Supporting Information

Synchronous, efficient and fast removal of phosphate and organic matter by carbon-coated lanthanum nanorods

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Experimental section

Digestion method

(1) Boil 0.01 g of products with 10 mL of aqua regia and 2 mL of HClO$_4$ at 120 °C until the products were dissolved; (2) After cooling, add 1mL HClO$_4$ into the solution, evaporate at 160 °C until the residual liquid volume was approximately 1 mL; (3) After cooling, dilute the solution with 2% HNO$_3$ (MOS grad) to 100 mL.

HA stock preparation and determination

HA stock solution was prepared by dissolving 1 g of HA solid in 500 mL of 0.1 M NaOH, followed by filtration with 0.45 μm glass fiber filters, and was stored at 4 °C for later use. The HA stock solution was diluted in gradient and the amounts of HA were measured by TOC analyzer (Multi N/C 2100, Analytik-Jena, Germany) and UV-vis spectrophotometer at the same time. The linear regressions between the values of UV254 absorbance at 254 nm and TOC (TOC-UV254) and between the TOC values and the corresponding multiplicative inverse of dilution ratios were done. And the equations of linear regression were obtained (TOC-1/dilution ratios). In the text, the target concentration solution (mg TOC/L) and the practical concentration (mg TOC/L) were acquired by the linear regression equations of TOC-1/dilution ratios and TOC-UV254, respectively. The results were shown in Figure S1.
Figures

**Figure S1.** (a) Relationship between the TOC values and the corresponding multiplicative inverse of dilution ratios. (b) Relationship between the TOC values and the UV254 absorbance at 254 nm.

![TOC values vs 1/dilution ratios](image1)

![TOC values vs UV254 absorbance](image2)

**Figure S2.** (a) and (b) are the TEM images of G-La-MOF (C-La-MOF before carbonization) at various magnification.

![TEM images of G-La-MOF](image3)
Figure S3. (a) HRTEM image of C-La-MOF. (b) SAED pattern of C-La-MOF. (c) XRD pattern of C-La-MOF.
Figure S4. (a) and (b) are the TEM images of C-La-MOF10 and C-La-MOF12, respectively. (c-e) are the thickness distribution of C-La-MOF, C-La-MOF10 and C-La-MOF12, respectively.
Figure S5. (a) and (b) are TEM and SEM images of C-La, respectively. (c) SEM image of C-La-MOF-500. (d) High angle annular dark field (HAADF) image of C-La-MOF-500 and the corresponding elemental mapping of C, O and La. (e) SEM image of C-La$_2$O$_3$. (f) and (g) are SEM images of C-La$_2$O$_3$ after phosphate adsorption.
Figure S6. (a) and (b) are the pseudo-first-order model and pseudo-second-order model, respectively, for the phosphate adsorption onto C-La-MOF (initial P concentration = 50 mg P/L).

Fig. S7. (a) and (b) are the SEM images of C-La-MOF after capturing phosphate at various magnification. The surface of La-MOF-500 became rough.
Fig. S8. Zeta potentials of C-La-MOF at pH 2~12.
Tables:

**Table S1.** Equilibrium isotherm model parameters of phosphate adsorption by C-La-MOF at 25 °C.

|        | Langmuir | Freundlich |
|--------|----------|------------|
|        | $q_m$ (mg P/g) | $K_L$ (L/mg) | $R^2$ | $1/n$ | $K_F$ (mg/g) | $R^2$ |
|        | 58.97    | 1.37       | 0.569 | 0.132 | 37.41       | 0.911 |

**Table S2.** Kinetics parameters of phosphate adsorption over C-La-MOF at 25 °C.

|        | Pseudo first-order kinetics | Pseudo second-order kinetics |
|--------|-----------------------------|------------------------------|
|        | $k_1$ (1/min) | $q_e$ (cal) (mg P/g) | $R^2$ | $k_2$ (g/mg·min) | $q_e$ (cal) (mg P/g) | $R^2$ |
|        | 0.0041 | 27.12 | 0.870 | 0.0004 | 56.72 | 0.999 |

**Table S3.** Turbidity of solutions with C-La-MOF at different pH.

| pH | Turbidity after sedimentation for 20 min (NTU) | Turbidity after further filtration (NTU) |
|----|-----------------------------------------------|----------------------------------------|
| 2  | 8.34                                         | 0.092                                  |
| 3  | 2.98                                         | 0.042                                  |
| 4  | 2.89                                         | 0.003                                  |
| 5  | 5.98                                         | 0.048                                  |
| 6  | 5.37                                         | 0.048                                  |
| 7  | 8.04                                         | 0.035                                  |
| 8  | 13.27                                        | 0.405                                  |
| 9  | 12.87                                        | 0.115                                  |
| 10 | 95.87                                        | 0.035                                  |
| 11 | 31.67                                        | 0.195                                  |
| 12 | 9.76                                         | 0.748                                  |