NM WRRI Student Water Research Grant Final Report Form

Progress Report due Tuesday, April 1, 2025

Draft Final Report due Friday, August 29, 2025

Final Report due Tuesday, September 30, 2025

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2. Project title: Synthesis of the water-insoluble organic solid matrix and study of the removal of Uranium from the groundwater

3. Description of research problems and research objectives.

As surface water in New Mexico's streams, rivers, and reservoirs continues to decline, reliance on ground water has grown and serves as the primary, and often only, source of water in many areas of the state. Yet groundwater in New Mexico carries a heightened risk of uranium (U) contamination due to the abundance of natural deposits and a legacy of extensive mining throughout the 20th century. Both human activities and natural geological processes have contributed to uranium leaching into groundwater aquifers. This is particularly evident along the New Mexico and Texas border where documented uranium concentrations in some parts exceed the World Health Organization's permissible limits for drinking water. Although there is filtration technology capable of removing uranium from groundwater sources, the costs of this technology make it difficult to justify and utilize in rural communities where it just might matter the most. The chemical toxicity of U is six orders of magnitude greater than its radionuclide toxicity. It is highly hazardous to humans, causing numerous toxic effects such as renal failure, leukemia, and amentia. The World Health Organization (WHO) has set a permissible concentration of 30 µg/L in drinking water, considering an assumption that 60 kg of adults drink 2 L of water with a total permissible daily intake of 1 µg/kg.[1] Though Uranium exists at various oxidation states in nature, in an aquatic environment, the predominant states of U are tetravalent [U(IV)] and hexavalent [U(VI)] with the chemical forms UO_2 (urinous oxide) and UO_2^{2+} (uranyl ion), respectively. U(IV) is sparsely soluble in water, whereas U(VI) is soluble in water and exists in the form of UO_2F_2, $UO_2(NO_3)_2$, UO_2Cl_2, UF_6, uranyl acetates, uranyl sulfates, and uranyl carbonates. U groundwater contamination is extensive overall in the US, especially NM-TX, CO-KS, and WY-NE border areas, from 30 ppb to 500 ppb.[2] U is also present in the city-supplied water. Clovis (New Mexico) supplied water contains 5-13 ppb of U, and erosion of natural deposits is the primary source.[3] Since natural processes raise the uranium contamination in water, in the future, it may cross the acceptable limit of U in drinking water, so it is essential to have a uranium extraction or filtration facility for safe drinking water. U remediation from groundwater can be achieved using various methods such as adsorption, photocatalysis, electrocoagulation, ion exchange, and membrane filtration. These methods are prohibitively expensive and unsuitable to remediate U from a large amount of water in the presence of other minerals. Developing a cheap and efficient method to remove U from groundwater is essential for agriculture, dairy farming, and drinking water.

Project Goals (Objectives)

1. **Design and Synthesis**
    a. Design, synthesize, and characterize a new solid organic compound with functional groups that can selectively bind uranium ions in aqueous solutions.

b. Characterize physicochemical properties (surface area, porosity, stability, functional group distribution) that impact uranium sorption.
c. Evaluation of Sorption Performance in alkalized and non-alkalized media
d. Study the sorption capacity and selectivity of the synthesized compound towards uranium in simulated groundwater conditions
e. Explore the effects of competing ions, pH, and ionic strength on sorption performance.

Mechanistic Insights

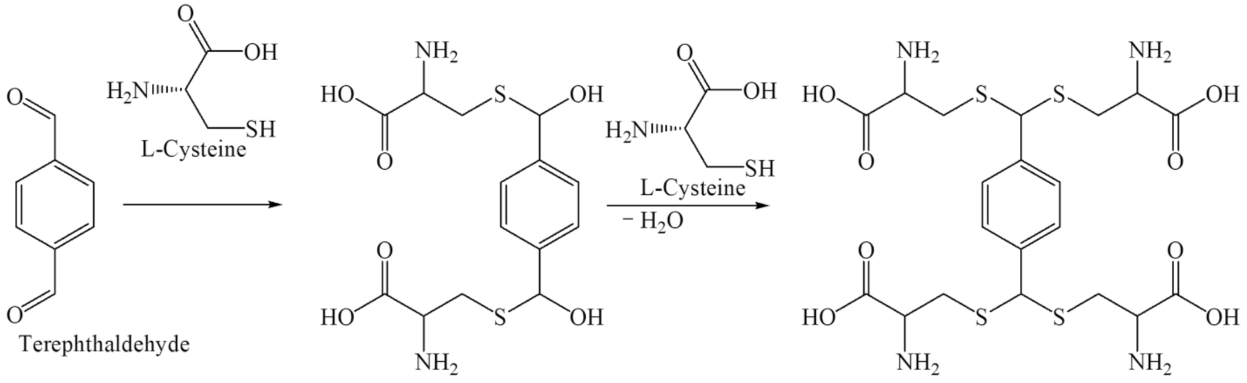
1. Investigate the interaction mechanisms between uranium species and the functional groups of the synthesized compound using spectroscopic and microscopic techniques.
2. Model adsorption isotherms and kinetics to determine binding capacity.

Application to Local Groundwater

1. Test the performance of the synthesized compound in groundwater samples collected from uranium-impacted areas in Portales, Clovis and major cities in New Mexico and the surrounding region.
2. Compare remediation performance with traditional sorbents and assess the cost-effectiveness and scalability for rural water treatment.

Description of methodology employed.

Synthesis: A water-insoluble ligand with multiple coordination sites was synthesized following Scheme 1. The advantage of the synthesized ligand is that it possesses flexible coordination sites, which can change their orientation in space to coordinate U ions strongly.



Scheme 1: Synthesis of water-insoluble ligands and capturing the U ion.

Sustainability and Impact Assessment

1. Evaluate the environmental safety, recyclability, and long-term stability of the developed material.
2. Assess the potential of this remediation technology as a community-scale intervention for groundwater and agricultural sustainability in New Mexico.

Description of the methodology that was employed

Reagents used: Benzene-1,4-dicarbaldehyde, $C_6H_4(CHO)_2$, and (R)-2-amino-3-sulfanylpropanoic, 95% Methanol, all these were purchased from Sigma-Aldrich, uranyl acetate which is a depleted Uranium (this was provided to me by my school ENMU through Mr. Quinton Flores), distill water.

Apparatus and instruments used: Whatman filter paper, weighing paper, electronic scale, tripod stand, clamp, fume hood, stopwatch, NMR-spectrometer, UV-Vis Spectrometer, etc.

Safety precaution!

^{235}U used in this study though depleted uranium is an alpha emitter with yield of daughter radioactive ^{228}Ra. ^{235}U is a radioactive, chemically toxic reagent and U-containing samples have to be handled by qualified personnel in appropriate facilities with suitable care and protection. Minimum handling time was ensured to reduce exposure.

Methodology: Synthesis of the ligand

Benzene-1,4-dicarbaldehyde (0.749 g, 5.58×10^{-3} mol; Mw = 134.13 g/mol) was accurately weighed and placed in a 250 mL round-bottom flask (RBF). (R)-2-amino-3-sulfanylpropanoic acid (2.704 g, 2.23×10^{-2} mol; Mw = 121.16 g/mol) was then added to the round bottom flask, 20 mL methanol was added to the flask to dissolve the reactants followed by gentle swirling. Another 30 mL of methanol was added followed by swirling of the mixture. The remainder of the 150 ml methanol was added to the flask making the final reaction volume of 200 ml.

The round bottom flask (RBF) was then fitted with a reflux condenser connected to a continuous cold-water circulation system. The setup was clamped in place. The mixture was heated under reflux at 80 °C with the magnetic stirring at 200 rpm. The reaction of benzene-1,4-dicarbaldehyde and (R)-2-amino-3-sulfanylpropanoic acid was allowed to proceed for 24 h with the formation of a white precipitated solution observed after which the reaction was allowed to complete as shown in figure 1.

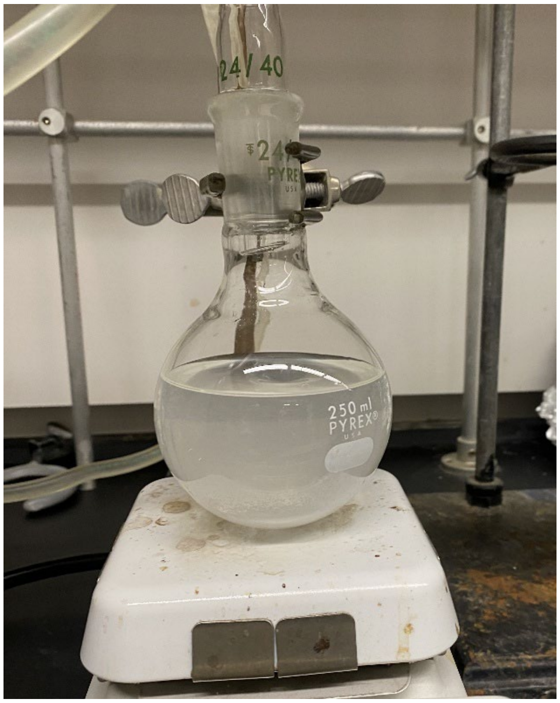
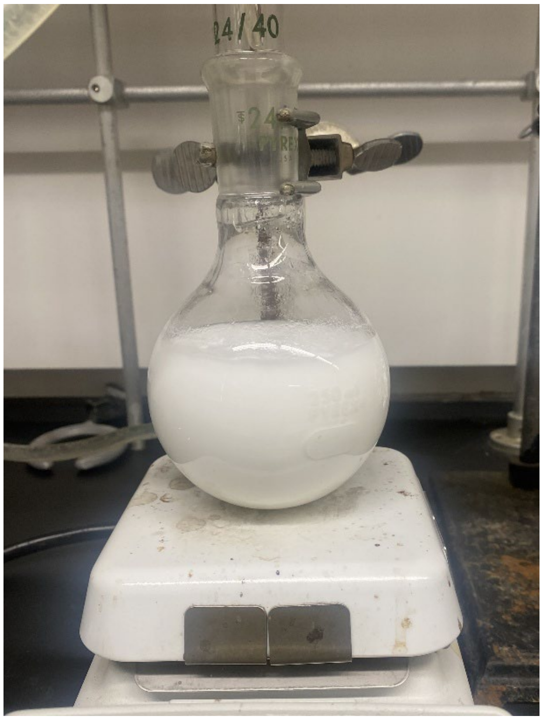
Reaction progress at the beginning	Reaction progress after 11min
	

Figure 1.

Purification process of the synthesized compound:

The reaction mixture was allowed to cool to room temperature, after which the solvent was carefully decanted. The crude product was washed with fresh ethanol, followed by successive washings with distilled water to ensure the removal of unreacted L-cysteine under reduced pressure. The resulting slurry was transferred onto Whatman filter paper placed in a glass funnel, and the purified product was subsequently dried under vacuum for 24 hours, as illustrated in Figure 2.

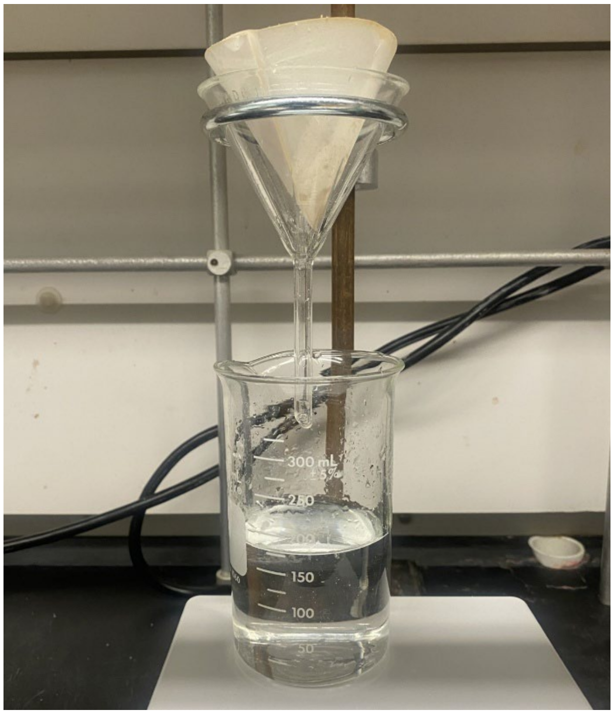


Figure 2. filtration and purification process

Product Isolation and Pulverization: The obtained product, a coarse white solid adhering to the Whatman filter paper, was ground with a glass rod in a 20 mL vial to yield a uniform fine powder. The powdered product was subsequently transferred into a clean 20 mL glass vial and sealed tightly.

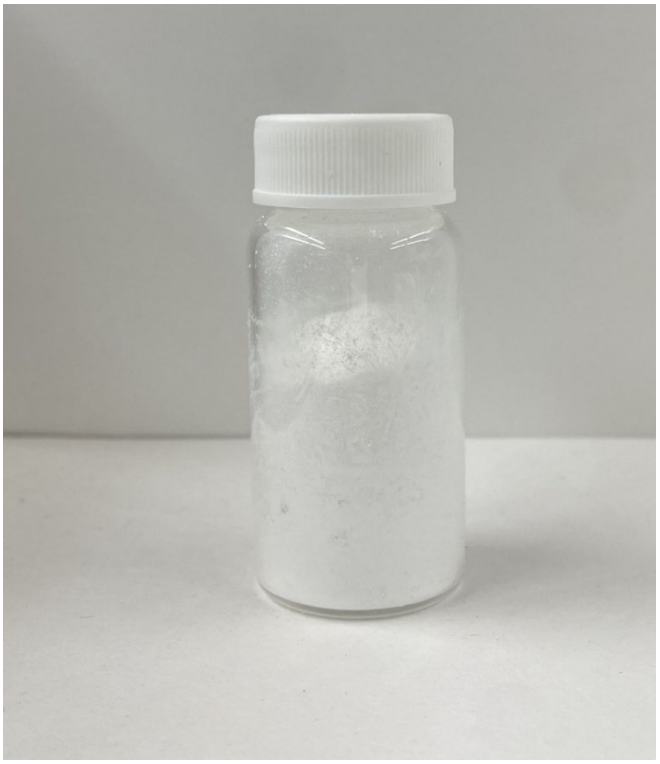


Fig 3 Final product

Theoretical yield = (b/a) x mole number of reactant x molecular weight of the product

b = Stoichiometric coefficient of product in the balanced reaction

a = Stoichiometric coefficient of reactant in the balanced reaction

Benzene-1,4-dicarbaldehyde is the rate limiting reagent

No. of moles of Benzene-1,4-dicarbaldehyde = reacting mass of Benzene-1,4-dicarbaldehyde/ molar mass of Benzene-1,4-dicarbaldehyde

Mole number = 0.749 g/ 134.13 g/mol

$= 5.58 \times 10^{-3}$ mol.

Molar mass of the interested products $C_{20}H_{25}N_4O_8S_4$ = 582.73g/mol

Theoretical yield = [(1/1) x 5.58×10^{-3} mol. x 582.73g/mol]

= 3.2516g

Experimental yield = [(Obtained product/Theoretical yield) x 100] %

= [(2.453 g / 3.2516g) x 100]%

= 75.44%

Preparation of the uranyl acetate stock solution

A stock solution of uranyl acetate was prepared by dissolving the appropriate mass of uranyl acetate powder (g) in a corresponding volume of distilled water (ml). Working concentrations of **0.012 M, 0.022 M, and 0.032 M** were obtained by dilution. For comparative studies, a second stock solution was prepared in **0.05 M KOH** to investigate ligand binding under basic conditions.

A total volume of **30 mL** of **0.01 M uranyl acetate** was prepared. Aliquots of **5 mL** were dispensed into six **20 mL vials** labeled as *control, 0.05g, 0.10 g, 0.15 g,* and *0.20g*. The vials were prepared as follows:

- **Control:** 5 mL of 0.01 M uranyl acetate solution.
- **0.05g vial:** 5 mL of 0.01 M solution + **0.05 g** ligand.
- **0.10g vial:** 5 mL of 0.01 M solution + **0.10 g** ligand.
- **0.15g vial:** 5 mL of 0.01 M solution + **0.15 g** ligand.
- **0.20g vial:** 5 mL of 0.01 M solution + **0.20 g** ligand

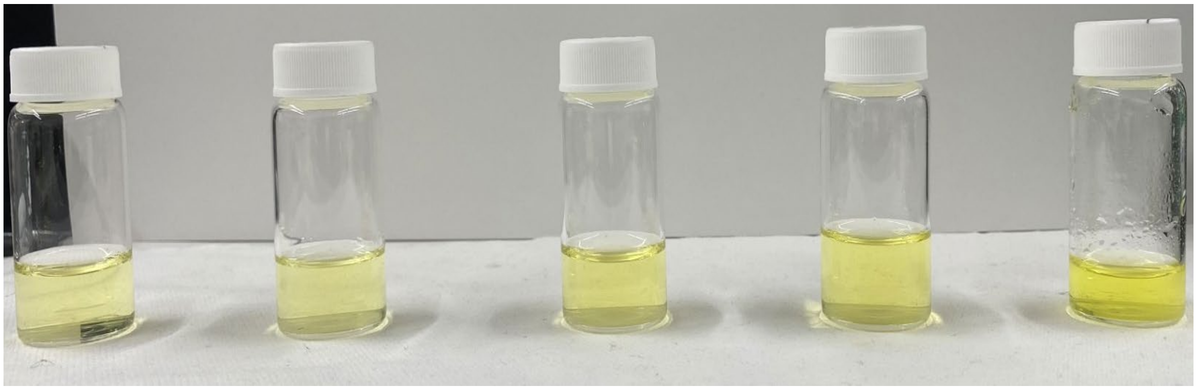


Fig 4 prepared uranyl acetate stock solution

Remediation process of uranium from the 0.012M stock solution of uranyl acetate.

There were five 20ml vials each with 5ml of a 0.012M of uranyl acetate solution, the control was without the synthesized ligand, the remaining four were treated with 0.05g, 0.10g, 0,15g and 0.20g of the synthesized ligand, a magnetic stirrer was placed in the mixture and the mixture was stirred at a speed of **100 rpm for 24 h**. The mixtures were then centrifuged at **5000 rpm for 5 min**, and the supernatant solutions were collected. Using the UV–Vis spectrophotometer the absorbance of the solution was measured and recorded.

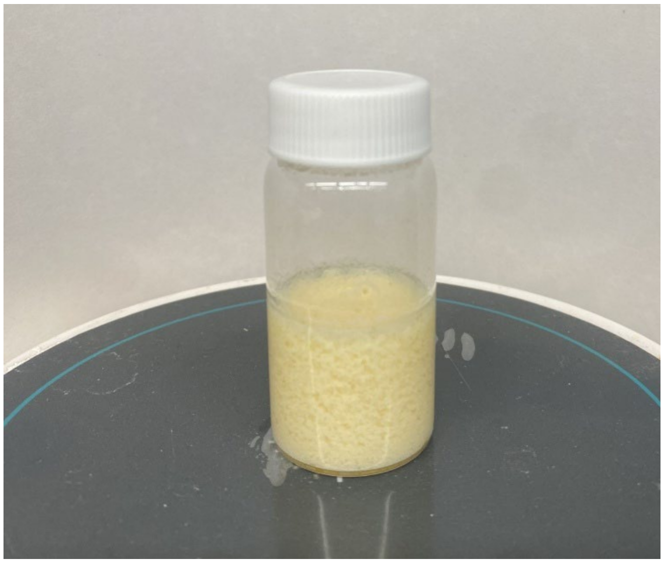


Figure 5. remediation process of uranium from the 0.012M stock solution of uranyl acetate.

Absorption measurement using the UV-Vis spectrophotometer

The absorption of the sample was measured using the UV–Vis spectrophotometer. The device was calibrated using distilled water as the blank solution (which is the solvent without the analyte) to set the zero and remove the background interference, then the sample solution was measured using the micropipette and the sample was transferred into a clean quartz cuvette. The sample cuvette was then inserted into the spectrophotometer, which was then ran to scan across the selected wavelength range (350nm-750nm) and the absorbance values were then recorded for the various samples. The absorption spectrum or absorbance at the wavelength of 350nm – 1100nm was then used to get quantitative information of the sample's concentration to know the extent at which the ligand was able to remediate the uranium from the aqueous solution.

Sample preparation for ICP-MS analysis (Ligand selectivity test)

Thirty-six (36) samples were prepare for the ICP-MS analysis, the 36 samples was divided into a group into six and each group is made up of 6 treatment concentration.

To the first group, a 60ml of **0.00002M** of uranyl acetate solution was prepared, 10ml of the stock solution was transferred into six 20ml vial,

- The first vial was labelled the control which was without treatment with the ligand, the second vial was labelled
- The second vial was labelled 20mg, and so 20mg of the ligand was carefully weighed and was transferred into this vial, with a magnetic stirrer
- The third vial was labelled 40mg, and so 40mg of the ligand was carefully weighed and was transferred into this vial, with a magnetic stirrer
- The fourth vial was labelled 60mg, and so 60mg of the ligand was carefully weighed and transferred into this vial, with a magnetic stirrer
- The fifth vial was labelled 80mg, and so 80mg of the ligand was carefully weighed and was transferred into this vial, with a magnetic stirrer
- The sixth vial was labelled 100mg, and so 100mg of the ligand was carefully weighed and transferred into this vial, with a magnetic stirrer

The six vials were tightly closed to avoid evaporation and were then set up on an individual electric magnetic stirrer and was stirred over 24hours, there after the clear liquid was filtered from the slur using the whatman filter paper, and the various vials were labelled and were set up for ICP-MS analysis.

Same process was repeated for a stock solution of

- 0.00002M Cobolt(II) Nitrate

- 0.00002M Nickel(II) Nitrate
- 0.00002M Cupper(II) Nitrate
- 0.00002M Zinc(II) Nitrate
- Mix metals solution (made up of cobolt ion [Co^{2+}], nickel ion [Ni^{2+}], cupper ion [Cu^{2+}], zinc ion [Zn^{2+}] and uranyl ion [UO_2^{2+}]

Results and Discussion.

Successful Synthesis of Ligand **L**

A polyamine-carboxyl ligand (Figure 6) was synthesized using benzene-1,4-dicarbaldehyde, $C_6H_4(CHO)_2$, and (*R*)-2-amino-3-sulfanylpropanoic acid in a ratio of 1:4. The crude product yield was 75.44%. Ligand **L** was insoluble in water and common organic solvents (chloroform, dichloromethane, dimethyl sulfoxide, dimethylformamide) and so few drops of deuterated HCl were added to dissolve the ligand in water and was then characterized using the ^1H NMR spectroscopy which confirmed the presence of certain functional groups that are responsible for the Ligand chemical properties. Water was used as the standard for ^1H NMR chemical shift.

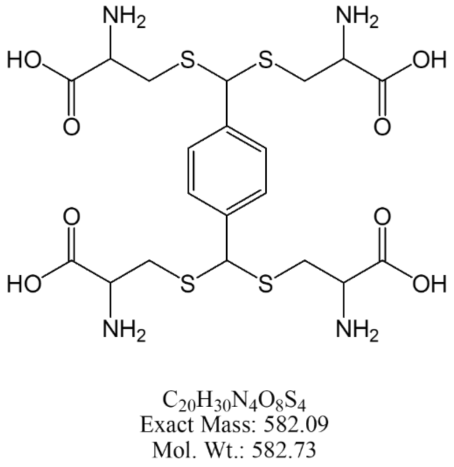


Figure 6: Ligand (L) structural formula

Absorption efficiency study of the synthesized ligand

Absorbance-Based Calibration Curve

Calibration is used to correlate absorbance with concentration (Beer–Lambert law). First, the blank solution which was a distilled water (solvent without analyte) was placed in the spectrophotometer. This was done to set a reading of zero absorbance on the instrument. Next, the set of standards which are the various samples of aqueous uranyl acetate solutions, and this includes **0.004M, 0.008M, 0.016M and 0.032M** (the analyte at a known concentration) were prepared in water. The absorbance of each solution was measured at wavelength from 350 to 750 nm (Figure 7). The following graph shows the absorbance of these standards as a function of concentration.

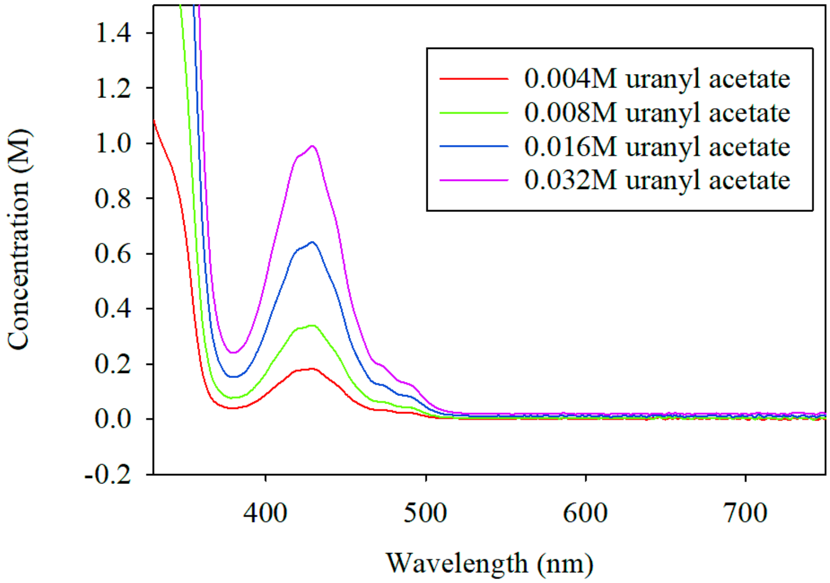


Figure 7: Absorbance spectra of standard solutions of uranyl (II) acetate

The absorbance values were plotted on the x-axis against the corresponding concentrations on the y-axis (Figure 8). A linear regression line was fitted through the data points, providing the calibration equation (y = mx + b), where *m* is the slope and b is the interception. The data exhibited a direct linear relationship between concentration and absorbance, verifying that Beer–Lambert's law is valid over the investigated range with regression R=0.987, slope m=0.0320, and intercept b= –0.0017463. This calibration curve (Conc. = 0.0320 x absorbance – 0.0017463) was used to calculate the concentration of unknown samples from their absorbance values.

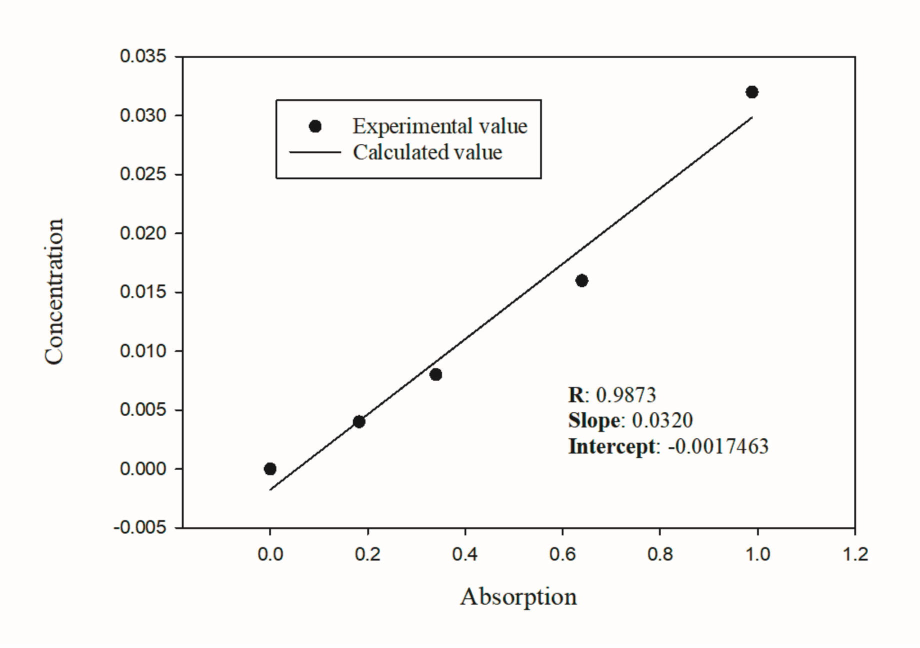


Figure 8: Calibration scale of concentration versus absorbance

Uranium absorption capacity of ligand using 0.012 M 10 mL Uranyl Acetate

The concentration of prepared uranyl acetate was found to be 0.012 M according to the calibration scale by measuring the absorbance. The impact of the ligand's amount on the absorption efficiency was investigated. The 0.012 M uranyl acetate was treated with various amounts of ligand and absorbance of the centrifuged solutions were measured (Figure 9)

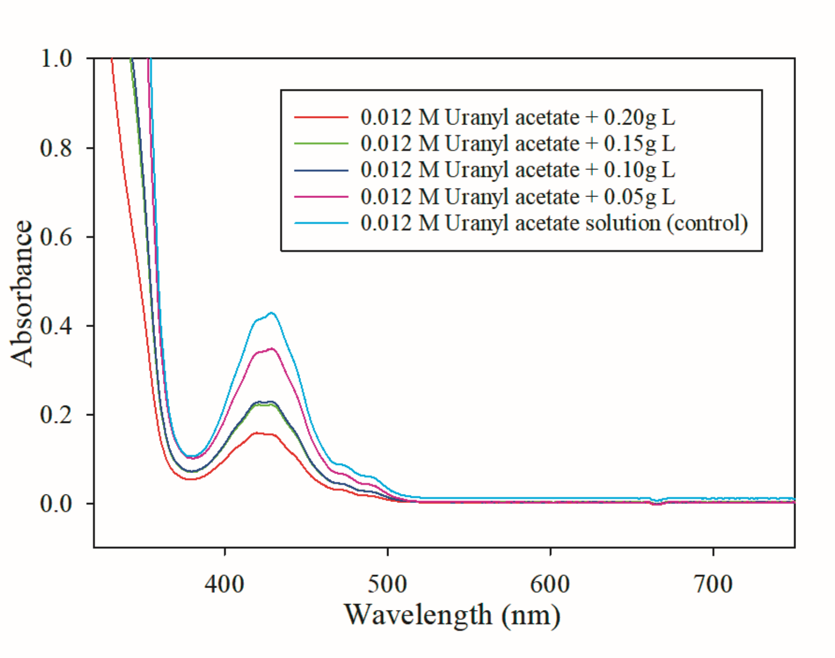


Figure 9. Absorbance vs wavelength graph for 0.012M uranyl acetate

The concentration uranyl acetate solution was measured from the absorbance using the equation Conc. = 0.0320 x absorbance –0.0017463.

Table 1: Absorbance and Calculated Concentrations of Uranyl Acetate in the Presence of Different Ligand Amount using 0.0120M stock solution

Ligand amount (g)	Absorbance (x)	Chosen Wavelength (nm)	Slope (m)	Intercept (b)	Concentration Y = mx + b
0.00	0.4283	429	0.0320406	-0.001704	0.0120
0.05	0.3476				0.0093772
0.10	0.2284				0.0055615
0.15	0.2215				0.0053423
0.20	0.1555				0.0032307

The residual concentration of uranyl acetate in solution was found to decrease with increasing amount of ligand.

The absorption efficiency (Ads%) was calculated using the equation below

$$Ads\% = \left(\frac{(C_i - C_f)}{Ci}\right)x100$$

Where

C_i and C_f are the initial and the final molar concentrations of uranyl acetate in the aqueous phase respectively.

Table 2. absorption efficiency at 0.012M uranyl acetate stock solution

Ligand Amount (g)	Concentration (M)	Absorption efficiency (%)
0.00	0.012	
0.05	0.00938	21.86
0.10	0.00556	53.65
0.15	0.00534	55.48
0.20	0.00323	73.08

At a ligand dosage of 0.05 g, the concentration of the analyte was 0.00938 M (Efficiency = 21.86%). Increasing the amount of ligand loaded on the adsorbent increased the efficiency to 53.65% and 55.48% for dosages of 0.10 g and 0.15 g, respectively. The efficiency of the adsorbent reached a maximum value of 73.08% at a ligand dosage of 0.20 g, at which the concentration of the analyte was 0.00323 M.

Uranium absorption capacity of ligand using 0.022 M 10 mL Uranyl Acetate

Removal efficiency with different ligand dosages was compared between systems with an initial analyte concentration of 0.022 M (present work) and 0.012 M (reported in previous work) (Figure 10). As observed earlier, a consistent trend of reducing residual concentration and increasing efficiency with increasing amount of ligand was also seen with these systems.

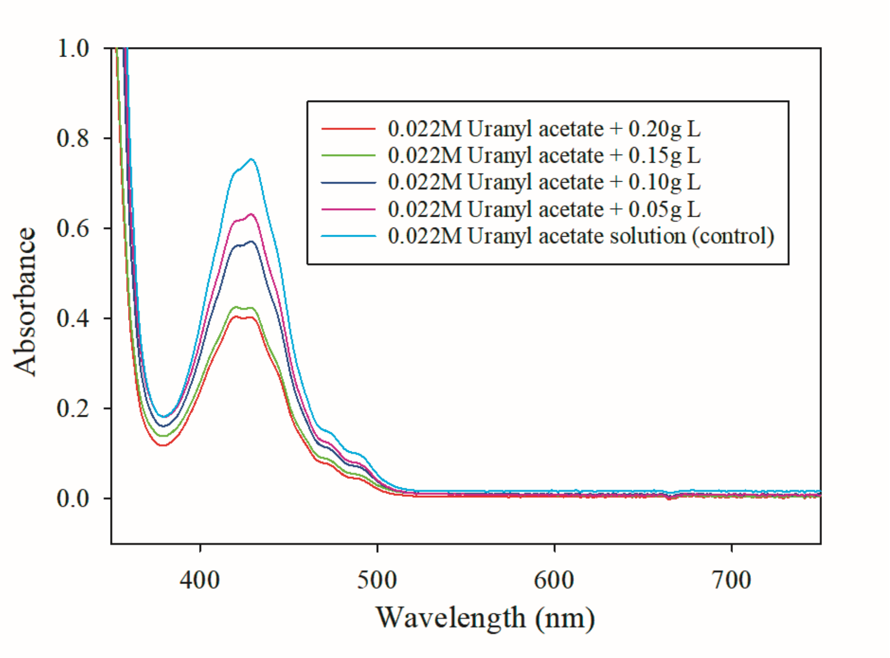


Figure 10. Absorbance vs wavelength graph for 0.022M uranyl acetate non-alkalized.

The analyte concentrations were determined from the UV–Vis absorbance readings by applying the Beer–Lambert law and comparing the measured absorbance values with those of the 0.022 M uranyl acetate standard solution.

Table 3. Absorbance and Calculated Concentrations of Uranyl Acetate in the Presence of Different Ligand Amount using 0.0224M stock solution

Ligand amount (g)	Absorbance (x)	Chosen Wavelength (nm)	Slope (m)	Intercept (b)	Concentration Y = mx + b
0.00	0.7536	429	0.0320406	-0.001704	0.0224
0.05	0.6313				0.0185
0.10	0.5715				0.0165

0.15	0.4243				0.0118
0.20	0.4034				0.0112

The absorption efficiency (Ads%) will be calculated using the equation below

$$Ads\% = \left(\frac{(C_i - C_f)}{Ci} \right) x100$$

Where C_i is the initial molar concentration (0.022M) and C_f is the final molar concentration of the uranyl acetate solution, plugging in the value in the equation above will generate the table below

Table 4. absorption efficiency of the ligand in 0.022M uranyl acetate stock concentration

Ligand Amount (g)	Concentration (M)	Absorption efficiency (%)
0.00	0.022	
0.05	0.018	17.61
0.10	0.016	26.16
0.15	0.012	47.18
0.20	0.011	50.17

For the experiment with the initial concentration of 0.022 M, the residual concentration reduced from 0.022 M (0 g of ligand) to 0.0112 M at 0.20 g of ligand, with a maximum efficiency of 50.17%. On the other hand, for the system with initial concentration of 0.012 M, a higher efficiency of removal was observed with the same ligand dosage (0.20 g), with a maximum value of 73.08%. For all the intermediate ligand loadings (0.05–0.15 g), the efficiencies were also higher for the 0.012 M system compared to the 0.022 M system, indicating that an overall lower initial concentration of the analyte favors its binding and removal with the ligand.

Uranium absorption capacity of ligand using 0.032 M 10 mL Uranyl Acetate

A 0.032 M uranyl acetate solution was prepared and treated with varying concentrations of the ligand, then stirred for 24 hours. The mixtures were centrifuged, and the clear supernatant was collected. After calibrating the UV–Vis spectrophotometer with a blank, the absorbance of each sample was measured at the wavelength of maximum uranyl acetate absorption to determine the analyte concentrations.

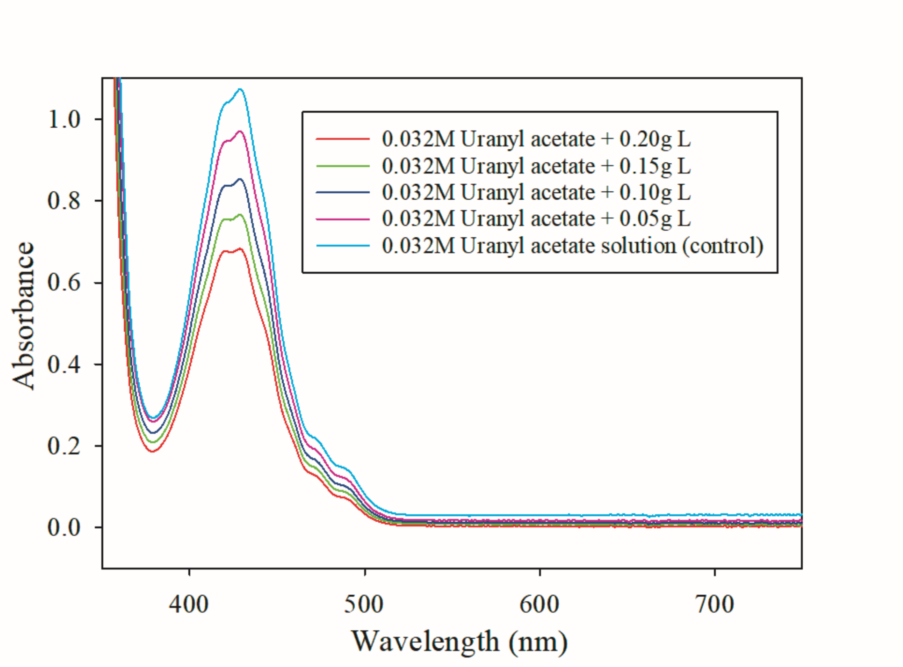


Figure 11. Absorbance vs wavelength graph for 0.032M uranyl acetate non-alkalized.

According to the Beer–Lambert law, absorbance is directly proportional to analyte concentration within the linear range of measurement Y = mx + b. After recording the absorbance values of the ligand-treated and control solutions, the corresponding uranyl acetate concentrations were determined by interpolation from the calibration curve generated with the standard solution. The difference between the initial concentration (0.032 M) and the measured concentration in the supernatant was then used to calculate the amount of uranium removed, which in turn provided the absorption efficiency of the ligand at different dosages.

Table 5: Absorbance and Calculated Concentrations of Uranyl Acetate in the Presence of Different Ligand Amount using 0.0326M stock solution

Ligand amount (g)	Absorbance (x)	Chosen Wavelength (nm)	Slope (m)	Intercept (b)	Concentration Y = mx + b
0.00	1.0742	429	0.0320406	-0.001704	0.0326
0.05	0.9701				0.0293
0.10	0.8536				0.0256
0.15	0.7663				0.0228
0.20	0.6825				0.0125

The absorption efficiency (Ads%) will be calculated using the equation below

$$Ads\% = \left(\frac{(C_i - C_f)}{Ci} \right) x100$$

Where C_i is (0.0326M) and C_f is the final molar concentration of the uranyl acetate solution.

Table 6. absorption efficiency in 0.022M uranyl acetate stock concentration

Ligand Amount (g)	Concentration (M)	Absorption efficiency (%)
0.00	0.032	
0.05	0.029	10.13
0.10	0.025	21.56
0.15	0.023	30.14
0.20	0.020	38.36

At 0.0326 M which is the initial concentration of the uranyl acetate at the third phase of the experiment, the ligand exhibited the highest absorption efficiency of 38.36% (residual concentration: 0.0125 M at 0.20 g ligand) which means that at a higher concentration with the same amount of ligand, the absorption efficiency drops.

Consolidated Results

As a final step in this session of the work, absorption efficiency of the ligand was calculated using three different initial analyte concentrations: 0.012, 0.022 and 0.032 M. In all three cases, an increase in the ligand dosage led to a reduction in residual concentration and, consequently, to an increase in absorption efficiency (Table 7).

Table 7.combined results showing absorption efficiency across all prepare concentrations of the analyte

Ligand Amount (g)	0.012M uranium acetate		0.022M uranium acetate		0.032M uranium acetate	
	Conc. U (M)	Absorption efficiency (%)	Conc. U (M)	Absorption efficiency (%)	Conc. U (M)	Absorption efficiency (%)
0.00g	0.012		0.022		0.032	
0.05g	0.00938	21.86	0.018	17.61	0.029	10.13
0.10g	0.00556	53.65	0.016	26.16	0.025	21.56
0.15g	0.00534	55.48	0.012	47.18	0.023	30.14
0.20g	0.00323	73.08	0.011	50.17	0.020	38.36

As previously, the best performance was recorded for the lowest initial concentration of 0.012 M, when the removal reached 73.08% at a ligand dosage of 0.20 g. At 0.022 M, the maximum absorption efficiency was reduced to 50.17%, while at the highest initial analyte concentration of 0.032 M it further dropped to

38.36% at the same ligand loading. This is in line with the results of the previous absorption studies, and the overall trend is the same, with efficiency increasing with the ligand loading and the residual concentration dropping (Figure x). At the same time, it is clear that an increase in the initial concentration of the analyte led to an overall decrease in absorption efficiency. This can be ascribed to saturation of available ligand binding sites when present in a larger amount of the analyte, which limits the extent of metal removal. From the above Table 6, a closer look at the absorption efficiency of the synthesized ligand, it was observed that absorption was directly dependent on the amount in grams of the ligand and also the concentration of the uranyl solution, meaning at a lower concentration or a higher amount of the ligand result in a higher uranyl ion **[UO_2^{2+}]** capturing.

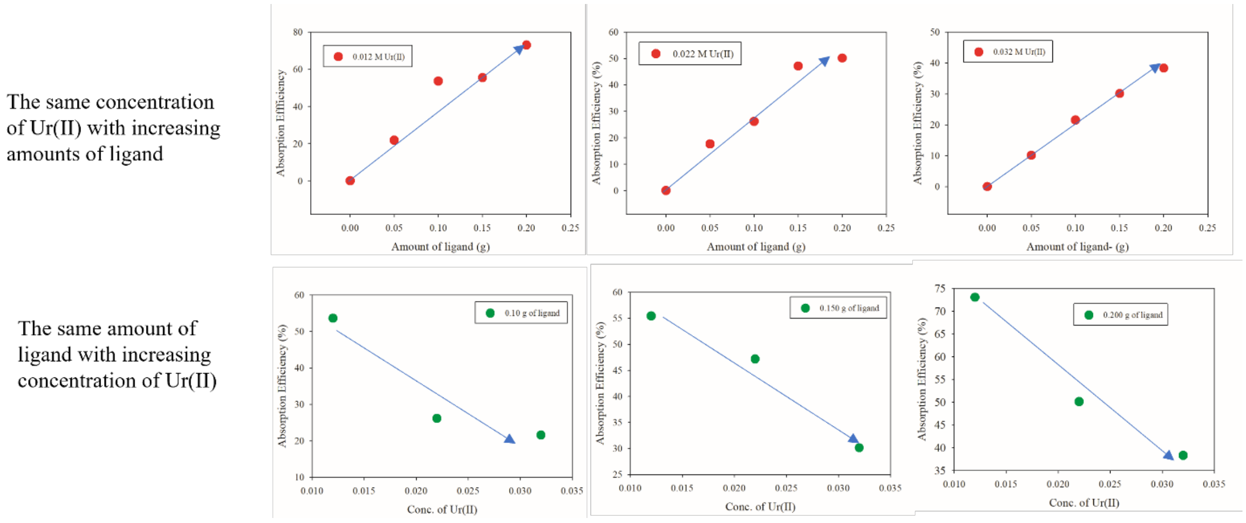


Figure 12: Comparison of uranium absorption efficiency with various concentrations of UO_2^{2+} and amounts of ligand

Absorption efficiency study of ligand pretreated with 2.0 mL of 0.005 M potassium hydroxide

KOH is used for deprotonating the carboxylic acid functional groups present in the ligand to produce carboxylate ions (COO^-) and the ammonium ions to amine. It is required for better chelation with the cation (UO_2^{2+}) in a defined manner in the uranium remediation.

Absorbance-Based Concentration Calibration Curve

0.005 M KOH as background electrolyte was used for the calibration experiment. The calibration experiment was conducted by preparing standard solutions of uranyl acetate in 0.005 K KOH, and the absorbance value was recorded using UV–Vis spectrophotometer (Figure 13). The absorbance value increased with the concentration which agrees with Beer–Lambert's law.

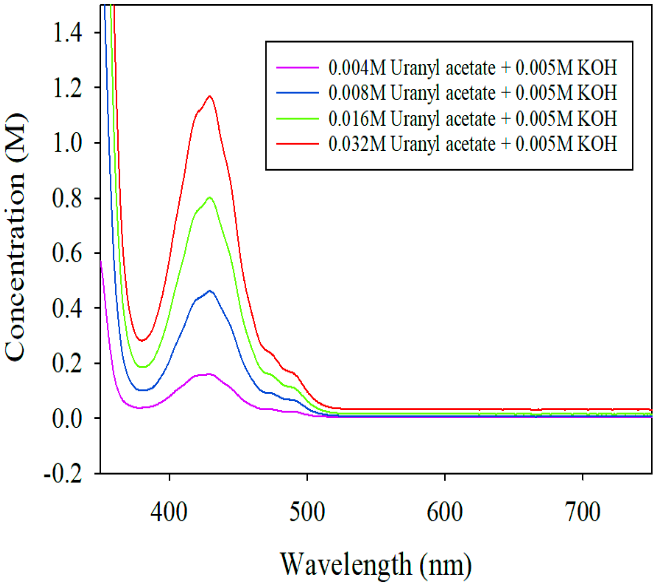


Figure 13: Concentration vs wavelength graph for alkalinized experiment

The absorbance values were plotted on the y-axis and the known concentrations of the standards on the x-axis (Figure 14). A straight-line calibration curve was constructed by linear regression, to produce a calibration equation (y = mx + b). The calibration curve allows a quantitative relationship to be drawn between an unknown sample's concentration and its absorbance.

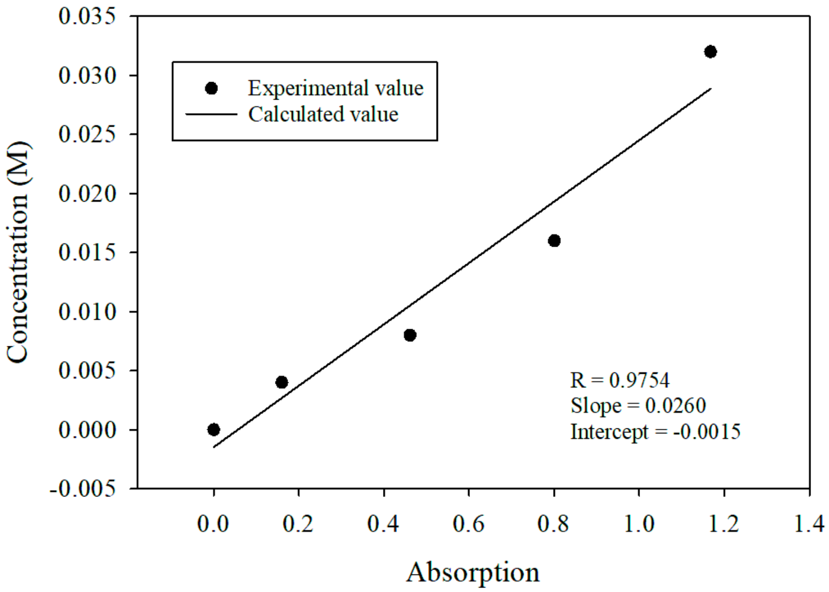


Figure 14. Calibration scale for alkalized experiment (0.005M KOH)

Uranium absorption capacity of ligand using 10 mL 0.034M Uranyl Acetate in 0.005 M potassium hydroxide

0.034M uranyl acetate solutions were treated with varying ligand concentrations of 0.05g, 0.10g, 0.15g and 0.20g that was pretreated with 0.005M potassium hydroxide, stirred for 24 hours, centrifuged, and the supernatants analyzed by UV–Vis spectrophotometry to determine residual uranyl concentrations and absorption efficiency.

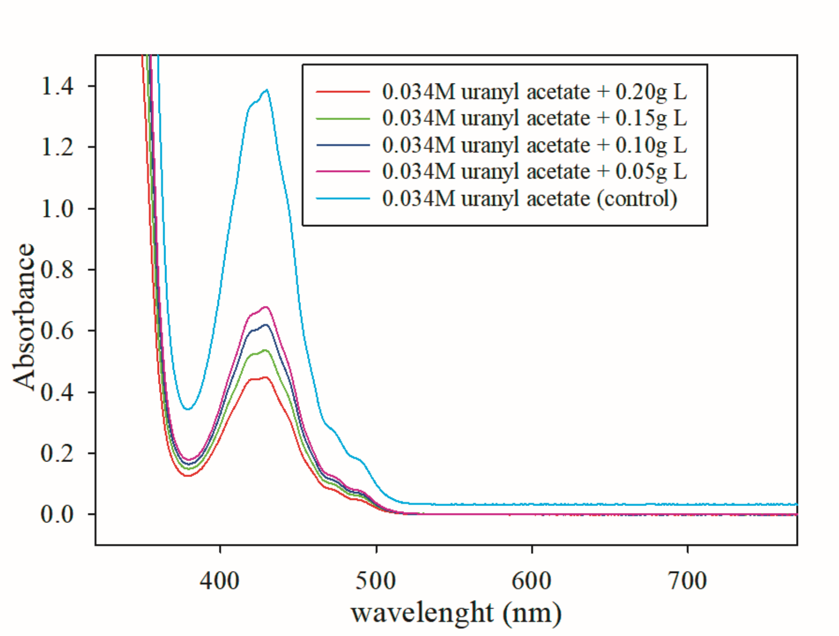


Figure 15. Absorbance vs wavelength graph for 0.034M uranyl acetate for an alkalized experiment.

The UV–Vis spectra of the alkalized treated ligand in uranyl acetate solutions showed characteristic absorption bands of the uranyl ion, with a gradual decrease in absorbance intensity as ligand doses increased. This reduction in absorbance reflects the progressive removal of uranyl ions from solution, confirming the ligand's increasing absorption efficiency in alkaline medium.

Table 8: Absorbance and Calculated Concentrations of Uranyl Acetate in the Presence of Different KOH pretreated Ligand Amount using 0.034M stock solution

Ligand amount (g)	Absorbance (x)	Chosen Wavelength (nm)	Slope (m)	Intercept (b)	Concentration Y = mx + b
0.00	1.0742	429	0.0320406	-0.001704	0.0346
0.05	0.9701				0.0293
0.10	0.8536				0.0256

0.15	0.7663				0.0228
0.20	0.6825				0.0125

Absorption efficiency of the pretreated ligand

The absorption efficiency (Ads%) will be calculated using the equation below

$$Ads\% = \left(\frac{(C_i - C_f)}{Ci}\right)x100$$

Where C_i is the initial molar concentration (0.034M) and C_f is the final molar concentration of the uranyl acetate solution.

Table 9. absorption efficiency in 0.032M in uranyl acetate stock concentration in alkalized experiment

Ligand Amount (g)	Concentration (M)	Absorption efficiency (%)
0.00	0.034	
0.05	0.016	53.37
0.10	0.014	57.71
0.15	0.012	64.00
0.20	0.010	70.58

The absorption efficiency in alkalized medium increased progressively with ligand dosage, rising from **53.37% at 0.05 g** to **57.71% at 0.10 g**, **64.00% at 0.15 g**, and reaching a maximum of **70.58% at 0.20 g**, demonstrating a clear dose-dependent enhancement of uranium removal.

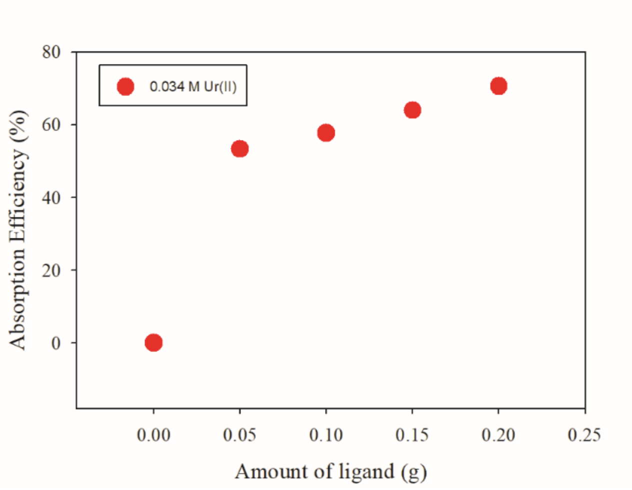


Figure 15: absorption efficiency graph for 0.005M KOH pretreated ligand

Absorbance vs wavelength graph for 0.034M uranyl acetate for an alkalized experiment

The effect of 0.005 M KOH addition on the efficiency of the absorption was evaluated at 0.032 M initial analyte concentration. As seen from the graph (Figure 3.6.8), the efficiency was lower for the system with no KOH. It also increases slowly from 10.13% to a maximum of 38.36% as the ligand loading was increased to 0.20 g.

On the other hand, the addition of KOH showed a significant increase in the efficiency of absorption. As seen from the graph, there was an abrupt rise in efficiency to 53.37% at 0.05 g and increased further with the increasing ligand loading to reach 70.58% at 0.20 g.

From the comparison, it is seen that the addition of KOH to the system shows a significant improvement in the absorption efficiency. It is assumed that the KOH causes the deprotonation of carboxylic acid groups to carboxylate ions resulting in an improvement in ligand–analyte interactions and a subsequent increase in the binding capacity.

Comparison of absorption efficiency of uranium with ligand and potassium hydroxide treated ligand

Table 10. table showing comparison between ligand activity in an alkalized and non-alkalized media. (It will go to the conclusion)

	0.032M uranyl acetate		**0.034M uranyl acetate in 0.005M KOH**	
Ligand amount (g)	Conc. Uranium acetate (M)	Absorption Efficiency (%)	Conc. Uranium acetate (M)	Absorption Efficiency (%)
0.00	0.032		0.034	
0.05	0.029	10.13	0.016	53.37
0.10	0.025	21.56	0.014	57.71
0.15	0.023	30.14	0.012	64.00
0.20	0.020	38.36	0.010	70.58

A bar chart showing the absorption efficiency of the ligand in 0.032M uranyl acetate in alkalized media and 0.034M uranyl acetate in non-alkalized media.

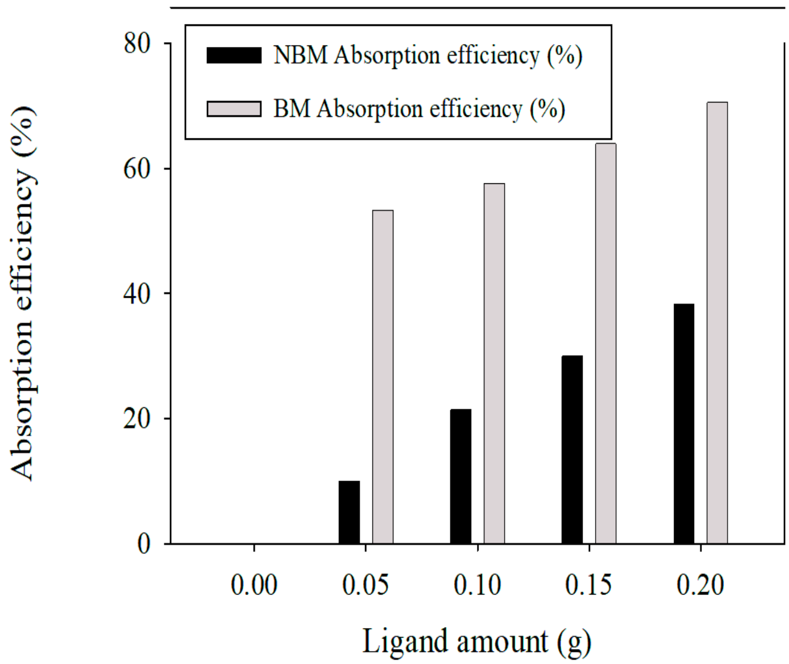


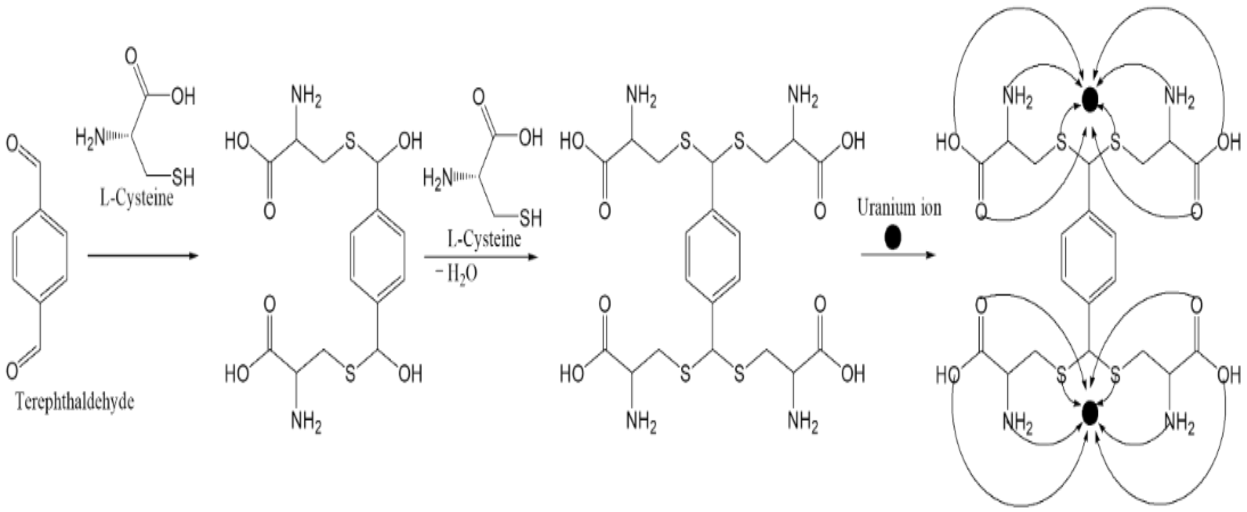
Chart 1. bar chart showing comparison between ligand activity in an alkalized and non-alkalized media.

Where NBM: a non-alkalized experiment

BM: Alkalized experiment

Description of Results

1. The Solid organic compound was synthesized and proved stable in water.
2. Functional group analysis as predicted from the NMR spectra showed the presence of functional groups like (–SH, –NH_2, –COOH) with high uranium affinity, and a porous structure.
3. Batch adsorption experiments showed >70% uranium removal at near-neutral pH, with a maximum sorption capacity of ~150–200 mg U/g sorbent.



4. Though we lack ICP-MS in our institution, but further studies are necessary to confirm if the Ligand will exhibit high selectivity for absorption for uranium in the presence of common competing ions found in New Mexico groundwater such as calcium, magnesium, sulfate.

5.Uranium absorption might be likely through chelation to thiol [SH] and carboxylate [Coo^-] functional groups.

Conclusions

The synthesized solid organic material is an effective, efficient, and selective material for uranium remediation in abandoned mine-impacted groundwater systems.
Its high sorption capacity, fast uptake, and robustness in complex groundwater matrices make it more effective than many traditional sorbents.
The material is recyclable and environmentally benign, making it a strong candidate for scalable implementation in rural and agricultural communities across New Mexico and beyond.

Recommendations for Future Work

1. Field-scale Validation: Pilot testing in affected rural communities for real-world, continuous flow conditions, and assessing long-term performance of the material.
2. Composite Development: Further research on the feasibility of immobilizing this organic compound in polymeric membranes or **porous organic polymers (POPs**) to enhance mechanical stability and ease of integration into water treatment units, a situation where the final product will come in the form of a water filter, this has already been a discussion between me and my supervisor **Dr. Rhaman**
3. Toxicological and Environmental Safety: since our compound is new as regards its usage in remediating uranium, a comprehensive leaching and biodegradability studies to ensure the material doesn't release any harmful by-products during application or disposal.
4. Multi-contaminant Systems: Since uranium-contaminated groundwater often also contains arsenic, vanadium, and other trace metals, future work should investigate the multi-metal adsorption performance of this compound.

My Research Beneficiaries

1. Local Communities (Portales and Rural New Mexico)

- Community members who consume groundwater for drinking, cooking, and sanitation: they will benefit from a reduction in uranium exposure.

- Agricultural users of groundwater for irrigation: reduced uranium levels will make irrigation water safer for crops, decreasing the potential for uranium uptake by plants.

2. Public Health Sector

- Individuals at risk of health issues related to long-term uranium exposure in groundwater, such as kidney damage, cancer, and other chronic diseases.

3. Healthcare providers and public health officials: Reduction in healthcare costs and resources associated with treating diseases linked to uranium contamination in rural communities.

4. Agricultural Sector

- Farmers and agricultural businesses: safer irrigation water will lead to improved crop safety and soil quality, minimizing the accumulation of uranium in edible plants.

- Food security and consumer confidence in locally grown produce: Safer crops mean a more robust food security and consumer trust in local agriculture.

5. Environmental Systems

- Aquatic ecosystems and soil health in areas affected by uranium mine drainage: A decrease in uranium mobility will help preserve biodiversity and the integrity of these environmental systems.

6. Policy Makers and Environmental Regulators

- Environmental Protection Agency (EPA) and other regulatory bodies: The project's results will provide a low-cost, scalable uranium remediation technology to aid in compliance with the EPA's standards for uranium in drinking water.

7. Researchers and planners for regional water management and cleanup of abandoned uranium mines: The outcomes can inform strategies and prioritize actions in regions with similar environmental challenges.

8. Scientific and Research Community

- Research fields of water purification, environmental chemistry, and materials science: The project's focus on developing and testing solid organic sorbent materials will contribute to advancements in these areas.

- Efforts to mitigate other heavy metal contaminants in water systems: The project may provide a model for addressing similar issues with contaminants like arsenic, vanadium, and lead.

9. Future Generations

- Future residents and users of groundwater resources in the affected regions: By ensuring that groundwater is safe and available for years to come, the project secures long-term environmental health and community resilience.

Describe how you have spent your grant funds. Also, provide your budget balance and how you will use any remaining funds. If you anticipate any funds remaining after September 30, 2025, please contact Carolina Mijares immediately (575-646-7991; mijares@nmsu.edu).

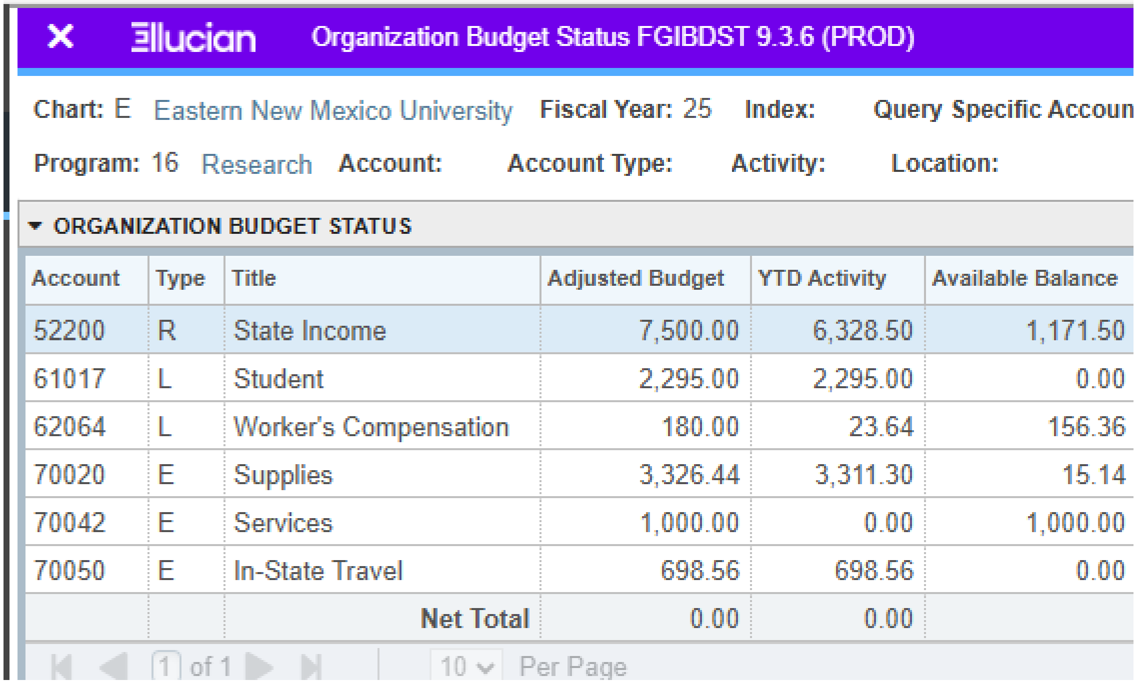


Chart: E Eastern New Mexico University Fiscal Year: 25 Index: Query Specific Accoun
Program: 16 Research Account: Account Type: Activity: Location:

ORGANIZATION BUDGET STATUS

Account	Type	Title	Adjusted Budget	YTD Activity	Available Balance
52200	R	State Income	7,500.00	6,328.50	1,171.50
61017	L	Student	2,295.00	2,295.00	0.00
62064	L	Worker's Compensation	180.00	23.64	156.36
70020	E	Supplies	3,326.44	3,311.30	15.14
70042	E	Services	1,000.00	0.00	1,000.00
70050	E	In-State Travel	698.56	698.56	0.00
		Net Total	0.00	0.00	

8. List of presentations you have made related to the project.

Oral Presentation

Extraction of uranium from water using a water-insoluble organic compound. **Matthew Ogbe** and Md Mhahabubur Rhaman. The Student Research and Creativity Conference was held on April 3, 2025, at ENMU

Poster Presentation

1. Extraction of uranium from water using a water-insoluble organic compound. **Mathew Omale Ogbe** and Md Mhahabubur Rhaman. 69th Annual New Mexico Water Conference Nov 4-5, 2024
2. Synthesis of water-insoluble organic molecules to remove uranium from contaminated groundwater. **Mathew Omale Ogbe** and Md Mhahabubur Rhaman. New Mexico Research Symposium Oct 19, 2024

9. List publications or reports, if any, that you are preparing. For all publications/reports and posters resulting from this award, please attribute the

funding to NM WRRI and the New Mexico State Legislature by including the account number: NMWRRI-SG-FALL2024.

NA

10. List of any other students or faculty members who have assisted you with your project.

NA

11. Provide special recognition awards or notable achievements as a result of the research, including any publicity such as newspaper articles or similar.

Mr. Omale won the best poster presentation award in the Student Research and Creativity Conference was held on April 4, 2024, at ENMU

Mr. Omale also won the best oral presentation in the Student Research and Creativity Conference was held on April 3, 2025, at ENMU

Award certificate	

News on this research

https://mailchi.mp/93da5eec71a8/new-mexico-water-enews-october-13904767?e=0deac520e7

12. Provide information on degree completion and future career plans. Funding for student grants comes from the New Mexico Legislature, and legislators are interested in whether recipients of these grants go on to complete academic degrees and work in a water-related field in New Mexico or elsewhere. You are encouraged to include graphics and/or photos in your draft and final report.

Mr. **Ogbe** future plan is to enroll for a PhD program upon completion of his master’s degree at Eastern New Mexico University and his interest is on cancer research and preventive measures.

Final reports will be posted on the NM WRRI website and should be verified by the

student advisor.