Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary material

Separation of vanadium and tungsten from synthetic and spent catalyst leach solutions using ion exchange resin

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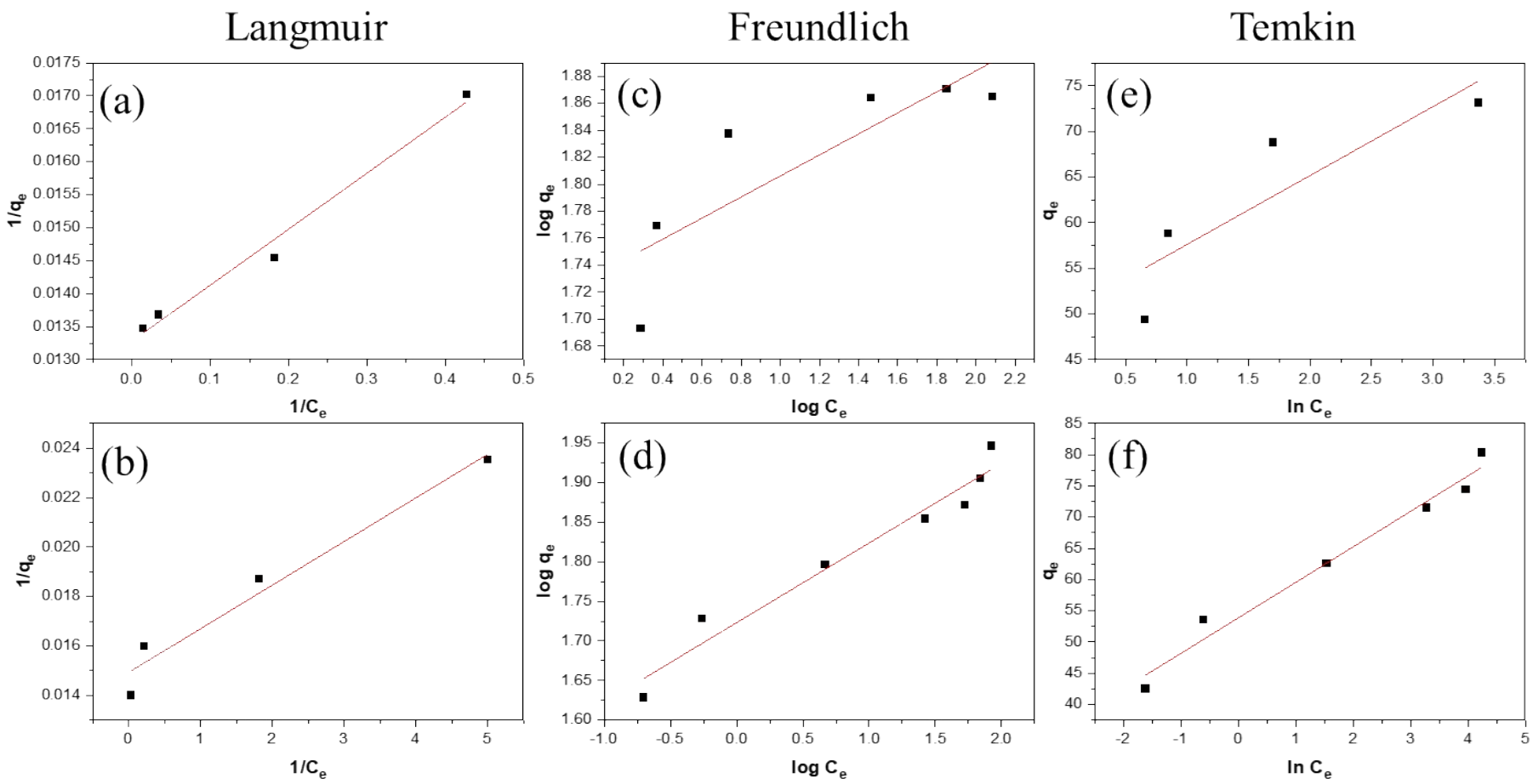

Figure S1 Langmuir isotherm models for (a) vanadium (b) tungsten, Freundlich isotherm models for (c) vanadium, (d) tungsten, and Temkin isotherm models for (e) vanadium, (f) tungsten adsorption at different metal initial concentrations on MP600 (Experimental conditions: vanadium or tungsten (1-500 mg/L) adsorption at pH 7.0 using 0.5 g of ion exchange resin and stirring at 303 K, agitation rate is 200 rpm, time for 1440 min)

The suitability of the Langmuir adsorption isotherm can be justified by the distribution of the separation factor proposed by Hall *et al.*, where R >1 is irrelevant, R = 1 is linear, R = 0 is irreversible, and 0<R>1 is known to be favorable [RS1 – RS7].

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

where b and C_0 values were derived from Langmuir isotherm. By applying the results of Table 2 obtained in this experiment to Eq. (1), the R values for vanadium were found to be 0.051. Moreover, R values decreased as increasing temperatures clearly denotes that the ongoing adsorption process is much favorable at higher temperatures [RS6, RS7] (https://doi.org/10.1016/j.jhazmat.2006.12.012; https://doi.org/10.1016/j.cej.2009.09.013). The R values are <1, suggests that Langmuir adsorption isotherm well fitted for both metal ions case, but adsorption characteristics are different because of different affinities between metal ions in solution. Further, this phenomenon clearly proved from thermodynamic studies also.

Supplementary References (RS):

RS1. S. V. Pol, V. G. Pol, V. G. Kessler and A. Gedanken, *New J. Chem.*, 2006, **30**, 370–376.
RS2. P. Cyganowski, I. Polowczyk, D. V. Morales, B. F. Urbano, B. L. Rivas, M. Bryjak and N. Kabay, *Polym. Bull.*, 2018, **75**, 729–746.
RS3. B. J. Smith and V. A. Patrick, *Aust. J. Chem.*, 2002, **55**, 281–286.
RS4. K. R. Hall, L. C. Eagleton, A. Acrivos and T. Vermeulen, *Ind. Eng. Chem. Fundam.*, 1966, **5**, 212–223.
RS5. J.-J. J.-H. H.-T. Lee, *Clean Technol.*, 2011, **17**, 346–352
RS6 A. Mittal, L. Kurup, J. Mittal, J Hazmat., 2007, **146**, 243-248.
RS7 K.Y. Foo, B.H. Hameed, Chemical Engineering Journal, 2010, **156**, 2-10

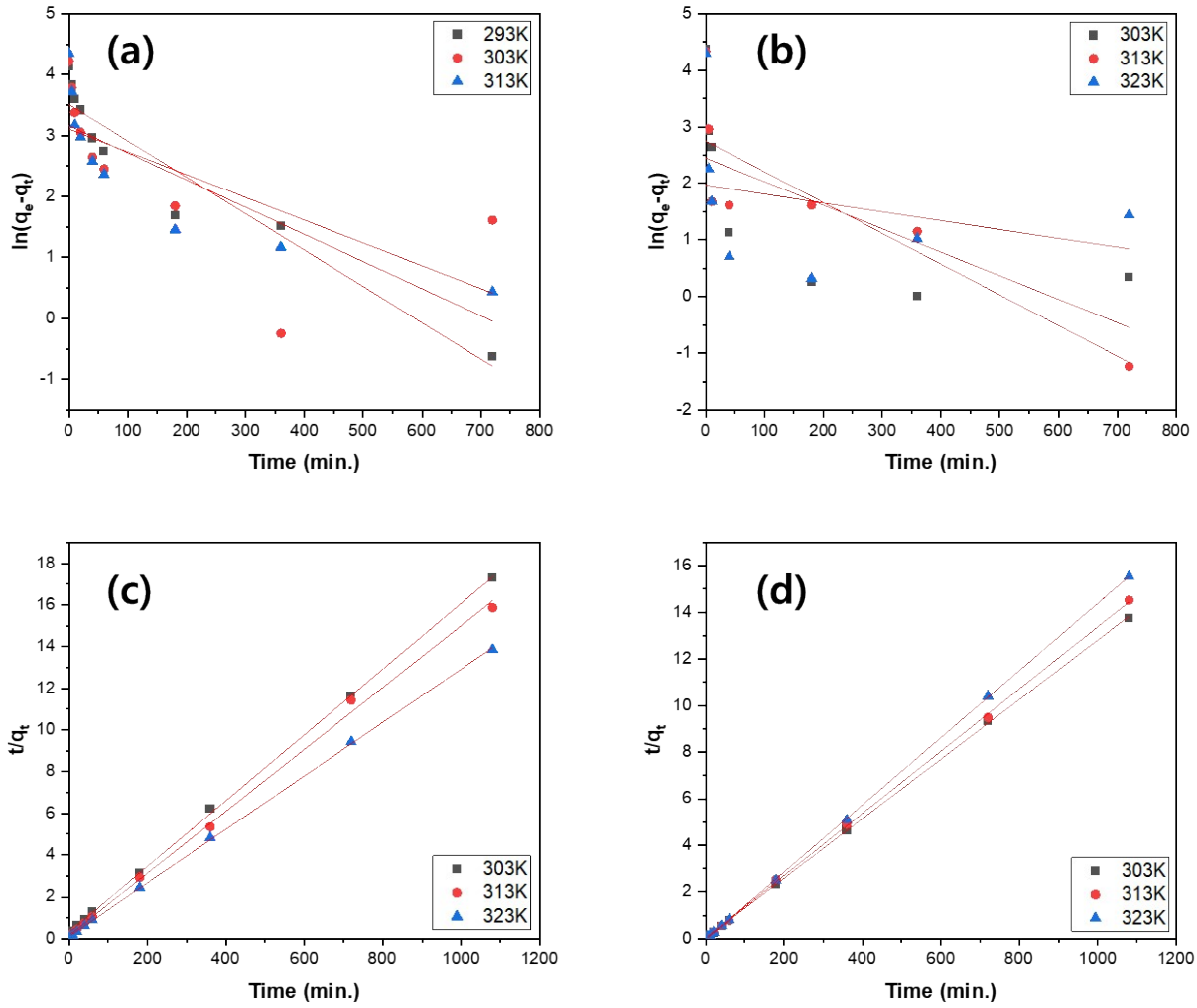

Figure S2 Pseudo-first-order model for (a) vanadium, (b) tungsten adsorption and pseudo-second-order model for (c) vanadium, (d) tungsten adsorption on resin (Experimental conditions: stirring at 200 rpm and different temperature ranging 293 to 313 K, initial concentration of the metals V (or) W = 120 mg/L, agitation rate is 200 rpm, volume is 100 mL, resin dose : 0.1 g)

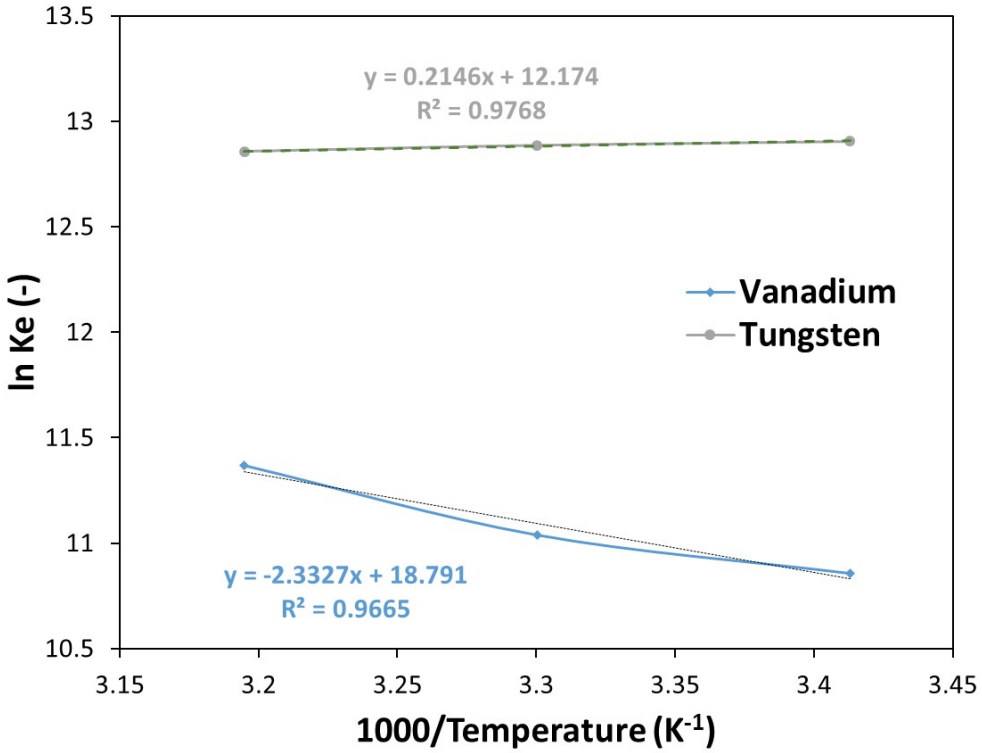

Figure S3: Plot of ln K_e vs 1000/T for thermodynamic studies (Experimental conditions: stirring at 200 rpm and different temperature ranging 293 to 313 K, initial concentration of the metals V (or) W = 120 mg/L, agitation rate is 200 rpm, volume is 100 mL, resin dose : 0.1 g)