La_{25}$MOSF, $La_{50}$MOSF, and $La_{100}$MOSF, respectively.

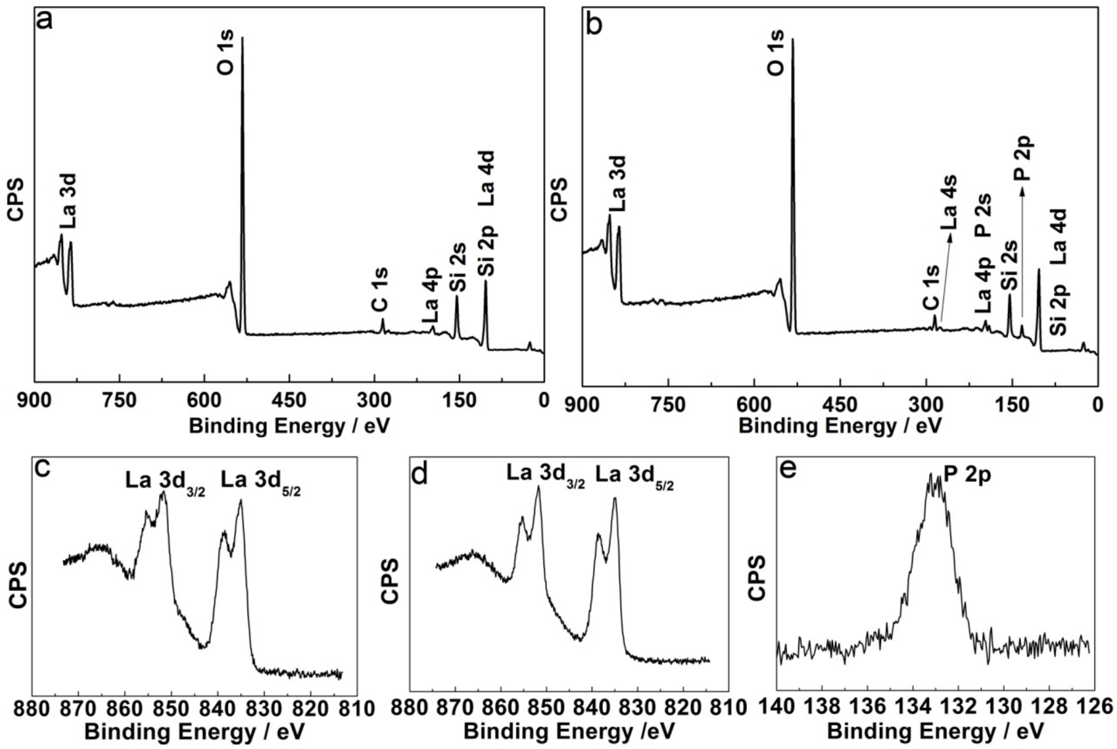


**Fig. S4.** (a) XPS survey scan of $La_{200}$MOSF; (b) XPS survey scan of $La_{200}$MOSF after phosphorus adsorption; (c) XPS spectrum of La 3d region of $La_{200}$MOSF; (d) and (f) are XPS spectrums of La 3d region and p 2p region of $La_{200}$MOSF after phosphorus adsorption, respectively.

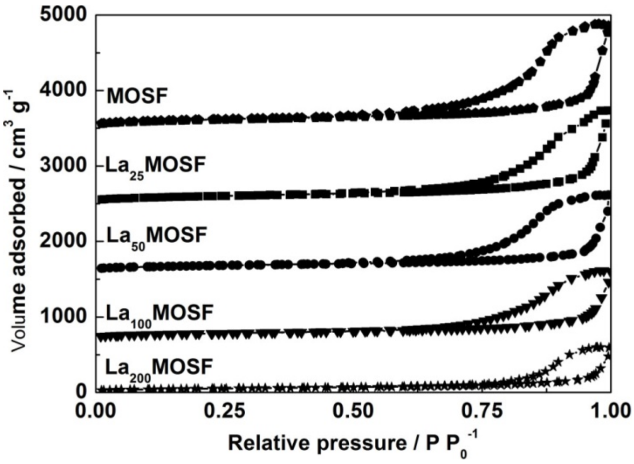


**Fig. S5.** Nitrogen adsorption-desorption isotherms for La$_x$MOSF materials. ). The adsorption isotherms for MOSF, La$_{25}$MOSF, La$_{50}$MOSF and La$_{100}$MOSF are shifted by 3500, 2500, 1600 and 700 cm$^3$·g$^{-1}$ (STP), respectively.

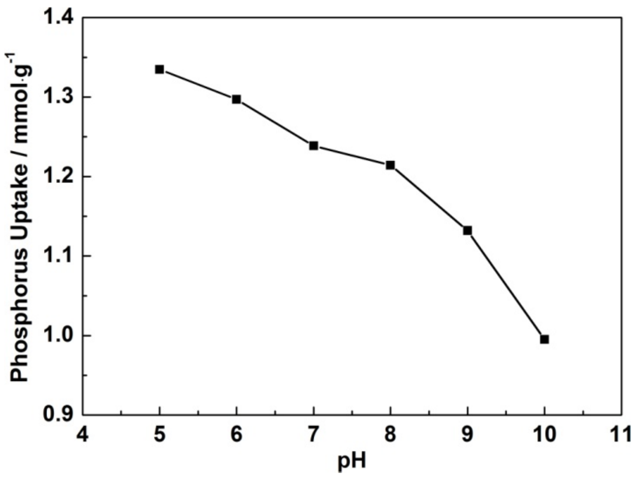


**Fig. S6** The phosphate uptake capacity of $La_{200}$MOSF as a function of the initial pH value of phosphate solutions. The pH value is adjusted using 0.1 M HCl and NaOH. The initial phosphate concentration is 50 mg/L and the adsorbent dosage is 50 mg/50 mL.

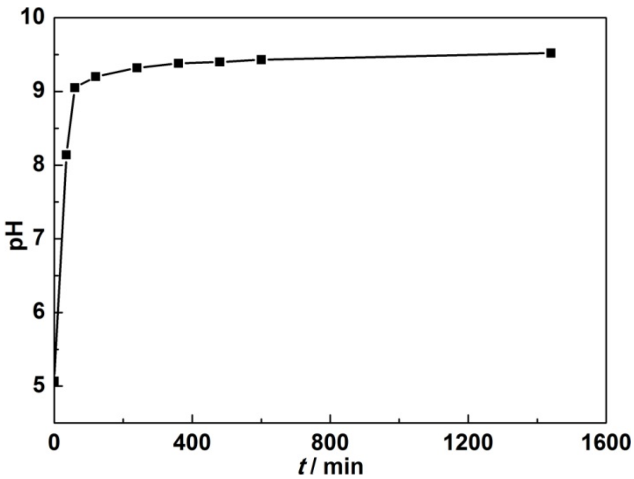


**Fig. S7** The pH value change during the adsorption process of $La_{200}$MOSF as a function of reaction time.

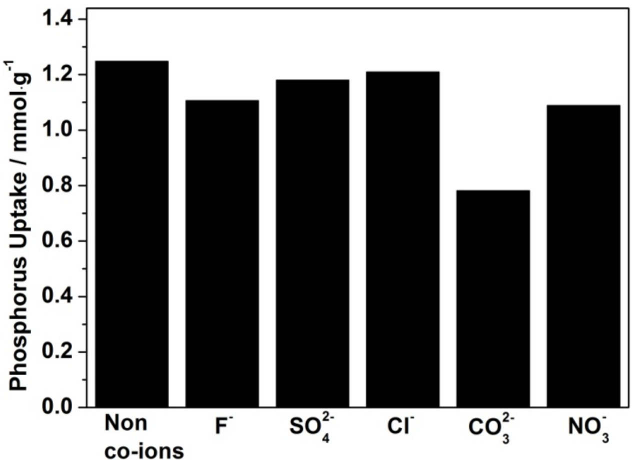


**Fig. S8**. The effect of coexisting anions on adsorption capacity of $La_{200}$MOSF. Sorbent dosage: 0.050 g/50 mL; phosphorus concentration: 50 mg/L; foreign anions concentrations: 400 mg/L; temperature: 25°C; stirring speed 150 r/min.

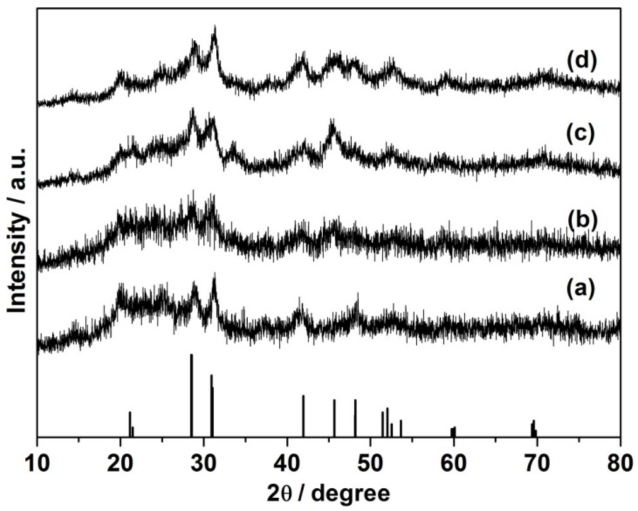


**Fig. S9.** The wide-angle XRD patterns of (a-d) La$_x$MOSF materials after phosphorus adsorption (x=25, 50, 100 and 200, respectively).

**Table S1.** The atomic percentage of La and Si of $La_{200}$MOSF

| Atomic percentage (%) | La | Si |
|---|---|---|
| 1 | 7.86 | 25.17 |
| 2 | 4.32 | 26.48 |
| 3 | 7.04 | 32.23 |
| 4 | 4.92 | 23.95 |
| 5 | 6.08 | 27.98 |
| 6 | 4.90 | 23.03 |
| 7 | 6.37 | 28.12 |
| 8 | 4.49 | 23.81 |
| 9 | 7.85 | 27.85 |
| 10 | 9.54 | 44.27 |
| average | 6.34 | 28.29 |

Electronic Supplementary Material (ESI) for Journal of Materials Chemistry


**Table S2.** Langmuir and Freundlich parameters for phosphate adsorption on each sample.

| samples | Langmuir modal | | | | Freundlich modal | | |
|---|---|---|---|---|---|---|---|
| | †$R^2$ | †$b$ (L/mmol) | †$Q_{max}$ (mmol/g) | P/La | ¶$R^2$ | ¶$K$ (mmol$^{(1-n)}$·L$^n$·g$^{-1}$ ) | ¶$n$ |
| $La_{25}$MOSF | 0.997 | 27.531 | 0.551 | 1.043 | 0.994 | 0.554 | 21.46 |
| $La_{50}$MOSF | 0.838 | 109.616 | 0.971 | 0.099 | 0.817 | 1.010 | 8.213 |
| $La_{100}$MOSF | 0.977 | 9.450 | 1.874 | 1.117 | 0.974 | 1.751 | 4.681 |
| $La_{200}$MOSF | 0.973 | 4.090 | 2.272 | 0.862 | 0.933 | 1.831 | 3.177 |

† Langmuir parameters: $R^2$ is the correlation coefficients, $Q_{\max}$ is the maximum adsorption amount (mmol/g), and $b$ is Langmuir constant (L/mmol).

¶ Freundlich paremeters: $R^2$ is the correlation coefficients, $K$ (mmol$^{(1-n)}$·L$^n$·g$^{-1}$ ) and $n$ are empirical constants.

**Table S3.** Composition of synthetic wastewater.

| Macro elements | mg/L | Trace elements | mg/L |
|---|---|---|---|
| Na-acetate | 42.85 | $FeSO_4.7H_2O$ | 2.50 |
| $KH_2PO_4$ | 14 | $ZnCl_2$ | 0.06 |
| $K_2HPO_4$ | 13 | $MnCl_2.4H_2O$ | 0.06 |
| $NH_4Cl$ | 191 | $NaMoO_4$ $.2H_2O$ | 0.19 |
| Starch | 81 | $CoCl_2.6H_2O$ | 0.13 |
| Milk powder | 110 | $NiCl_2.6H_2O$ | 0.04 |
| Sucrose | 80 | $CuSO_4$ | 0.06 |
| Peptone | 16 | $H_3BO_3$ | 0.06 |
| Yeast extract | 38 | $MgCl_2$ | 0.19 |
| $NaHCO_3$ | 600 | $CaCl_2$ | 0.44 |