

# **A Recyclable Magnetic Aminated Lignin Supported Zr-La Dual-Metal Hydroxide for Rapid Separation and Highly Efficient Sequestration of Phosphate**

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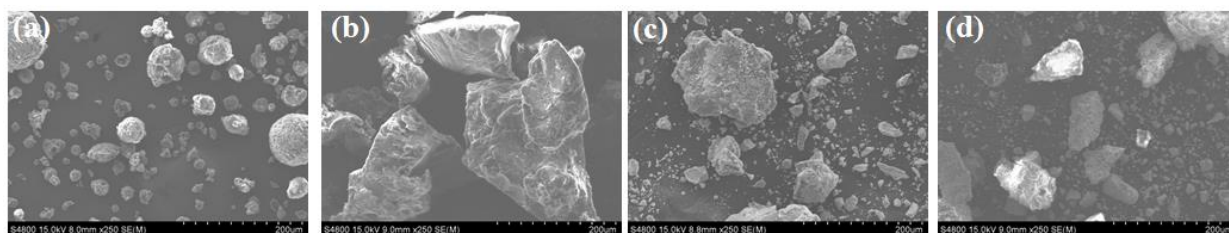
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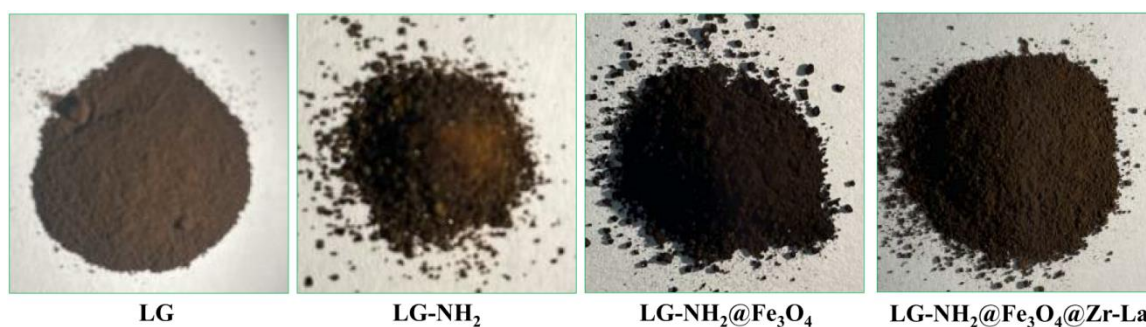
Equation:

$$R_L = \frac{1}{1 + bC_0} \quad (1)$$

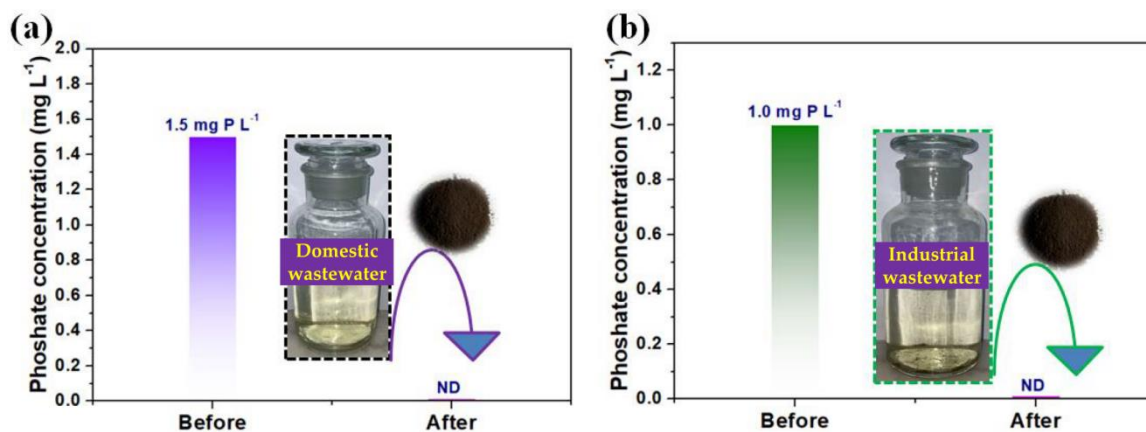
where  $C_0$  represents the initial concentration of phosphate in aqueous medium and  $b$  represents the Langmuir equilibrium constant. The value of  $R_L$  shows an indication for the feasibility of the adsorption process to proceed: irreversible ( $R_L = 0$ ), suitable ( $0 < R_L < 1$ ), linear ( $R_L = 1$ ), or unsuitable ( $R_L > 1$ ), respectively.



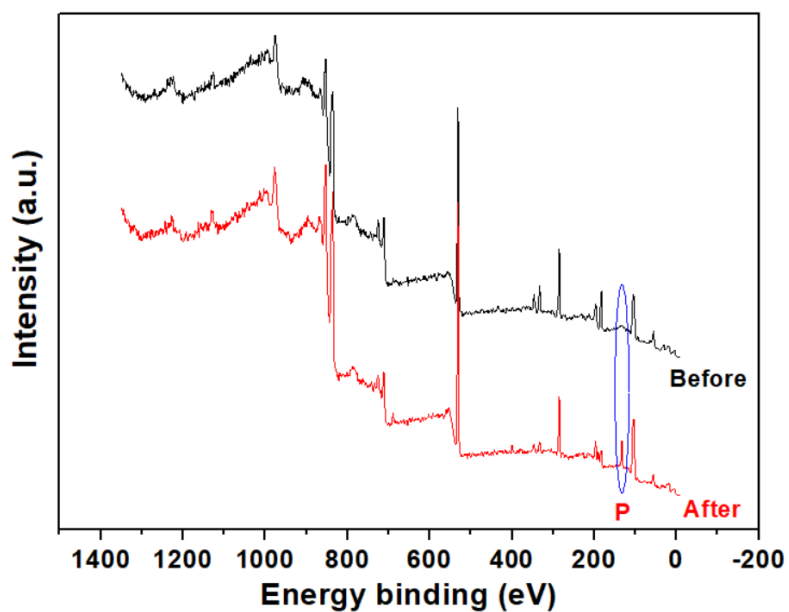
**Figure S1.** SEM images for (a) LG, (b) LG-NH<sub>2</sub>, (c) LG-NH<sub>2</sub>@Fe<sub>3</sub>O<sub>4</sub>, and (d) LG-NH<sub>2</sub>@Fe<sub>3</sub>O<sub>4</sub>@Zr-La.



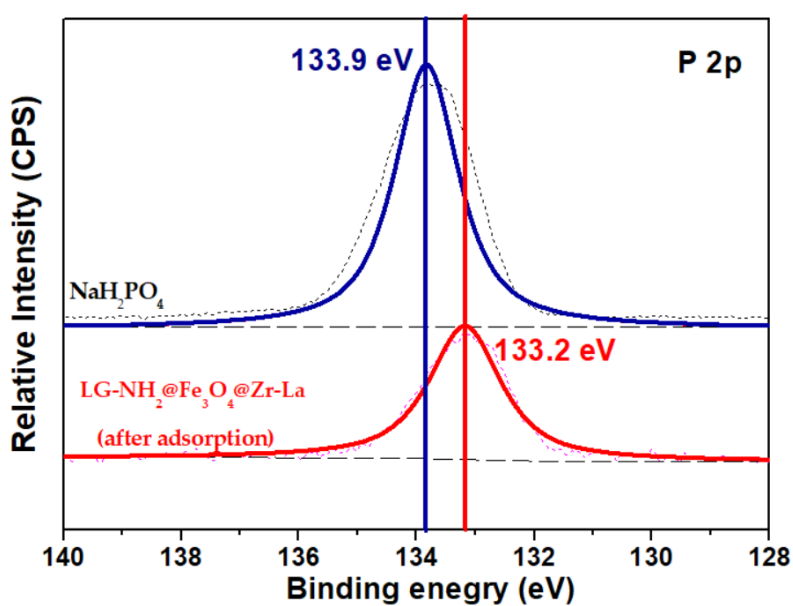
**Figure S2.** Digital images of different materials.



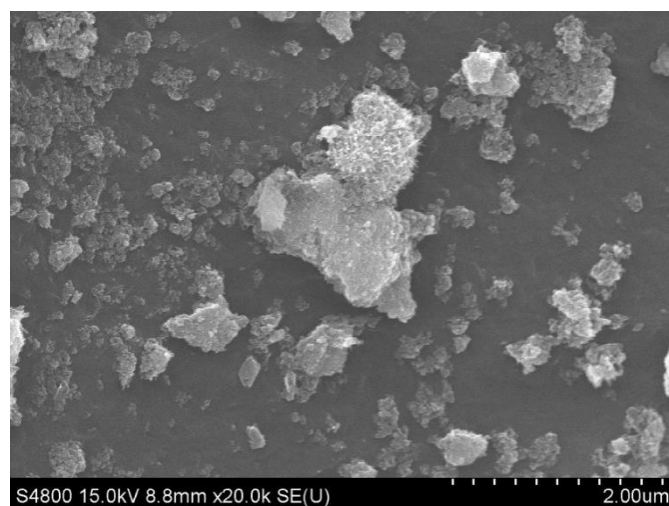
**Figure S3.** Changes in phosphate concentrations of two sewage samples before and after treatment by LG-NH<sub>2</sub>@Fe<sub>3</sub>O<sub>4</sub>@Zr-La (ND: Not detected).



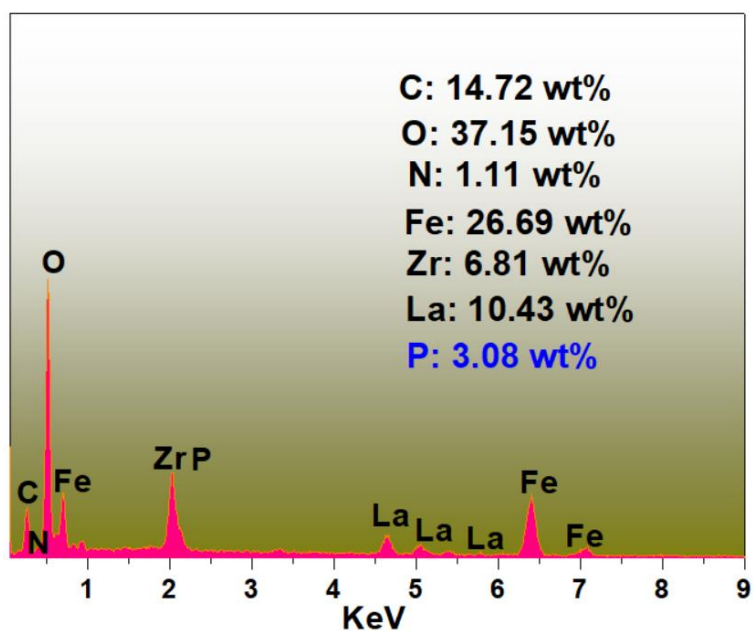
**Figure S4.** The wide-scan XPS spectra of LG-NH<sub>2</sub>@Fe<sub>3</sub>O<sub>4</sub>@Zr-La before and after phosphate adsorption.



**Figure S5.** XPS analysis of the P 2p spectral.



**Figure S6.** SEM image of the phosphate adsorbed-material.



**Figure S7.** EDX spectrum of phosphate adsorbed-material.

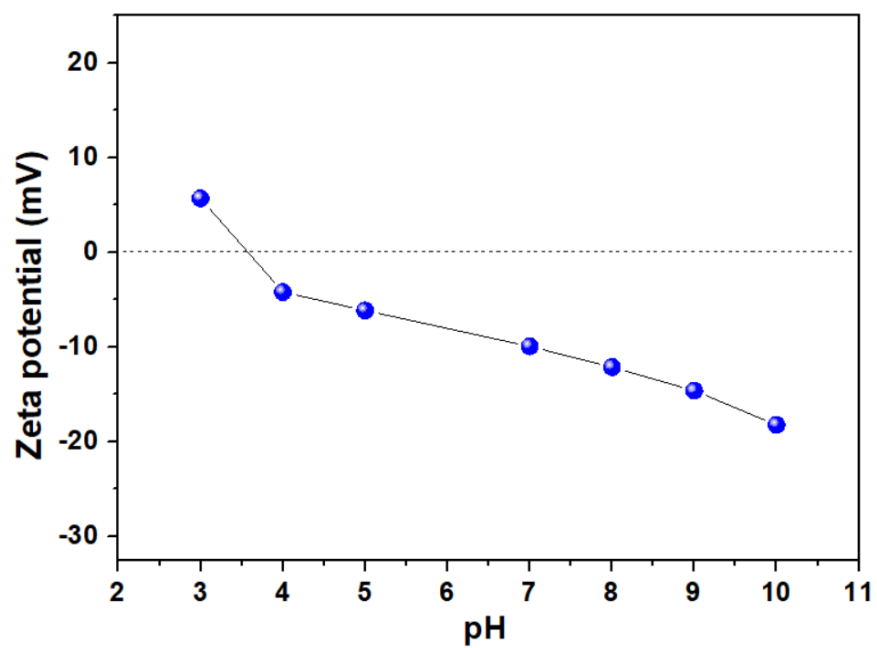


Figure S8. Zeta potential in response to pH change.