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2,839,459

ELECTROPLATING

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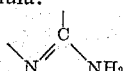
Serial No. 622,532

6 Claims. (Cl. 204—49)

This invention relates to electroplating and, more particularly, to electrodepositing nickel from an aqueous acidic nickel plating bath. The invention is based on our discovery that α -amino N-heterocyclic compounds, when incorporated in a nickel electroplating bath, particularly in conjunction with various sulfo-oxygen compounds, are capable of promoting the formation of excellent bright and ductile electrodeposits of nickel over a wide current density range.

The electrodeposition of nickel from a plating bath containing a sulfo-oxygen "carrier" brightener additive yields deposits of limited intensity. Moreover, such brightness as is produced using these agents is obtained only over a limited current density range. When, however, a small quantity of an α -amino N-heterocyclic compound is incorporated in the plating bath together with a sulfo-oxygen compound, the brightness capacity of the bath is extended, and the electrodeposit is ductile and bright over a very wide current density range.

The common structural feature of these α -amino N-heterocyclic compounds is the presence of an amino group on an unsaturated carbon in a position alpha to the heterocyclic nitrogen atom, as represented by the following structural formula:



Only relatively small quantities of the α -amino N-heterocyclic compounds are required in the plating bath, especially when they are used in conjunction with sulfo-oxygen "carrier" brightener, for we have found that the highly polarized spatial configuration of an α -amino N-heterocyclic compound appears to exert a pronounced synergistic effect on the brightening capacity of the sulfo-oxygen compound. In general, concentrations of the α -amino N-heterocyclic compound as low as 0.005 gram per liter are effective, but in many cases at least 0.08 gram per liter should be employed to secure the full benefit of their presence in the bath. Increasing the concentration of these amino compounds may produce brittle and perhaps cloudy deposits, and hence there is no advantage generally in using more than 1 gram per liter, and in most baths substantially full benefit of their presence is achieved with 0.3 gram per liter or less.

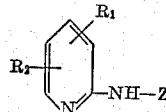
Any α -amino N-heterocyclic compound which is capable of being dissolved by acid and does not undergo decomposition upon protonation may be selected for inclusion in the plating solution. We have obtained particularly satisfactory results by using a carbon-nitrogen heterocyclic compound having an aromatic six-membered cyclic nucleus containing from 1 to 3 nitrogen atoms and at least one amino group attached to a carbon atom in a position alpha to the heterocyclic nitrogen. The basic ring structure for such α -amino N-heterocyclic compounds may be chosen from pyridines, pyridazines, pyrimidines, pyrazines, and 1,3,5-triazines.

A preferred process according to this invention for producing bright nickel deposits comprises electrodepositing nickel from an aqueous acidic solution of at least one nickel salt, in which there is dissolved from about

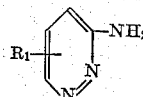
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0.08 to about 0.3 gram per liter of a nitrogen-containing heterocyclic compound of the group consisting of:

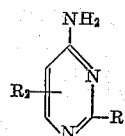
(a) α -Aminopyridines having the structure



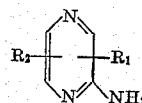
(b) α -Aminopyridazines having the structure



(c) α -Aminopyrimidines having the structure

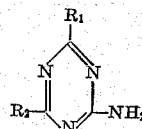


(d) α -Aminopyrazines having the structure



and

(e) α -Amino-1,3,5-triazines having the structure



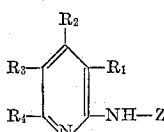
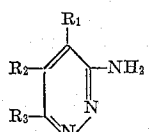
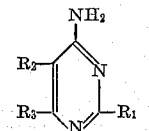
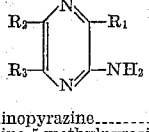
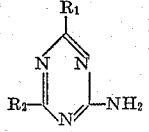
in which Z is a substituent selected from the group consisting of hydrogen and 2-pyridyl radicals, and R₁ and R₂ are substituents selected from the group consisting of hydrogen, amino, methyl, ethyl, and propyl radicals. The synergistic effect of these compounds on the brightening capacity of various sulfo-oxygen compounds is especially pronounced when they are used in the nickel plating solution together with from about 1/4 to about 80 grams per liter of a water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfinic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides.

Preparation of the α -amino N-heterocyclic compounds may be effected by a variety of standard organic reactions. For example, the α -aminopyridines may be prepared by heating pyridine or an alkyl-substituted pyridine with sodamide, since the sodamido ion attacks the pyridine nucleus at the carbon atom alpha to the ring nitrogen. One general technique which is useful in preparing all of the α -amino N-heterocyclic compounds is based on initially forming the α -carboxamide of the N-heterocyclic compound. Upon treatment with sodium hypobromite, the carboxamide undergoes decarbonylation to form the corresponding α -amino N-heterocyclic compound.

Examples of the α -aminopyridines, α -aminopyridazines, α -aminopyrimidines, α -aminopyrazines, and α -amino-1,3,5-triazines, which may be used successfully in embodiments of this invention are listed in Table I. Although these α -amino N-heterocyclic compounds may be used in concentrations as high as one gram per liter, or even more, there is no particular advantage to be gained from the higher concentrations, and they are preferably used in the range of concentrations from about 0.08 to about 0.3 gram per liter.

TABLE I

Alpha-amino N-heterocyclic compounds

Compounds	R ₁	R ₂	R ₃	R ₄	Z
					
(1) α -Aminopyridines					
2-aminopyridine.....	H	H	H	H	H
2-amino-3-methylpyridine.....	CH ₃	H	H	H	H
2-amino-4-methylpyridine.....	H	CH ₃	H	H	H
2-amino-5-methylpyridine.....	H	H	CH ₃	H	H
2-amino-6-methylpyridine.....	H	H	H	CH ₃	H
2-amino-4-ethylpyridine.....	H	C ₂ H ₅	H	H	H
2-amino-4-isopropylpyridine.....	H	C ₃ H ₇	H	H	H
2-amino-4,6-dimethylpyridine.....	H	CH ₃	H	CH ₃	H
2,4-diaminopyridine.....	H	NH ₂	H	H	H
2,6-diaminopyridine.....	H	H	H	NH ₂	H
2,2'-dipyridylamine.....	H	H	H	H	C ₅ H ₄ N
2-(4-methylpyridyl)-2'-pyridyl-amine.....	H	CH ₃	H	H	C ₅ H ₄ N
2-(4-aminopyridyl)-2'-pyridyl-amine.....	H	NH ₂	H	H	C ₅ H ₄ N
2,4-diamino-6-methylpyridine.....	H	NH ₂	H	CH ₃	H
(2) α -Aminopyridazines					
					
3-aminopyridazine.....	H	H	H	-----	-----
3-amino-6-methylpyridazine.....	H	H	CH ₃	-----	-----
3-amino-6-ethylpyridazine.....	H	H	C ₂ H ₅	-----	-----
3-amino-6-isopropylpyridazine.....	H	H	C ₃ H ₇	-----	-----
3,6-diaminopyridazine.....	H	H	NH ₂	-----	-----
(3) α -Aminopyrimidines					
					
2-aminopyrimidine.....	H	H	H	-----	-----
2-amino-4-methylpyrimidine.....	H	H	CH ₃	-----	-----
2-amino-4,6-dimethylpyrimidine.....	CH ₃	H	CH ₃	-----	-----
2-amino-6-ethylpyrimidine.....	H	H	C ₂ H ₅	-----	-----
2,6-diaminopyrimidine.....	NH ₂	H	H	-----	-----
2,6-diamino-3-methylpyrimidine.....	NH ₂	CH ₃	H	-----	-----
2,6-diamino-4-methylpyrimidine.....	NH ₂	H	CH ₃	-----	-----
(4) α -Aminopyrazines					
					
2-aminopyrazine.....	H	H	H	-----	-----
2-amino-5-methylpyrazine.....	H	CH ₃	H	-----	-----
2,6-diaminopyrazine.....	H	H	NH ₂	-----	-----
2,3-diaminopyrazine.....	NH ₂	H	H	-----	-----
2-amino-5,6-dimethylpyrazine.....	H	CH ₃	CH ₃	-----	-----
2-amino-3,5-dimethylpyrazine.....	CH ₃	CH ₃	H	-----	-----
(5) α -Amino-1,3,5-triazines					
					
2-amino-1,3,5-triazine.....	H	H	-----	-----	-----
2,4-diamino-1,3,5-triazine.....	H	NH ₂	-----	-----	-----
2,4-diamino-6-methyl-1,3,5-triazine.....	CH ₃	NH ₂	-----	-----	-----
2-amino-4,6-dimethyl-1,3,5-triazine.....	CH ₃	CH ₃	-----	-----	-----
2-amino-4,6-diethyl-1,3,5-triazine.....	C ₂ H ₅	C ₂ H ₅	-----	-----	-----

The compounds listed in Table II are examples of sulfo-oxygen compounds which, when used in the plating bath in combination with the α -amino N-heterocyclic

compounds, extend the current density range over which the formation of bright and ductile nickel deposits may be obtained. These sulfo-oxygen compounds may be used over a very wide range of concentrations (1/4 to 80 grams per liter), but preferably are used in an amount in the range from about 1 to about 20 grams per liter.

TABLE II

Organic sulfo-oxygen compounds

- 10 (1) Unsaturated aliphatic sulfonic acids, and alkali metal, ammonium, magnesium, and nickel salts thereof:
Sodium vinyl sulfonate, $\text{H}_2\text{CCHSO}_3\text{Na}$
Sodium allyl sulfonate, $\text{H}_2\text{CCHCH}_2\text{SO}_3\text{Na}$
- 15 (2) Mononuclear aromatic sulfonic acids, and alkali metal, ammonium, magnesium, and nickel salts thereof:
Benzene monosulfonic acid, $\text{C}_6\text{H}_5\text{SO}_3\text{H}$
Sodium benzene monosulfonate, $\text{C}_6\text{H}_5\text{SO}_3\text{Na}$
Nickel benzene monosulfonate, $(\text{C}_6\text{H}_5\text{SO}_3)_2\text{Ni}$
Sodium p-toluene monosulfonate, $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_3\text{Na}$
p-Chlorobenzene sulfonic acid, $\text{ClC}_6\text{H}_4\text{SO}_3\text{H}$
Sodium p-chlorobenzene sulfonate, $\text{ClC}_6\text{H}_4\text{SO}_3\text{Na}$
Sodium p-bromobenzene sulfonate, $\text{BrC}_6\text{H}_4\text{SO}_3\text{Na}$
1,2-dichlorobenzene sulfonic acid, $\text{Cl}_2\text{C}_6\text{H}_3\text{SO}_3\text{H}$
1,2- or 2,5-dichlorobenzene sulfonate sodium salt,
25 $\text{Cl}_2\text{C}_6\text{H}_3\text{SO}_3\text{Na}$
Sodium m-benzene disulfonate, $\text{C}_6\text{H}_4(\text{SO}_3\text{Na})_2$
m-Benzene disulfonic acid, $\text{C}_6\text{H}_4(\text{SO}_3\text{H})_2$
Nickel m-benzene disulfonate, $\text{C}_6\text{H}_4(\text{SO}_3)_2\text{Ni}$
30 o-Sulfobenzoic acid monoammonium salt,
 $\text{HOOC}-\text{C}_6\text{H}_4\text{SO}_3\text{NH}_4$
1-amino-2,5-benzene disulfonic acid, $\text{H}_2\text{NC}_6\text{H}_3(\text{SO}_3\text{H})_2$
o-Aminobenzene sulfonic acid, $\text{H}_2\text{NC}_6\text{H}_4\text{SO}_3\text{H}$
- 35 (3) Mononuclear aromatic sulfonic acids, and alkali metal, ammonium, magnesium, and nickel salts thereof:
Sodium benzene sulfinate, $\text{C}_6\text{H}_5\text{SO}_2\text{Na}$
Sodium p-toluene sulfinate, $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{Na}$
- 40 (4) Mononuclear aromatic sulfonamides and sulfonamides
Benzene sulfonamide, $\text{C}_6\text{H}_5\text{SO}_2\text{NH}_2$
p-Toluene sulfonamide, $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{NH}_2$
o-Sulfobenzoic imide, $\text{C}_6\text{H}_4\text{CONHSO}_2$
- 45 Benzyl sulfonamide, $\text{C}_6\text{H}_5\text{CH}_2\text{SO}_2\text{NH}_2$
Benzene sulphydroxamic acid, $\text{C}_6\text{H}_5\text{SO}_2\text{NHOH}$
N,N-dimethyl-p-toluene sulfonamide,
 $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{N}(\text{CH}_3)_2$
- 50 N,N-dicarboxyethyl benzene sulfonamide,
 $\text{C}_6\text{H}_5\text{SO}_2\text{N}(\text{C}_2\text{H}_4\text{COOH})_2$
- (5) Binuclear aromatic sulfonic acids, and alkali metal, ammonium, magnesium, and nickel salts thereof:
- 55 2-naphthalene monosulfonic acid, $\text{C}_{10}\text{H}_7\text{SO}_3\text{H}$
1,5- or 2,7-naphthalene disulfonic acid, $\text{C}_{10}\text{H}_6(\text{SO}_3\text{H})_2$
Nickel 1,5- or 2,7-naphthalene disulfonate,
 $\text{C}_{10}\text{H}_6(\text{SO}_3)_2\text{Ni}$
- 60 Sodium naphthalene trisulfonate, $\text{C}_{10}\text{H}_5(\text{SO}_3\text{Na})_3$
Naphthalene trisulfonic acid, $\text{C}_{10}\text{H}_5(\text{SO}_3\text{H})_3$
Diphenyl p,p'-disulfonic acid, $\text{HSO}_3\text{C}_6\text{H}_4-\text{C}_6\text{H}_4\text{SO}_3\text{H}$
2-naphthol-3,6-disulfonic acid, $\text{HOC}_{10}\text{H}_5(\text{SO}_3\text{H})_2$
Sodium 2-naphthol-3,6-disulfonate, $\text{HOC}_{10}\text{H}_5(\text{SO}_3\text{Na})_2$
- 65 1-naphthylamine-3,6,8-trisulfonic acid,
 $\text{H}_2\text{N}\cdot\text{C}_{10}\text{H}_4(\text{SO}_3\text{H})_3$
- (6) Heterocyclic sulfonic acids, and alkali metal, ammonium, magnesium, and nickel salts thereof:
- 70 Thiophene sulfonic acid, $\text{C}_4\text{H}_3\text{S}\cdot\text{SO}_3\text{H}$
Sodium thiophene sulfonate, $\text{C}_4\text{H}_3\text{S}\cdot\text{SO}_3\text{Na}$
2-(4-pyridyl)ethyl sulfonic acid, $\text{C}_5\text{H}_4\text{N}\cdot\text{C}_2\text{H}_4\text{SO}_3\text{H}$

For the most part, only free sulfonic acids are listed in Table II. However, the alkali metal, ammonium, magnesium, and nickel salts are in all cases the full equivalent

lent of the acids, and may be used in their place in carrying out the process of the invention.

Brightener additions according to this invention have, of course, been used successfully in the standard Watts nickel electroplating bath. However, these brightener additions are also effective in all other nickel electroplating baths, and consequently the invention is applicable to electrodeposition from any aqueous acidic plating solution of one or more nickel salts.

To illustrate the applicability of using the α -amino N-heterocyclic compounds in different nickel electroplating baths under a variety of conditions, Table III lists the basic compositions of several types of plating baths which were employed in carrying out the examples of the invention that are set forth below.

TABLE III

Bath concentrations in grams per liter

	Bath A	Bath B	Bath C
Nickel sulfate.....	300		
Nickel chloride.....	45	30	
Nickel sulfamate.....		300	
Nickel fluoborate.....			220
Boric acid.....	37.5	30	15

In each of the following examples of the invention, the electrodeposit was formed in a Hull test cell on brass cathodes so that the effect of a wide range of current densities could be observed. The pH of the bath was adjusted to about 3.5 in each case, and the electrodeposit was formed at a temperature of 50° C. Mild agitation of the bath was provided in each case.

EXAMPLE I

To the Watts bath (bath A) described in Table III were added 16 grams per liter of sodium naphthalene-1,3,6-trisulfonate. A test panel which received a nickel electroplate from this bath was semi-bright over a wide current density range, but exhibited slight haziness in the low and middle current density range. Upon the addition of various concentrations of representative α -amino N-heterocyclic compounds to this bath, exceptionally bright electroplates were formed in each case over a very wide current density range.

Table IV sets forth in detail the concentrations of specific α -amino N-heterocyclic compounds added to a Watts bath (bath A) which also contained 16 grams per liter of sodium naphthalene-1,3,6-trisulfonate, and the character of the deposit produced from the bath.

TABLE IV

Effect of α -amino N-heterocyclic compounds on bright nickel plating

Compound	Concentration (grams/liter)	Character of deposit
2-aminopyridine.....	0.02	Very bright.
	0.1	Do.
2-amino-3-methylpyridine.....	0.02	Do.
	0.06	Do.
2-amino-4-methylpyridine.....	0.02	Do.
	0.06	Do.
2-amino-5-methylpyridine.....	0.02	Do.
	0.06	Do.
2-amino-6-methylpyridine.....	0.02	Do.
	0.06	Do.
2-amino-4, 6-dimethylpyridine.....	0.02	Do.
	0.06	Do.
2,6-diaminopyridine.....	0.008	Bright.
	0.016	Very bright.
2,2'-dipyridylamine.....	0.01	Do.
	0.03	Do.
2-aminopyrimidine.....	0.1	Do.
	0.3	Brilliant.
4-amino-2,6-dimethylpyrimidine.....	0.004	Very bright.
	0.02	Do.
2,4-diamino-6-methyl-1,3,5-triazine.....	0.005	Do.
	0.01	Do.

Identical results were obtained when only 8 grams per

liter of sodium naphthalene-1,3,6-trisulfonate were used in the plating solution in combination with the various α -amino N-heterocyclic compounds.

EXAMPLE II

As a general rule, the effect of the α -amino N-heterocyclic compounds on the brightening capacity of the bath is more pronounced at the low and medium current densities. The test panel of a Hull cell received a nickel electrodeposit from Bath A which contained 15 grams per liter of benzene disulfonic acid. The plated panel was fairly bright except at and near the high current density end, when it was streaked and matted. By adding 0.2 gram per liter of 2-aminopyrimidine to the electroplating solution, the nickel deposit became very bright almost over the entire current density range of the panel. Increasing the concentration of 2-aminopyrimidine to 0.3 gram per liter did not increase the brightness nor extend the range further.

EXAMPLE III

Brilliant nickel deposits are formed when the α -amino N-heterocyclic compounds are used in conjunction with aromatic sulfonamides or sulfonimides. Table V summarizes the results obtained when the electroplate was formed from a Standard Watts plating solution (bath A) containing 2 grams per liter of o-sulfobenzoic imide (saccharin) together with varying concentrations of representative α -amino N-heterocyclic compounds.

TABLE V

Compound	Concentration (grams/liter)	Character of deposit
2-amino-3-methylpyridine.....	0.03	Brilliant.
2,2'-dipyridylamine.....	0.01	Do.
	0.03	Do.
2-aminopyrimidine.....	0.1	Do.
	0.3	Do.

EXAMPLE IV

To a sulfamate plating bath (bath B) which had been properly purified were added 15 grams per liter of sodium naphthalene-1,3,6-trisulfonate, and nickel electrodeposited on a Hull test panel at a total current of two amperes per 250 ml. Hull cell. The deposit was semi-bright over a wide current density range with a strong haze at the middle and low current densities. Upon the addition of 0.08 to 0.26 gram per liter of 2-aminopyridine to this bath, a very bright deposit was obtained over the entire current density range of the test panel. Similarly, when 0.008 to 0.016 gram per liter of 2,2'-dipyridylamine or 0.06 gram per liter of 2-aminopyrimidine was added to the bath in place of the 2-aminopyridine, an equally bright electrodeposit was obtained over substantially as wide a current density range.

Substitution of 2 grams per liter of o-sulfobenzoic imide (saccharin) in the sulfamate bath in place of sodium naphthalene-1,3,6-trisulfonate yielded brilliant electrodeposits when used in conjunction with the aforementioned concentrations of 2-aminopyridine, 2,2'-dipyridylamine, and 2-aminopyrimidine.

EXAMPLE V

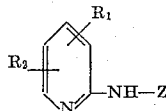
Using a previously purified nickel fluoborate bath (bath C) which contained 2 grams per liter of o-sulfobenzoic imide, a fairly bright electroplate was deposited on the test panel of a Hull cell operated at 50° C. and a pH of about 3.5. When, however, 0.08 to 0.26 gram per liter of 2-aminopyridine was added to the bath, the brightness range was substantially increased and a brilliant deposit formed. Similar results were obtained when 0.008 to 0.016 gram per liter of 2,2'-dipyridylamine and 0.06 gram per liter of 2-aminopyrimidine were separately added to the bath in place of 2-aminopyridine.

We claim:

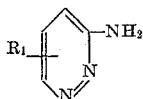
1. The process for producing bright nickel deposits which comprises electrodepositing nickel from an aqueous acidic nickel electroplating solution in which there is dissolved from about 0.005 to about 1 gram per liter of an aromatic heterocyclic carbon-nitrogen compound having a six-membered cyclic nucleus containing from 1 to 3 nitrogen atoms and at least one amino group attached to a carbon atom in a position alpha to the heterocyclic nitrogen, and from about 1/4 to about 80 grams per liter of a water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfonic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides.

2. The process for producing bright nickel deposits which comprises electrodepositing nickel from an aqueous acidic solution of at least one nickel salt in which there is dissolved from about 1/4 to about 80 grams per liter of a water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfonic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides, and from about 0.08 to about 0.3 gram per liter of a nitrogen-containing heterocyclic compound of the group consisting of:

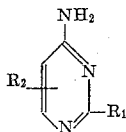
(a) α -Aminopyridines having the structure



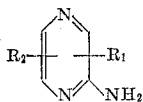
(b) α -Aminopyridazines having the structure



(c) α -Aminopyrimidines having the structure

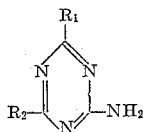


(d) α -Aminopyrazines having the structure



and,

(e) α -Amino-1,3,5-triazines having the structure



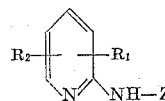
wherein Z is a substituent selected from the group consisting of hydrogen and 2-pyridyl radicals, and R₁ and R₂ are substituents selected from the group consisting of hydrogen, amino, methyl, ethyl, and propyl radicals.

3. An aqueous acidic electroplating solution of at least one nickel salt in which there is dissolved from about 0.005 to about 1 gram per liter of an aromatic heterocyclic carbon-nitrogen compound having a six-membered cyclic nucleus containing from 1 to 3 nitrogen atoms and at least one amino group attached to a carbon atom in a position alpha to the heterocyclic nitrogen, and from about 1/4 to about 80 grams per liter of a

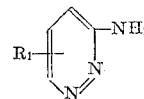
water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfonic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides.

4. An aqueous acidic electroplating solution of at least one nickel salt in which there is dissolved from about 1/4 to about 80 grams per liter of a water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfonic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides, and from about 0.08 to about 0.3 gram per liter of a nitrogen-containing heterocyclic compound of the group consisting of:

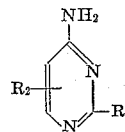
(a) α -Aminopyridines having the structure



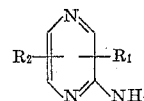
(b) α -Aminopyridazines having the structure



(c) α -Aminopyrimidines having the structures

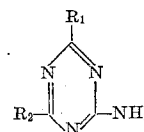


(d) α -Aminopyrazines having the structure



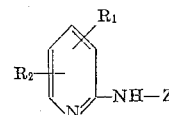
and,

(e) α -Amino-1,3,5-triazines having the structure



wherein Z is a substituent selected from the group consisting of hydrogen and 2-pyridyl radicals, and R₁ and R₂ are substituents selected from the group consisting of hydrogen, amino, methyl, ethyl, and propyl radicals.

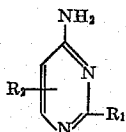
5. The process for producing bright nickel deposits which comprises electrodepositing nickel from an aqueous acidic solution of at least one nickel salt in which there is dissolved from about 1/4 to about 80 grams per liter of a water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfonic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides, and from about 0.08 to about 0.3 gram per liter of an α -aminopyridine having the structure



wherein Z is a substituent selected from the group consisting of hydrogen and 2-pyridyl radicals, and R₁ and

R_2 are substituents selected from the group consisting of hydrogen, amino, methyl, ethyl, and propyl radicals.

6. The process for producing bright nickel deposits which comprises electrodepositing nickel from an aqueous acidic solution of at least one nickel salt in which there is dissolved from about $\frac{1}{4}$ to 80 grams per liter of a water-soluble sulfo-oxygen compound of the group consisting of unsaturated aliphatic sulfonic acids, mononuclear and binuclear aromatic sulfonic acids, heterocyclic sulfonic acids, mononuclear sulfinic acids, the alkali metal, ammonium, magnesium, and nickel salts of said acids, and mononuclear aromatic sulfonamides and sulfonimides, and from about 0.08 to about 0.3 gram per liter of an α -aminopyrimidine having the structure



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wherein R_1 and R_2 are substituents selected from the group consisting of hydrogen, amino, methyl, ethyl, and propyl radicals.

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