# CHELATION ION-EXCHANGE PROPERTIES OF 8-HYDROXY QUINOLINE-ACRYLAMIDE- FORMAL DEHYDE COPOLYMER RESIN

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## Abstract

**8-Hydroxyquinoline, acryl amide, and formaldehyde were condensed using an acid catalyst to make 8-HQAFcopolymer resin. Various physic chemical techniques were used to characterize the produced copolymer. Numerous characterization techniques, including element a analysis, FTIR, UV–Visible, NMR (1H and 13C), XRD, and SEM, were employed to examine the structure and properties of the copolymer resin. In order to determine the heat stability of the copolymer resin and its kinetic parameter, the TGA method was utilised. For the purpose of determining the activation energy, Freeman–Carroll (FC) and the Sharp– Wentworth (SW) procedures were utilised. It was discovered that the decomposition reaction for the copolymer was of the first order, whereas for the composite, a higher order was produced. Based onthe findings, the activation energy, frequency factor, and entropy change all point to the copolymer's impressive capacity for withstanding high temperatures. A measurement of the cation exchange capacity was performed, and the influence of pH and metal ion concentration on the capability of ion exchange was investigated. Using the batch equilibration approach, we also investigated the ratio of cation exchange and the distribution coefficient in EDTA medium at a range of different pH values.**
**Keywords: Copolymer, Morphology, Thermal degradation, Poly condensation, Resin, Activation energy, Chelation Resin, Batch Equilibration**.

## Introduction

The class of polymers known as copolymers is particularly unique and noteworthy due to the wide range of applications to which it can be put. The structure of these polymers can be crystalline, amorphous, or resinous in appearance [1-4]. In recent years, there has been a significant rise in the application of copolymers for the current generation; as a result, these molecules now hold a unique place in the study of polymer science [5]. Gupta and his colleagues have investigated the kinetics of thermal degradation for polymer 2- amino 6- nitrobenzothiazole, melamine, and formaldehyde. Michael et.al. analysed the synthesis,characterization, and thermal degradation of a terpolymer composed of 8- hydroxyquinoline, formaldehyde, and acrylamide [6-7]. Rahangdale and his colleagues conducted research on the heat degradation of a polymer that was produced from 2,4-dihydrogen acetophenone, formaldehyde, and dithioxamide [8-9]. Oxidation of the 8- hydroxyquinolate was the starting point for the synthesis of poly (8– hydroxyquinoline), also known as PHQ. In addition to this, polymeric metal is of tremendous importance in a number of other subfields of chemistry. Several distinct techniques, such as 1HNMR spectroscopic, FTIR spectroscopy, differential scanning calorimetry (DSC), thermal gravimetric (TG), and differential thermal gravimetric (DTG), have been utilized in its characterization. At a negatively charged electrode potential, The cathodic stripping voltammetric of the PHQ, which was carried out at the hanging mercury dropping electrode (HMDE), displays a weak

signal. The spectro analytical sensitivity of PHQ coordination polymers with an assortment of metal ions has been calculated. Potentiometric Studies of a Polymeric and Coordination Polymeric Form of 8-Hydroxyquinoline The spectrophotometric method was utilized in order to conduct study on the cation exchange characteristics. Studies were conducted on the immobilization of polymeric, monomeric, and polymeric chelate forms of the (8- Hydroxyquinoline) matrix when it was integrated in aluminium oxide. In addition to this, the immobilisation of polymeric, monomeric, and polymeric chelate forms of the (8- Hydroxyquinoline) matrix was converted into silica gel, and the results were examined [10- 12]. Application of Analytical Techniques, Obtaining a patent about Poly(8-Hydroxyquinoline) immobilized on some substance as risen for removal of metal ion is one of the many applications that can be used for previous studies conducted in a variety of fields.

Other applications include the preconcentration of certain metal ions and the preconcentration of other metal ions. Other applications include: In an acid media, the polycondensation process was used to create the copolymer 8-HQAF from the monomers 8-Hydroxyqunoline, acrylamide, and furfural in a molar ratio of 2:1:3. Several different physico-chemical methods were used in order to characterise the synthetic copolymer resin that was created. In this work, the thermogravimetric analysis of the copolymer resin was performed using a nonisothermal thermogravimetric analysis approach. This technique requires the sample to be subjected to a situation in which the temperature is continuously increased at a linear rate. A thermal investigation of the resins was carried out in order to ascertain the processes by which they decompose and their degrees of relative thermal stability. In order to analyse the structure of the copolymer as well as its properties, a number of different characterisation techniques, such as elemental analysis, FTIR, UV–Visible, XRD, and SEM, were utilised. In order to determine the heat stability of the copolymer resin and its kinetic parameter, the TGA method was utilised.

## Experimental

### Material

8-Hydroxyquinoline acid, acrylamide and formadehyde was possible to acquire from Central Scientific Company Nagpur. The solvents like HCl, Himedia was the source of the DMSO that was purchased. The entire assortment of chemicals is of the pure and analytical quality.

### Synthesis of 8-HQAF Copolymer Resin

p-Hydroxyquinoline-acrylamide- formadehyde ( 8-HQAF) copolymer wassynthesised by polycondnsation of 8- Hydroxyquinoline, formadehyde and acrylamide with 2M HCl in the ratio 2:1:3an oil bath at a temperature of 123 °C for about with occasio 5hrs. The copolymer obtained was black in color, rinsed with hot water until all of the chloride ions were removed from it. The process is repeated several times with hot water,it was then dried in a vacuum at a temperature above silica gel after being filtered. The dried, powdered and purified copolymer was further finely crushed. The yield of the copolymer was found to about 88%.

The production of polymers from resources that can be replenished has captured the interest of a significant number of research workers [1]. There has been a significant amount of work reported from the laboratories on the synthesis, characterisation, structure, and thermal studies of a number of different polymers [2]. In order to examine the various kinetic characteristics associated with the copolymer, both the Freeman-Carroll and the Sharp- Wentworth methods have been utilised. In particular, the procedures for TGA research [3] are predicated on the assumptions of the Arrhenius equation, which state that the barriers posed by thermal energy and diffusion are deemed to be minimal. The chemicals that were utilised were either of the chemically pure or analytical reagent grade. The synthesis of 8-HQAF was carried out by condensing 8-hydroxyquinoline, formaldehyde and Acrylamide in a mole ratio of 2:3:1 in the presence of 2M HCI as a catalyst at a temperature of 130 degrees Celsius for eight hours. This process was detailed earlier in reference 12. In order to use it in all of the many experiments that were conducted for the ion-exchange study, the purified polymer had to be extremely finely ground so that it could fit

through a sieve with a mesh size of 300. A polymer sample that weighed 25 mg was first suspended in a solution that included 25 ml of an electrolyte whose concentration was known. This step was done with the intention of evaluating metal uptake even if the electrolyte concentrations that were present in the environment varied. Either0.1 N HN03 or 0.1 N NaOH was used to bring the pH of the suspension up to the desired level so that it could be used. At a temperature of 25 degrees Celsius, the suspension was mixed for a total of twenty-four hours. Following the addition of 2 m1 of a solution with a concentration of 0.1 M of the metal ion, the pH of this suspension was brought up to the desired level. The mixture was agitated once more at 25°C for twenty-four hours before it was filtered [6-7]. After that, the polymer was rinsed and put through a filter. When the filtrate and the washings were mixed together, For the purpose of determining how many metal ions were present, a titration was performed against a reference solution of ethylene diamine tetraacetic acid. In addition to the other experiments, a blank experiment was carried out in exactly the same way as the others, but the polymer sample was omitted from it. In addition, an estimate was made for the amount of metal ions present in the blank. The difference between the reading taken with a blank strip and the reading taken during the The following equation provides a definition for the distribution ratio.

experiment was used to compute the quantity of metal ion that was absorbed by the polymer while it was in the presence of an electrolyte whose concentration was known.

The experiment was conducted multiple times in the presence of various electrolytes containing seven distinct types of metal ions, including.

In order to ascertain the amount of time required to attain the state of equilibrium under the experimental conditions that were specified, a series of experiments of the kind described above were carried out. During these experiments, the amount of metal ion uptake by the chelating resins was estimated at various time intervals at atemperature of 25 degrees Celsius (in presence of 25 m1 of lM NaN03 solution). Within twenty-four hours, the state of equilibrium was achieved under the conditions that were presented. The ratio of the number of metal ions that are taken up after a specific period of time to the amount that would be present in equilibrium (Table 3 and 4). At a temperature of 25 degrees Celsius, a metal/1M NaN03 solution was used to measure how each of the seven metal ions was distributed between and the aqueous phase and the polymer phase. The studies were conducted in the same manner as stated above, but at a variety of pH levels. The following equation provides a definition for the distribution ratio referred to as D:

$$D = \frac{Weigh(in\,mg)\,of\,metal\,ions\,taken\,up\,by\,1\,g\,of\,terpolymer}{Weigh(in\,mg)\,of\,metal\,ions\,present\,in\,1\,ml\,of\,solution}$$

**Results and discussion**
Tables I and 2 the results of the investigation on the batch equilibrium will be presented that was conducted with the terpolymer sample 8-HQAF. These findings may be found below. In order to determine the selectivity of the 8-HQAF terpolymer for the desired metal ions, a number of factors, including the manner in which electrolytes influence metal ion selectivity, the absorption rate, and the

distribution ratio between the terpolymer and the solution containing the metal ions, were all investigated. This was done so that the selectivity of the 8-HQAF terpolymer could be determined.

**Elemental analysis**:
The estimated and experimental result for carbon (74%), hydrogen (4.78%), nitrogen (4.33%), and oxygen (20.06%), which are all in good alignment with one another, was used

to determine the percentage of elements present analysis support the copolymer predicted

**Table 1** Elemental analysis and empirical formula of copolymer resin.

| Copolymer resin | % of C Observed (Cal.) | % of H Observed (Cal.) | % of O Observed (Cal.) | % of N Observed (Cal.) | Emperical formula | Emperical formula weight |
|---|---|---|---|---|---|---|
| 8- HQAF | 73.90% (74%) | 5.76 (4.78%) | 18.98% (20.06%) | 4.01% (4.33%) | $C_{36}H_{18}O_7N_2$ | 339 |

in the copolymer. The benefits of elemental structure C36H18O7N2. [14-16]

### UV-visible spectra:

While the less intense band may be caused by $\pi \rightarrow \pi^*$ the appearance of the more intense band can be explained by $n \rightarrow \pi^*$ electronic transition. The additional shift of absorption from the basic value (240 nm and 310 nm, respectively) to the longer wavelength area may be caused by conjugation action and the presence of phenolic hydroxyl group, which is responsible for the hyperchromic effect, or max higher value.
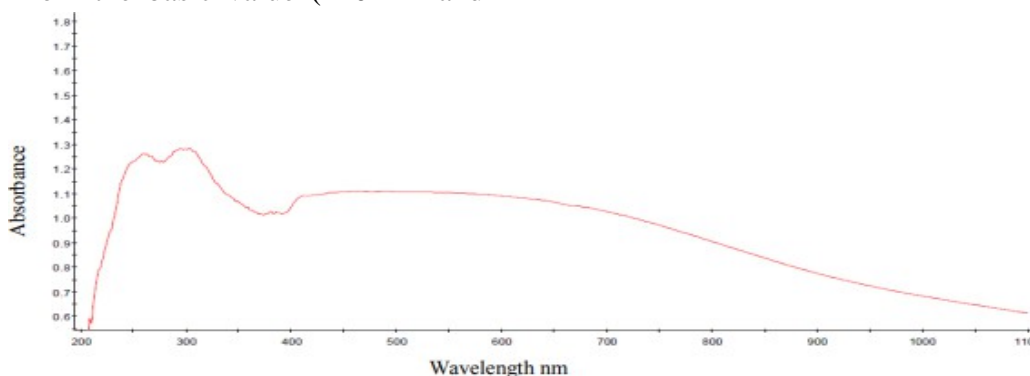


Figure 1. U V spectra of co-polymer 8-HQAF

### FT-IR spectral analysis

In fig. 2, the FTIR spectrum of 8-HQAF was used to analyse the structure of the synthesised resin. The amine group of the Ar-NH group and -OH group combined in the copolymer is responsible for the broad peak that was observed in the vicinity of 3423.12 cm-1. Aromatic ring stretching modes are responsible for a peak that appeared at 2755 cm-1. The presence of the CH2 bond in the copolymer is what caused a peak to arise in the region of 2825 cm-1. The -NH bridge from the copolymer was what created the distinct adsorption band at 3258.21. A band at 2927 suggests that the copolymer underwent CH2 stretching. [17,18]
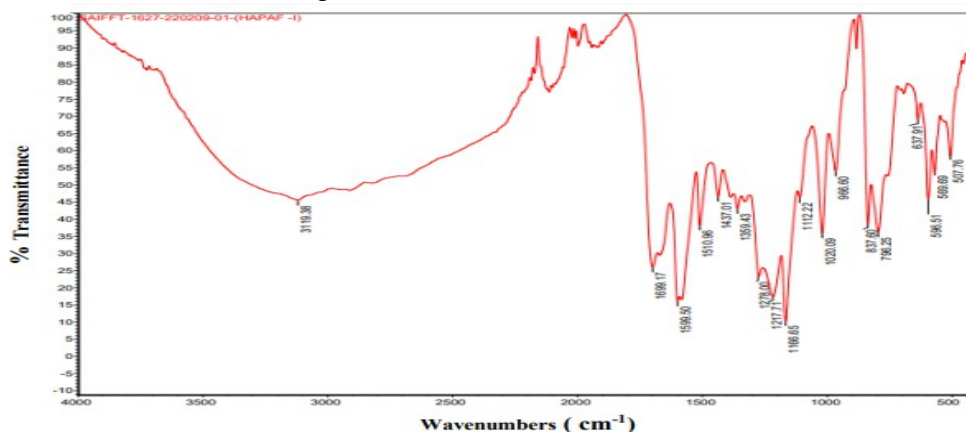


Figure 2. FTIR spectra of copolymer 8-HQAF

## ^{1}HNMR Spectroscopy:

NMRspectroscopyfor[1]HFigure3displays theprotonnuclearmagneticresonancespectrum. The methylene proton that caused the signal at2.3 ppm may have been attributed to Ar-CH2-N.

analysed using scanning electron micrographs, the results of which are shown in Figures 2 and 3,respectively. The photograph staken with an optical camera of the synthetic resin revealed that it has a brown appearance. The crystalline-amorphous structure is modelled after a fringed
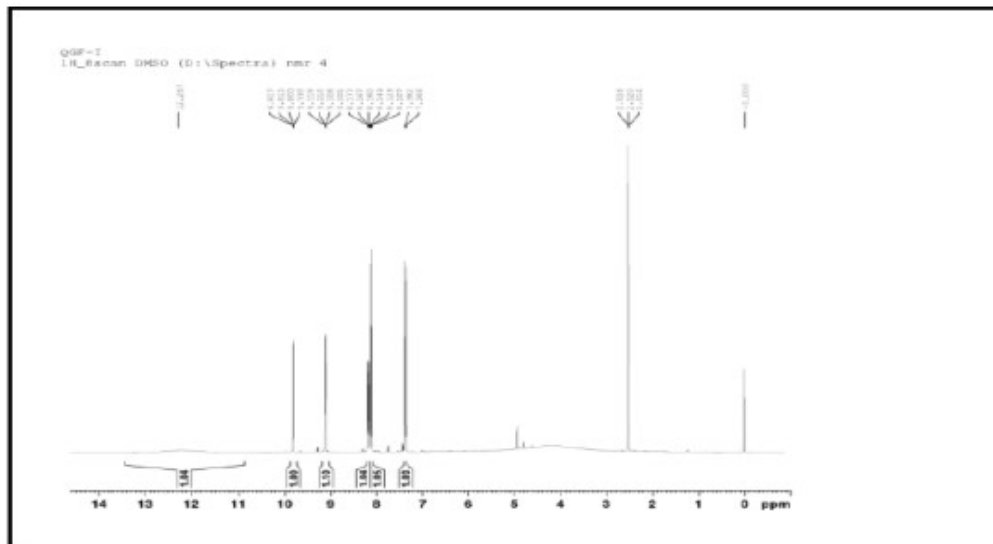


Figure 3. ^{1}H NMR spectra of copolymer 8-HQAF

Thearomatic ring proton in the local range of 6.2-7.9 (ppm) can be assigned. At 9.2($\delta$) ppm, a Phenolic hydroxyl group exhibits a strong signal. The lack of power at 6.97($\delta$) ppm may be the result of -NH bridging protons.

## SEM morphological details

SEM images taken at various magnifications were used to examine the morphology of the produced 8-HQAF copolymer and are shown in Fig. 4. The resin's morphology shows spherules and a fringed model. The spherules have a smooth,complicated polycrystalline surface. This demonstrates that the copolymer resin is naturally crystalline. A fringes model of the amorphous-crystalline structure is also displayed. The degree of crystallinity is determined by how acidic the monomer is. The copolymer exhibits additional amorphous characteristics,including a closed-packed surface with deep pits and the reactivity of active sites concealed inside the copolymer matrix. There is evidence of a small number of holes and cracks, which may be the result of air voids that are helpful for ion exchange research. [20]
The morphology of the insert resin sample was

structure that may be seen in the morphology of the resin. The fringes illustrate the transition stage between the crystalline and amorphous phases of the material. [20-24]. When compared to anthranilic acid-formaldehyde-resorcinol resin and 8-hydroxyquinoline-formaldehyde-pyrogallol resin, which were both described earlier, the resin displays a more amorphous nature with a closed packed surface that has deep pits[25]. It has been discovered that surface analysis can be helpful in better comprehending the surface characteristics of the material. The shape of the resin components crystal formation from polymer solutions corresponds to the largest organisation on a large scale in polymers, for example, in the size of spherulites that are only a few millimetres in diameter.
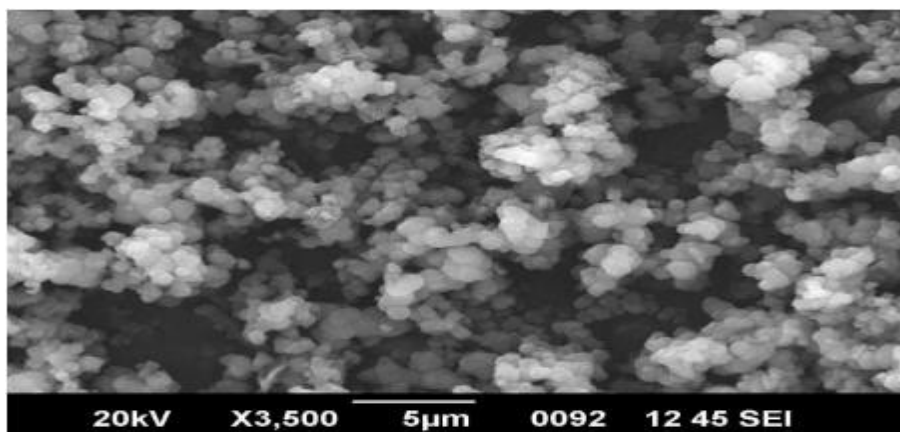
Figure 4. SEM of 8-HQAF Copolymer

### X-RAYDiffraction

The degree of crystallinity, the orientation of the crystals, and the size of the lattice are the three most important aspects of investigating the crystal structure. Herman, Karst, and Flaschner developed a quantitative method for determination of the degree of the crystallinity, which can be defined as the relative proportion of crystalline domain in the crystalline-amorphous composite structure.
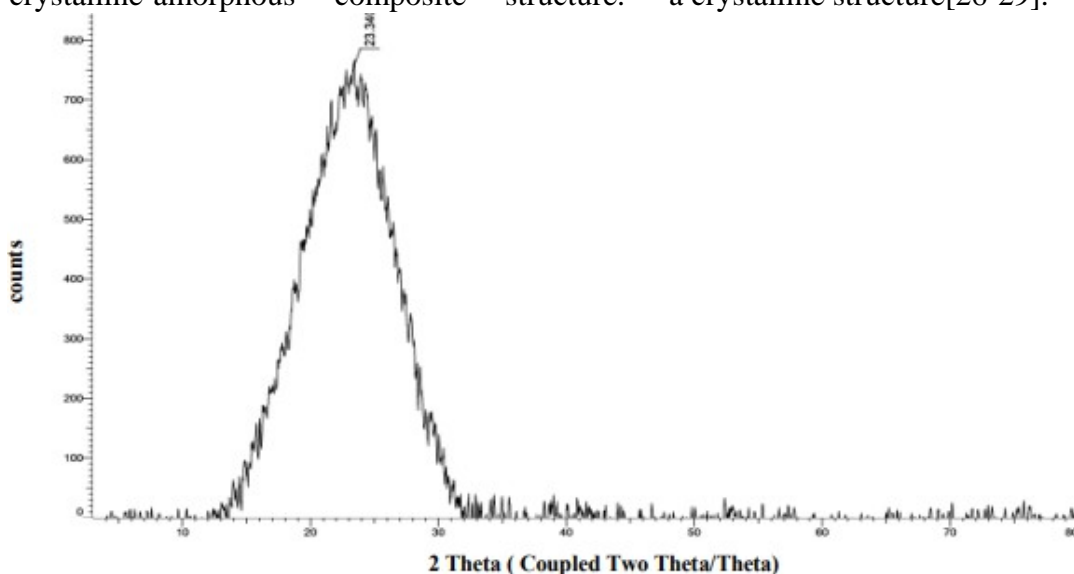
Figure 4. SEM of 8-HQAF Copolymer TheRuland and Vonk method was used in the investigation that was described above for the purpose of determining the degree of crystallinity value.Allofthesteeppeaksaroundthecoordinates2 =120,140,180,210,260,280,and300suggest thatthepolymericmaterialhasahighlycrystalinech aracter.Followingexaminationofthedata,ithas been determined that the synthetic polymer has a crystalline structure[26-29].



Figure 5. XRD spectra of 8-HOAF

### Preparation of solid coordination of Some Polymeric Materials with Some Metal Ions

The study of metal-containing polymers is crucial to the scientific community because these systems have an advantage in a wide range of chemical processes over non-polymeric- metal salts. Polymeric metal, and even greater over, are of enormous significance in a variety of areas of chemistry, such as mining separations, catalytic reactions, medicine, biochemistry, environmental chemistry, and so on. This is because polymeric metals are even greater over.

For instance, it was discovered that molecular chelates with Rh(III) were effective hydrogenation catalysts for olefins and some acid derivatives. Antibacterial activity was discovered in polymers containing

triethylenetetramine side chains and/or thio-groups that were complexed with metals. The polymers were tested on Escherichia coli and staphylococcus aurous. Instead, the interactions of metal ions with immobilised organic polymer might result in the formation of numerous different complexes on the solid surface electrodes. However, due to the fact that the connected ligands have decreased mobility, the complexes that are generated at the solid-solution interface are subject to a few restrictions.

By the use of a bidentate 8–quinolinolin in which pair of 8–hydroxyquinolines A linear aliphatic bridge connects the end groups of the molecule, Thomsen et al. have discovered a potentially useful method for increasing the capacity of 8-quinolinol compounds to bind chelating agents in preparation for the production of coordination polymers. This method involves the utilisation of an 8–quinolinol compound with two 8–hydroxyquinolines end groups. The method for determining Mw as well as the diameters of polymer coils is well stated in terms of how light scattering works. Polymer chelates are widely utilised for this purpose because they give a one-of-a-kind structural environment for complexation, and are simultaneously functionalized by a large number of ligands. The complexation of a ligand like this one is governed by a number of distinct parameters, factors such as the make-up of the polymer backbone and the characteristics of the complexing medium are taken into consideration. In accordance with the following approach, the preparation of solid coordination polymers was carried out[30-34]. The elemental analysis of the PHQ–Cu (II) matrix in conjunction with the suggested formulas that are given various stoichiometries about the amounts of water. The chemical equation of the polymer complex agrees with these findings, which are compatible with it, which states that PHQ interacts with one core metal ion at four coordination sites, and two water molecules are required for each Cu(II).

**Effect of electrolytes onmetaluptake**

According to the information that is presented in Table 3, the number of metal ions that are absorbed from a specific amount ofter polymeris determined by the kind of electrolytethatispresent in the solution as well as its concentration. The absorption of $Fe^{3+}, Cu^{2+}, Ni^{2+}$ions increases as the electrolyte concentration rises in the presence of chloride, perchlorate, and nitrateions. On the other hand, in an environment where sulphate ions are present .When there is a rise in the concentration of electrolytes, there is a corresponding drop in the amount of the ions discussed before that are absorbed by the terpolymers. In addition to this, the uptake of ions such as $Co^{2+}, Zn^{2+}, Cd^{2+}, Pb^{2+}$ rises when the concentration of ions such as chloride, nitrate, perchlorate, and sulphate falls[35-40] .Thisissomethingthatmaybedescribedusingthestabilityconstantsofthevariouscomplexeswhich $Fe^{3+}, Cu^{2+}, Ni^{2+}, Co^{2+}, Zn^{2+}, Cd^{2+}, Pb^{2+}$ionsformwiththeseanions[41].$SO4^{2+}$isexpectedto form strong complexes with $Fe^{3+}, Ni^{2+}$and $Cu^{2+}$ions, while $ClO_4$, $NO_3$ and are anticipated to form weak complexes and, consequently, cannot affect the position of the $Fe^{3+}, Cu^{2+}, Ni^{2+}$,chelates equilibrium as much as.$SO_4, ClO_4, NO_3$ and CT might formrathe r strong cheats with $Co^{2+}, n^{2+}, Cd^{2+}, Pb^{2+}$ and, therefore, might be expected to influence the position of the $Co^{2+}, n^{2+}, Cd^{2+}, Pb^{2+}$chelates equilibrium. This type of trend has also been observed by other investigators in this field

Table:2 Evaluation of effect of different electrolyte on uptake of several metal ions
Weight in meq x 10 of the metal ion uptake in the presence of

| Metal ions | Electrolyte(mol/l) | pH | NaCl04 | NaCL | NaNo3 | Na2SO4 |
|---|---|---|---|---|---|---|
| | 0.01 | | 1.38 | 0.68 | 1.74 | 2.52 |
| | 0.05 | | 2.30 | 1.06 | 2.16 | 1.60 |
| $Fe^{3+}$ | 0.10 | 2.75 | 2.56 | 1.90 | 2.54 | 1.50 |
| | 0.50 | | 2.88 | 2.36 | 2.71 | 1.06 |
| | 1.00 | | 3.01 | 3.10 | 3.22 | 0.62 |
| | 0.01 | | 2.28 | 2.56 | 2.76 | 3.53 |
| | 0.05 | | 2.27 | 2.51 | 3.54 | 2.82 |
| $Cu^{2+}$ | 0.10 | 4.5 | 3.12 | 3.01 | 3.59 | 2.02 |
| | 0.50 | | 3.62 | 3.58 | 3.75 | 1.01 |
| | 1.00 | | 4.88 | 3.92 | 4.07 | 0.31 |
| | 0.01 | | 1.34 | 0.94 | 0.76 | 3.21 |
| | 0.05 | | 1.45 | 3.21 | 0.76 | 1.82 |
| $Ni^{2+}$ | 0.10 | 4.5 | 1.61 | 1.51 | 1.68 | 1.68 |
| | 0.50 | | 1.68 | 1.76 | 1.87 | 1.55 |
| | 1.00 | | 2.11 | 3.03 | 2.56 | 0.80 |
| | 0.01 | | 2.32 | 2.52 | 2.12 | 2.36 |
| | 0.05 | | 2.05 | 1.85 | 1.73 | 1.93 |
| $Co^{2+}$ | 0.10 | 5.0 | 1.60 | 1.66 | 1.62 | 1.44 |
| | 0.50 | | 0.94 | 0.87 | 1.58 | 1.19 |
| | 1.00 | | 0.42 | 0.62 | 0.76 | 0.82 |
| | 0.01 | | 2.39 | 2.89 | 2.32 | 1.57 |
| | 0.05 | | 2.01 | 1.64 | 1.92 | 1.28 |
| $Zn^{2+}$ | 0.10 | 5.0 | 1.52 | 0.89 | 0.86 | 1.09 |
| | 0.50 | | 0.76 | 0.54 | 0.48 | 0.63 |
| | 1.00 | | 0.62 | 0.34 | 0.33 | 0.26 |
| | 0.01 | | 2.12 | 1.88 | 2.71 | 1.96 |
| | 0.05 | | 1.81 | 1.41 | 2.06 | 1.49 |
| $Cd^{2+}$ | 0.10 | 5.0 | 1.35 | 1.17 | 1.14 | 1.19 |
| | 0.50 | | 0.82 | 0.93 | 0.75 | 0.59 |
| | 1.00 | | 0.69 | 0.44 | 0.50 | 0.37 |
| | 0.01 | | 1.38 | 1.65 | 1.70 | 2.71 |
| | 0.05 | | 0.81 | 1.52 | 1.56 | 1.54 |
| $Pb^{2+}$ | 0.10 | 6.0 | 0.69 | 1.46 | 1.11 | 1.38 |
| | 0.50 | | 0.58 | 0.86 | 0.75 | 1.24 |
| | 1.00 | | 0.36 | 0.72 | 0.28 | 0.81 |

$M^{n+}(NO3)n{=}0.1^{m}$;
$volume\ of\ electrolyte\ solution: 25ml$;
$volume\ of\ metal\ ion\ solution{=}2ml$;
$weight of\ resin{=}25mg$
$time{=}24h$; $room temperature$

### Rate of metal up take

It has been demonstrated that the type of metal has an influence on the rate of metall ion uptake, which is broken down in Table 4.The rate is defined as the rateat which Whnanaqueous solutionis brought into contact with a certain polymer, the concentration of metal ions in the solution shifts. According to the findings, the amount of time necessary for the uptake of various metal ions at a specific stage is contingent on the nature of the metal ion as well as the conditions that are now in place. It has been discovered that $Fe^{3+}$ ions require approximately 4 hours for the establishment of equilibrium, whereas $Cu^{2+}$, $Ni^{2+}$ ions require approximately 6 hours for $Co^{2+}$, $Zn^{2+}$, $Cd^{2+}$, $Pb^{2+}$ ions require almost 7 hours for equilibrium. Thus, the rate of metal ion uptake conforms to the sequence Fe3 + > Cu2 +,Ne+> Co2 +,Zn2 +,Cd2 +,Pb2 +. This type of tendency was previously noted by other earlier researchers.

Table:3 Comparison of rate of metal ion up take
Percentage of metalionuptakeat time

| Metal Ion | pH | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| $Fe^{3+}$ | 2.75 | 54 | 77 | 89 | 96 | 99 | - | - | - |
| $Cu^{2+}$ | 4.5 | 40 | 53 | 66 | 73 | 80 | 89 | 100 | - |
| $Ni^{2+}$ | 4.5 | 42 | 48 | 54 | 63 | 73 | 87 | 99 | - |
| $Co^{2+}$ | 5.0 | 25 | 36 | 50 | 57 | 70 | 79 | 89 | 100 |
| $Zn^{2+}$ | 5.0 | 28 | 41 | 50 | 60 | 66 | 79 | 90 | 99 |
| $Cd^{2+}$ | 5.0 | 21 | 32 | 48 | 64 | 76 | 88 | 91 | 97 |
| $Cd^{2+}$ | 6.0 | 11 | 21 | 24 | 28 | 37 | 67 | 87 | 98 |

$M^{n+}(NO3)n = 0.1\frac{mol}{l}$; Volume:2ml; NaNo3 = $1\frac{mol}{l}$; volume = 25ml; roomtemperature

Metal ion uptake = Amount of metal ion absorbed x 100 / Amount of mrtal ion absorbed at equilibrium
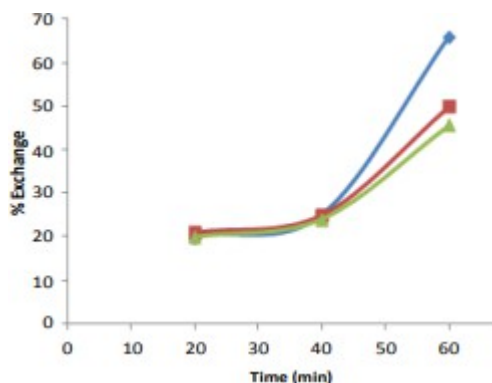


Figure 6.Rate of metal io0n uptake at different time

### Distribution ratio so fmetalions at different pH

The influence that pH hason the quantity of metalionsinits whole that are splitup between the two phases was investigated. According to the findings, The proportional quantity of metal ions that are taken up by the terpolymers will increase as the pH of the media is increased. In order to prevent the hydrolysis of the m etalions at higher pH values, the investigation was carried output oa particular pH value for each individual metal ion. The findings also suggest that the terpolymer takes up the $Fe^{3+}$ ion in a more selective manner than it does any of the other metal ions that were investigated. There is a possibility that steric hindrance 19 is to blame for the reduced distribution ratio of $Fe^{3+}$19. $Ni^{2+}$ and $Cu^{2+}$ ions are among those that are taken up by the terpolymerinamore selective manner compared to theo the rmetal ions. Over the pH rangeof4-6, the distribution ratio D for the other four metal ions, namely

$Co^{2+}, Zn^{2+}, Cd^{2+}, Pb^{2+}$ is rather low. This may be due to the fact that the metal complexes have low stability constants, which hints that the

This could be explained by themetal complexes' low ligand stabilization energy or low stability constants of the complexes themselves as a
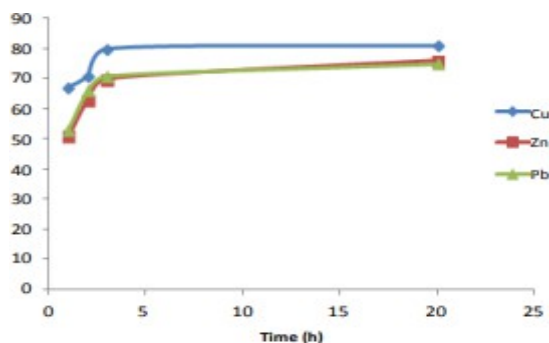


ligand stabilisation energy of these complexesison the lower end of the spectrum.

whole. [42-45].

Figure 7. Distribution ratio of metal ions at different pH

Therefore, The following was found to be the order of selectivity of the terpolymer towards metal ions:

$Fe^{3+} > Cu^{2+} > Ni^{2+} > Co^{2+} > Zn^{2+} > Cd^{2+} > Pb^{2+}$. As a result, the findings of this kind of investigation

are useful in determining the pH that is optimal for the selective uptake of a particular metalionfromamixturecontainingavarietyofdifferentmetalions.[46-49]



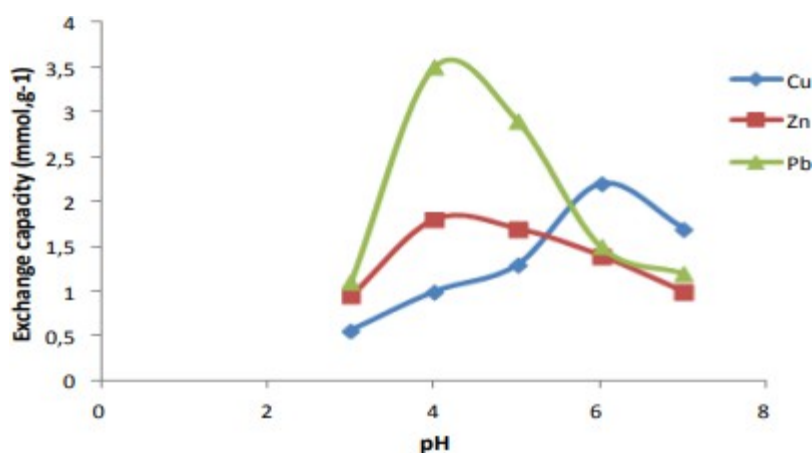Figure 8.EffectofpHoncationexchangecapacity

**Reference**
[1] ElshazlyR, KamalR, NassarA, AhmedN andS yedG2020 Appl.Petro.Res.10 115
[2] SasikalaT, Greeshma K, Gnana P, Muthulingam S and Nandhakumar C 2020GSC Advanced Research and Reviews 05 19
[3] GurnuleW. B. ,RathodY and BelsareA 2020 Materils Today Proceedings.
[4] Joshi RM & PatelMM, Proc IndianA cadSci ChernSci,91(1982)351.
[5] Manavalan R & PatelMM, Makromol Chern,184(1983)717
[5] Gregor HP,TaiferM,CitarelL&BeckerEI, lndEng Chern,44(1952)2834
[6] Patel8S & Patel SR, Makromol

Chern,180(1979)1159.
[7] Patel MN & PatelJ8, JIndianchemSoc,58 (1981)491.
[8] Patel HS, Patel SD & PatelSR, Makromol Chern,I06 (1982)23.
[9] Pancholi HB & PatelMM, HighPerformancePolymers,3(1991) 257.
[10] CottanFA & WilkinsonG, Advancedin organic chemistry, 3rdEdn, (Wiley, NewYork)1972
[11] DavydovaSL & PlateNA, CoordchemRev,16( 1975)195.
[12] HelfferichF,Jon-exchange, (Mc GrawHill, NewYork)1962.
[13] KuninR,Ion-exchangeresins, 3'dEdn, (Wiley,NewYork)1958

[14] GurnuleW,DasN2019MaterilasTodayProceedings15611

[15] GurnuleW,RathodY2020CurrentAppl.Polym.Sci.41

[16] Azarudeen R and Burkanudeen A 2012J.Inorg.Met.Polym.22791

[17] Kohad Cand Gurnule W. B. 2019MaterialsTodayProceedings15438

[18] KukadeS,NaikRandBawankarS2014Orbital :ElectronJ.Chem.6 240

[19] TadaviS,RajputJ, BagulS, SangshettiJ, Hosamani A and BendreS 2017 Mod.Chem.Appl.51

[20] Thakre MB. And Gurnule W. B. 2019 Materials Today Proceedings 15516

[21] Y. U. Rathod, V. Pandit, D. Bhagat, W. B Gurnule,. Mat. Tod. Proc, 2022; 53: 123-129.

[22] W.B. Gurnule, N. C Das, K. V Vajpai, Y.U. . Mat. Tod. Proc 2020; 29: 1071-1076.

[23] W. B. Gurnule, Y. U. Rathod, A. D. Belsare, N. C Das,. .Mat. Tod. Proc, 2020; 15:611.

[24] S. P. Chakole, Y. U. Rathod, V. U. Pandit, W. B Gurnule,. Mat. Tod. Proc, 2022; 52: 96.

[25] P. G. Gupta, R. H. Gupta, W. B. Gurnule, S. N. Rao, Y. U. Rathod,.Indian. J. Engr. Mat. Sci, 2023; 30: 838-844.

[26] W. B. Gurnule, P. K. Gupta, R. H. Gupta, Y. U. Rathod, N. B. Singh,.Int. Conf. Ener. Tech, 2023; 1281: 012026.

[27] S. S. Rahangdale, W. B. Gurnule, Mat. Tod. Proc, 2020; 43:163-174.

[28] Y. U. Rathod, S. B. Zanje, W. B. Gurnule, J. Phy ConfSer, 2021; 1913: 012061.

[29] W. B. Gurnule, R. R. Dubey, D. S. Bhagat, Y. U. Rathod, B. P. Kafle,. J. Mod Nanotechnol, 2022; 2: 10.

[30] J. V. Khobragade, M. Ahamed, W. B. Gurnule, J. Chem. Pharm. Res, 2014; 6:364.

[31] M. B. Thakre, W. B. Gurnule,.Mat. Tod. Proc. 2019; 3: 516–525.

[32] W. B. Gurnule, N.C. Das, Mat. Tod. Proc. 2019; 15: 611–619.

[33] W. B. Gurnule, Y. U. Rathod, and A. D. Belsare, Mat. Tod. Proc, 2020; 29: 1044-1049.

[34] S. S. Rahangdale, N. C. Das, K. Vajpai, W.B. Gurnule, Int. J. Recent Sci. Res 2019; 10: 31772–31778.

[35] C. Kohad, W. B. Gurnule, Mat. Today Proc 2019; 15: 438–446.

[36] N. C. Das, W. B. Gurnule,. Int. J. Curr. Eng. Sci. Res 2019; 6: 1414–1425.

[37] W. B. Gurnule, R. U. Rathod, A. D. Belsare, N. C. Das, Mat. Tod. Proc, 2020; 29:1044.

[38] S. S. Rahangdale, W.B Gurnule,. J. Appl. Polym. Sci, 2018; 43: 108-120.

[39] N. C. Das, Y.U. Rathod , V. Pandit, W.B. Gurnule,. Mat. Tod. Proc 2020; 53: 80-85.

[40] R. Mohurle, Y.U Rathod, A. Ghatole, W.B Gurnule,. Int. J. of Adv. Res. Sci. Comm. and Tech. 2021; 12.

[41] M. M. Rangari, S. S. Rahangdale, S. Shrivastva, Y. U Rathod,. Indian. J. Engr. Mat. Sci, 2023; 30: 816-822.

[42] P. Gupta, R. H. Gupta, W. B. Gurnule,. Appl. Polym. Sci 2020; 8: 156-162.

[43] R. H. Gupta, P. Gupta, W. B. Gurnule, Int. J. Chem. Conf. 2019; 6: 101-107.

[44] S. P. Chakole, K. Nandekar, W. B. Gurnule, J. Phys. Conf. Ser 2021; 1913: 1–8.

[45] W. B. Gurnule, S. P Chakole, N.C Das, Copolymer resin. VII..Mat. Tod. Proc, 2020; 63: 1125-1136.

[46] Y. U. Rathod, W. B. Gurnule.. Mat. Tod. Proc 2020; 6: 163-170.

[47] W. B. Gurnule, C.G Kohand,.Res. J. Pharm. Bio. Chem. Sci, 2018; 9: 393-402.