



Equilibrium, Thermodynamic Behaviour and Kinetic Analysis of the Adsorption of Lead (II) and Chromium (VI) Ions Using Moringa Olifera Seeds

Osundiya, M.O., Oyewole, T.S., Olowu, R.A., Akinlabi, A.O., Alegbe, Osifeko, L. O., M.J., Adejare, A.A.

Department of Chemistry, Lagos state University, Ojo,

Nigeriacorresponding e-mail: medinat.osundiya@lasu.edu.ng.

INTRODUCTION

- Adsorption is a surface phenomenon where particles are attached to the top layer of a materials
- Application sewage sludge to farm land has resulted to the contamination of water bodies where lakes and rivers are overwhelmed with a large number of toxic substances. This has become a vital environmental worry.
- The search for an effective treatment method lead to the discovery of biosorption in which *moringa olifera* seeds has been chosen as an ideal, low-cost and techno-friendly biosorbent for the removal of Pb(II) and Cr(VI) from model aqueous solution and industrial wastewater.

METHODOLOGY

- The volumetric flask (1000 mL) was cleaned, dried, and labelled. Stock standard solutions of Cr(VI) and Pb(II) (1000 ppm) were made in de-ionized water by accurately weighing their salts. The solutions were then diluted to the desired concentrations using continuous dilution. Samples were diluted to 100ppm, 200ppm, 300ppm, 400ppm, and 500ppm for calibration. The particles were washed with distilled water, air-dried, and oven-dried at 80 °C for 2h. Moringa olifera was crushed, ball-milled, homogenized, and sieved at 120µm.
- Batch adsorption studies were used to remove heavy metal ions. 0.6g of the prepared adsorbent was placed in a 100 mL Erlenmeyer flask, and 400 ppm (Co) metal solutions were added. The flask was shaken at 100 rpm for 2hrs to reach equilibrium. The mixtures were filtered and stored in a cool, dry place. Concentration was quantified by AAS (Thermo Scientific Evolution 600, Waltham, MA, USA) at equilibrium.



Fig 1: Image of moringa olifera seeds

$$\% \text{CR(VI) removal} = \frac{(C_o - C_e)}{C_o} \times 100 \quad (1)$$

$$q_e = \frac{(C_o - C_e)}{C_o} \times V \quad (2)$$

$$q_t = \frac{(C_o - C_t)}{M} \times V \quad (3)$$

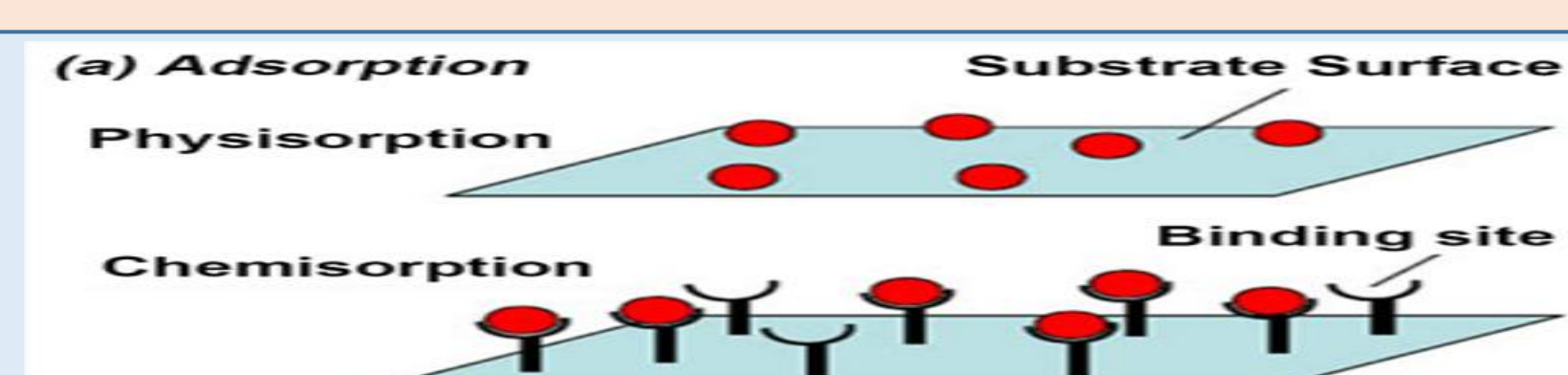


Fig 2: Mechanism of adsorption studies

$$\frac{C_e}{q_e} = \frac{1}{q_m K_L} + \frac{C_e}{q_m} \quad \text{Langmuir}$$

$$\log q_e = \log K_F + \frac{1}{n} \log C_e \quad \text{Freundlich}$$

$$q_e = \frac{RT}{b} \ln(k_T C_e) \quad B = \frac{RT}{b} \quad \text{Temkin}$$

RESULTS AND DISCUSSION

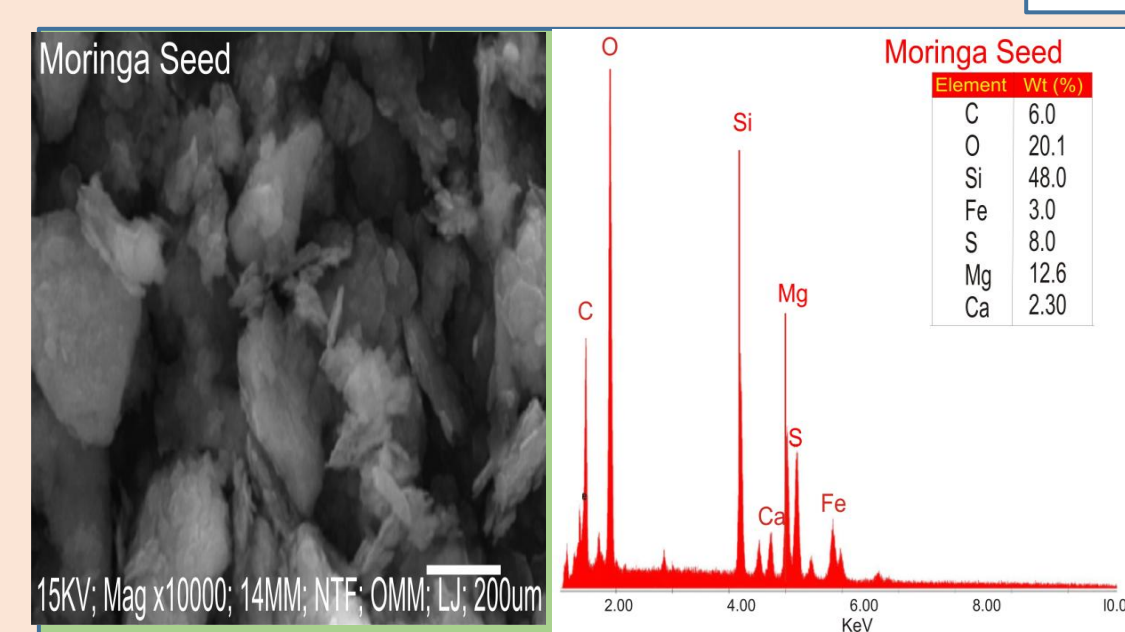


Fig 3: SEM-EDX result before adsorption

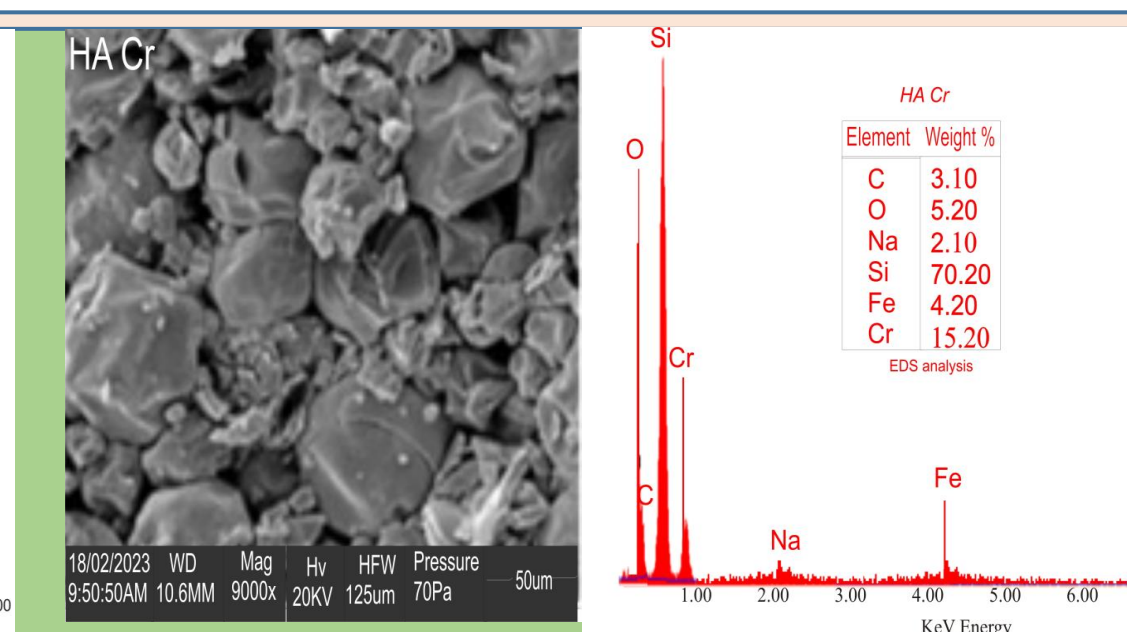


Fig 4: SEM-EDX result after adsorption of Cr

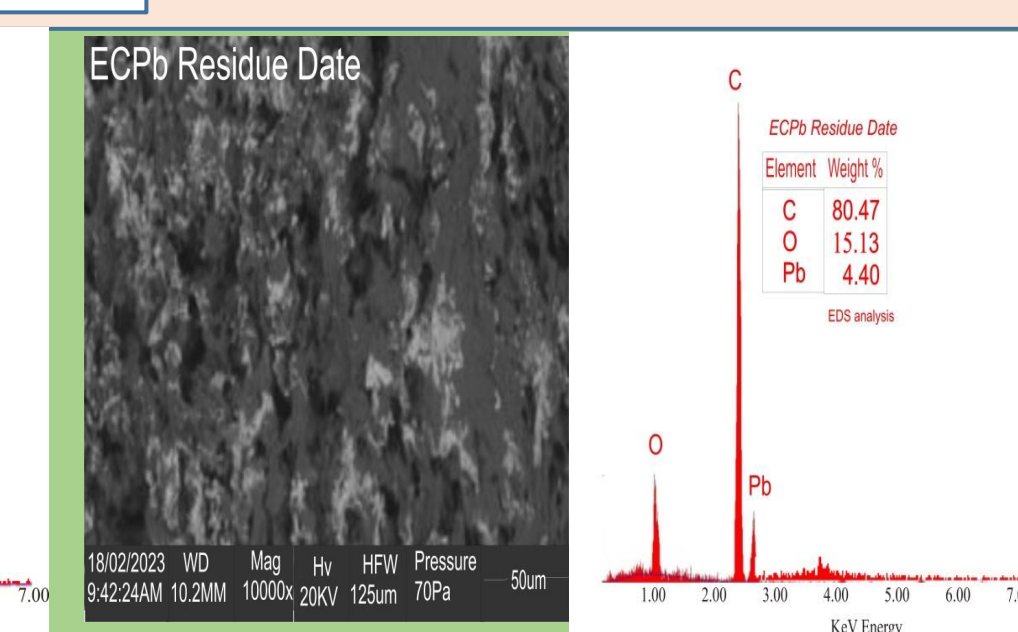


Fig 5: SEM-EDX result after adsorption of Pb

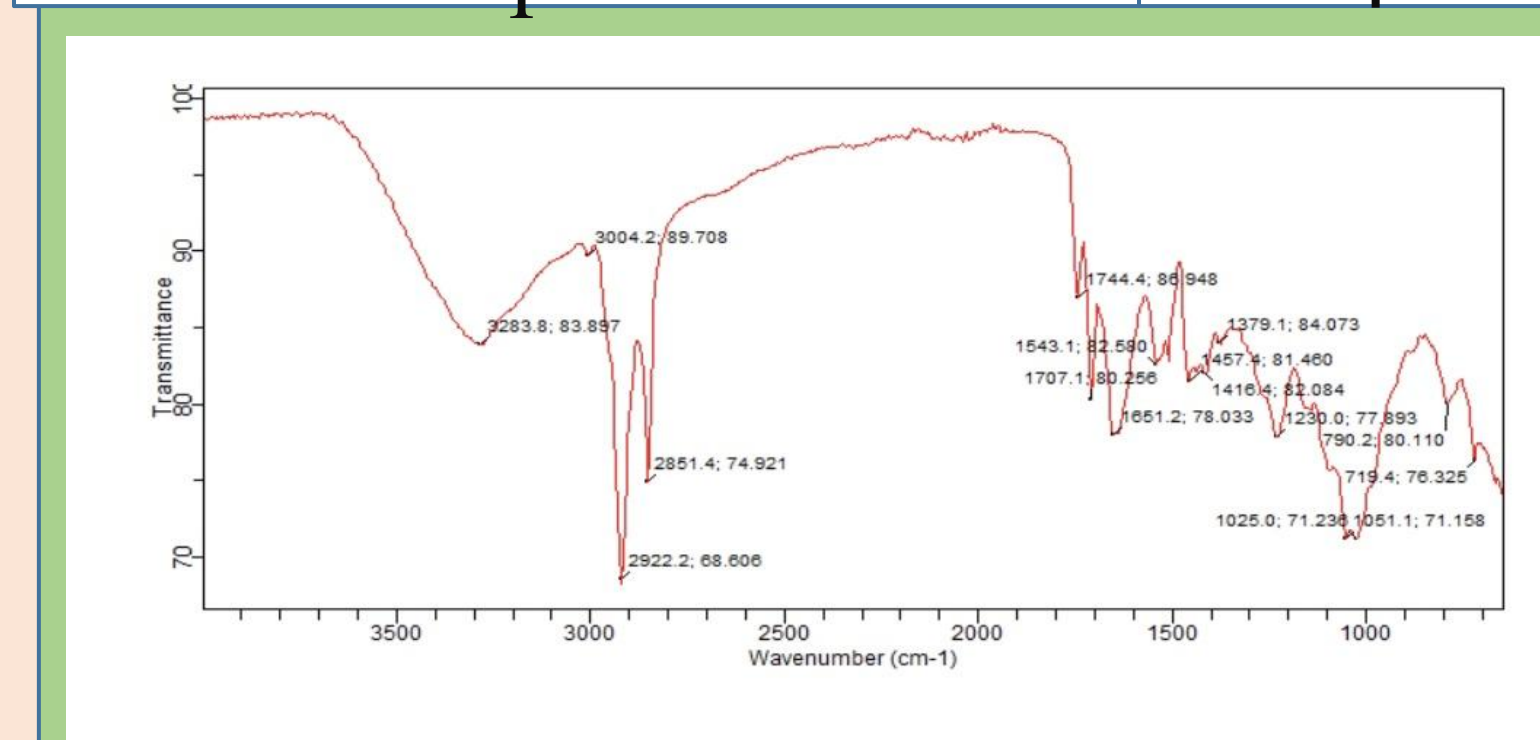


FIG 6: FTIR result of moringa olifera

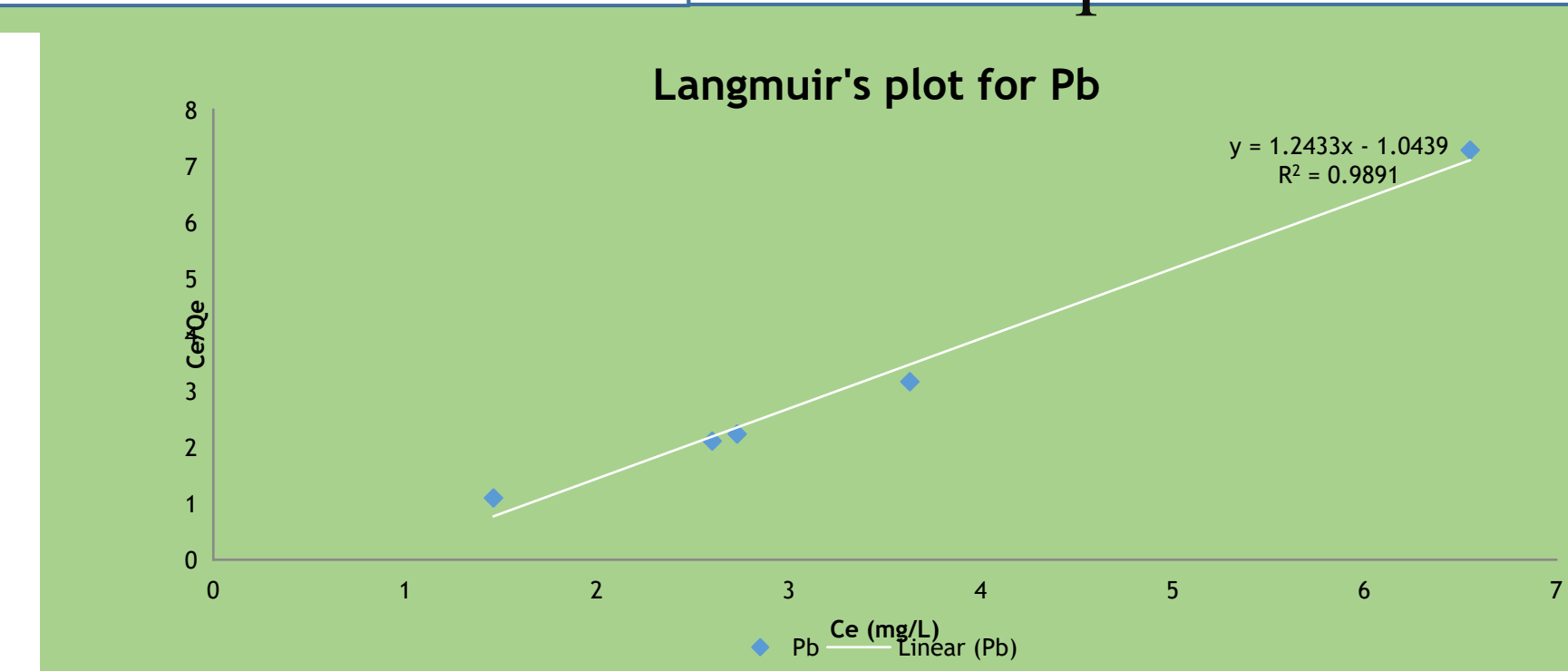


Fig7: showing the Langmuir plot for Pb (II) ion

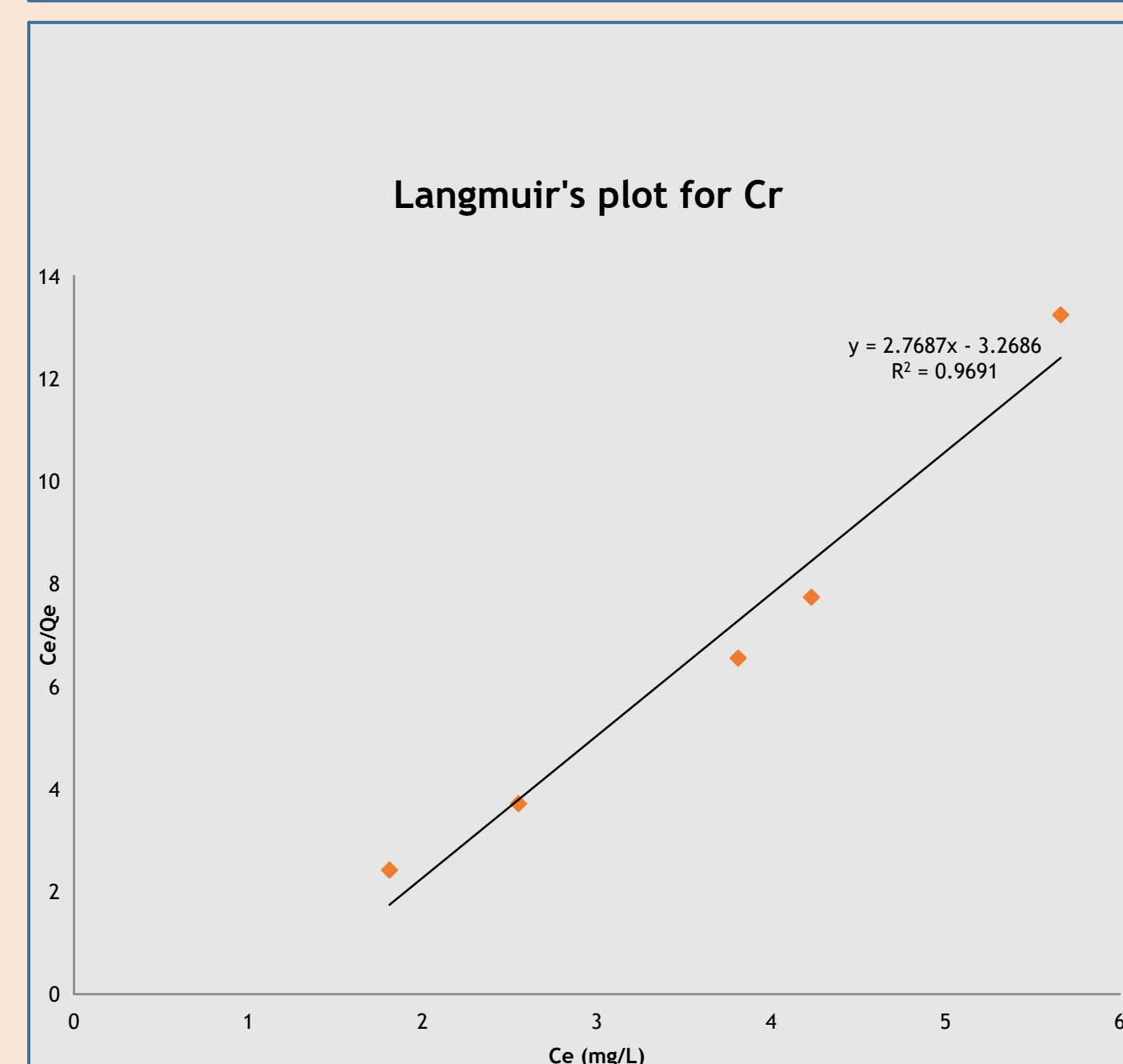


Fig 8: Showing the Langmuir plot for Cr (VI) ion.

Table: Showing the calculated values of the isotherms parameters/constants.

ISOTHERMS	Pb (II)	Cr (VI)
LANGMUIR		
Q_{max}	0.8043	0.3612
K_L	1.191	0.847
R_L	0.046	0.0986
R^2	0.9891	0.9691
FREUNDLICH		
n	3.8270	2.1390
K_F	1.5426	1.0341
R^2	0.9104	0.9385
TEMKIN		
B_T	1.6805	2.6791
K_T	0.8234	0.7439
R^2	0.939	0.9715

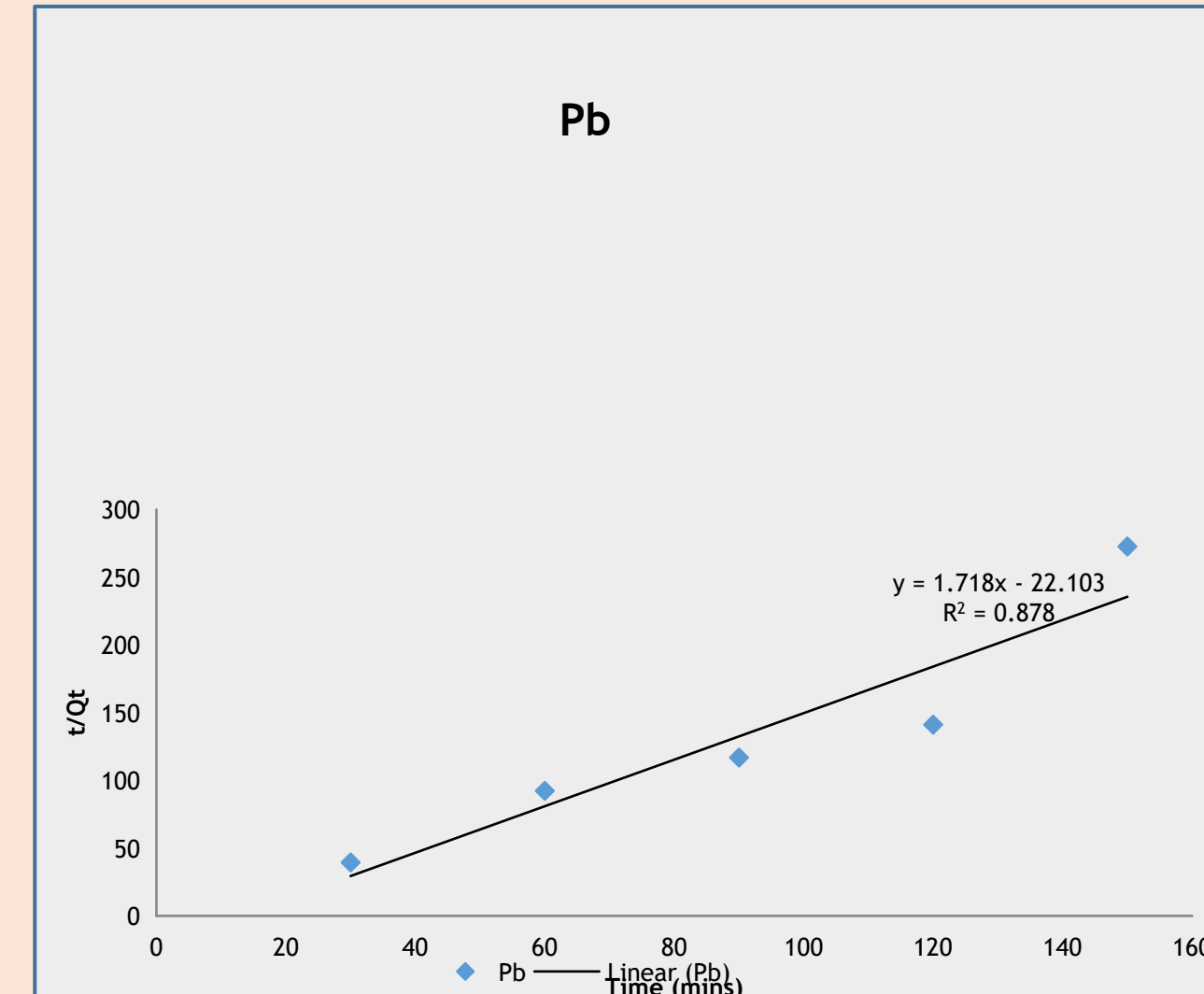


Fig 9: Showing the Pseudo-Second Order Kinetic graph for Pb (II) ion.

RECOMMENDATION: I recommend that moringa olifera seeds should be further treated with activators such as H₂O₂ or KCl most especially on an industrial scale in order to improve its effectiveness and performance for the adsorption of heavy metals.

CONCLUSION

Results showed that Lead (Pb) and Manganese (Cr) adsorption followed Pseudo-second order reaction kinetic, indicating Physisorption. Thermodynamic parameters (ΔG , ΔH , and ΔS) revealed the process was spontaneous, endothermic, and feasible. This RDS can be used as a low-cost option for removing heavy metals from synthetic solutions.