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SYNTHESIS AND CHARACTERIZATION OF A NOVEL POLYMER DERIVED FROM THE DRUG METOCLOPRAMIDE FOR ANALYTICAL DETECTION OF TOXIC ELEMENTS FOR WATER POLLUTION TREATMENT

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ABSTRACT

In this study, the synthesis of a new chelating polymer through a reaction from the Drug Metoclopramide with Aldehyde (Salicylaldehyde). The characterization of the Monomer Schiff base was detected by (FT-IR),(C.H.N.S), and (1H-NMR) Techniques, then the Monomer Schiff base with (0.02 mol) of (Bisphenol A) and (0.2g) of para-formaldehyde. To the reaction mixture, (20ml) of formaldehyde and (15ml) of tetrahydrofuran are added. The potential of hydrogen is raised to pH=9.5 by adding 5% sodium hydroxide solution (polymerization) the chelating polymer was confirmed by (FT-IR). The effectiveness of the synthesized polymer was validated through its evaluation as a chelating agent for several toxic metal ions found in water, including Pb^{2+}, Cu^{2+}, $Ni^{2+,}$ and Co^{2+}, using a batch processing method. The chelating polymer prepared from drug material shows higher results, The highest affinity of polymer to attach with Ions was achieved with Pb^{2+}. Finally, the ability of the polymer to recover and separate from Ions was detected thereby the Pb^{2+} Ion had the highest value in the recovery process with (%85.3) meanwhile the Cu^{2+} was the lowest value in the recovery processing with a value of 50% from all amount. Activation of the polymer was also achieved by a Hydrochloride solution.

KEYWORDS: Metoclopramide, bisphenol A, chelating resins,tetra hydro furan, paraformaldehyde.

1. INTRODUCTION

Water pollution caused by toxic metal ions poses serious problems due to its impact on various living organisms, as they are toxic even at low concentrations.[1,2] Various techniques and processes have been employed to reduce the concentration of toxic metal ions in water, including biological treatments[3], membrane processes[4], advanced oxidation processes[5], chemical and electrochemical techniques[6], and adsorption processes.[7] While these techniques are commonly used to remove toxic metal ions, researchers have focused on the use of chelating resins due to their potential for regeneration, ease of operation, high adsorption capacity, efficiency, and selectivity for certain toxic metal ions.[8] Therefore, chelating resins are important and have been prepared from different materials for this purpose. Some chelating resins are considered selective resins, designed to possess high specificity for certain ions or ion groups.[9] These resins differentiate metal ions through ion-interactions and coordination complexities rather than simple electrostatic interactions found in traditional ion exchange processes. Therefore, chelating resins exhibit greater selectivity than traditional ion exchange resins.[10] Extraction of these resins for numerous metals from their aqueous solutions can be achieved either through batch systems or columns, where the resin is immobilized on a support medium such as glass and silica gel.[11] The selectivity of these resins towards metals depends on the nature of their ligands, treatment time, and pH value.[12] Due to the complex chemical structure of some pharmaceutical compounds and their containing of amine groups, Schiff bases have been prepared from these pharmaceutical substances such as Metoclopramide It is an organic pharmaceutical compound.[13] Its scientific name is (4-Amino-5-Chloro-N-(2-diethylamino) ethyl -2-methoxy benzamide), and Its molecular formula is ($C_{14}H_{22}CIN_3O_2$).The molecular weight of this compound is 299.5 g/mol. It exists in the form of white crystalline powder with a melting point of 183°C. It is soluble in water and alcohol, partially soluble in dichloromethane, and insoluble in ether.[14] This drug has various applications, as it exhibits significant efficacy in treating nausea and as an antiemetic. It is considered more suitable than phenothiazine drugs in treating vomiting associated with gastrointestinal disorders such as dyspepsia resulting from digestive system disorders or some diseases of the duodenum and liver diseases and jaundice and cases of migraine headaches.[15] Its use is accompanied by some side effects such as lethargy, fatigue, and some cases of diarrhea.[16]

2. METHODS AND EXPERIMENTS

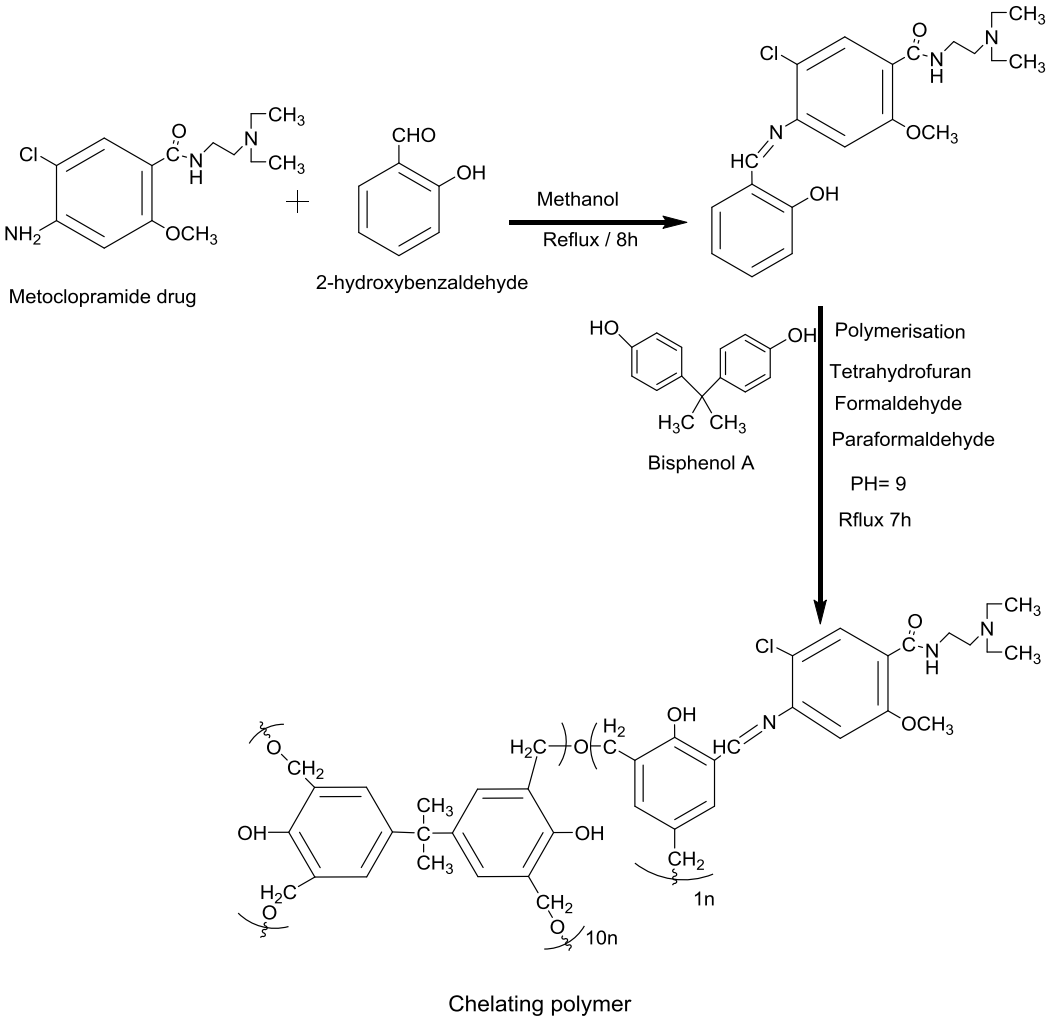
The chemicals and solvents employed in the study were sourced from (Fluka, Aldrich, and BDH), and were utilized without undergoing recrystallization. Infrared spectra were recorded using a Shimadzu 8400 spectrophotometer with KBr as the type. Proton nuclear magnetic resonance (1H-NMR) spectroscopy was conducted on a Bruker 400MHz instrument equipped with an Ultra Shield 400 MHz device at Ahl–Albate University in Jordan.

2.1. Synthesis of Schiff Base [A]

Dissolve 2.99g (0.01 mol) of the amine (metoclopramide) in 25 ml of methanol, and 1.2g (0.01 mol) of the aldehyde (Salicylic aldehyde) in 15ml of methanol. Add 0.02g of para-toluenesulfonic acid as a catalyst. The reflux reaction was conducted in a water bath for 8 hours. The reaction mixture was filtered, and then allowed to cool, forming a light yellow precipitate. The mixture was filtered and dried using an oven dryer. It was then recrystallized with methanol, and its melting point was determined to be 127-130°C. The yield was 2.8g, with a reaction yield of 69%. The product was characterized by IR spectroscopy, ^{1}H-NMR spectroscopy, and elemental analysis (C.H.N.S).

2.2. Synthesis of Chelating Polymer [C.P.A.]

The reaction setup consists of a three-necked flask attached to a mechanical stirrer, a condenser, and an addition funnel. In the flask, 0.599g (0.002 mol) of Schiff Base is mixed with 4.5g (0.02 mol) of Bisphenol A and 0.2g of para-formaldehyde. To the reaction mixture, 20ml of formaldehyde and 15ml of tetrahydrofuran are added. The potential of hydrogen is raised to pH=9.5 by adding 5% sodium hydroxide solution. The reaction flask is then placed on a heated magnetic stirrer and the reaction is continuously stirred for 7 hours. After the reaction is complete, a viscous gel-like substance (Softjelly) of light yellow color is formed. The mixture is neutralized to pH=7-7.5 after cooling, using a cold 5% H3PO4 solution. The solvent is evaporated, and the resulting product is dried at a temperature of 120°C for two hours to complete the curing process. The resulting polymer is then ground and thoroughly washed with distilled water to remove any unreacted residues, and then dried. The ratio of Schiff Base to Bisphenol A is 10:1. Infrared spectroscopy was performed, and the proposed formula for the Chelating resin is Scheme 1.



Scheme 1: Preparation of Schiff bases [A] and [C.P.A.].

2.3. Preparation of Standard Solutions for Elements Ions

Standard solutions for metallic elemental ions were prepared in a volume of 500ml by dissolving the required weights of nitrates or chlorides of the metallic elements in the least possible amount of concentrated nitric acid or hydrochloric acid. Then, 2ml of each acid was added, and the necessary volume was completed with deionized water to reach 500ml. This resulted in a solution with a concentration of 1000ppm. Specific volumes of these ion solutions were then diluted to give a concentration of 100 ppm for each ion at different acidic pH levels. Ion-free water was used in all analytical preparation operations. The acidity was adjusted using solutions of nitric acid and ammonium hydroxide with a concentration of 1M for each, as in table (1).

Table 1: Illustrates the weight of each metallic element salt used to obtain (500ml) of the solution with a concentration of (1000ppm).

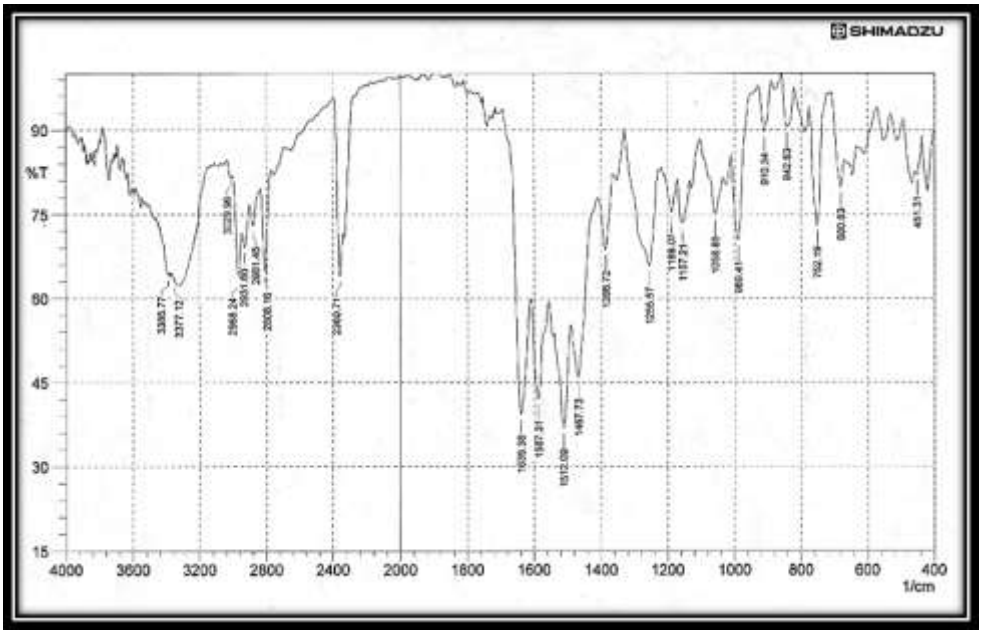
NO.	The molecular formula of elements salts.	The weight (mg) in (500 ml).
1	$Co(NO_3)_2.6H_2O$	2.470
2	$Cu(NO_3)_2.6H_2O$	2.327
3	$Pb(NO_3)_2$	0.7992
4	$Ni(NO_3)_2.6H_2O$	2.477

RESULTS AND DISCUSSION

The prepared Schiff base [A] compound was characterized using infrared (FT-IR) spectroscopy.[17] It was observed that the carbonyl aldehyde group absorption band disappeared at the wavenumber range of (1700_1720cm^{-1}), and the primary amine symmetric and asymmetric stretching bands also disappeared at (3400cm^{-1}). Additionally, the aldehyde group (C-H) absorption band vanished at (2720 cm^{-1}), while a new absorption band appeared at the wavenumber range of (1602_1639 cm^{-1}), attributed to the stretching frequency of the imine group (-HC=N), then the prepared Chelating Polymer [C.P.A.] was also characterized using infrared (FT-IR) spectroscopy. It was noted that an absorption band appeared at the wavenumber range of (2925_2964 cm^{-1}), corresponding to the stretching frequency of the aliphatic (CH_2) group. Additionally, an absorption band appeared in the range of (3336-3394cm^{-1}), attributed to the stretching frequency of the (O-H) group. as Table (2) and Figures (1), (2).

Table 2: FTIR spectroscopy for synthesized compounds.

compounds	FT-IR – KBr. , υ – cm^{-1}										
	N-H	O-H	C-H Ar.	C=C Ar.	C=N	C-N	C-Cl	SO_2	C-O	C-S	CH_2 aliphatic
Schiff base[A]	3386	3377	3029	1512	1639	1255	752	-----	1157	-----	-----
Chelating Resin	-----	3352	-----	1481	1598	1251	-----	-----		-----	2962



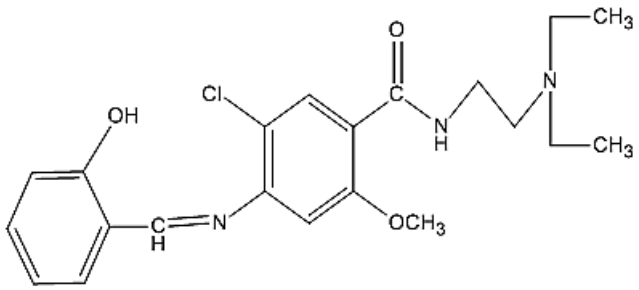
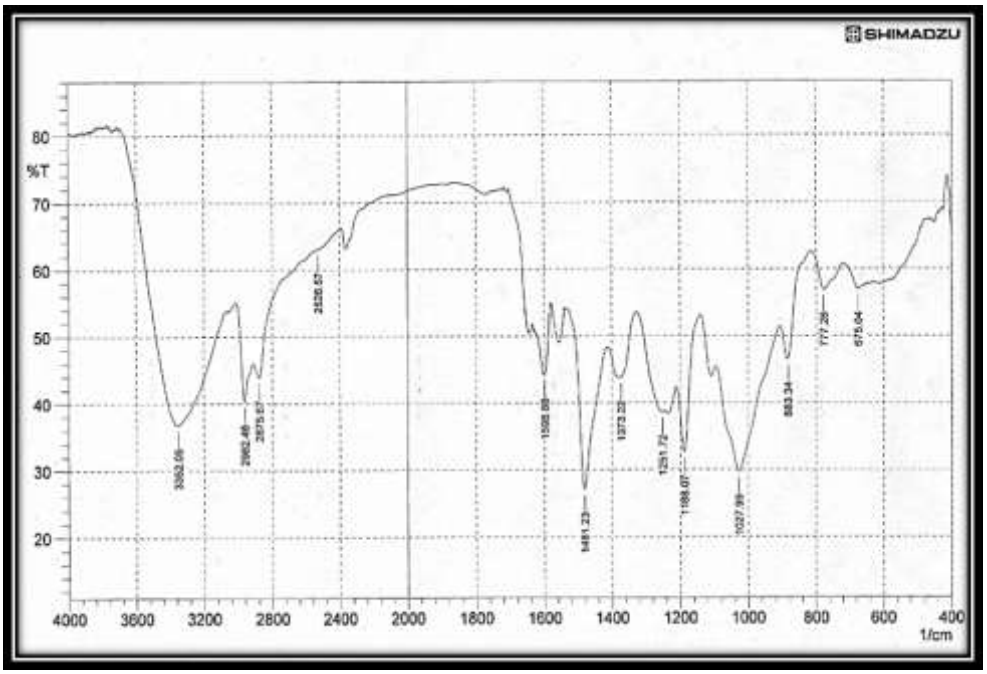


Fig. 1: FT-IR spectrum for compound(Schiff base[A]).



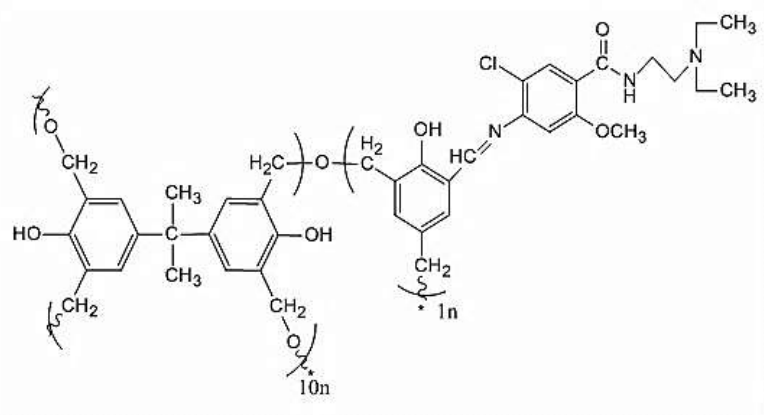


Fig. 2: FT-IR spectrum for compound(Chelating polymer [C.P.A.]).

3.1 The ^{1}H-NMR spectrum

The monomer for the Schiff base [A] spectrum shows the appearance of a triplet at δ =1.010ppm, attributed to proton (1) in the compound, corresponding to the (CH_3) group. Additionally, a quartet appears at δ = 3.375 ppm, attributed to proton (2) in the compound, corresponding to the (CH_2) group, Protons (3) and (4) exhibited triplet signals at δ = 2.480 ppm and δ = 2.550 ppm, respectively, with these signals overlapping with the DMSO signal. Additionally, a singlet appeared at δ = 3.826 ppm, attributed to proton (5) in the compound, corresponding to the (OCH_3) group, a signal appeared at δ = 5.362 ppm, attributed to proton (6) in the compound, corresponding to the (OH) group, a singlet was observed at δ = 7.958 ppm, attributed to proton (a). Furthermore, a multiplet signal was observed for protons (b) in the range of δ =7.711-7.733 ppm, and another multiplet signal was observed at δ =7.469-7.508 ppm, attributed to protons (d). Protons (e) exhibited a doublet signal at δ = 7.382-7.469 ppm. Protons (f, c), as indicated by the spectrum, appear as multiplet signals in the range of δ = 7.005-7.048 ppm, A singlet signal was also observed at δ = 8.410 ppm, attributed to proton number (7) in the compound, corresponding to the NH group. Additionally, another singlet signal was detected at δ = 9.107 ppm, attributed to proton number (8) in the compound, corresponding to the azomethine group (N=CH), Figures (4) and (5) illustrates the ^{1}H-NMR spectrum of monomer Schiff base [A].

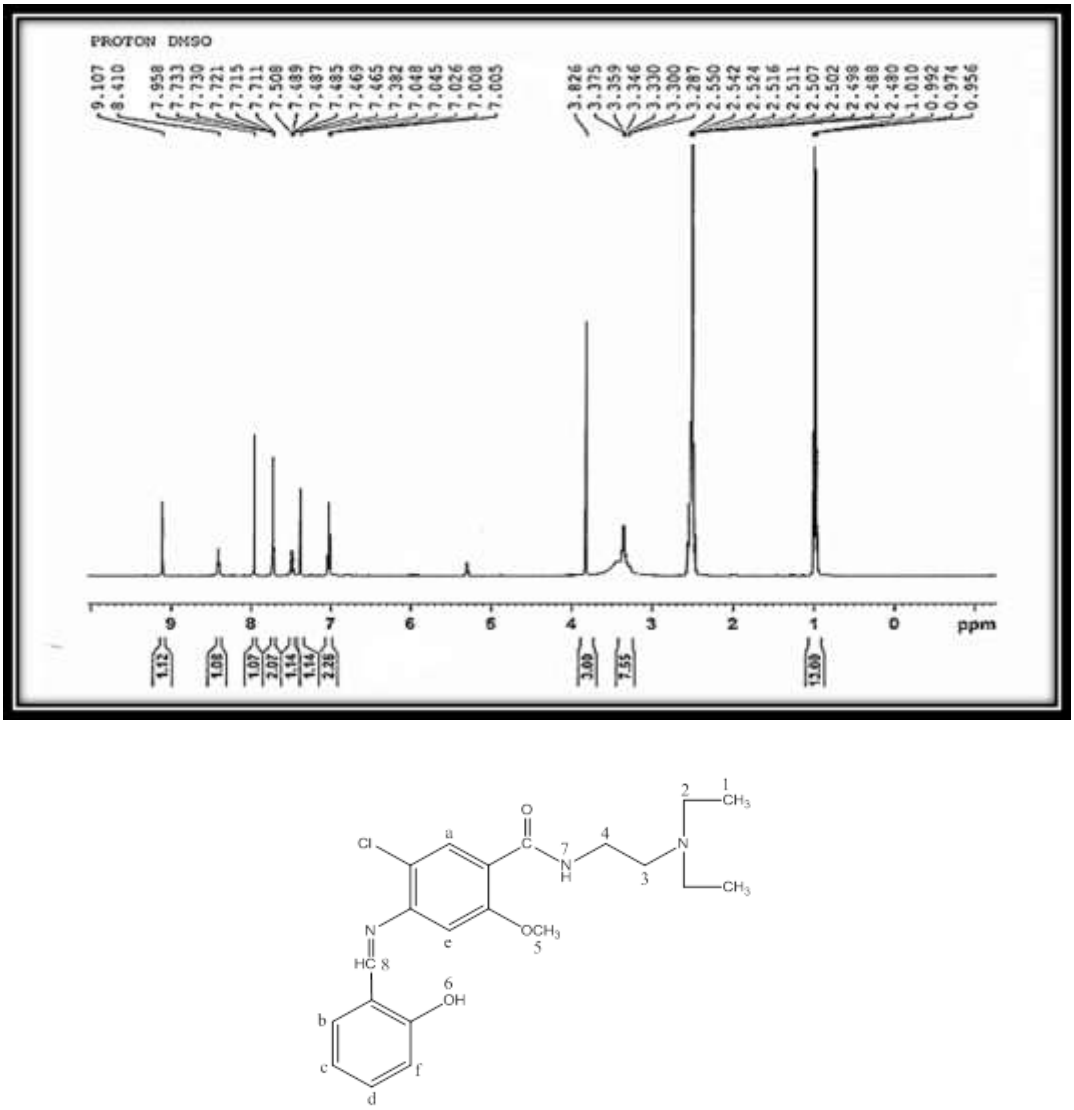


Fig. 3: ^{1}H-MNR spectrum of compound [A].

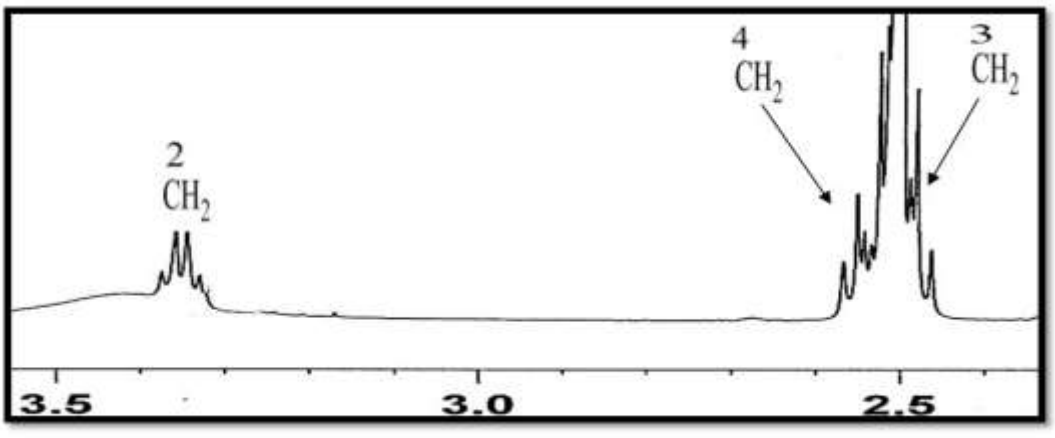


Fig. 4: ^{1}H-MNR spectrum of compound[A].

3.2 Elemental Analysis (C.H.N.S)

The Schiff base [A] compound was diagnosed using precise elemental analysis, and the results showed close agreement between the measured percentages of C, H, N, and S with the theoretical values for the prepared Schiff base compounds. This indicates the accuracy of the expected structures of the prepared compounds. Table (3) below presents these results.

Table 3: Elemental Analysis (C.H.N.S).

No.	Analysis of elements (C.H.N.S)	Found (calc) %			
		C	H	N	S
Schiff base[A]	Theoretical values. Experimental values.	62.45 (62.30)	6.49 (6.21)	10.40 (10.37)	-------

4. Analytical measurements to study the efficiency of chelating resins

The study involved assessing the selectivity of prepared resins towards ion species using standard solutions at the maximum treatment time, which is 24 hours, necessary for measuring the maximum loading capacity. This was done at the highest possible acidity level for the metal ion solution, ensuring the ion remains in a liquid state and not precipitated, depending on the type of ion under study. The temperature was set to the laboratory temperature. Among the factors affecting the ion-binding process to resins, two of the most important are the treatment time and the acidity function. The impact of treatment time on the analytical efficiency of the resin was investigated by treating 0.1g of resin with various metal ion solutions at different treatment times (0.5, 1, 3, 9, 24) hours. For each acidity function value studied to determine the loading capacity at equilibrium time, which is the time at which the change in loading capacity becomes minimal or negligible, the effect of the acidity function was also studied. The loading capacity of resins for each ion was examined at various acidity functions to assess the effect of acidity function on loading capacity, using HNO_3 and NH_4OH to adjust the acidity function.[18]

4.1 Analytical efficiency study of the chelating polymer [C.P.A.]

The batch method was employed to investigate the analytical efficiency of the polymer [C.P.A.] towards several ions, including Ni^{2+}, Cd^{2+}, Co^{2+}, Cu^{2+}, Pb^{2+}, and Cr^{3+}. The concentrations of these ions in the solutions were determined using flame atomic absorption spectroscopy after mixing 10ml of the ion solution with a concentration of 100ppm, except for lead ion (Pb^{2+}), which had a concentration of 200ppm, with (0.1g) of the polymer for 24 hours. Nickel (Ni^{2+}), lead (Pb^{2+}), copper (Cu^{2+}), and cobalt (Co^{2+}) ions exhibited significant

responsiveness to the polymer, while cadmium (Cd^{2+}) and chromium (Cr^{3+}) ions showed very low responsiveness. Therefore, these ions were further studied in detail.

4.2 The Effect of Treatment Time on the Maximum Loading Capacity of the Polymer [C.P.A.]

The impact of treatment time on the loading efficiency of the polymer [C.P.A.] in extracting the studied element ions was investigated. It was observed that with an increase in the treatment time of the studied ion solutions, the loading capacity of the polymer increased. The ions (Ni^{+2}, Pb^{2+}, Cu^{2+}, Co^{2+}) reached equilibrium after approximately (9) hours of treatment, with a slight increase in loading capacity even after reaching (24) hours of treatment as in tables (4) and Figures (5), (6), (7), and (8).

Tables 4: Illustrate the effect of treatment time on the loading capacity of the polymer [C.P.A.] for ions (Ni^{+2}, Pb^{2+}, Cu^{2+}, Co^{2+}) under the studied acidity.

Ions	pH	Loading Capacity ion mg / g resin				
		Time(hr.)				
		0.5	1	3	9	24
Co(II)	2	2.2	3.1	4.3	5.7	6.2
	4	2.7	4.2	5.6	7.2	7.8
	6	3.7	5.3	7.0	8.5	9.3
Cu(II)	2	2.3	3.3	3.9	4.7	5.4
	4	2.6	3.8	4.5	5.7	6.9
	6	3.1	4.2	6.4	8.0	8.4
Pb(II)	2	5.7	7.9	8.8	11.5	12.3
	4	7.7	9.5	12.5	14.4	14.6
	5.3	9.3	11.8	13.2	15.4	16.2
Ni(II)	2	1.9	2.3	3.4	4.0	4.4
	4	2.0	3.1	3.9	4.7	5.5
	6	2.7	4.4	5.9	6.9	7.3
	8	3.9	4.8	6.8	8.1	8.7

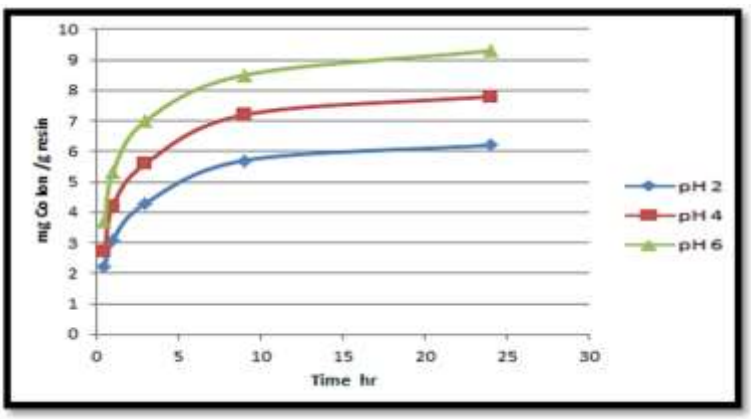


Fig 5: Number of (Co^{2+})mg withdrawn by (0.1g) of resin [C.P.A.] as a function of time in different acidic functions.

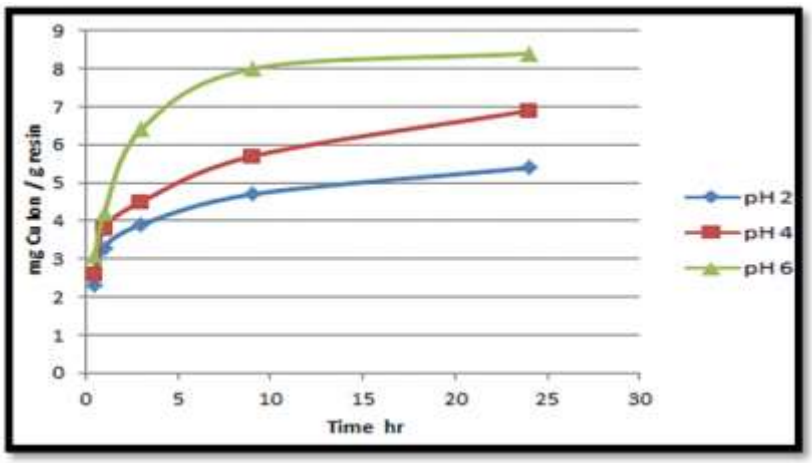


Fig 6: Number of (Cu^{2+})mg withdrawn by (0.1g) of resin [C.P.A.] as a function of time in different acidic functions.

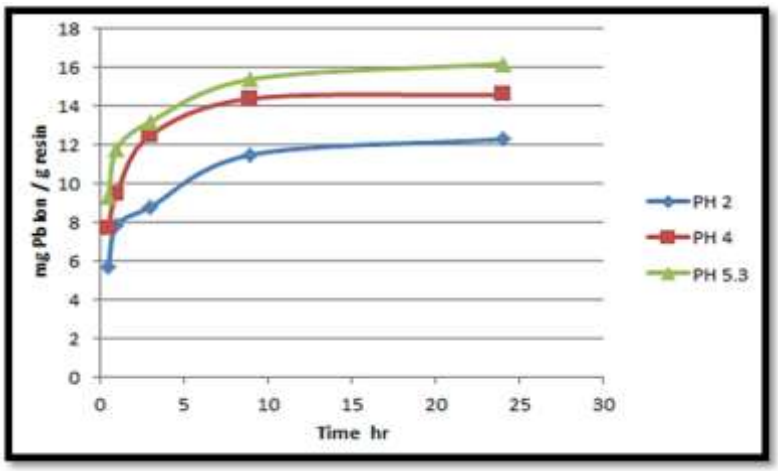


Fig. 7: Number of (Pb^{2+}) mg withdrawn by (0.1g) of resin [C.P.A.] as a function of time in different acidic functions.

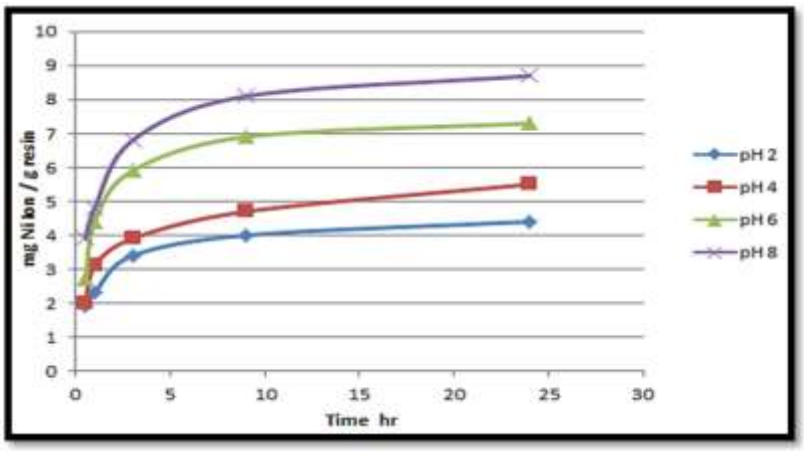


Fig 8: Number of (Ni^{+2}) mg withdrawn by (0.1g) of resin [C.P.A.] as a function of time in different acidic functions.

4.3 The Effect of Acidity Function (PH)on the Analytical Efficiency of the Polymer [C.P.A.]

The study revealed that the acidity function (PH) significantly affects the resin loading capacity for all studied ions. It was generally observed that the highest loading capacity for the resin for these ions occurs at the highest acidity function used in the study for each ion at all times, as Figures (9), (10), (11), and (12) illustrate the effect of treatment PH on the loading capacity of the polymer [C.P.A.]

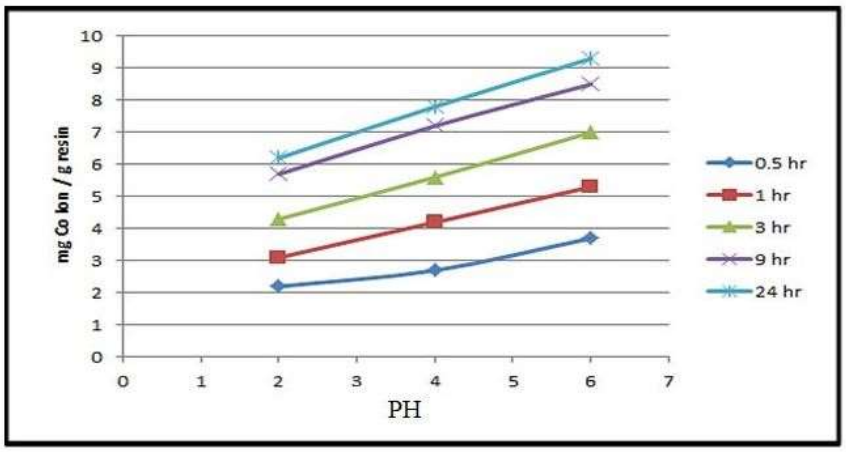


Fig 9: The effect of (PH) on the loading capacity of the polymer [C.P.A.] for (Co^{2+})mg at different treatment times.

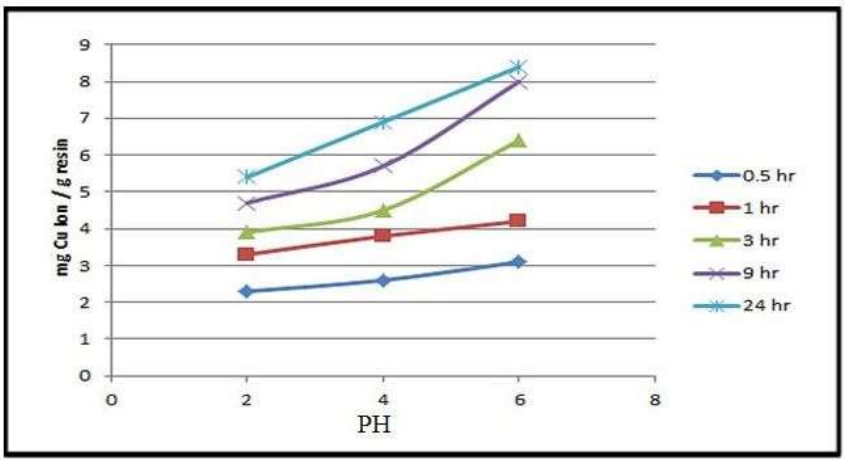


Fig. 10: The effect of (PH) on the loading capacity of the polymer [C.P.A.] for (Cu^{2+})mg at different treatment times.

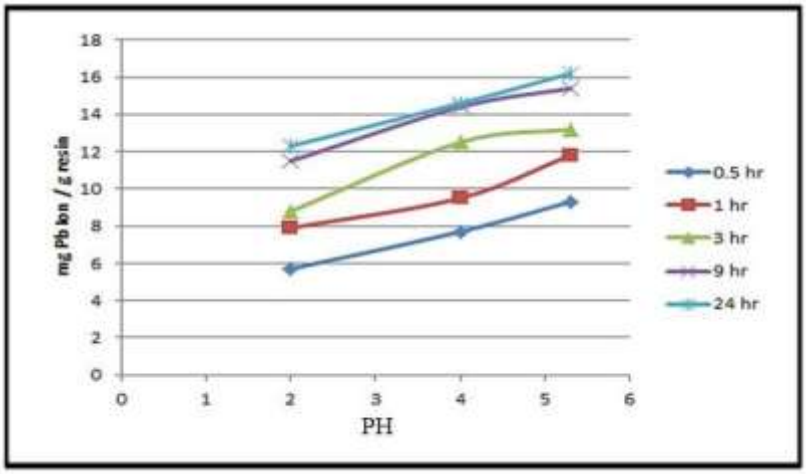


Fig. 11: The effect of (PH) on the loading capacity of the polymer [C.P.A.] for (Pb^{2+}) mg at different treatment times.

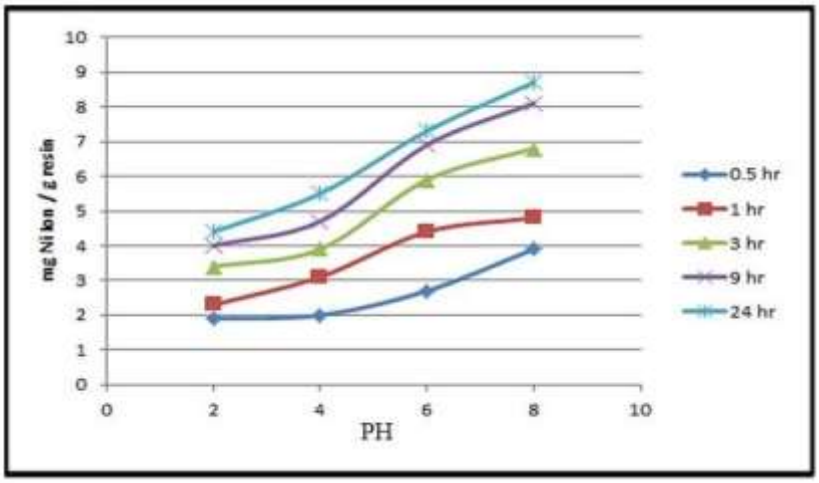


Fig 12: The effect of (PH) on the loading capacity of the polymer [C.P.A.] for (Ni^{2+}) mg at different treatment times.

4.4 Ion Recovery

The process of regenerating resin [C.P.A.] associated with ions (Ni^{+2}, Pb^{2+}, Cu^{2+}, Co^{2+}) was studied using the same method employed in the practical part. The study indicated that increasing the treatment time with nitric acid (3M HCl) increases the percentage recovery (%Recovery). This is evident in Table (5) and Figure (14).

Table (5): Percentage Recovery of Ions from the Polymer [C.P.A.] using (3M HCl) at Different Treatment Times.

Time	%Recovery			
	Pb^{2+}	Cu^{2+}	Ni^{2+}	Co^{2+}
0.5 hr	43.7	17.4	24.3	29.1
1 hr	59.2	22.5	32.5	32.8
3 hr	71.8	30.9	43.1	49.3
9 hr	79.1	41.3	59.3	63.1
24 hr	85.3	45.8	65.8	67.4

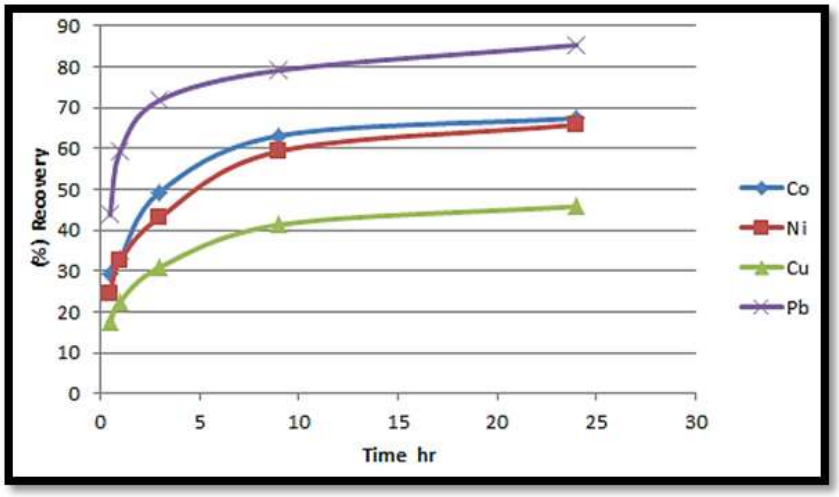


Fig 13: Percentage Recovery of Ions from the Polymer [C.P.A.] using (3M HCl) at Different Treatment Times.

CONCLUSION

The research deals with the preparation of new chelating polymers from pharmaceutical materials and studying their analytical applications in water purification from toxic ions. The results showed that pharmaceutical-based compounds show higher results under various acidity functions and different treatment times. The prepared polymers demonstrated an increase in loading capacity at shorter treatment times, which was significant but became slight to negligible upon reaching equilibrium time. This is the time when the change in loading capacity becomes minimal or negligible. The increase in loading capacity of the prepared resins with increasing acidity function (pH) of the studied ion solutions can be explained by the decrease in the concentration of positively charged hydrogen ions that compete with metal ions for binding sites within the loaded chelator. Additionally, the rise in acidity function aids the hydroxyl group (OH) in ionization to form the phenoxide ion, whereas the phenoxide ion (O-) enhances the basicity of the azomethine nitrogen group in forming metal complexes.

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