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SYNTHESIS AND CHARACTERISATIONS OF NATURAL POLYSACCHRIDE BASED CELLULOSE ANTHRANILIC ACID (CAA) RESIN FOR REMOVAL TO TOXIC METAL IONS AS Cu (II) AND Zn (II) FROM CONTAMINATED WATER OR FROM STEEL INDUSTRIAL EFFLUENTS

Chemistry

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ABSTRACT

The cellulose-based resin containing anthranilic acid resin (CAA) has been synthesized and their adsorption behavior for heavy metal ions as Zn (II) and Cu (II) has been investigated using batch and column experiments. The anthranilic acid group has been incorporated into cellulose by a modified Porath's method of functionalization of polysaccharides. The cellulose anthranilic acid resin (CAA) can selectively remove of heavy metal ions, which are contained in industrial wastewater. The CAA resin was characterized by FTIR and thermogravimetric analysis. The effects of various adsorption conditions, such as pH, treatment time, ion exchange capacity and adsorbent dose were also investigated. The optimum adsorption condition was found at pH 7, 120 minutes of equilibrium time and 0.1 gram of resin dose. The orders of distribution coefficient values were determined.

KEYWORDS

Cellulose Anthranilic Acid Resin, Distribution Coefficient, Heavy Metal Ions And Industrial Wastewater.

INTRODUCTION

Water pollution is a one of the most critical issue not only in India but all over the world. Whole world affected by this hazardous problem. Water pollution in environment can originate from natural source and human sources. Natural sources like Volcanoes, earth quake, heavy rain fall, flood, and geological weathering etc, but the ratio of pollution originate by natural sources is very low compared with man- made sources.

Mining, textiles and industries effluents are mainly the man-made sources, which originates heavy metal pollution in environment. This type of toxic effluent resulted from different kind of industries like metal processing, tannery, electroplating, textile, paper, pulp, paint etc. This type of toxic industrial effluent contaminated with a large number of heavy toxic metal ions as Cr (II), Hg (II), Ag(I), U(II), As (III), Sn (II), Fe (III), Ni (III), Pb (II) and radio-active metal ions which are very difficult to detoxify in environment. The quality of surrounding freshwater and marine life cycle varies directly with healthy growth, propagation and harvests of living organism.

With progressing of economical activities and increasing population, results are that day by day quantity of sewage and effluents are also increasing. It's contaminated with heavy metals ions which are non-biodegradable and having tendency to accumulated in livings organism.

The presence of heavy metals in aqueous water streams and livings organism has creates a difficulty due to their hazardous effect on living being' shealth and on the flora and fauna of receiving water bodies. Electroplating band, metal working industries discharge a large amount of heavy metal ions including Cu (II), Ni (II), Zn (II), ions in their effluents have been organized as a major problem to human health and aquatic life.

Thus, it's very essential to separate out of these heavy metal's ions from aqueous medium or effluents at trace level. For this purpose, there are various methods has been found for removal of toxic metal ions from contaminated solution like, reduce the concentration of heavy toxic metal ions in contaminated wear, precipitation method, flotation, solvent extraction, adsorption, reverse osmosis, electrochemical reduction methods, and ion- exchange method.

Adsorption on activated carbon is a well-known method for removing toxic metal ion, but the high cost of activated carbon restricts its use in developing countries, so cheap and effective alternatives for the removal of heavy metals should reduce operating costs, reduce the prices of products, improve competitiveness and benefit the environment.

That is the reason to develop a applicable and relevant method which can not only use for separation of heavy metal but also recover of valuable metal from effluents. Thus, adsorption of heavy toxic metal ions on ion exchange resin from contaminated water is becoming one of the efficient methods [1] for removal of toxic metals from industrial effluents.

Ion exchange method using batch method and fixed bed column [2] and natural modified polymer become an emerging and trending method for removal of toxic metal ions at very trace level. Ion exchange materials become suitable tools for this purpose because of their high selectivity, higher chemical stability and capacity to resist at high temperature.

Ion exchange removes unwanted ions from contaminated solution by transferring them to a solid material which is known as ion-exchanger which accepts them and provide back an equal number of desirable species stored on the ion exchange solid material.

MY OBJECTIVES

In recent year, many techniques have been studied for the development of cheaper and more efficient natural biopolymers. biopolymer represent an interesting and smart alternative as absorbent because of their particular construction, physio-chemical features, chemical permanence, great reactivity and outstanding choosiness to metals**.**

My research work depends on preparation of natural biopolymer-based ion exchange resin, in which chelating functional group have been incorporated.

This type of insoluble functionalized resin provides flexible, wide working range, high stability and good capacity toward metal ions.

I was interested to work on this type of resin because of it had higher selectivity, less swelling nature, rapid adoption ability of heavy metal ions. That natural polysaccharide base ion exchange resin, had excessive potency to eliminate cations weighty metal species from industrialized wastewater [3-5]. Ion exchange capacity of any resin depends upon the functional group which incorporate in resin, pH of the solution and contact time the most functional groups which are used in resin for the removal of metal [6-8] ion from the effluents.

The object of the present work is to develop such chemicals preferably using the raw material which are locally [9] available.

My present work described the synthesis and characterization of cellulose anthranilic acid (CAA) resin with removal of heavy metal ions from industrial effluents in ppm or at trace level.

APPARATUS WERE USED DURING WORK:

1.Magnetic Stirrer

Magnetic stirrer manufactured by Metrex Scientific Pvt. Ltd. was used.

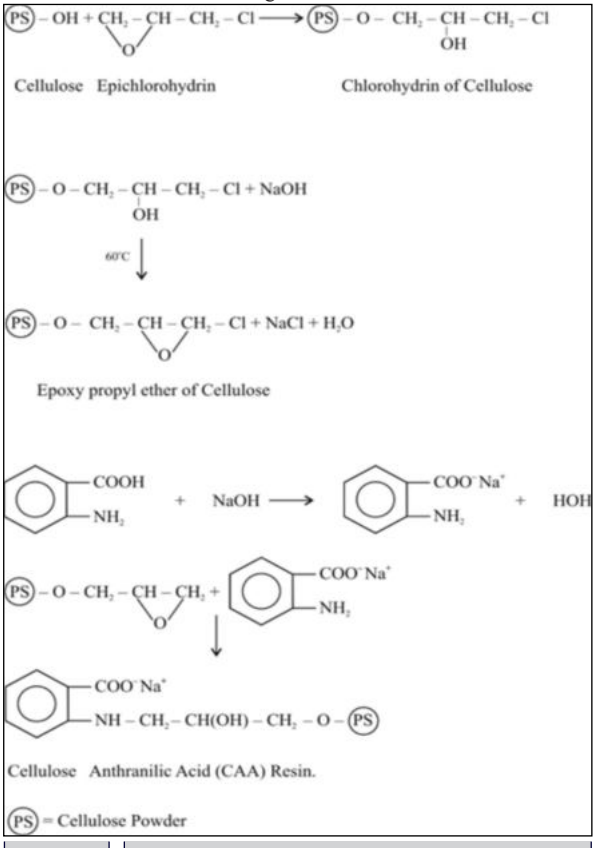
2.FTIR (Fourier Transform Infrared Spectroscopy)
The structure of newly synthesized resins was characterized by Perkin Elmer model 5000 FTIR spectrometer. The solid samples were tested with KBr pellet method. Infrared spectroscopy exploits the fact that molecules absorb specific frequencies that are characteristic of their structure.[10]

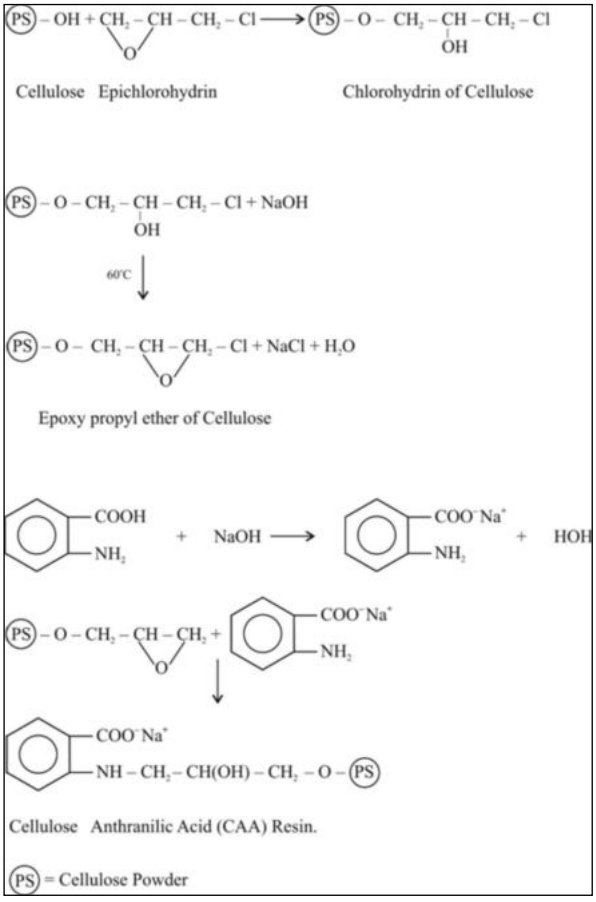
3. AAS (Atomic Absorption Spectrophotometer)
The concentrations of studied metal ions were measured by Perkin Elmer 2380 atomic absorption spectrophotometer (AAS). Atomic absorption spectrophotometer was used in the quantitative determination of metals ion concentration in traces **.The technique is based on the fact that that ground state metals absorb light at specific wavelengths which quantitatively measures the concentrations of elements present in a sample.**

4. pH meter
Digital pH meter model no. 5651, (Electronics corporation of India, ECI) was used in the determination of pH values. The pH measurement of metal ions and buffer solution were carried out by this**.[11]**

METHODOLOGY
Synthesis of cellulose Anthranilic Acid (CAA) Resin
The Synthesis of cellulose Anthranilic Acid resin accomplished in the following steps.
1. Preparation Epoxy Propyl Ether of cellulose 32.4 g. of cellulose powder (0.2 mol) was taken in round bottom flask and it was slurred with dioxane. 15 ml of 40% (w/v) sodium hydroxide was added to it to make it alkaline, till pH reached to 8.5 and the solution is stirred at 60°C. 9.25 g. epichlorohydrin (0.2 mole) was added with constant stirring. the stirring was further continued for 5 hours at 60°C. The product epoxy propyl ether of cellulose powder was filtered under vacuum and washed with methanol to remove impurities and dried.

2. Preparation of cellulose Anthranilic Acid (CAA) Resin: - Epoxy propyl ether of cellulose was then allowed to react with 13.71g (0. 1 mole) of Anthranilic acid and the stirring was continued for another 4 hours at 60°C. The product so formed was filtered under vacuum and washed with methanol, containing few drops of HC1 to remove inorganic impurities and to neutralize excess of NaOH and finally washed with methanol and dried. The yield of cellulose anthranilic acid resin is 42.2 gm and degree of substitution (DS) is 0.45. The reaction scheme is shown in "Figure 1





FTIR Characterization
Agilent Technology Cary 630 FTIR instrument was employed for all the FTIR Spectral analysis of the synthesized resin.

FTIR Characterization Of Cellulose Anthranilic Acid (CAA)
Resin FTIR spectral analysis of resin was done in H+ form. The characteristic bonds observed in the spectra of CAA results from C–H stretching at 2927.7 cm–1, – C–H stretching at 2858.3 cm–1, N–H bending at 1508.2 cm–1, >C=0 stretches of carboxylic acid at 1720.4 cm–1, and –OH hydrogen bonded broad stretches at 3444.6 cm–1 and N–H stretches peak at 3442 cm-1. The FTIR spectra is shown in Fig. 2

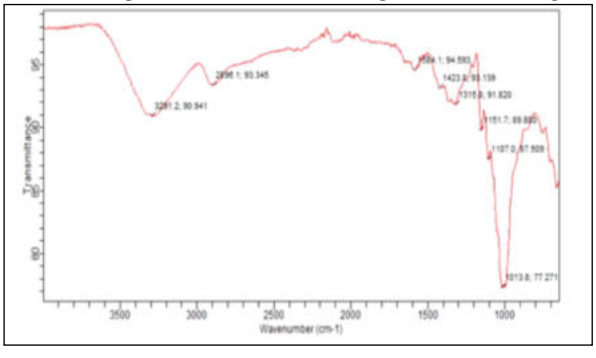


Fig no.2

MOISTURE CONTENTS
A physical property of the ion exchange resin with changes in cross linkage is the moisture contents of the resin.

1 g of the resin in hydrogen form was taken and dried to a constant weight .Cellulose Anthranilic Acid (CAA) Resin vacuum desiccator at 75 0C for 24 hours and the resin was weighted.

The weight of dried resin: 0.92 g

Weight of the moisture: 0.08 gm

Moisture percentage: 8%

ION Exchange Capacity Determination

The total capacity of an ion exchange resin is define as the total number of chemical equivalents available for exchange per some unit weight or unit volume of resin. The capacity may be expressed in terms of milli equivalents per dry gram of resin or in terms of milli equivalents per milliliter of wet resin. Although few functional groups are introduced into a highly cross–linked resin. Thus the capacity on a wet volume basis increases as cross linking increases. Resin capacity is usually expressed in terms of equivalents per liter (eq/L) of resin. An equivalent is the molecular weight in grams of the compound divided by its electrical charge, or valency. [12].

For example a resin with an exchange capacity of 1 eq/L could remove 35.7 g divalent zinc (Zn2+, molecular weight of 65) from solution. The determining of total ion exchange capacity of the synthesized resin by following method Back titration procedure was followed for the determination of capacity of resin. One gram resin was taken in an Erlenmeyer flask and 200 ml of standardized NaOH (0.05N) containing 5 ml of 5% NaCI solution was added and was allowed to stand overnight. 25 ml aliquot of supernatant solution was back titrated with standard solution of 0.05 N HCI using phenolphthalein as indicator. Finally total ion exchange capacity [Q(Meq/g)] was calculated using the formula:

$$Q\ (Meq/g) = \frac{(0.05N \times V_1) - 8(0.05N \times V_2)}{M}$$

V1 = Volume of 0.05 N NaOH solution
V2 = Volume of 0.05 N HC1 consumed
M = Weight of dry resin in grams
Q (Meq/g) = (0.05 x 200) – 8 (0.05 N x 13.5) / 0.85
= 10 – 8 (0.675) / 0.85
= 5.41

Bulk Density Of The Dry CAA Resin
Procedure:

10 g of the resin dried to a constant weight and it was poured to a 100 cm3 measuring cylinder. The cylinder was poured gently on a hard rubber filter until the volume of the resin does not change. The volume of the stationary layer was read. The results are as under:
Resin Bulk Density (g/cm3) of CAA 1.39

DETERMINATION OF NITROGEN CONTENT

Kjeld's method was used for determination of nitrogen in the synthesized resin. In Kjeldahl flask 0.25 g of vacuum dried resin was taken and 10 cm3 of conc. H2SO4 (18 N) and 0.5 g catalyst (5 g of metallic selenium 120 g of CuSO4 and 150 g of potassium sulphate grounded finally to a homogenous mixture) was added.

The mixture was heated to boiling till the solution gets clear and hearting continued for other 2 hours. The solution was then chilled and quantitatively transferred with 30 cm 3 of water, to a distillation apparatus for ammonia determination. 12 cm3 of 10 M NaOH was then added and the total volume in the flask was made to 75 cm3. Ammonia liberated was steam distilled for 5 min. into the receiver containing 5 cm 3 of 4% boric acid and 5–6 drops of the indicator (75 g of bromo creosol green and 50 g methyl red are dissolved in 100 cm3 of ethanol). The distilled ammonia was titrated with 0.05 M HC1. 1 ml of 0.05 M HC1 = 0.7003 mg of nitrogen. 3.5.1.

Nitrogen content in CAA Amount of resin = 0.25 g

Volume of 0.05 N HCI consumed = 6.55 ml

mg of nitrogen in the resin = 6.55 x 0.7003

4.58mg nitrogen/0.25g of resin % of nitrogen = 1.83

pH TITRATION OF CAA BY (BATCH METHOD)

The cellulose derivative was firstly converted to hydrogen ion form. The resins were then washed with water to remove excess acid and dried at 500 C overnight. 0.1 g portion of the resins were taken in 8–9 different flasks successively decreasing amount of 1 n NaCl solution was added to each flask and increasing amount of 0.1 N NaOH was added in successive flasks. Deionized water was then added to each flask as required to keep the ratio of solution volume to resin weight constant (25 ml solution per 0.1 g of resin).

The tightly closed flask was equilibrated by magnetic stirrer until the pH of the solution attained constant value. The observed pH values are given in the tables no.1.

Table No.1

Flask No.	Volume of 0.1N NaOH (ml)	Volume of 1M NaCl (ml)	deionized water (ml)	Final pH
1	0.0	1.4	23.6	6.3
2	0.3	1.2	23.5	7.5
3	0.6	0.1	23.4	8.7
4	0.9	0.8	23.3	9.4
5	1.2	0.6	23.2	10.1
6	1.5	0.4	23.1	11.3
7	1.8	0.2	23.0	11.9
8	2.1	0.0	22.9	12.3

DETERMINATION OF DISTRIBUTION COEFFICIENT BY BATCH METHOD

The molar distribution coefficient 'Kd' of metals showing pronounced adsorption on chelating resins is Cu (II) and Zn (II), were determined by batch method. The weighed number of different resins were used. Cellulose anthranilic Acid (CAA). The concentration of metal ion in filtrates were determined using corresponding calibration curve.
Finally the distribution coefficient were calculated using the formula,

$$K_d = \frac{\text{Amount of metal ion in resin phase / gm of dry resin}}{\text{Amount of metal ion in solution / ml of solution}}$$

To get the buffers of 3-7 pH, appropriate amounts of 0.2 M acetic acid and 0.2 M sodium acetate were added in different flasks.

Table No.2

Flask No.	Volume of 0.2 M Sodium Acetate	Volume of 0.2 M Acetic Acid	Final pH
1	1	39	2
2	2	38.8#	3
3	8	32	4
4	28	12	5
5	39	1.0	6
6	0.1**	39.9*	7

In the above table no.2
0.5 M Acetic Acid
** 1 M Sodium Acetate
* De-mineralized water

Likewise to get the buffers of pH 8.0, an appropriate amount of 0.2M NH_4OH and 0.2 M NH_4Cl were added in flask as below table no 3

Table No.3

Flask No.	Volume of 0.2 M NH_4OH	Volume of 0.2 M NH_4Cl	Final pH
7	1.0	39	8

Dematerialized water Similarly to get the buffers of 8 pH, an appropriate amounts of 0.2 M NH4 OH and 0.2 M NH4Cl were added.

Chelation Of Copper On CAA Resin

Appropriate amounts of 0.2 M Sodium acetate and 0.2 M acetic acid were added to each flask to get the buffers of desired pH i.e. 2 to 7. Similarly different flask to get the buffers of desired pH i.e., 6 to 8. 0.070 g of dry resin and 1 ml of 1000 ppm Cu (II) solution was added to each flask. The contents were equilibrated by magnetic stirrer for 1 hour and then filtered. The filtrates were analyzed for copper. The results are given in table 4.

Table No.4 'KD' Values For Cu (II) on CAA Resin

pH	Absorbance	Conc. Of Cu (II) in Filtrate (ppm)	Amount of Cu (II) in Solution (mg)	Amount of Cu (II) in Resin (mg)	'K_d'	% Adsorption of Cu (II) by resin	Metal Exchange Capacity mg/g
2	0.675	17.4	0.7155	0.2845	233.57	28.45	4.0641
3	0.496	12.7	0.5225	0.7475	537.120	47.75	6.8271
4	0.432	10.5	0.4327	0.5673	771.83	56.73	8.1042

5	0.385	9.4	0.3985	0.6015	914.13	60.15	8.5928
6	0.328	9.8	0.4025	0.5975	870.90	59.75	8.5357
7	0.148	3.8	0.1625	0.8375	3067.76	83.75	11.9642
8	0.453	11.6	0.4765	0.5235	644.70	52.35	7.4785

Inference:-
It is observed that KD values for Cu (II) on CAA resin increases with pH, with a maximum value at pH 7

Chelation of Zn (II) on CAA
resin in different glass stoppered conical flasks appropriate amounts of 0.2 M acetic acid and 0.2 M sodium acetate were added to get the desired pH i.e., 2 to 7. In the same way appropriate amounts of 0.2 M NH4OH and 0.2 M NH4Cl were added to get the pH of 8. 0.070 g of the dry resin and 1ml of 1000 ppm Zn (II) solution was added to each flask. The contents were stirred magnetically for 1 hour and then filtered. The filtrates were analyzed for zinc by AAS. The results are given in Table 5

Table No.5

pH	Absorbance	Conc. of Zn (II) in filtrate (ppm)	Amount of Zn (II) in Solution (mg)	Amount of Zn (II) in resin (mg)	'K_d'	% Adsorption of Zn (II) by resin	Metal Exchange Capacity mg/g
2	1.28	7.2	0.2955	0.7045	1397.81	70.45	10.0642
3	1.37	6.5	0.2655	0.7345	1614.28	73.45	10.4928
4	1.51	6.2	0.2545	0.7455	1717.74	74.55	10.6499
5	1.39	6.3	0.2575	0.7425	1683.67	74.25	10.6071
6	1.35	6.1	0.2465	0.7535	1764.63	75.35	10.7642
7	1.17	5.2	0.2155	0.7845	2155.21	78.45	9.5535
8	1.55	5.5	0.2250	0.7750	2012.98	77.50	11.0713

Table 4 'Kd' values for Zn (II) on CAA resin

Inference:
From the results it is seen that zinc can be adsorbed maximum at pH 7.0.

Separation Of Mixture Of Zinc And Copper On CAA Resin
A glass column was packed with 2 gm of swollen resin. The column was equilibrated with NH4OH–NH4Cl buffer at pH 9. 20 ml of mixture containing 10 ml of Cu (II) and 10 ml of Zn (II) were loaded on the column. The rate of flow was controlled at 2 ml/min. The column was washed with same buffer solution and the adsorbed metal ions were eluted with 0.1 N HCl. 5 ml of fractions were collected and were analyzed for concentration of Zn(II) and Cu (II) by A.A.S. The results are given in Table no.7 and 9.

Table No.6 Absorbance Of Standard Zinc Solutions		
S.No.	Concentration (ppm)	Absorbance
1.	1	0.142
2.	2	0.295
3.	3	0.420
4.	4	0.581
5.	5	0.704
6.	6	0.863

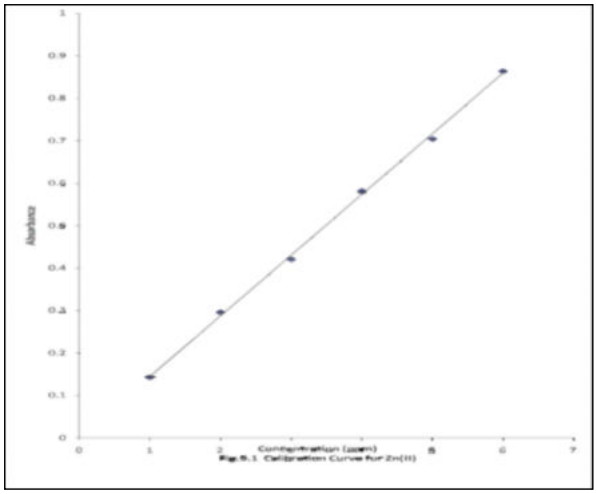


Fig.no.3 Calibration curve of n(II)

Table No.8 Absorbance Of Standard Copper Solutions

S.No.	Concentration (ppm)	Absorbance
1.	1	0.060
2.	2	0.129
3.	3	0.181
4.	4	0.243
5.	5	0.309
6.	6	0.363

TABLE NO.7 Concentration of Zn (II) in Meq.			
S.No.	Volume of eluant (ml)	Absorbance	Concentration (Meq/gm)
1.	5	0.00	0
2.	10	0.00	0
3.	15	0.00	0
4.	20	0.001	0.006
5.	25	0.002	0.0018
6.	30	0.004	0.0024
7.	35	0.005	0.009
8.	40	0.025	0.038
9.	45	0.038	0.0285
10.	50	0.133	0.0575
11.	55	0.311	0.0418
12.	60	0.540	0.397
13.	65	0.278	0.0145
14.	70	0.054	0.0047
15.	75	0.002	0.01
16.	80	0.001	0.01

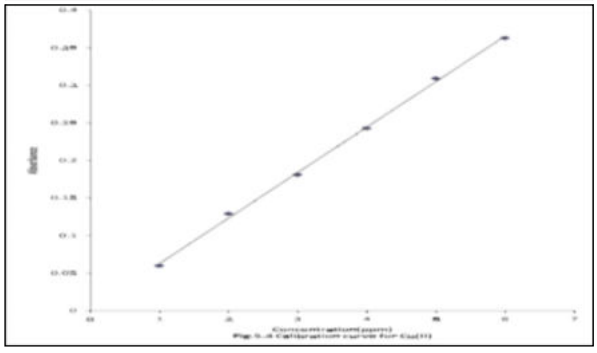


Fig.no.4 Calibration curve of Cu (II)

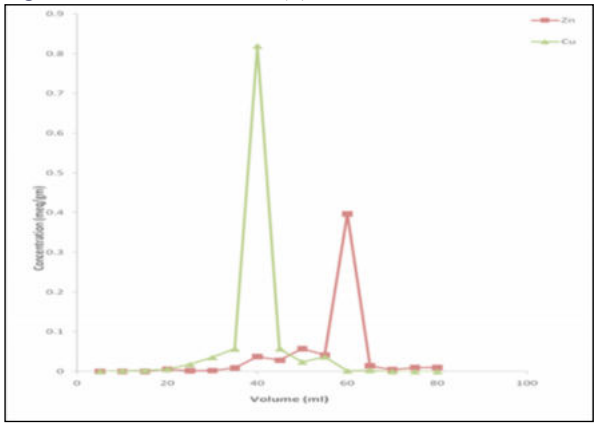


Fig No.5 Separation Of Binary Mixture Of Copper And Zinc

Table No.9 Concentration of Cu (II) in Meq.			
S.No.	Volume of eluant (ml)	Absorbance	Concentration (Meq/gm)
1.	5	0.00	0.00
2.	10	0.002	0.0017
3.	15	0.003	0.0024
4.	20	0.169	0.0056
5.	25	0.039	0.0177
6.	30	0.063	0.0357
7.	35	0.117	0.0569
8.	40	0.172	0.819
9.	45	0.117	0.0574

10.	50	0.038	0.024
11.	55	0.029	0.037
12.	60	0.003	.003
13.	65	0.002	.002
14.	70	0.001	.000
15.	75	.000	.000
16.	80	.000	.000

Column Separation Most of the ion exchange operation are carried out in columns. The mixtures containing different metal ions can be separated using CAA resin on the basis of their distribution coefficient values at different pH.

1. Column Preparation 10 cm long glass column of uniform diameter i.e. one centimeter was used. CAA resin was swelled in DMF. The swollen resin was poured down the column wall and the resin was allowed to settle in order to form a homogenous layers. The height of the resin in the column was about 2 cm. The resin was washed with the buffer of pH at which the adsorption of mixture is to be carried out. the loaded metal ions were eluted using suitable eluants. The quantity of individual metal ions was determined in the eluate by AAS.

2. Separation of binary mixture of Copper and Zinc: Glass column was packed with two grams of swollen resin. The column was equilibrated with NH4OH–NH4Cl buffer at pH 9.0. Twenty milliliter of mixture containing ten milliliter each of copper and Zinc were loaded on the column. The rate of flow was controlled at 2 ml/min., the column was washed with same buffer solution and the adsorbed metal ions were eluted with 0.1 N HCl. Five milliliters of fractions were collected and were analyzed for concentration of copper and zinc by AAS. The results are given in Tables.

DETERMINATION OF K_d BY BATCH METHOD FOR METAL IONS OF PRINCE STEEL INDUSTRY, JODHPUR (RAJ.)

The effluents from smelters, mines and other non ferrous metal industries pose a serious problem in the removal of heavy metal ions i.e. copper, lead, zinc, cadmium and iron. These heavy metal ions are present in the effluent at a level above the permissible limit. The lime treatment considerably reduces the concentration of undesirable metal ions, however such treatment still leaves the residual metal ions concentration at a level considered unsafe for discharge into stream. Therefore it is necessary to develop more sophisticated treatment to remove the heavy metal ions from the effluent of these industries. Cation exchangers can effectively reduce the concentration of toxic metal ions to a desired safe limit [12].

In context to above, we have synthesized and used CAA for the treatment of effluent of Prince Steel Industries. The Effluent sample containing heavy metal ions was collected from the Prince Steel Industries, Jodhpur, Rajasthan. These sample contains heavy metal ions along with other metal ions as shown in below Table no.11

Characteristics Of Effluents Contaminated With Heavy Metal Ions Obtained From Prince Steel Industries, Jodhpur (Raj.)

Table No.11

Color	**Dirty Brown/Green**
Ph	4.3
Total Hardness (ppm)	833
Metal ions concentration in ppm	
Lead	0.65
Zinc	7.24
Copper	0.74
Iron	1.02

Table No. 11

Cadmium	0.12
Calcium	177.2
Magnesium	94.12
Anions Concentration in ppm	
Cyanides	0.05
Fluoride	0.87
Sulphate	925.1

The distribution coefficient K_d of metal ions on resins were determined by Batch method. In all cases for the determination of K_d, 100 ml sample solution was taken in a conical flask and the pH was adjusted by appropriate buffer. seventy milligrams of resin were added to the solution and stirred on a magnetic stirrer for 2 hours and the contents were equilibrated. The solution was filtered through Whatman filter paper No. 40. The residue on the filter paper was equilibrated with 4N HCL and the metal ion concentration in the filtrate as well as in the residue was estimated using atomic absorption spectrophotometer. The calibration curves for different metal ions were plotted, by analyzing a series of standard solutions of metal ions using AAS.

The distribution coefficient (K_d) values of metal ions of Prince Steel Industry on CAA given in table no 12,13.

Table No.12 Distribution Coefficient (K_d) Values Of Cu (II) Of Prince Steel Industry On

pH	**Absorbance**	**Conc. Of Cu (II) In Filtrate (ppm)**	**Amount of Cu (II) in Solution (mg)**	**Amount of Cu (II) in**	**'K_d'**	**Metal Exchange Capacity (mg/g)**
3	0.031	2.65	0.106	0.031	1603.77	4.24
4	0.029	4.50	0.180	0.036	9910.62	44.59
5	0.023	2.20	0.088	0.040	2272.72	4.99
6	0.211	1.60	0.064	0.048	3750.00	6.00
7	0.011	1.25	0.050	0.056	5600.00	7.00

Table No.13 Distribution Coefficient (K_d) Values Of Zn (II) Of Prince Steel Industry On

Ph	**Absorbance**	**Conc. Of Zn (II) In Filtrate (ppm)**	**Amount of Zn (II) in Solution (mg)**	**Amount of Zn (II) in resin (mg)**	**'K_d'**	**Metal Exchange Capacity (mg/g)**
3	0.169	2.20	0.88	0.367	2102.33	4.62
4	0.159	2.05	0.82	0.518	3184.17	6.52
5	0.151	1.95	0.78	0.529	3359.34	6.35
6	0.131	2.37	0.95	0.573	3301.69	7.82
7	0.055	1.15	0.46	0.643	7588.11	8.72

RESULT AND DISCUSSION

Resin CAA is highly selective for the removal of heavy metal ion from their aqueous solution as well as samples of Prince Steel Industry, Jodhpur (Raj.). On the basis of results, it can be concluded that distribution coefficient (K_d) value first increases and then decreases with increasing pH. The equilibrium adsorption studies of Cu^{2+}, and Zn^{2+} with CAA, resin at the pH of their maximum adsorption follows the following sequence:

The metal equilibrium studies with CAA resin follows the following order of 'K_d' values at the pH of their maximum adsorption.

$Cu^{2+} > Zn^{2+}$

3067.76>2155.21

Cu^{2+}, Zn^{2+} shows maximum adsorption at High pH 7.

Thus the resin CAA shows high affinity for Cu^{2+}, Zn^{2+} at pH 7, therefore these metal ions can be separated from other metal ions at pH 7.

CONCLUSION

These reagents are dual functioning reagents, acting as flocculants cum selective ion binders. They can be used as large scale on the commercial basis. The polysaccharide used in the preparation of the reagents is basically a flocculant. It is cheap and also available in abundance. It is possible to incinerate the flocculant and recover the metals. Since the reagents are directly added to the effluent, there is no limitation to the quantity of water that can be treated in one batch. In case of conventional ion exchangers, such restrictions are imposed by the size of the resin bed and flow rate.

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