Electronic Supplementary Information

Large-pore silica particles with antibody-like bio-recognition sites for efficient protein separation

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1. Equations

The pseudo-first-order rate equation is listed as follows:

$$\ln(Q_e - Q_t) = \ln Q_e - k_1 t \qquad (1)$$

where Q_e and Q_t (mg/g) are the amount of BSA adsorbed on MI-LPSPs at equilibrium and time t, respectively. k_1 (cm^{-1}) is the rate constant of pseudo-first-order model.

The pseudo-second-order rate equation is listed as follows:

$$\frac{t}{Q_t} = \frac{1}{k_2 Q_e^2} + (\frac{1}{Q_e})t \qquad (2)$$

where k_2 is the rate constant of pseudo-second-order model.

Langmiur adsorption equation has the linear form as following:

$$\frac{C_e}{q_e} = \frac{1}{k_L q_{\max}} + \frac{C_e}{q_{\max}} \qquad (3)$$

where C_e is the equilibrium concentration of BSA (mg/mL); q_e denotes the adsorption capacity of MI-LPSPs at equilibrium (mg/g), and q_{max} is the maximum adsorption capacity (mg/g). k_L is the Langmuir constant (L/g) that relates to adsorption energy and affinity of binding sites.

The linear mathematical expression of the Freundlich model is presented as:

$$\log q_e = \log k_F + (n)\log C_e \qquad (4)$$

k_F (g^{1-n} L^n/g) is Freundlich constant related to the adsorption capacity of the adsorbent, and n signifies adsorption intensity.

2. Supporting data

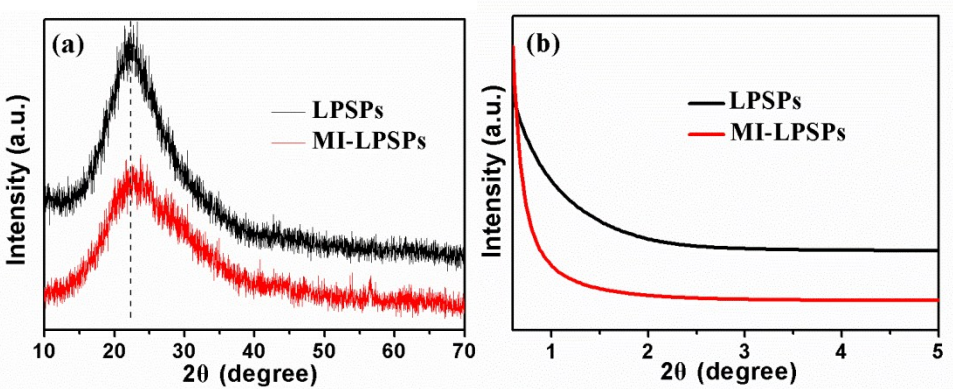

Fig. S1 Wide-angle (a) and low-angle (b) XRD spectra of LPSPs and MI-LPSPs

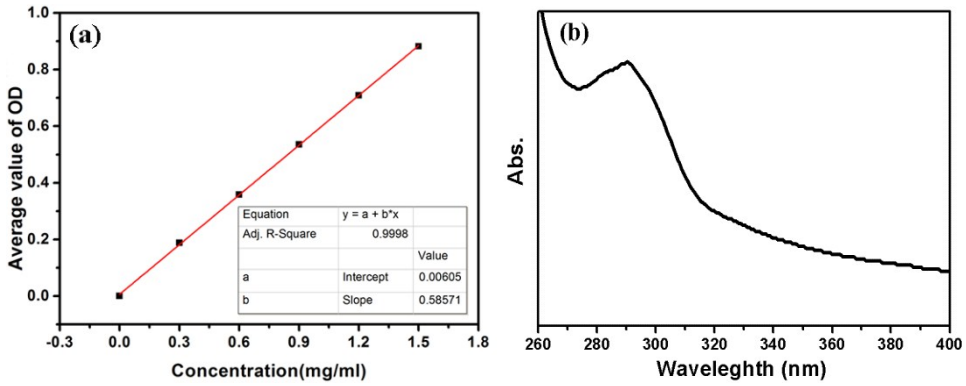

Fig. S2 (a) Standard curve of BSA solution; (b) UV-vis spectra of BSA desorption from MI-LPSPs

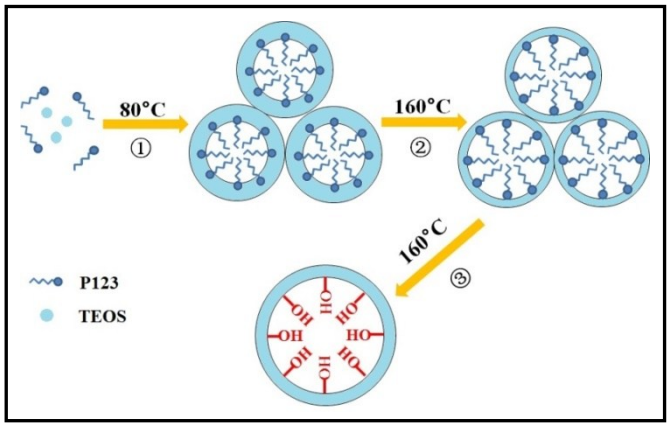

Fig. S3 The proposed mechanism for synthesis of LPSPs

① TEOS and P123 combine to form organic-inorganic composite in aqueous solutions with relatively low acid concentration at 80 °C; ② In the early stage of hydrothermal treatment at 160 °C, PEO shrink into the hydrophobic region of micelles to expand the size of hydrophobic region; ③ With the increase of time of hydrothermal treatment at 160 °C, organic template are gradually removed because of weaker hydrogen bond

interaction. Simultaneously, mesoporous channel were merged to form larger mesopores, and abundant Si-OH groups are maintained.

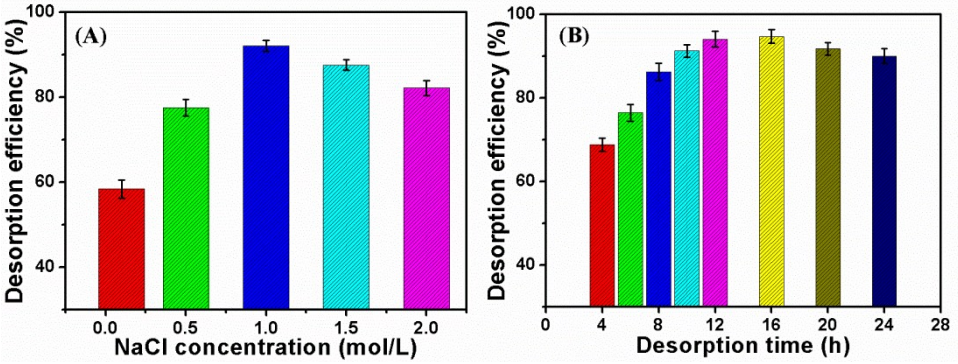

Fig. S4 The effects of (A) NaCl concentrations (desorption period: 10 h, solution volume: 20 mL, pH: 7.0) and (B) desorption period (NaCl concentration: 1.0 mol/L, solution volume: 20 mL, pH: 7.0) on the desorption of BSA from MI-LPSPs

Table. S1 Physi-chemical parameters of LPSPs, MI-LPSPs-BSA and MI-LPSPs

Samples	Specific surface area (m^2/g)	Pore volume (cm^3/g)	Average pore diameter (nm)
LPSPs	472.8	2.35	23.8
MI-LPSPs-BSA	303.2	0.64	5.6
MI-LPSPs	337.5	0.81	8.8

Table S2 Kinetic parameters for BSA adsorption by MI-LPSPs and NI-LPSPs

Adsorbent	q_{exp} (mg/g)	Pseudo-first order			Pseudo-second order		
		k_1 (min^{-1})	q_e (mg/g)	R^2	k_2 (g/(mgmin))	q_e (mg/g)	R^2
MI-LPSPs	153.62	1.47×10^2	144.09	0.996	0.35×10^{-3}	149.53	0.998
NI-LPSPs	50.43	0.51×10^2	246.31	0.988	0.38×10^{-3}	52.82	0.979

Table S3 The Langmuir and Freundlich isotherm parameters obtained by the adsorption of BSA on MI-LPSPs and NI-LPSPs

Adsorbent	q_{exp} (mg/g)	Langmuir			Freundlich		
		q_m(mg/g)	K_L(L/mg)	R^2	K_F	n	R^2
MI-LPSPs	165.82	167.50	86.65	0.999	107.8	1.68	0.701
NI-LPSPs	62.68	63.09	11.24	0.998	290.3	2.17	0.857