LIQUID ION EXCHANGE JOINED WITH CLOUD POINT EXTRACTION FOR SPECTROPHOTOMETRIC DETERMINATION OF SULFADIAZINE

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Abstract

A simple and sensitive method is studied to determine sulfadiazine in pure form. The method utilizes a liquid ion exchange reaction based upon forming an ion-pair association complex for SDz with Ni(II) in the presence of HCl and non-ionic surfactant Triton X-100. The maximum wavelength was 291nm. The optimum condition effect on the separation method was studied: temperature 90°C, heating time 15min., the concentration of Ni(II) was 50µg/mL, and the best surfactant was TritonX-100. The reaction kinetics were studied by using the initial rate method. The calibration curve was linear over the concentration range of 1-100µg/mL with LOD of 5.09 µg/mL and LOQ of 15.43µg/mL.

Keywords: Sulfadiazine, Liquid ion exchange, Surfactant, Nickel.

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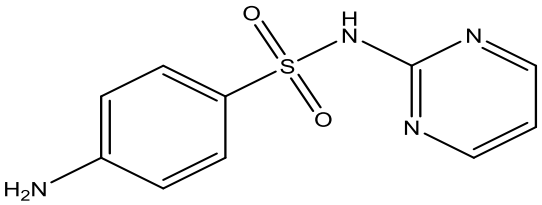
1. Introduction

Sulfadiazine SDz, 4-amino-N-pyrimidin-2-yl-benzenesulfonamide:



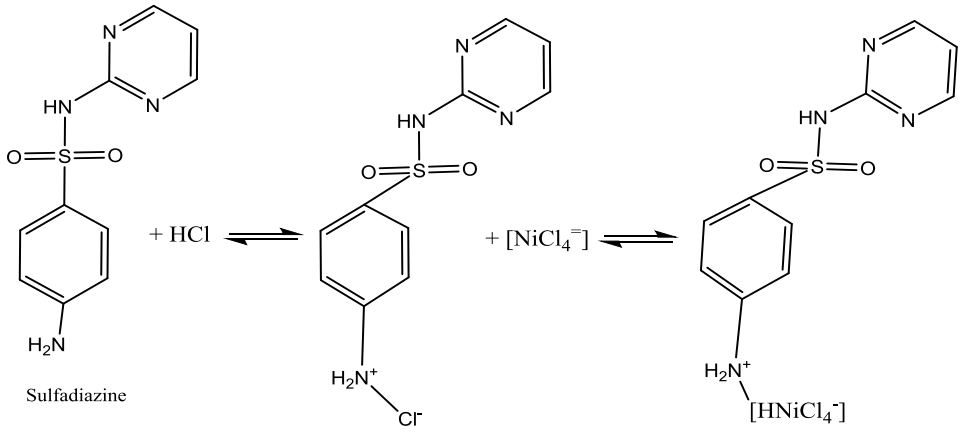
It is a sulfonamide group of antibiotics which has been used in veterinary and human remedy over 60 years [1]; it works to inhibit the product of folic acid inside the bacterial cell[2]. Different analytical methods have used the determination sulfadiazine; among them have reversed-phase high-performance liquid chromatography coupled with online atmospheric pressure chemical ionization mass spectrometry[3], cloud point extraction /flow injection-flame atomic absorption spectrometry[4], high-performance liquid chromatographic methods (HPLC) [5-7], different analytical methods are used for the determination of sulphadiazine such as spectrophotometric methods [8-10]. The present study developed a new method for a sensitive and selective spectrophotometric determination of SDZ by using Ni(II) as chloro anion to form an ion pair association complex in an HCl medium; the method was applicable for the determination of SDZ in pharmaceuticals.

Experimental

- **Apparatus:** A biochem double beam UV-Vis. A spectrophotometer model (Biochrom libra S60) (UK) and an Electrostatic water bath (Germany) were used.
- **Solutions:** the standard Ni(II) solution (1mg/mL) was prepared by dissolving 0.2210g from $NiCl_2.6H_2O$ (Merck 99.8%) in 100 mL distilled water, 1% TritonX-100 (Alpha Chemika) and Sulfadiazine (100µg/mL) were prepared by dissolving 0.01g (Merck 99.96%) in 100 mL distilled water, any other working solutions prepared by serial dilution with distilled water to as appropriate volume.
- **General Procedure:** Prepared aqueous solutions with a volume of 10mL containing sulfadiazine (100µg/mL), Ni(II) (100µg/mL) in HCl media, then add a suitable volume of 1%TritonX-100 as a non-ionic surfactant, the solutions were heated in an electrostatic water bath for adequate temperature and time after that separated the cloud point layer from aqueous solution, and dissolved in 5mL ethanol. The absorbance was measured against ethanol as a blank at λmax.

2. Results and Discussion

Mechanism of Liquid ion exchange to form Ion pair association c omplex



Scheme (1)

The procedure of maximum wavelength

The absorbance of ion association complex solution was measured from (200-400nm); the spectrum obtained was represented in Fig.(1), where λ_{max}=291nm.

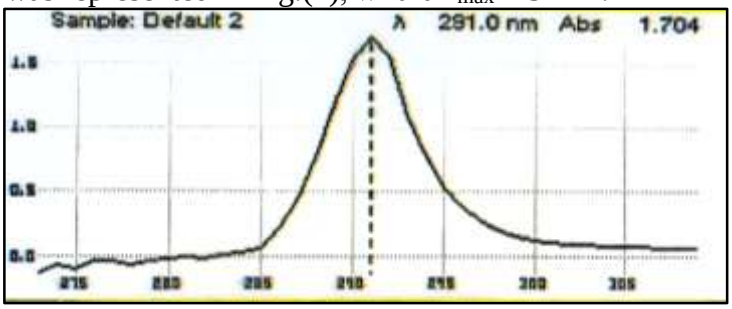


Fig (1): UV-Vis. Spectrum for ion association complex between SDz and $NiCl_4^=$

Optimization of the Experimental Conditions

Hydrochloric Acid Concentration

The effect of different hydrochloric acid concentrations in the range (0.1-1.0M) was investigated as in the general procedure; the results were as in Fig (2):

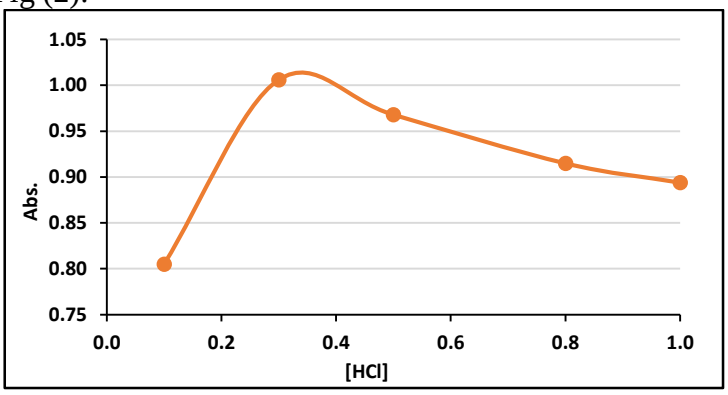
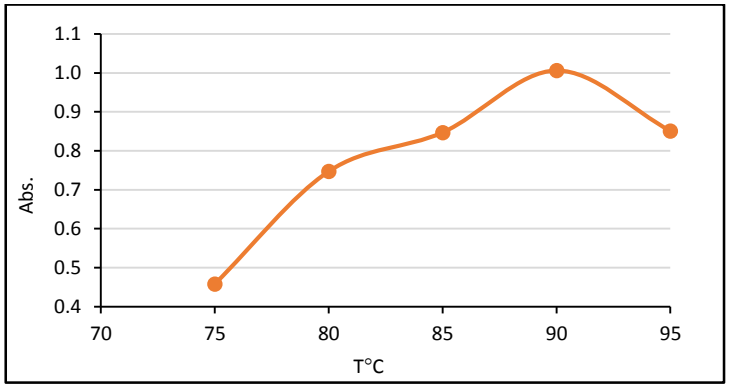


Fig (2): [HCl]=f (Absorbance)

shown in scheme (1); any HCl concentration less or more than the optimum is inappropriate for reaching for the best equilibrium[11].

The optimum value of HCl concentration was (0.3M); this concentration permits to form of liquid ion exchanger of sulfadiazine and chloro anion complex of Ni(II) as

clarify its role by extraction of sulfadiazine at different temperatures (75-95) °C, as in the general procedure; the results as in Fig (3):



Fig(3): Temperature effect on the absorbance of ion association complex

Effect of Temperature

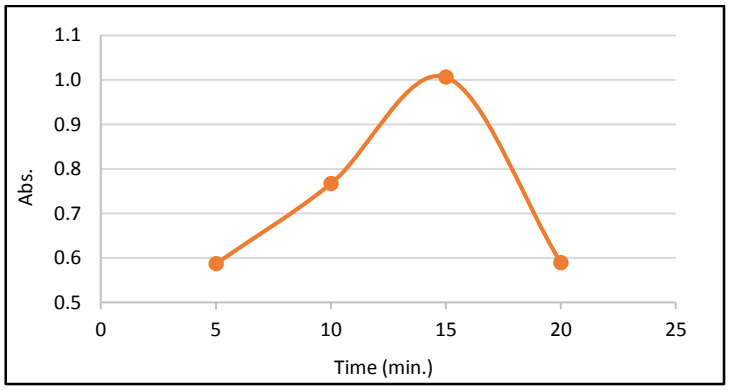
The temperature has an essential role in the formation of CPL, so it was studied to

complex between Sulfadiazine and $NiCl_4^{2-}$ quantitatively[12].

Effect of Heating Time

Extracted sulfadiazine according to the general procedure at different heating times. The results depicted in Fig. 4:

The results show optimum temperature was (90°C) giving higher extraction efficiency of sulfadiazine according to the liquid ion exchange method; this temperature explains the necessary energy for good aggregation micelles of surfactant to formation CPL to ion pair association



Fig(4): Variation of the absorbance of ion association complex with Heating time

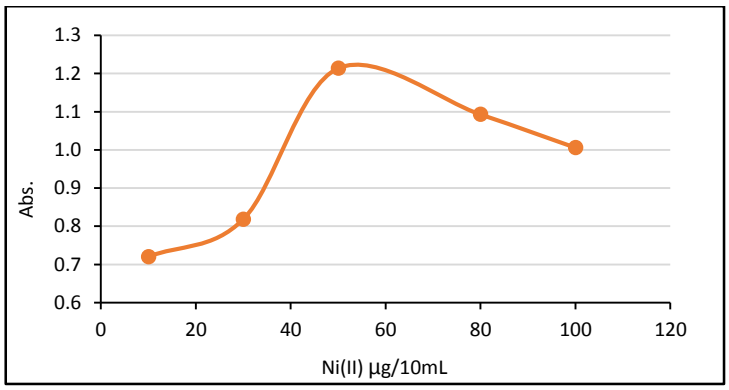
best equilibrium, whilst any time more than optimum causes decreasing extraction efficiency by increasing diffusion of micelles[13].

Effect of Ni(II) Concentration

According to the general procedure described above, extracted sulfadiazine from 10mL aqueous solutions contains a

The optimum time of heating for sulfadiazine was 15min. This time allows us to reach the best thermodynamic and kinetic equilibrium for ion pair association complex formation of sulfadiazine and $NiCl_4^{2-}$ which was extracted by the CPE method. Heating time acts as the kinetic side of complexation to reach the favourable energy in solution for gathering micelles and forming the best CPL. Time less than optimum is unsuitable to reach the

rising concentration of Ni(II). The results are presented in Figs. 5.

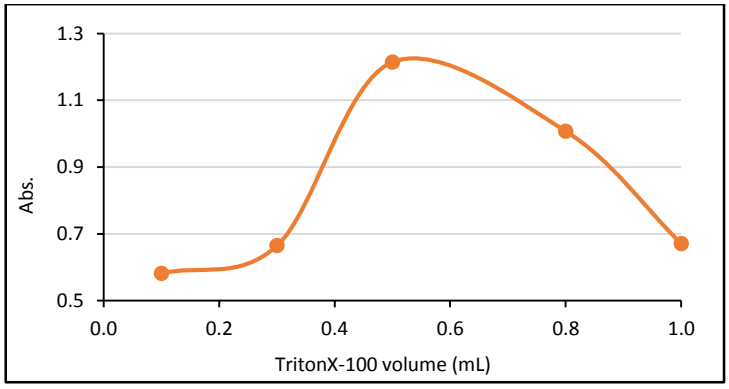


Fig(5): Effect of Ni(II) concentration on ion association complex formation

Effect of Surfactant Volume

By applying the general method, extracted sulfadiazine has been made in the presence of increasing the volume of 1%Triton X–100. The results were as in Figs. 6.

The concentration of 50µg/10mL was the optimal quantity, giving higher extraction efficiency. Concentrations less than the optimum value are inappropriate to reach the best equilibrium, and concentrations more than the optimum value decrease extraction efficiency according to mass action law[14].



Fig(6): Effect of surfactant volume on CPL formation

CPL, so a volume more than the optimum effect causes increased diffusion and prohibits the formation of CPL[15].

Surfactant Type

According to the general method, extracted sulfadiazine has been made in the presence of different surfactants. The results were as in Figs. 6.

The results demonstrated that the Triton X–100 volume was (0.5mL). Optimum volume assists in getting higher extraction efficiency, and this volume is sufficient to reach the favourite thermodynamic and kinetic equilibrium to form the best CPL. Likewise, reaching the critical micelle concentration (CMC) less than the optimum value does not allow equilibrium to form

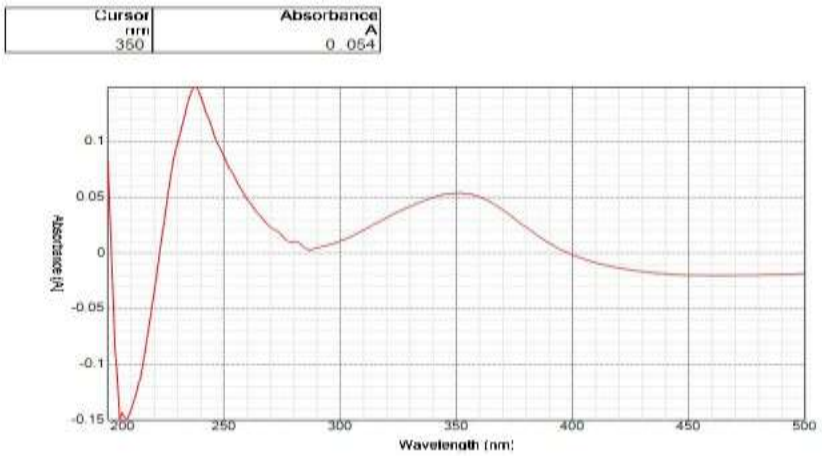


Figure (7): UV-Vis. The spectrum of SDz complex with Ni(II) in the presence of SDS

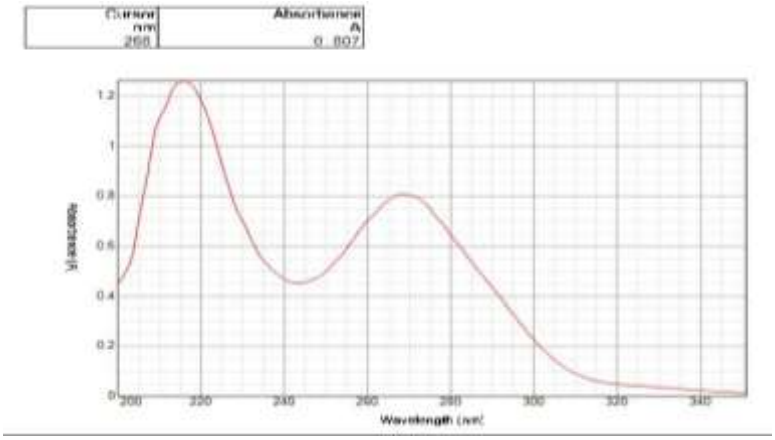


Figure (8): UV-Vis. The spectrum of SDz complex with Ni(II) in the presence of Tween 20

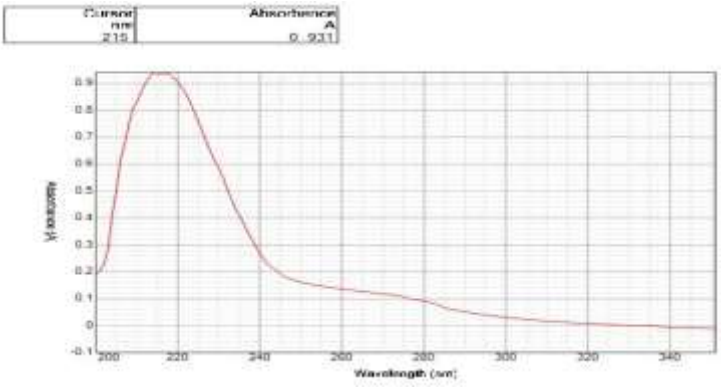


Figure (9): UV-Vis. The spectrum of SDz complex with Ni(II) in the presence of Tween 40

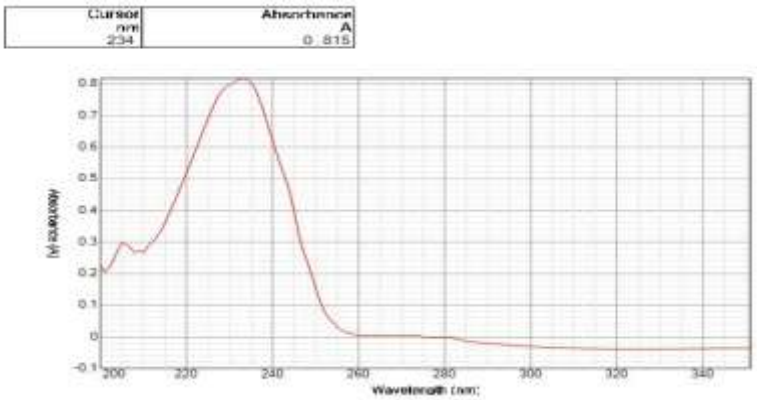


Figure (10): UV-Vis. The spectrum of SDz complex with Ni(II) in the presence of Tween80

Evaluation of kinetic method (Initial Rate Method)

Under the optimum conditions, the absorbance time curves for extracting SDz with Ni(II) were constructed. The initial rates of the extraction were determined from the slopes tangents of the absorption-time curves, which were measured for 15 min at intervals of 5 min at room temperature. The initial rates of SDz reaction with Ni(II) would follow a pseudo-first-order concerning SDz concentration and be found to obey the following equation[16,17]:

$$V = \frac{\Delta A}{\Delta t} = K'C^n$$

where V is the reaction rate, A is the absorbance, t is the heating time, K′ is the pseudo-first-order rate constant, C is the molar concentration of SDz, and n is the reaction order. The logarithmic form of the above equation is as follows:

$$\log V = \frac{\Delta A}{\Delta t} = \log K' + n \log C$$

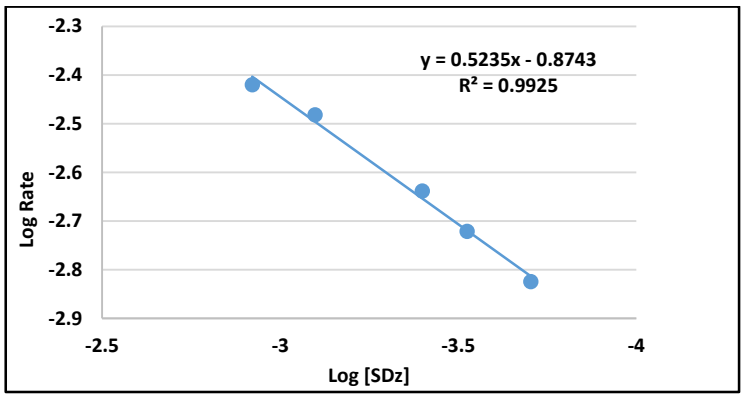


Figure (11): Calibration plots of the log Rate of the reaction vs log[SDz] for the initial rate method

Table (1): Analytical information for the initial rate method

Linear range (M)	Least square $\log V = \log K' + n \log C$		Correlation coefficient (r)	LOD (M)	LOQ (M)
	Intercept (logK')	Slope (n)			

1.98×10^{-4} – 1.19×10^{-3}	-0.8743	0.5235	0.9974	0.0178	0.054

Cloud point extraction joined with the Liquid ion exchange method as a sensitive and selective method used for spectrophotometric determination of SDz with Ni(II). Prepared calibration curve at λmax=291nm as fundamental process and at optimum conditions Figure (12).

The rate constant of the kinetic reaction of SDz with Ni(II) (k, at 90 °C) was 0.1336 min^{-1}. The value of n in the regression equation was 0.5235(≈1), confirming that the reaction of SDz with Ni(II) was in first order concerning the SDz concentration.

Calibration Curve Construction

Table (2): Analytical parameters for calibration curve of sulfadiazine

Parameter	**Proposed method**	**Literature method[18]**	**Literature method[19]**
linearity (µgmL^{-1})	1.0-100	3-15µg/mL	0.25-15 µg/mL
Limit of Detection (µgmL^{-1})	5.09	0.0307µg/mL	0.192 µg/mL
Limit of Quantity (µgmL^{-1})	15.43	-	0.563 µg/mL
Molar absorptivity ($L.mol^{-1}.cm^{-1}$)	2.863×10^{3}	2.23×10^{4} L/mol. cm	3.81×10^{4} L/mol.cm

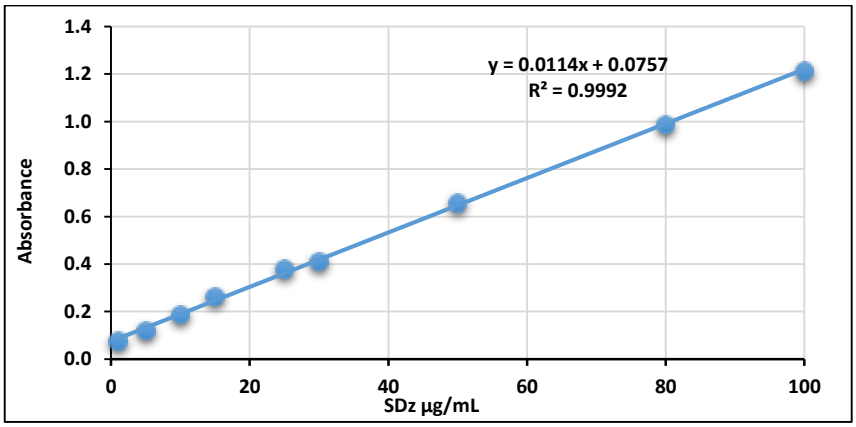


Figure (12): Calibration curve for sulfadiazine

effect on the separation method: the temperature was 90 degrees Celsius, the heating period was 15 minutes, the concentration of Ni(II) was 50 micrograms per milliliter, and the best surfactant was Triton X-100. The initial rate approach was utilized for the purpose of doing research on the kinetics of the reaction. The linearity of the calibration curve was maintained across the whole concentration range of 1-100 g/mL, with a limit of detection of 5.09 g/mL and a limit of quantitation of 15.43 g/mL.

4. References

3. Conclusions

The pure form of sulfadiazine is being investigated using a technique that is both straightforward and sensitive. The procedure makes use of a liquid ion exchange process, which is predicated on the formation of an ion-pair association complex for SDz with Ni(II) in the presence of HCl and the non-ionic surfactant Triton X-100. The longest wavelength that was measured was 291 nm. It was determined that the following conditions had the best

performance liquid chromatography. Journal Agric. Food Chem., **53** (22):8468-8473.

8. Kothacota, V.; Arun, K.D.; Umadevi, K.; Kishore, T.S.; Loya, H.; Kishant, K.P. (2011). Method development and validation of sulphadiazine in bulk and pharmaceutical dosage form by UV-spectrophotometric method. Intern. J. Pharm. Biolog. Arch., **2**(4),1167-1171.
9. Mahdi, M.I. and Kadim, K.H. (2015). Spectrophotometric determination of Sulfadiazine in Various samples by coupling with 2,5-dimethoxy aniline. Iraqi National Journal of Chemistry, **15** (1).
10. Shaheed, H.A. (2015). Atheromdynamic study of Adsorption of Sulfadiazine on tween 20, tween 40. Journal AL qadisiyah University, 2 (20):125-136.
11. Salim, A.M. and Haseeb, Y.S.Z. (2013). Spectrophotometric Determination of Sulfadiazine via Diazotization and Coupling Reaction-Application to Pharmaceutical Preparations. Raf. J. Sci., **24** (6):61-73.
12. Azooz, E. A., Moslim, J. R., Hameed, S. M., Jawad, S. K., & Al-Mulla, E. A. J. (2021). Aspirin in food samples for separation and micro determination of copper (II) using cloud point extraction/solvation method. Nano Biomed. Eng, 13(1), 62-71.
13. Safa Majeed Hameed, Sahar Aqeel Hussain, Alaa J. AL-Khkany. Extraction for Mo(VI), W(VI) and Mn(VII) as Oxyanions by Incorporation Cloud Point with Liquid Ion Exchange Methods. Research Journal of Pharmacy and Technology. 2022; 15(8):3685-9. doi: 10.52711/0974-360X.2022.00618
14. Hussain, S. A., Hameed, S. M., Abed, A. S., & Mahdi, N. S. (2023). Separation, Pre-concentration, and

1. Pecorelli, I.; Bibi, R.; Fioroni, L.; Galarini, R. (2004). Validation of a confirmatory method for determining sulfonamides in muscle according to the European Union regulation 2002/657/EC. J. Chromatogr. , A, **1032**, 23- 29.
2. Kothacota, V.; Arun, K.D.; Umadevi, K.; Kishore, T.S.; Loya, H.; Kishant, K.P. (2011). Method development and validation of sulphadiazine in bulk and pharmaceutical dosage form by UV-spectrophotometric method. Intern. J. Pharm. Biolog. Arch., **2**(4),1167-1171.
3. Combs, M.T.; Ashraf-Khorassani, M.; Taylor, L.T. (1999). HPLC/ atmospheric pressure chemical ionization-mass spectroscopy of eight regulated sulfonamides. J. Pharm. Biomed. Anal., **19**, 301-308.
4. Dadfarnia, S.; Hajishabani, A.M.; Rad, H.F. (2011). Indirect determination of sulfadiazine by cloud point extraction /flow injection-flame atomic absorption (CPE/FI-FAAS) spectrometry. J. Chin. Chem. Soci., **58**, 503-508.
5. Valentina, G.; Chiara, T.; Fioroni, L.; Moretti, S.; Dusi, G.; Galarini, R. (2009). Development and validation of a confirmatory method for the determination of sulphonamides in milk by liquid chromatography with diode array detection. Anal. Chim. Acta, **(1)**, 18-23.
6. Croubels, S.; Wassink, P. and Backer, P.D. (2002). Simultaneous determination of sulphadiazine and trimethoprim in animal feed by liquid chromatography with UV and tandem mass spectrometric detection. Anal. Chem. Acta, 473:183-194.
7. Wen, Y.; Zhang, M.; Zhao, Q. and Feng, Y.Q. (2005). Monitoring of five sulphonamide antibacterial residues in milk by in-tube solid-phase microextraction coupled to high–

Determination of Al(III) by Cloud Point Extraction as a Compact Method with Liquid Ion Exchange. Journal of Medicinal and Chemical Sciences, 6(3), 656-667. doi: 10.26655/JMCHEMSCI.2023.3.22

15. Jawad, S. K., & Hameed, S. M. (2017). Separation and Extraction Micro Amount of Cadmium (II) and Mercury (II) with Liquid Anion Exchange Method. Ibn Al-Haitham Journal for Pure and applied science, 24(2).
16. Naser, N. A., Alasedi, K. M., & Khan, Z. A. (2018). A new approach for determination of sulfadiazine in pharmaceutical preparations using 4 (4-sulphophenylazo) pyrogallol: Kinetic spectrophotometric method. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 201, 267-280.
17. El-Brashy, A., Eid, M., & Talaat, W. (2006). Kinetic spectrophotometric method for the determination of ketoprofen in pharmaceuticals and biological fluids. International Journal of Biomedical Science: IJBS, 2(4), 406.
18. Azeez, Dheyaa Thamer. "Development of a spectrophotometric method to assay sulfadiazine in pure and in pharmaceutical dosage form through diazotization and coupling reaction." Rafidain Journal of Science 31.1 (2022): 23-34.
19. Ahmed, Najlaa Abd AL Salam, and Ali Ibraheem Khaleel. "Spectrophotometric determination of sulphadiazine Using 2, 4–dinitrophenylhydrazine as Coupling Reagent." Tikrit Journal of Pure Science 23.8 (2018): 77-82.