Supplementary information

Efficient adsorptive removal of potassium from potassium perrhenate solution by cationic ion exchange resin

Kunkun Chen [1, 2], Linbo Li [1,*], Kai Yang [1], Qigao Cao [2], Yunfei Chen [2]

1. School of Metallurgical Engineering, Xi'an University of Architecture and Technology, Xi'an 710055, China
2. Electronic Material Research Center, Northwest Institute for Nonferrous Metal Research, Xi'an 710016, China

***Corresponding author**

E-mail addresses: yj-lilinbo@xauat.edu.cn (L. Li)

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Text S1. Adsorption isotherm models

Adsorption isotherm is used to describe the relationship between adsorption capacity and concentration of solution after adsorption equilibrium at a certain temperature. Adsorption isotherm is usually fitted by adsorption isotherm models. At present, there are four commonly used models include Langmuir model, Freundlich model, Temkin model and Dubinin–Radushkevich model [1-3], as follows:

Langmuir model:

$$q_e = \frac{q_{\max} K_L C_e}{1 + K_L C_e} \tag{S-1}$$

$$R_L = \frac{1}{1 + K_L C_0} \tag{S-2}$$

Freundlich model:

$$q_e = K_F C_e^{1/n} \tag{S-3}$$

Temkin model:

$$q_e = B_T \ln K_T + B_T \ln C_e \tag{S-4}$$

$$B_T = RT / b \tag{S-5}$$

Dubinin-Radushkevich model:

$$\ln q_e = \ln q_m - K_{DR}\varepsilon^2 \tag{S-6}$$

$$\varepsilon = RT \ln(1 + \frac{1}{C_e}) \tag{S-7}$$

$$E = \frac{1}{\sqrt{2K_{DR}}} \tag{S-8}$$

Where C_e, C_0 are the equlilibrum and initial concentration of the adsorbate in the solution (mg·L^{-1}), respectively, q_e is the adsorption capacity of adsorbent to adsorbate after adsorption equilibrium, (mg·g^{-1}), q_{max} is maximum adsorption capacity of single molecular layer of adsorbent related to adsorption sites (mg·g^{-1}), n is Freundlich constant indicating the adsorption intensity, b represent the Temkin constant, q_m refers to theoretical isotherm saturation capacity (mg·g^{-1}), K_L, K_F, K_T and K_{DR} are the equilibrium constants of Langmuir, Freundlich, Temkin, and Dubinin-Radushkevich models, respectively, ε refers to the Polanyi potential constant (J/mol), and E refers to energy per molecule of adsorbate (kJ/mol)

Text S2. Adsorption kinetic models

Adsorption kinetics mainly describes the change of adsorption rate and the influence of external factors on the adsorption process. The models of Pseudo-first-order, Pseudo-second-order and Weber-Morris [4, 5] are commonly used adsorption kinetic models, as follows:

Pseudo-first-order equation: $q_t = q_e(1 - e^{-K_1 t})$ (S-9)

Pseudo-second-order equation: $\frac{t}{q_t} = \frac{1}{K_2 q_e^{\ 2}} + \frac{t}{q_e}$ (S-10)

Weber-Morris equation: $q_t = K_P t^{1/2} + C$ (S-11)

where K_1 is the adsorption rate constant of the Pseudo-first-order model, min^{-1}; K_2 is the adsorption rate constant of the Pseudo-second-order model, $g \cdot mg^{-1} \cdot min^{-1}$; K_p is the intra-particle diffusion rate constant, $mg \cdot g^{-1} \cdot min^{-0.5}$; C is a constant, which is related to the thickness of boundary layer.

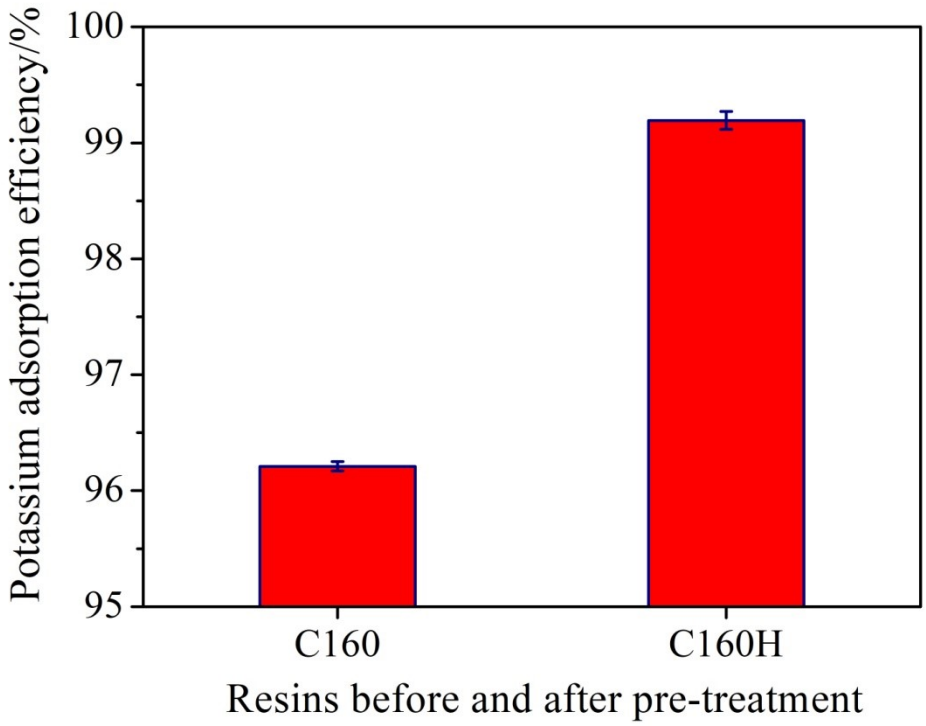


Fig. S1 The potassium adsorption efficiency of C160 and C160H

($KReO_4$ solution concentration of 2 $g \cdot L^{-1}$, solid-to- liquid ratio of 1:20, rotating speed of 180 rpm, temperature of 25℃, contact time of 6h)

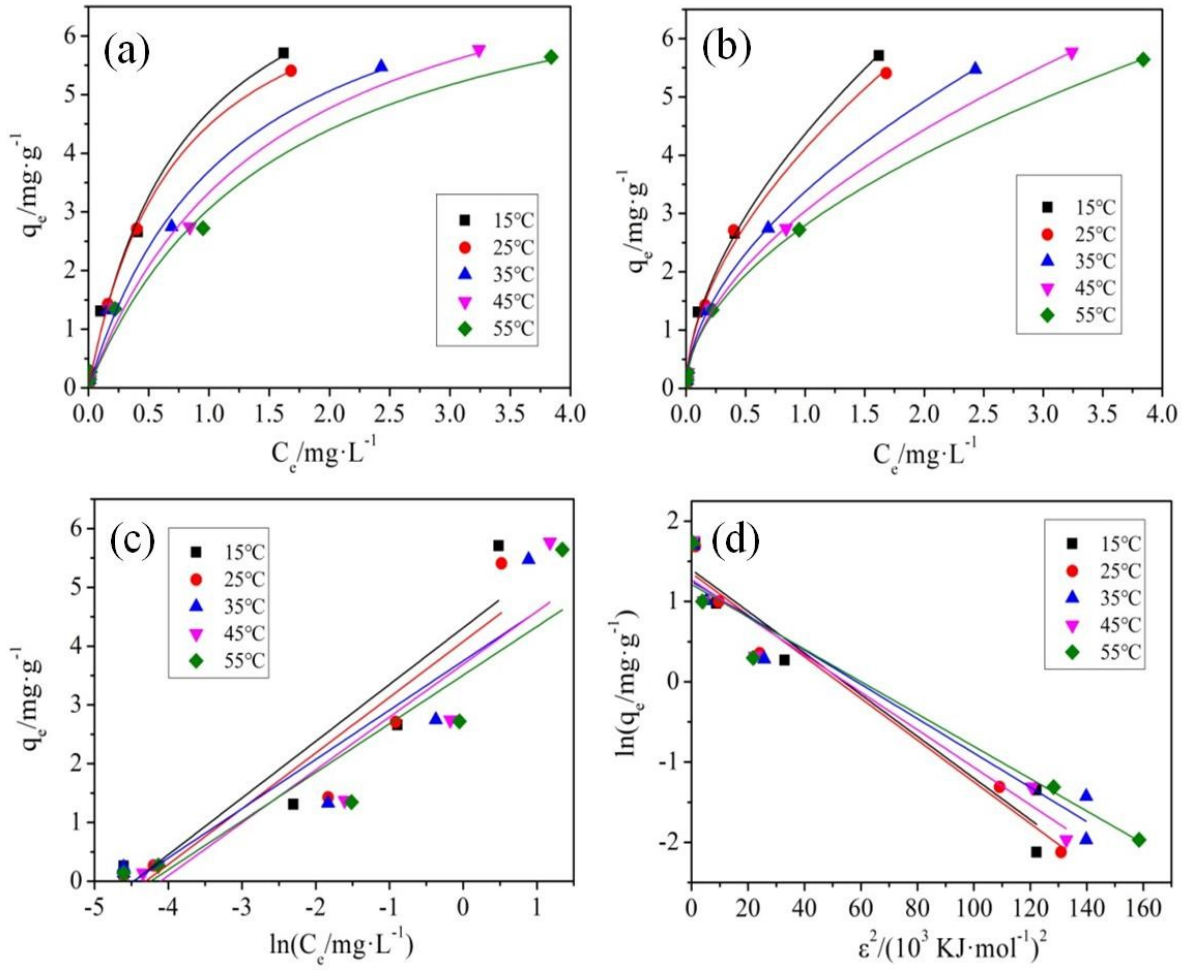


Fig. S2 Adsorption of potassium by resin according to various isotherm models: (a)-Langmuir; (b)-Freundlich; (c)-Temkin; (d)-Dubinin-Radushkevich

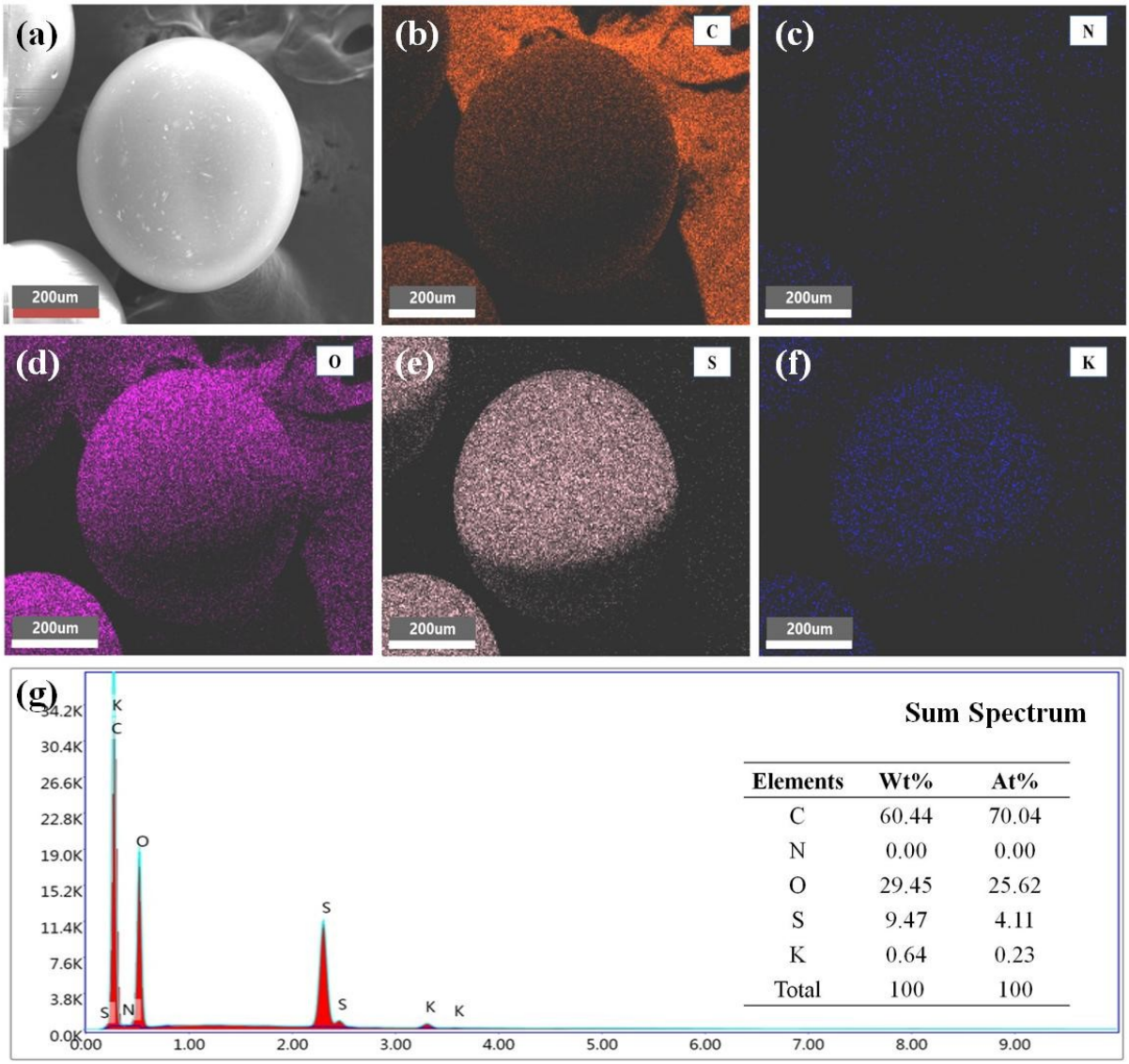


Fig. S3 SEM-EDS scanning results of C160H resin loaded with potassium: (a) SEM images, (b-f) EDS maps for elemental distribution, and (g) elemental composition spectrum

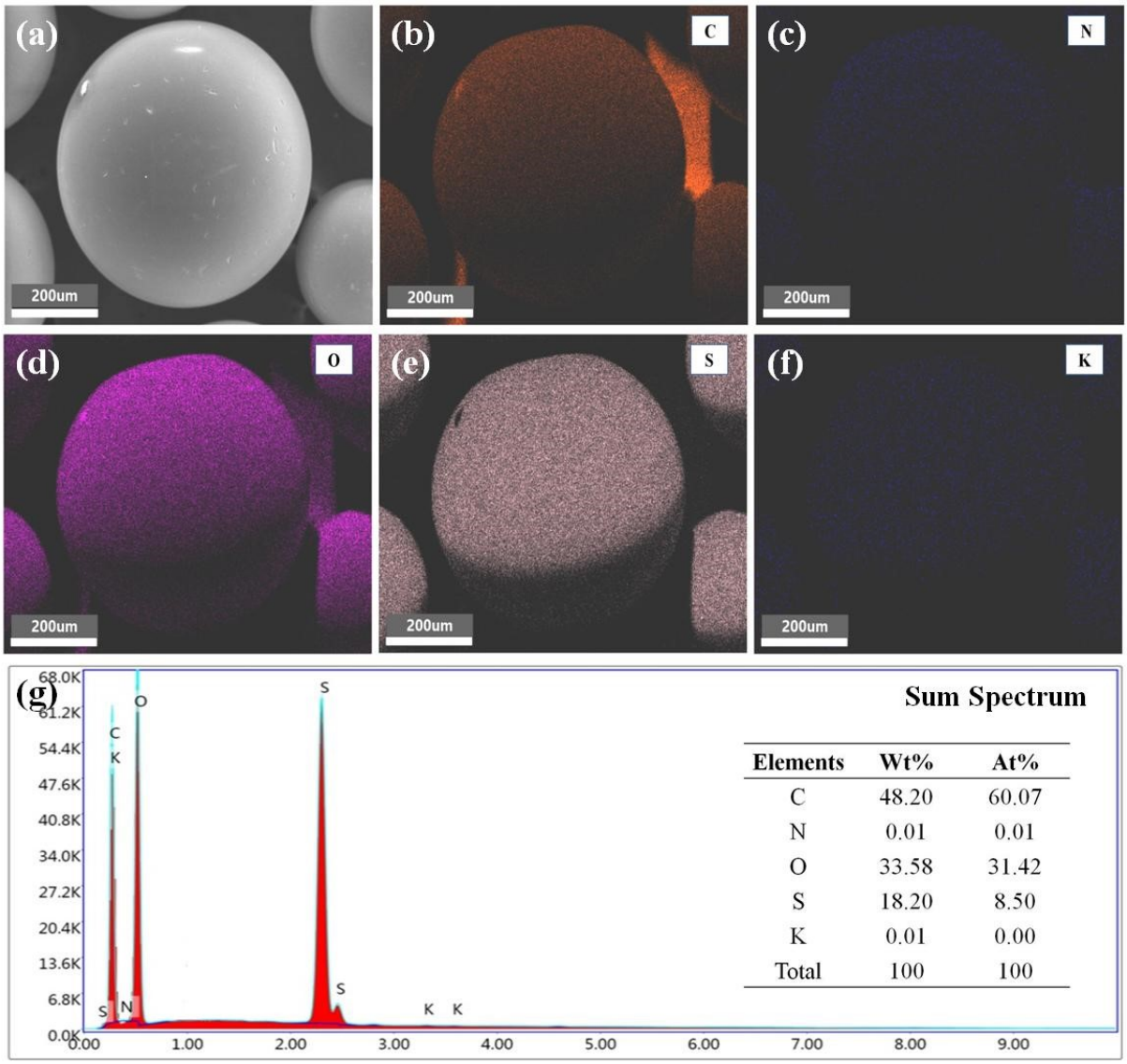
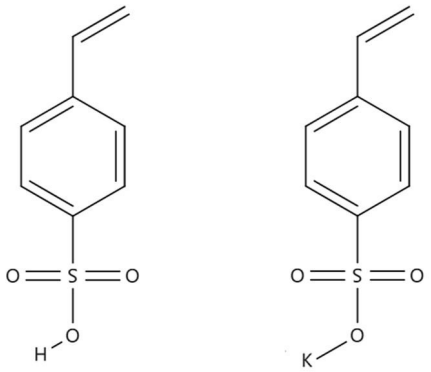


Fig. S4 SEM-EDS scanning results of C160H resin before adsorption: (a)SEM images, (b-f) EDS maps for elemental distribution, and (g) elemental composition spectrum



$\triangle E_{binding}$ 321.24 kcal·mol^{-1} 5.43 kcal·mol^{-1}

Fig. S5 Binding energy between H^+ / K^+ and ligand

Table S1 Physical and chemical properties of Purolite C160 ion exchange resin

Preperty	Description
Structure	Macroporous
Matrix	Polystyrene / divinylbenzene
Functional group	Sulfonic Acid
Ionic form	Na^+
Bead size	0.3-1.2 mm
Specific gravity	1.3 g/mL (in Na^+ form)
Moisture retention	35%-40% (in Na^+ form)
Total capacity	2.3 meq/mL (in Na^+ form)

References

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