Electronic Supplementary Material (ESI) for RSC Advances.

High capacity and fast removal of Cr(VI) by alkali lignin-based poly(tetraethylene pentamine-pyrogallol) sorbent

Rufei Xing [a], Yanxin Song [b]*, Tingting Gao [c], Xiaoxia Cai [a], Jinshui Yao [a], Qinze Liu [a]*, Changbin Zhang [d]

* Corresponding author at: School of Materials Science and Engineering, Qilu University of Technology (Shandong Academy of Sciences), #3501 Daxue Road, Western University Science Park, Jinan City 250353, Shandong Province, P. R. China.

Tel: +008613806410075

E-mail: liuqinze@qlu.edu.cn (Prof. Qinze Liu, Ph.D)

* Corresponding author at: School of Chemical Engineering & Pharmacy of Jining Technician College, #3166 Chongwen Road, Jining City 272100, Shandong Province, P. R. China.

Tel: +008615668106398

E-mail: syxlhy001@163.com (Prof. Yanxin Song, Ph.D)

---

[a] *School of Materials Science and Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, P. R. China*

[b] *School of Chemical Engineering & Pharmacy, Jining Technician College, Jining 272100, P. R. China*

[c] *School of Chemistry and Chemical Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, P. R. China*

[d] *Research Center for Eco-Environmental Sciences, Chinese Academy of Science, Beijing 100085, P. R. China*

Characterization

Fig. S1 shows the SEM and EDS spectra of AL-PTAP before adsorption of Cr(VI). It can be seen from Fig. S1 that there is no chromium in AL-PTAP before adsorption and there is no significant change in the surface morphology of AL-PTAP before and after adsorption

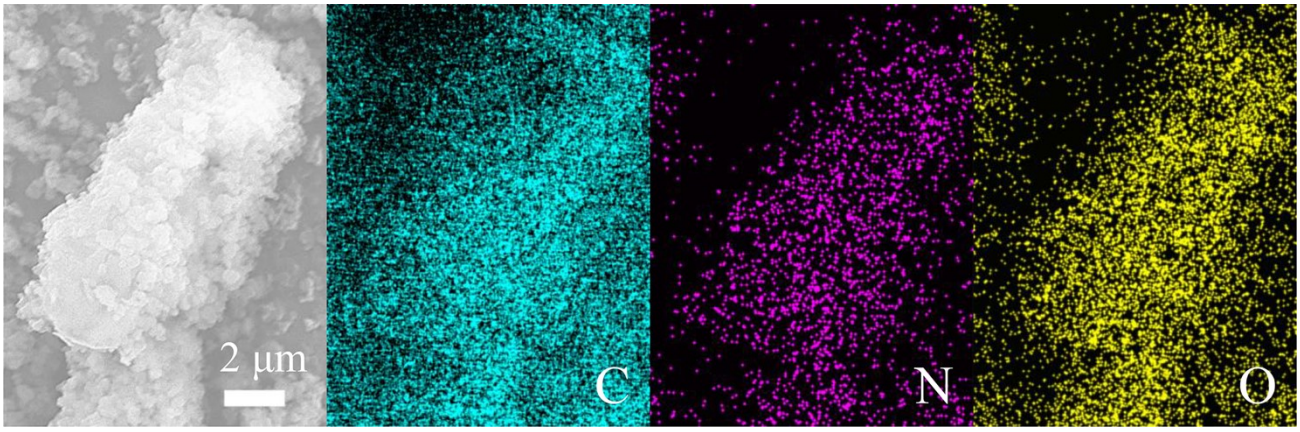

Fig. S1. EDS mappings of AL-PTAP before adsorption.

Adsorption thermodynamic study

Thermodynamic parameters can be used to study the thermodynamic properties of the adsorption process of Cr(VI) by AL-PTAP and determine whether the adsorption process is a spontaneous reaction. Thermodynamic parameters such as enthalpy change (ΔH), entropy change (ΔS) and Gibbs free energy (ΔG) can be calculated from equation (1). If the calculated ΔG<0 and ΔH>0, it proves that the adsorption process is endothermic and spontaneous.[1] The formula for calculating the thermodynamic parameters is as follows:

$$\Delta G = \Delta H - T\Delta S \quad (1)$$

Van't Hoff equation:

$$lnK_c = -\Delta H/RT + \Delta S/R \quad (2)$$

$$K_c = C_a/C_e = (C_0 - C_e)/C_e \quad (3)$$

where K_c (mg/L) is the standard thermodynamic equilibrium constant. T(K) is the ambient temperature. R (8.314 J mol/K) is the gas constant. C_a is the amount of Cr(VI) adsorbed on the adsorbent. C_e is the amount of residual Cr(VI) in the solution.

The values of ΔG, ΔH and ΔS were calculated from the slope and intercept of the $\ln K_c$ versus 1/T curve (Fig. S2, Table S1). The calculated ΔG<0 indicates that the adsorption process of Cr(VI) by AL-PTAP is spontaneous. The calculated ΔH>0 reflects that the adsorption process is endothermic.

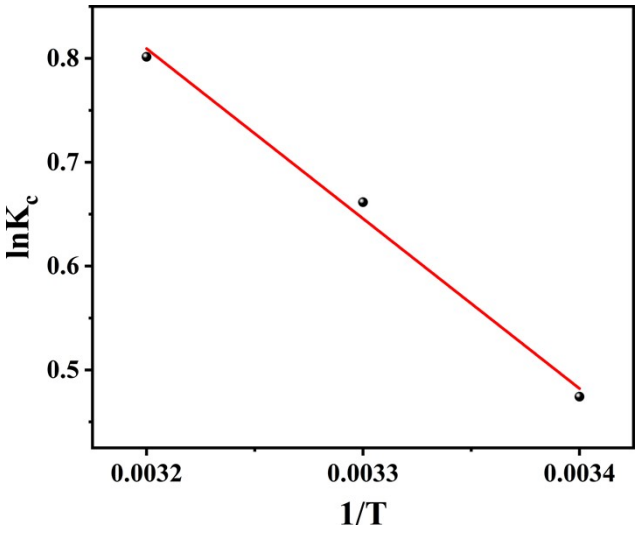

Fig. S2. Thermodynamic model of adsorption of Cr(VI) by AL-PTAP.

Table S2. Thermodynamic parameters of Cr(VI) removal by AL-PTAP.

Temperature (K)	Van't Hoff equation	ΔG (KJ/mol)	ΔH (KJ/mol)	ΔS (J/mol·K)
293.15	$lnK_c = 6.0446 - 1636/T$	-1.13		
303.15		-1.63	13.6017	50.2548

313.15		-2.13

BET surface area analysis.

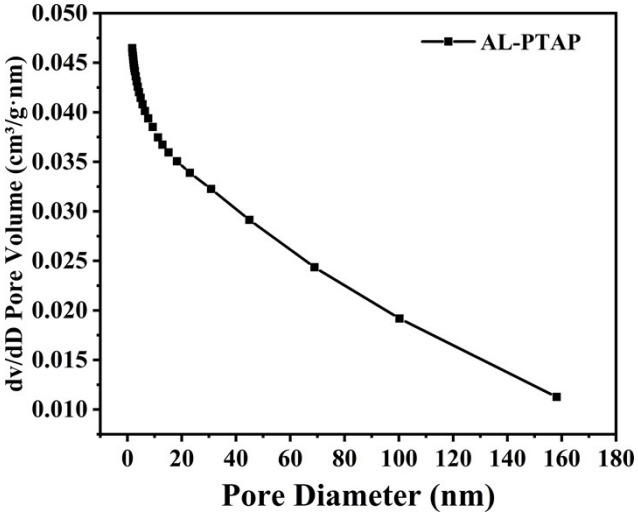

Fig. S3. Pore size distribution of Al-PTAP.

66

67

68

69 ## References

70 1. P. Sharma and M. R. Das, *Journal of Chemical & Engineering Data*, 2012, **58**, 151-158.

71