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(54) Title: DITHIOCARBAMATE POLYMERS

**(57) Abrégé/Abstract:**

A water soluble ethylene dichloride ammonia polymer having a molecular weight of from 500 to 10,000 which contains from 5 to 50 mole % of dithiocarbamate salt groups. Also, disclosed are the use of these polymers in removing heavy metals from water.

## ABSTRACT OF THE DISCLOSURE

A water soluble ethylene dichloride ammonia polymer having a molecular weight of from 500 to 10,000 which contains from 5 to 50 mole % of dithiocarbamate salt groups. Also, disclosed are the use of these polymers in removing heavy metals from water.

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## BACKGROUND OF THE INVENTION

This invention relates to water soluble dithiocarbamate salt polymers and their use in a metal scavenging process.

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## INTRODUCTION

As more problems are caused by contamination of rivers, waterways and the like by waste water from industrial sources, stricter regulations have been enacted to avoid contamination. It is now a mandatory requirement 10 to control metals in waste water below their prescribed concentrations. Particularly stringent regulations have been established for heavy metals harmful to humans, such as mercury, cadmium, zinc, copper and chromium.

Various processes have been proposed to remove 15 heavy metal ions in waste water. In one process, heavy metal removal is achieved using simple dithiocarbamates (i.e. dimethyldithiocarbamate, DMDTC). There are several drawbacks to using low molecular weight dithiocarbamates. The precipitate formed can be small and settling or 20 filtering of the precipitate from the waste water can be slow. Separate addition of flocculants and/or coagulants are often required for faster precipitation and filtration.

One proposal for improving the ability of 25 diathiocarbamates to remove metals is to react them with polyethyleneimine polymers. Such a proposal is set forth in European patent application 0090551 A1. The polyethyleneimine polymers described in this patent are water insoluble. While evidencing the ability to chelate undesirable metals, the separation of the chelated metal 30 polymer

complex is relatively slow. The action of these materials is believed to be similar to the action of water insoluble ion exchange resins.

Another example of polyethyleneimine-dithiocarbamate polymers is set forth in U.S. 4,670,160. In Example 8 of this patent, a polyethylene imine resin having molecular weight of 60,000 was modified with carbon disulfide. The finished resin, while evidencing some water solubility, contained substantial quantities of insoluble materials.

Experimental data has indicated that while polyethyleneimine resins may be modified with carbon disulfide to produce water soluble resins, the molecular weight must be about 10,000 or less. Also, the amount of carbon disulfide which may be used, e.g., 25 mole % or less.

As will be shown hereafter, the polymeric dithiocarbamate polymers of this invention are water soluble, have the ability to readily chelate undesirable heavy metals which are easily removable from aqueous systems.

#### THE INVENTION

The invention comprises a water soluble ethylene dichloride ammonia polymer having a molecular weight of from 500 to 10,000 which contains from 5 to 50 mole % of dithiocarbamate salt groups. The invention also comprises using these polymers to remove heavy metals from waters containing these metals.

## THE ETHYLENEDICHLORIDE-AMMONIA POLYMERS

These polymers are prepared by the reaction of ethylene dichloride and ammonia. A typical reaction for producing these polymers will be illustrated hereafter. The starting ethylene dichloride ammonia polymers generally have a molecular weight range of 500 - 100,000. In a preferred embodiment the molecular weight is 1,500 to 10,000, with a most preferred molecular weight range being 1,500 - 5,000. To illustrate the preparation of such polymers, Example 1 is presented below.

## EXAMPLE 1

To a pressure reactor were charged 10.8 weight % aqueous ammonia, 7.7 weight % anhydrous ammonia, 2.3 weight % water and 0.3 weight % EDTA. The reactor was sealed and heated to 115-130°C and the Ethylene Dichloride (EDC) was pumped in. After the addition of about 0.5 weight % of EDC, 50% sodium hydroxide was added at about the same rate as the EDC and the additions were completed in 4.5 hours. Samples during the reactant addition were obtained. These samples were then concentrated under reduced pressure to remove residual EDC, NH<sub>3</sub>, and vinyl chloride which is a byproduct of the reaction. Weight average molecular weights of the polymers were then measured using a liquid chromatography method and polyethylene glycol standards. A series of polymers were prepared with their make-up and properties being set forth in Table 1.

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TABLE 1

<u>Sample #</u>	<u>Wt%EDC</u>	<u>Wt%NaOH</u>	<u>Mw</u>	<u>Mn</u>	<u>Poly-</u>	<u>Polymer</u>
					<u>Dispersity</u>	<u>Solids</u>
1	12.9	10.4	1380	1010	1.3	41.2
2	15.4	12.3	1620	1100	1.5	46.4
3	17.5	15.2	1670	1100	1.5	41.9
4	20.2	19.3	1850	1290	1.6	43.1
5	22.3	23.1	2320	1290	1.8	37.8
6	24.7	25.7	2970	1440	2.0	47.1
7	26.7	27.4	3470	1540	2.2	41.5
8	29.2	29.2	4420	1700	2.6	42.5
9	32.1	32.8	6040	1910	3.1	37.9
10	33.8	34.6	7970	1910	4.2	36.5
11	36.3	42.6	92,100	2600	35.0	35.0

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## POLYMER MODIFICATION WITH CARBON DISULFIDE

The reaction of polyamines or polyimines with carbon disulfide to produce dithiocarbamates or their salts is well known. Such reactions are described with 5 specificity in U.S. 4,731,187. The reaction between polyamines and carbon disulfide is preferably conducted in a solvent, such as water or alcohol. The reaction goes smoothly between the temperature of ranges of 30 - 100°C for periods of time ranging between 1 and 10 hours. Good 10 conversions are achieved when the temperature is between 40 - 70°C for 2 to 5 hours. These general reaction conditions apply to modifying the ethylene dichloride ammonium polymers described previously.

The mole % of dithiocarbamate salt groups placed 15 in the finished polymer, generally is within the range of 5 to 50 mole %. The preferred range is 20 - 40 mole %, with a most preferred range being about 25 - 35 mole %.

To illustrate the conversion of the ethylene dichloride polymers to dithiocarbamate salt groups, Example 20 2 is presented below.

## EXAMPLE 2

To 82 gm of an EDC/NH<sub>3</sub> polymer were added 38 gm of 50 % sodium hydroxide and 41 gm of D.I. water. The mixture was placed in a pressure reactor and 14 gm of carbon 25 disulfide were added. The mixture was heated to 45 - 50°C for three hours. After the three hours reaction time, the mixture was cooled and a vacuum applied for 5 minutes to remove any residual carbon disulfide. The

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resulting solution product contained 30% modified polymer.

Using this preparative technique, the following modified polymers were prepared: (See Table 2)

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TABLE 2

<u>Example</u>	<u>MW</u>	<u>Wt%</u>	<u>Wt%</u>	<u>Mole%</u>	<u>Wt%</u>	<u>Comments</u>
		<u>Polymer</u>	<u>CS<sub>1</sub></u>	<u>CS<sub>2</sub></u>	<u>50%NaOH</u>	<u>Rxn Product</u>
A	2970	22.1	8.0	21	21.7	Soluble
B	2970	20.9	9.7	26	20.5	Soluble
C	2970	18.0	11.1	35	22.3	Soluble
D	3470	20.6	9.6	26	20.2	Soluble
E	3420	18.9	11.7	35	18.5	Soluble
F	4400	20.1	9.4	26	25.0	Insoluble
G	4092	22.0	8.0	21	17.1	Insoluble
H	4096	22.0	8.0	10	17.1	Soluble
I	1850	20.6	4.0	21	21.1	Soluble

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As molecular weight increases the amount of carbon disulfide which can be reacted to form a water soluble reaction product decreases. With less than about 20 mole % CS<sub>2</sub>, in the polymer metal removal efficiency decreases.

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## DOSAGE

The amount of the modified polymers of the invention that are capable of effectively removing metals from contaminated waters is generally within the range of 0.5 to 3 moles of polymer per mole of heavy metal contained 10 in the water to be treated. Generally 1 to 1.5 moles of the polymer, per mole of heavy metal contained in the water give excellent results. The dosage may be expressed in another form e.g., between 3 - 10 ml of a 0.3% polymer active 15 solution per mole of heavy metal in the water will produce satisfactory metal removal and allow such complexes formed to be self flocculating; e.g. they quickly settle and are easily separated from the treated water.

## EXAMPLE 3

To illustrate the ability of the carbamate 20 polymers set forth in Table 2 to effectively chelate and remove copper metal from a water supply, the following data is presented in Table 3:

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TABLE 3

Polymer	<u>Equal Activis Dosage (ml)</u>						Observed
<u>Table 2</u>	<u>0</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>Filtration Rate</u>
A	20	-	1.1	0.09	0.05	-	Fast
B	20	3.9	0.2	0.07	0.07	0.05	Fast
C	20	3.1	0.2	0.06	0.05	0.05	Fast
D	20	3.4	0.1	0.06	0.04	0.04	Fast
E	20	2.2	0.11	0.06	0.06	0.06	Fast
D	20	-	0.14	0.08	0.08	-	Slow

It should be noted that the observed filtration rate was fast.

#### ADVANTAGES OF THE INVENTION

1. The EDC/NH<sub>3</sub> polymers can be derivitized with CS<sub>2</sub> under mild conditions to form water soluble polymeric dithiocarbamate polymers.
2. The polymeric dithiocarbamates can chelate and precipitate heavy metals from waste water faster than DMDTC (small molecules). This is evident from the fast formation of precipitate.
3. In addition to good chelation ability of the polymeric dithiocarbamates, the precipitate formed is larger than that produced by DMDTC, and settles very quickly. Because the precipitate is large, there is little need for coagulants or flocculants to aid in settling. Therefore, the polymeric dithiocarbamate of this invention can be a one product, one step treatment chemical for removing heavy metals from waste waters.

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CLAIMS:

1. A water soluble ethylene dichloride ammonia polymer having a molecular weight of from 500 to 100,000 which contains from 5 to 50 mole % of dithiocarbamate salt groups.
2. The water soluble ethylene dichloride ammonia polymer of Claim 1 wherein the molecular weight is from 1,500 to 10,000 and the polymer contains from 5 - 50 mole % of dithiocarbamate salt groups.
- 10 3. The water soluble ethylene dichloride ammonia polymer of Claim 1 wherein the molecular weight is from 1,500 to 5,000 and the polymer contains about 20 to 40 % of dithiocarbamate salt groups.
4. The polymer according to Claim 1 having a molecular weight of 1,500 to 5,000 and containing 25 to 35 mole % of dithiocarbamate salt groups.
- 15 5. The polymer according to Claim 1 having a molecular weight of 1,500 to 5,000.
6. A method of removing a heavy metal from water containing said heavy metal which comprises the steps of:
  - 20 a) treating the water with a complexing amount of the water soluble polymer of any one of Claims 1 to 5 to form a complex of the heavy metal;
  - 25 b) allowing the complex to settle rapidly from the water as a precipitate;
  - c) and, separating the precipitate from the water.

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7. The method according to Claim 6 wherein the water is treated with 0.5 to 3 moles of the polymer per mole of heavy metal in the water to be treated.

8. The method according to Claim 6 wherein the water  
5 is treated with 1 to 1.5 moles of the polymer per mole of heavy metal in the water to be treated.

9. A process for preparing a polymer according to  
Claim 1 which process comprises reacting ethylene dichloride  
with ammonia to form an ethylene dichloride ammonia polymer  
10 having a molecular weight of from 500 to 100,000 and  
reacting the polymer so formed with carbon disulfide at a  
temperature of from 30 to 100°C for 1 to 10 hours.

10. The process according to Claim 9 wherein the  
reaction with carbon disulfide is effected at 40 to 70°C for  
15 2 to 5 hours in a solvent of water or alcohol.

11. A method of removing heavy metals from waters  
containing these metals which comprises the steps of:

a) treating such waters with a complexing amount  
of a water soluble ethylene dichloride ammonia polymer  
20 having a molecular weight of from 500 to 100,000 which  
contains from 5 to 50 mole % of dithiocarbamate salt groups,  
to form a complex of these heavy metals;

b) allowing such complexes to rapidly settle from  
the water as a precipitate;

25 c) and, separating the precipitate from the water.

12. The method of Claim 11 where the water soluble  
polymer has a molecular weight from 1500 to 5000 and  
contains from 15-50 mole % of dithiocarbamate salt groups.

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13. The method of Claim 11 where the water soluble polymer has a molecular weight from 1500 to 5000 and contains about 25-40% of dithiocarbamate salt groups.

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