

*Collection of formulas for the chemical,electrochemical and heat colouring of metals,the
cyanide free immersion plating and electroplating*

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CONTENTS:

1. CHEMICAL COLOURING OF COPPER/COPPER ALLOYS
 2. CHEMICAL COLORING OF IRON
 3. CHEMICAL COLORING OF STAINLESS STEEL
 4. CHEMICAL COLORING OF SILVER
 5. CHEMICAL COLORING OF ZINC
 6. CHEMICAL COLORING OF ALUMINIUM
 7. CHEMICAL COLOURING OF TIN, LEAD AND NICKEL
 8. LUSTRE (INTERFERENCE) COLOURS
 9. ELECTROLYTIC COLOURING
 10. JAPANESE PATINAS
 11. HEAT COLOURING
 12. DEGREASING
 13. PICKLING AND CHEMICAL POLISHING, MATT FINISHES
 14. IMMERSION PLATING
 15. ELECTROPLATING
 16. SHORT INSTRUCTIONS FOR SUCCESSFUL AND SAFE COLOURING AND PLATING OF METALS
 17. LITERATURE
 18. RECOMMENDED WEBPAGES
- DISCLAIMER

ADDITIONAL EXPLANATIONS: Cu 1

1. Some methylated spirit can be added. Before a treatment objects can be coloured black or brown. Between the applications we can use 3-6% hydrogen peroxide solution, every application can be applied only after previous layer is dry!
2. For bronze!
3. For bronze!
4. There are variants with smaller amount of ammonium chloride or carbonate. Before treatment objects can be coloured black or brown. Instead water you can use vinegar. If we take more carbonate, more bluish, if more chloride more yellowish colour.
5. Yellowish green. If we want more bluish green we must use ammonium carbonate solution, if more yellowish then sodium chloride.
6. For a large surfaces and an application by spraying.
7. Dark green-add only 200 gms water not 1 liter!
8. Yellowish green, no water!
9. Can be used on objects pretreated with black or brown colour, between applications 3-6% hydrogen peroxide solution can be used!
10. Bluish green, objects can be previously coloured black or brown!

INGREDIENTS,in grams on
liter of water

GREEN FOR COPPER/COPPER ALLOYS/II, Cu 2

	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Copper nitrate						80				X
Copper sulphate									70	
Copper acetate	120	10		80						
Copper chloride			200							X
Zinc chloride									9	
Ammonium carbonate							60			
Ammonium chloride	60	20		220	8	10	75	15	36	
Hydrogen peroxide 30 %										
Sodium chloride				80	8	45			36	
Potassium chloride			100							
Potassium polysulphide							50			
Acetic acid conc., ml.					50	60	120		18	
Acetic acid 5 %		1L						11		
Potassium bitartrate				80		10				
Potassium oxalate					4					
Iron acetate							50			
Glycerine									9	
Sodium oxalate								15		

ADDITIONAL EXPLANATIONS- Cu 2

11. After application leave it to dry.
12. Yellowish green,no water!
13. For brass!
14. For brass!
15. Light green on a copper.Can be used on object previously coloured black or brown !
16. Bluish green on copper.Can be used on object previously coloured black or brown!
17. Greyish green on bronze,1000 cm³ water,120 cm³ acid!
18. For bronze!
19. For copper ,brush it on object!
20. Green on copper/copper alloys.three step process-first we use concentrated copper chloride/copper nitrate solution(15 minutes,90 C temp.),then rinse it well and treat it with sodium hydroxide solution(blue green,if we use only nitrate - azure blue),rinse again,and treat with iron-II-sulphate solution (or sodium oxalate or sulphite)-colour must then be yellowish green.Finally we can coat it with very diluted waterglass.According to USA patent USPT 1,428,170!

ADDITIONAL EXPLANATIONS: Cu 3

1. Dissolve copper nitrate in 40 ml of water(hot),then add silver nitrate solution(hot water,10 ml).We can add some methylated spirit too.Brush or spray it on a warm object and let it dry at warm place.Then we must heat the object until its green colour blackens. After that we can brush it and if needed repeat the treatment.Wax or lacquer,as you wish!
- 2.i 3. Different variants of a liver of sulphur treatment.We can take 2 grams potassium polysulphide/2 grams kitchen salt or 25 grams polysulphide/3 grams ammonia. The brass must be immersion coppered previously.Use only fresh solution!
4. Black on brass,immerse objects until the colour is satisfactory.Do not mix solution with acids!Deadly dangerous!
 - 5.Matt black,immerse an object in boiling solution,approximately 20 minutes.
 - 6.Black on a copper,tombac or tin bronze.For a brass and aluminium bronze take 100 grams hydroxide.In boiling solution we must add persulphate and then immerse objects.Oxygen bubbles forms during process and that is sign of the usability of solution,when this process ends add new portion of persulphate(10 grams).Copper blackens for 5 minutes,brass need 10 minutes.
7. Bluish black on brass.Use it in well vented room.Colour forms in 1-4 minutes.
8. Immerse objects in boiling solution.
9. Dark grey.Immerse objects in hot solution,approximately 30 minutes.
10. For copper and its alloys.Immerse an object in solution heated to 60-70 C temperature,approximately 20 minutes.

ADDITIONAL EXPLANATIONS: Cu 4

1. Brown on a copper/copper alloys. Heat the solution to 90 C, immerse objects 2-50 minutes. It is better to use several short immersions. Can be used at room temperature too, but then solution works slowly.
2. i 3. Olive colour /golden tinted brown on copper and bronze, yellowish brown to orange red on brass. Immerse objects in solution heated to 90 C. Can be used at room temperature, but then works slowly.
4. Japanese red patina for golden yellow tombac. 60 minutes, boiling solution.
5. For copper/copper alloys. A 5 minutes immersion in boiling solution - brown or reddish brown on copper, yellowish brown on brass, yellowish red on tin bronze. Before use it must stay for 3 days, at least.
 6. Japanese patina for copper and brass. Immerse objects in a boiling solution. The 5-10 minutes immersion colours brass chocolate brown, copper greenish red. Variant with 62,5 gm copper sulphate + 10,5 gm copper acetate and 25 gm potassium aluminium sulphate + few drops of acetic acid colours coinage bronze red. Variant with 60 gm copper sulphate and 20 gm potassium aluminium sulphate colours copper, tin bronze and tombac violet red, brass yellow green. Very diluted solution - 6,25 gm copper sulphate and 1,25 gm copper acetate colours copper red.
7. The boiling solution colours copper violet brown, brass yellow brown. If we add 5-30 gm acetic acid the colour will be more reddish brown to violet red.
8. Red on coinage bronze.
9. Golden yellow on brass. Dissolve sugar and hydroxide in 1 liter of water, boil 15 minutes, then add sulphate dissolved in a small amount of water. Use hot solution (80 C).
10. Brown, dissolve oxochloride in acid, heat it until crystals of copper acetate forms, then dilute to 4,3 liter and filter. Immerse an object in boiling solution.

Ingredients,grams on liter of
water

CHEMICAL COLOURING OF IRON: Fe1

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Ethyl alcohol	90	50							30	
Nitrous ether									15	30
Nitric acid	5								19	
Iron-III-chloride	35	15				10	15		30	30
Antimony(III)chloride				3		10				12
Iron sulphate		30								
Copper sulphate		12						60	15	
Sodium hydroxide			600							
Sodium nitrate			25							
Olive oil				9	2					
Tannic acid						2				
Zinc chloride					3					
Ammonia 25 %								60		
Copper chloride										18
Tartaric acid								X		

ADDITIONAL EXPLANATIONS: Fe1

1. and 2. Swiss black. Objects must be very sparingly covered with the solution. Dry them at 100 C temperature 30 minutes, or six hours at 18 C. Reddish brown coating must be without patches and bumps. Then we must immerse objects in a boiling water for 30 minutes, if we want the best results 30 minutes in a hot steam and 30 minutes in a boiling water. The quality must be tested with steel wire scratch brush. Colour must be black. Repeat complete process at least 3 times. Finish with immersion in a hot linseed oil.

3. Black or bluish black. Immerse objects in a boiling solution until colour is satisfactory, approximately 10 minutes. When finished rinse well, dry and immerse in a hot linseed oil. Protective clothing, gloves and goggles must be used. Modified process—first immerse objects in the next solution—14 gm oxalic acid and 1,2 gm phosphoric acid, with addition of 6 gm m-nitrobenzenesulphonate and 0,4 gm potassium sodium tartarate, dissolved in 1 lit w-60 second or until the object is grey coloured. After that we can immerse them in the solution made of 100 gm NaOH, 35 gm sodium nitrate, 5 gm sodium nitrite, 5 gm sodium thiosulphate, 5 gm sodium molybdate and 0,2 gm tin chloride, 1 lit water. According to USPT 6,889,769!

4. Brown colour. Heat oil in water bath, add antimony-III-chloride, mix carefully and apply with a cottonwool or piece of cloth. After 24 hours oil and polish with piece of cloth. Repeat if needs. If we take only 1 gm antimony-III-chloride colour will be greenish brown.

5. Brown. Solution must be applied on a heated object. When colour is satisfactory, rinse well, dry, brush with fine steel wire brush and then oil it..

6. Dark brown. Mix it with 20 cm³ of water. When dry repeat if needs, at end of the treatment rinse well, dry and oil.

7. Reddish brown. Instead water we can use ethyl alcohol. Everytime coating must dry well. Finish with oil rubbing.

8. Black. Must be acidified with tartaric acid, A piece of cloth must be moistened with solution and rubbed on object, Finally rinse well.

9. For damascened objects. Pickle objects in a diluted nitric acid. Rinse well and rub object with solution. Dry by indirect heat, polish with a finest steel wool, repeat the treatment 2 times every day/8 days. Finally polish it and apply wax. 30 parts iron chloride= 30 parts solution, only 75 parts water!

10. Measures as in previous process,1 lit of water.Treatment as 1. and 2.

INGREDIENTS,grams on liter
of water

CHEMICAL COLOURING OF IRON: Fe 2

	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Selenious acid							45			
Sodium nitrate										75
Tartaric acid						2				
Potassium permanganate								12	1-3	
Iron nitrate			5			2				
Zinc powder		18								
Phosphoric acid		57						2,5		
Flowers of sulphur	1									
Lard	20									
Manganese dioxide										5
Linseed oil	X?									
Silver acetate				1						
Sodium thiosulphate			35							
Copper nitrate					50					
Manganese nitrate					50					
Barium nitrate								100		
Calcium nitrate									20	
Potassium chlorate										5
Lead nitrate			10							
Oil of lavender				X						
Copper sulphate							100			
Nitric acid							50			

ADDITIONAL EXPLANATIONS: Fe 2

11. Black. Mix flowers of sulphur and lard, rub it on object very sparingly. Heat indirectly to 200-400 C temperature. Hot air gun can be used too. Linseed oil or fat can be used instead lard. You can also use oil only too...
12. Black. Dissolve zinc in phosphoric acid, then mix 65 parts of that solution and 10 000 parts of water. 30-180 minutes immersion. Rinse well, dry, rub with oily cloth or lacquer..
13. Blue on iron and steel. Immerse objects in hot solution (70 C).
14. Green. Take 1 part of silver acetate and 20 parts of oil of lavender, mix well, rub on the object and then heat that object to 150 C.
15. Blue. Immerse objects in a heated solution (50 C). When colour is developed, stop process and rinse well. If we take 75 gm manganese nitrate, colour will be more intensive.
16. Black. It must be rubbed on object. Stronger solution can be used too (20/20).
17. Brilliant black. Immerse objects in the solution until colour is developed. If we take more selenious acid, colour will be bluish black.
18. For iron and steel. The temperature of solution 94 -98 °C. Immerse objects in solution for 40-60 minutes.
19. For carbon steel. Immerse objects in solution, when colour is developed rinse well.
20. Bluish black. Immerse objects in the boiling solution.

ADDITIONAL EXPLANATIONS: Fe 3

21. Black. Immerse objects in the boiling solution for 10-15 minutes .Rinse well,dry,oil or wax.
22. Different colours,depends on how long we immerse objects in boiling solution-20 minutes golden bronze,60 minutes indigo blue,120 minutes turquoise,180 minutes green.
23. Black.Only 25-49 parts of water!Immerse objects in boiling solution.According to USA patent USPT 2,219,554
- 24.Black ,brown or golden.Only.40 parts water!Immerse objects in boiling solution. According to USA patent USPT 2,283,171
- 25.Black.Immerse objects in the hot solution,then rinse and immerse in 1% sodium sulphide solution.
- 26.Black.Acid in ml!Immerse objects in lukewarm solution until colour is developed.
27. Black.Measures in volume parts,add 20 parts water.Immerse objects in the boiling solution(90-100 C) for 15-45 minutes.
- 28.Dark blue to black.Dissolve every componet in one liter of the water and then mix them before use. Solution must be hot(60 C).
- 29.Black,according to Naylor.Specific density of acid 1,55gm/cm³.Temperature 18-25 C.Duration 5-10 minutes.. Potassium dichromate is carcinogenic compound!
- 30.Brown to black.Oil objects very sparingly,then heat them to 200-400 C(indirectly).Repeat if needs.

INGREDIENTS,grams on liter
of water

CHEMICAL COLOURING OF SILVER: Ag

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Potassium polysulphide	10									
Sodium nitrate			10							
Copper sulphate			20			10	30			
Ammonia 25 %			20							
Iron-III-chloride		200								
Sodium hydroxide		20								
Graphite				6						
Hematite				1						
Iodine					1					
Hydrohloric acid					3			300		
Ammonium chloride						5			950	4
Vinegar						100				
Sodium chloride							15			16
Sulphuric acid								100		
Potassium hydrogentartarate										12
Copper nitrate										20
Copper acetate									200	
Turpentine								200		

ADDITIONAL EXPLANATIONS : Ag

1. Dark grey,bluish.Immerse objects in the solution,room temperture.Take not more than 50 gm sodium or potassium polysulphide.Hot solution can be used too,then colour development is faster.
2. Dark grey to black.We must make 2 solutions,every one in 1 liter of water.Solution 1. iron chloride,solution 2. sodium hydroxide.Immerse objects in solution 1. for 5 seconds,then rinse well and immerse in solution 2.(it must be hanged on aluminium or zinc wire).Then rubb it with fine pumice or chalk and wax or lacquer it.
- 3.Brown.Immerse objects in the solution,when they are coloured rinse well,dry and wax.
4. Patina on silver.Mix hematite , graphite and turpentine.Paint that mixture on objects,when they are dry rinse well and rub it with cloth moistened with alcohol.
5. Green oxide.Three parts acid and one part iodine must be mixed together,then immerse objects in the solution and when colour is developed rinse well and dry.After some time it blackens.
6. Brown.Immerse objects until colour is developed.
7. Grey.Only 1 dl water!Immerse objects in the solution until colour is satisfactory.
8. Patina on silver.Slowly add acid to turpentine and then add hydrochloric acid.Paint objects with the solution,after every application rinse well!
9. Green on grey background.Rubb object with the cloth moistened with solution,twice every day for 5 days,then it must be dried for next 5 days.
10. Dark brown.Take as little water as possible,result must be the thick paste!Rubb it on object,after 4 hours rinse well and dry..

ADDITIONAL EXPLANATIONS: Zn

1. Black. Ingredients must be dissolved in hot water, then filter and use. Immerse objects and take them out immediately. Colour develops after contact with air. Repeat if needed, rinse well and dry.
2. Zinc lustre colours. Immerse objects in cold solution, when colour is satisfactory rinse well and dry. Wax or lacquer.
3. Black. Immerse objects in heated solution (90 C).
4. Brown. 50 cm³ ammonia. Objects must be painted with the solution and then scratch brushed with fine brass wire brush.
5. Black. Paint it on objects.
6. Blue. Immerse objects in the solution. If we take nickel sulphate instead nickel ammonium sulphate colour will be violet blue.
7. Green. Dissolve hypo in the water, when the solution is cleared add acid, result will be milky fluid, after that filter it and it is ready for use. Filtered solution must be clear ! Immerse objects in the boiling solution.
8. Black. Instead acetate we can use sodium thiosulphate. Immerse objects in the solution.
9. Greyish black. Immerse objects in the solution (approximately 20 minutes).
10. Greenish brown. Dissolve ingredients in 0,5 liter water. Objects must be painted with solution. When the colour is satisfactory, rinse well. Longer immersion will produce almost black.

INGREDIENTS,grams on liter
of water

DIRECT CHEMICAL COLOURING OF ALUMINIUM:
Al 1

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Potassium permanganate	10			20						
Copper nitrate	25									
Ammonium molybdate		10								
Sodium thiosulphate		5								
Nitric acid 38 Be	4									
Sodium chromate								10		
Sodium carbonate calc.								4		
Potassium polysulphide					25					25
Potassium bichromate					0,3					
Vanadium sulphate										1
Alizarine					1					
Antimony(III)-chloride						100				
Manganese oxide						50				
Hydrochloric acid						200				
Methylated spirit						1L				
Potassium hydroxide								4		
Egg white									X	
Potassium ferrocyanide			5							
Iron-III-chloride			5							
Platinum chloride							10			

ADDITIONAL EXPLANATIONS: AI 1

1. Brown to black(according to Krause).Temperature of the solution 80-100 C.Immerse objects-5 minutes - light brown,15 min. -dark brown,30 min.- black.
2. Black.Temperature of the solution 100 C.Immerse objects in the solution.
3. Blue.Immerse objects until colour is developed.
4. Golden yellow.If we add 5 gm of manganese sulphate- brass colour.Use of copper sulphate instead will produce bronze colour.
5. Red.Objects must be immersed at least 30 minutes,temperature of the solution 80-90 C.
6. Black.Objects must be previously pickled in 80 % sulphuric acid.Then rinse well and immerse in the solution.Rinse in a hot water,dry,lacquer.
7. Black.Platinum chloride must be dissolved in 100 mll water or alcohol.Expensive!
8. Grey.Mix ingredients with 10-15 gm water.Paint it on objects and after 20 minutes(30-40 C) rinse well and dry.Potassium chromate is carcinogenic compound!
- 9.Dark brown to black. Paint it on objects and then heat it to 350-400 C (indirectly).Repeat it if needs.Linseed oil can be used too.
10. Brown to black.Same process as 5.

INGREDIENTS,grams on liter of
water

COLOURING OF OXIDIZED ALUMINIUM: A1 2

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Cobalt acetate	20									
Potassium permanganate	20							10		
Lead nitrate		50								
Potassium chromate		50								5
Copper sulphate			25		X					
Ammonium			1			X			X	
Iron(III)-sulphate				50						
Potassium ferrocyanide				25	X					
Lead acetate						X				
Cobalt acetate							40			
Sodium polysulphide							15			
Sodium thiosulphate								10		
Cadmium acetate									X	
Silver nitrate										X
Iron(III)-ammonium oxalate								X		

ADDITIONAL EXPLANATIONS: Al 2

Before colouring aluminium must be oxidized chemically or electrochemically (anodized). Colours develop by chemical reaction.

Chemical oxidation: 2-5% waterless sodium carbonate and 0,5-2,5% sodium chromate. Ingredients must be dissolved in 1 liter of water (add second only if the first is dissolved). Degreased objects must be immersed in a boiling solution, 3-5 minutes. Because sodium chromate is a carcinogenic compound we can use next alternative process - 5 gm potassium permanganate, 10 gm sodium hydroxide, 1 liter of water, 90-100°C, 45 minutes. After that step rinse objects well and immediately colour them!

Anodic oxidation: Solution of 230 gm sulphuric acid/1 lit. water, at least 12 V, current density 1 A/dm², cathode = lead plate, anode = object. An object connected to the positive pole of transformer must be immersed in the solution, in which lead plate connected to negative pole must be previously immersed, at least 10-15 minutes. Then rinse well and colour immediately. According to literature dyes for a cottonwool can be used too. Finish with boiling in water for 30 minutes, after colouring!!!

1. Bronze colour. Immerse in acetate (up to 50 gm) solution, rinse well and immerse in the permanganate solution (up to 50 gm), rinse again. 35-50°C.
2. Yellow. Immerse in nitrate (up to 100 gm), rinse well and immerse in the chromate solution (up to 100 g), finally rinse again. Chromate is a carcinogenic compound!
3. Green. Immerse in the sulphate solution, rinse and immerse in the sulphide solution, rinse again.
4. Blue. Immerse in sulphate, rinse, immerse in potassium ferrocyanide, rinse again (50°C).
5. Reddish brown. Immerse in sulphate, rinse and immerse in ferrocyanide solution, rinse again.
6. Dark brown. Immerse in an acetate solution, rinse and immerse in sulphide, rinse again.
7. Black. Immerse in an acetate solution (up to 100 gm), rinse well, immerse in sulphide (up to 25 gm), rinse again.
8. Golden yellow. Immerse in the thiosulphate (up to 50 gm), rinse, immerse in a permanganate (up to 50 gm), rinse again.
9. Yellow. Immerse in acetate, rinse well, immerse in sulphide, rinse again.
10. Orange. Immerse in chromate, rinse well and immerse in nitrate (up to 10 gm), rinse

again. Chromate is carcinogenic compound!

INGREDIENTS,grams on
liter of water

COLOURING OF TIN,LEAD AND NICKEL

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Bismuth nitrate	5								3	
Nitric acid	50								100	
Tartaric acid	80									
Ammonium chloride		30		3	32					
Molybden acid		7,5								
Iron-III-chloride			200							100
Copper acetate				12						
Vinegar				20						
Copper sulphate						20	X			
Hydrochloric acid									40	500
Potassium bichromate					7,5					
Potassium permanganate						5				
Acetic acid					31					
Potassium rhodanide								0,5		
Sulphuric acid, ccm								5		
Hydrogen peroxide 30 %, ccm								25		
Chromic acid					6,25					
Copper nitrate					62					
Potassium hydrogentartarate							X		10	

ADDITIONAL EXPLANATIONS: tin,lead,nickel

1. Black on tin.Nitric acid in ccm,tartaric in grams.Immerse objects in heated solution(70 C).When colour is developed rinse well,dry and wax.
2. Black on tin.Immerse objects in the hot solution.
3. Greyish black on tin.Immerse objects in the solution.
- 4.Bronze brown on tin.Dissolve ingredients in 0,5 lit water acidified with nitric or hydrochloric acid.
- 5.Green patina on lead.A temperature of the solution 35-40 C.Copper nitrate 62,5 gm!
Potassium bichromate is carcinogenic compound!
6. Brown on lead.A temperature of the solution 70-80 C/ 1-5 minutes
7. Bronze colour on tin.Mix diluted solution of copper sulphate and cream of tartar,Rubb it on an object.
- 8.Black on nickel.Immerse objects in the cold solution(15 C).Use only fresh solution!
9. Steel grey on tin.Nitric acid in ccm,hydrochloric in grams.
- 10.Black on lead.Acid in mll!

ADDITIONAL EXPLANATIONS: Lustre(interference) colours

1. For brass.Pink-blue-black(one after another).Immerse objects in the hot solution.
2. For copper/copper alloys,iron and steel(blue,black,brown),silver,nickel,gold,platinum.Colour sequence on brass:golden yellow-copper-violet-dark blue-light blue-chromium like-nickel like-reddish grey.
Temperature 25 -30 °C.
3. For brass.Immerse objects in the solution for 30-120 seconds.Rinse and dry.
4. For brass.Pink-blue-black.Hot solution.
5. For brass.Golden yellow-orange-carmine red.Do not lacquer!
6. For zinc.Yellow-brown-purple-violet-indigo blue.
7. For brass.As 2.The solution must stay for 4 days, before use..
8. For zinc.At 10 C temp.:2 minutes violet-3 minutes blue-4,5 minutes green-6,5 minutes yellow-8,5 minutes purple red.Do not lacquer!
9. For zinc.Rainbow colours.Use cold solution.Dissolve sulphate,then add acid and as last hydroxide.
10. For brass.Rainbow colours.Hot solution.

INGREDIENTS,grams on
liter of water

ELECTROLYTIC COLOURING /I

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Sodium bicarbonate	100									
Copper sulphate		23				70	96	8		
Potassium bichromate		89								
Ammonium chloride			40							
Sulphuric acid									1 L	
Potassium-sodium-tartarate						160				
Potassium hydroxide						300				
Sodium hydroxide				25			108			
Lactic acid							150			
Lead nitrate				25						
Borax								125		
Sodium bichromate									7,5	200
Sodium sulphate										5
Phosphoric acid					X					

ADDITIONAL EXPLANATIONS: Electrolytic colouring /I

1. Green on copper. Object = cathode, anode = stainless steel, 40 v, 15 A/dm². Potassium or sodium carbonate can be used too. Voltage and current density can be much weaker.

2. Yellow green on copper. Object = cathode, 6 v, undefined current density. Potassium bichromate is a carcinogenic compound! If we use a solution of ammonium nitrate and sodium nitrate (50 gm/50 gm) the colour will be blue green. 1 A/dm², max. 4 v

3. Red and green on copper/copper alloys. 2 v, object = anode

4. Green on gold and gilt objects. Dissolve every component in a half liter of the water, then mix solutions together. Object = anode, cathode = stainless steel or platinum. Small cathode (needle), big anode. Distance between electrodes 1 cm. 15 minutes. Colours platinum blue. If we use the lead acetate solution (100g/lit) result will be Nobilis rings (rainbow colored rings) if anode is gold or gilt. Other usable solutions: manganese sulphate (50 gm/lit), ammonium sulphate (25 gm/lit), manganese acetate (67 gm/lit), manganese chloride (125 gm/lit) copper acetate,

5. For titanium, colours depend on voltage, stainless steel cathode, object is anode.
Straw yellow/10 v - purple/29 v - blue/30 v - blue green/45 v - light green/55 v - purple red/75 v - grey/110 v

Danger! Potentially deadly voltage! Use rubber gloves!

6. Black on copper. 2-4 A/dm², 20 minutes, object = anode, cathode stainless steel

7. Different colours on copper. Violet, blue, green, yellow, orange, red. Voltage 0,25 v, current density 0,15 A/dm². Object = cathode, anode copper. There are other formulas too: copper sulphate 40/45/50, hydroxide 35/40/50, sugar 85/90/100 - gm/lit. A solution of 60 gm copper sulphate/50 gm hydroxide/100 gm sugar is another possible option. Or solution of 100 gm copper sulphate / 355 gm citric acid/246 gm NaOH. Or 15 gm copper sulphate and 150 gm borax.

8. Different colours on tin. Yellow-green-red-blue. 35-40 C. Current density 0,005-0,010 A/dm². Duration 3-20 minutes. Anode copper.

9. For stainless steel (CrNi 18/8). Object = anode, cathode lead. 70-95 C. 1,3 v. 0,06 A/dm². 5-50 minutes.

Colour sequence: brown-blue-yellow-red brown-purple-green

Sodium bichromate is a carcinogenic compound!

10. Black on zinc. Object=anode, pH 2,5-4,5. 0.5-5 A/dm². 1,5-4 v. Temp. 15-25 C
Sodium bichromate is carcinogenic compound!

ADDITIONAL EXPLANATIONS: Electrolytic colouring/II

11. For stainless steel, boiling solution, cathode = stainless steel, 15 minutes, up to 0,4 A/dm², golden, brown, red, blue

12. For niobium, object = anode, cathode stainless steel, colours depends on voltage violet/15-16 v + blue/20 v + yellow/50 v + magenta red/60 v + turquoise/80 v + pink/100 v

Danger! Potentially deadly voltage! Use rubber gloves!

13. Black nickel, pH 5,6-5,9, up to 2 A/dm², 55 C temp., 0,5-1,5 v. Nickel anode.

14. Black chromium, measures in ozs/gallon water. Up to 20 A/dm². Chromium compounds are carcinogenic!

15. Green nickel. pH 6,4. Up to 1,5 A/dm²

16. Different colours for zinc, aluminium, copper, brass, steel. Add up to 2,4 gm zinc chloride. Sodium chloride 0-100 gr. Sodium lactate in ml! 27 C. Up to 0,12 A/dm². according to USA patent USPT6,800,190

17. Blue nickel. Add 0,5 gm butylene 1.4 diol. Temp. 50 C. Nickel anode.

18. Bancrofts blue on copper. Anode and cathode copper. 0,45 A/dm². Cathode must be covered with gelatinous brown coating, then rinse well and immerse in solution of 50 gm copper acetate/1 lit. water - blue colour will be formed. It must be lacquered!

19. Different colours on steel. First we treat object as cathode for 2 minutes, and then next 5 minutes as anode. Voltage 0,5-2 v, current density up to 5 A/dm². Violet, blue, red brown, yellow.

20. Black on tin. Add 10 ml phosphoric acid (1,75 gm/cm³). 90 C, 6 minutes, cathode copper, 3-4 A/dm²

INGREDIENTS,grams on liter of water

JAPANESE PATINATION

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Copper acetate			40			30				
Copper sulphate	50	5			30					3
Lime							35			
Vinegar	1 L								1 L	1L
Sulphur							100			10
Sodium chloride	10									10
Rokusho		5								
Iron cuttings									200	
Ammonium chloride		2,5		3	3	3		40		
Calcium chloride								25		
Sodium hydroxide			14							
Calcium carbonate			14							

ADDITIONAL EXPLANATIONS: Japanese patination

Important!

We must use copper or pyrex glass (add some copper cuttings) pot for heating of solutions. Only copper or wooden tools must be used, any contact with iron must be avoided!

1. Su-tanpan, mainly used as base for other colours, can be used for colouring of copper/copper alloys, violet to bluish black on shibuichi, silver (dark grey), zinc (black). Instead vinegar we can use water too. Immerse objects in hot or cold solution.
2. Niage, mainly used as base for other colours, light green on brass, matt black on copper, light to dark grey on shibuichi (japanese alloy, 75 parts copper/25 parts silver), can be used without ammonium chloride too. Immerse objects in cold or hot solution.
3. Rokusho, important ingredient of Japanese patinas, instead it we can use described solution as substitute. Dissolve compounds in water, then after 7 days filter it and use filtrate as rokusho substitute – 30 gms must be obtained/more or less.
4. Enka, for copper/copper alloys, green to yellow green. Use 1. or 2. as base. Immerse object in hot solution-
5. Ryusan-do, for copper/copper alloys, green to blue green, use 1. or 2. as base. Brush it on object.
6. Sakusan-do, light blue for copper/copper alloys. Use 1. or 2. as base. Brush it on object.
7. Ryoka, for copper and silver (bluish black). Immerse object in solution.
8. Furubi, black for silver. Immerse objects in solution.
9. Ohagura, heat cuttings to red glow, then drop it in vinegar, after 5-6 months standing we can use solution, we must use solution as concentrate which must be diluted with 4 parts water. For copper/copper alloys (reddish colour on bronze), iron and steel (grey to black).
10. Sabi-tsuke, for iron and steel, brush it on object, when colour is Ok rinse well in baking soda solution, finish with wax or oil.

HEAT COLOURING OF METALS

Very simple process. A metal must be heated to the specific temperature, when the colour is developed, the process is ended. A heating must be, in principle, indirect (without contact with an open flame). A kiln with precise temperature control must be preferred. Hot air gun can be used too.

1. HEAT COLOURING OF IRON AND STEEL

yellow/228 C-brown/254 C-purple red/265 C-slight blue/264 C-dark blue/293 C

2. HEAT COLOURING OF STAINLESS STEEL

light yellow/290 C-brown/390 C-purple/450 C-blue/540 C-dark blue/600 C

3. HEAT COLOURING OF TITANIUM

light yellow/371 C-purple/412 C-blue /440 C-light green/510 C-brownish grey/635 C

4. HEAT COLOURING OF COPPER/COPPER ALLOYS

When we heat copper or its alloys to 161-341 C interference colours develop first. Sequence: light brownish orange-reddish brown orange-rose reddish orange-rose red-rose reddish violet-purplish blue-violet white-steel white-yellowish white-brass yellow-dark yellow-meat red-pinkish blue-bluish green. At higher temperatures (more than 600 C) red and black oxides.

5. HEAT COLOURING OF DIFFERENT METALS IN BLACK

This treatment can be used on any metal, if it can be heated to 200-400 C. It was used in the Late Middle Ages on copper (email brun) and iron or steel. Metal must be rubbed with linseed oil (very sparingly) and heated slowly to 200-400 C. Repeat if needed. Instead of oil we can use 20% shellac solution.

Other oils can be used too (sunflower, olive, peanut, soy).

ADDITIONAL EXPLANATIONS: Degreasing

1.2.3.4. Solvent degreasing. 1., 2., 3. flammable, 4. not flammable but toxic. Mixture of gasoline and trichloroethylene not flammable but toxic too!

5. For copper and its alloys, iron, silver, gold and nickel—immerse objects in a boiling solution. Safety goggles and rubber gloves must be used. Very harmful for the skin and mucous membranes. After degreasing, rinse well and then brush with lime and chalk slurry. Then rinse well again with water, and then with diluted citric acid (35-50 gm/lit.). Rinse once more and dry.

6. For copper and its alloys. Same process as 5., temperature of the solution 70-80 C, duration 3-4 minutes.

7. Electrolytic degreasing for copper and its alloys. $5-2,5 \text{ A/dm}^2$, 30 C, voltage 6 v. Simple electrolyte can be used too (50 gm sodium hydroxide or 25 gm sodium hydroxide/25 gm sodium carbonate).

8. i 9. Same as 7. For aluminium, tin(8.), zinc, lead.

10. Electrolytic degreasing. Treatment same as 7.

ADDITIONAL EXPLANATIONS: Pickling,chemical polishing ,matt finish/I

1. For iron and steel,copper and its alloys,silver,zinc(20-50 ml/lit only).We can add up to 1 % of the scotch glue or gelatine.You must slowly add acid to the water!
2. For iron and steel.
3. For tin.
4. For copper/copper alloys.Prepickling before polishing.
5. For copper and its alloys.Chemical polishing.Work under strong ventilation.Slowly add sulphuric to nitric acid,soot and hydrochloric acid must be added last-when the solution is cold.The gas formed during the application is toxic.If we add 5% zinc sulphate the result is matt finish.
6. For iron and steel,chemical polishing.Use only fresh solution!
7. For aluminium,chemical polishing.Phosphoric acid density 1,75,nitric 1,42,sulphuric 1,84.95-100 C.15-60 seconds..
8. For aluminium,we can add 30 gm sodium chloride.
- 9.Chemical polishing of copper/copper alloys.No toxic gas!Only 800-890 mll water! Peroxide 60-150 mll.Use only fresh solution!
10. Matt finish for copper and its alloys.Before use it must stay 24 h/30-40 C.No toxic gas!Chromium compounds are carcinogenic,use rubber gloves!

ADDITIONAL EXPLANATIONS: Pickling,chemical polishing,matt finish/II

- 11.For austenitic stainless steel. Acid concentration 25 %,55-65 C temp. You must work in a well wentilated room!
- 12.For austenitic stainless stell. Acid concentration 30 %.
- 13.Gold electropolishing.Temp. 50-60 C,1-3 minutes,current density 1,5-3,5 A/dm²,object= anode
- 14.Silver electropolishing .Duration 20 seconds,current density 1,5 A/dm²,object= anode,measures in mll,without water!
- 15.Copper electropolishing. Acid in grams,water in mll,object=anode
- 16.A chemical polishing of the stainless steel,in volume percents,add 10 gm soot,temp.80 C!
- 17.For steel wire,1000 cm³ water!
- 18.For magnesium sheet,not for cast objects!
- 19.For nickel,in volume percents!
- 20.Satin finish for aluminium. Up to 260 gm hydroxide,sodium nitrate 120-160 gm,dextrine 1 gm,trisodium phosphate up to 80 gm. Temp.70-80 C. Duration 30-60 seconds!

INGREDIENTS,grams on
liter of water

IMMERSION PLATING / I

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Tin chloride	15								5	
Sodium sulphate	160									
Hydrochloric acid	X									
Sodium hydroxide			200							
Nickel sulphate										250
Sodium chloride					20	30				
Basic copper carbonate		X								
Silver chloride					10					
Potassium carbonate						30				
Potassium nitrate							1			
Copper sulphate								20	5	
Potassium ferrocyanide						30				
Gold chloride						7	7			
Ammonia 25 %								50		
Tartaric acid								X		
Zinc powder			X							
Silver nitrate				15						
Sodium thiosulphate				30						
Ammonium chloride		X		10			3,5			250
Potassium bitartrate					20					

ADDITIONAL EXPLANATIONS: Immersion plating/I

1. Tining of iron. Dissolve ingredients, add a few drops of acid. Immerse objects on perforated zinc sheet and cover them with zinc cuttings. Duration 45 minutes.
2. Brassing by friction. Take 10 parts saturated ammonium chloride solution and 1 part basic copper carbonate. Rub it on the object.
3. Zinc plating for copper. In a boiling lye add zinc dust in small portions, until some zinc dust stayed undissolved. Hang object in the solution until zinc coating is satisfactory.
4. Bright silvering for copper and copper alloys. Dissolve nitrate in 50 gm water, add ammonium chloride dissolved in the same amount of water, and at the end add sodium thiosulphate solution (in 900 ml water). Immerse objects in the solution, bigger objects must be splashed or sprayed. Brush objects with fine brass wire scratch brush, which is previously immersed in the soapy water or stale beer. Rinse well. Keep in dark bottle.
5. Silvering paste for copper and copper alloys. Mix thoroughly dry ingredients, add the smallest possible amount of water and rub it on an object with a piece of leather, cork or cloth. Rinse well and brush with fine brass wire previously immersed in the soapy water or stale beer. Rinse well and lacquer as soon as possible.
6. Gilding for copper and copper alloys. Dissolve chemicals one after another, gold chloride last. Immerse objects in a hot solution, rinse well, brush them with fine brass wire brush, previously immersed in soapy water or stale beer, rinse well, dry and lacquer. Never try to mix the solution and acids! Deadly dangerous!
7. Gilding powder. For silver and copper/copper alloys. Dissolve chemicals in 200 ccm water, moisten small linen cloth with solution, and when it is dry burn it. Obtained ash is gilding powder - with piece of cork moistened with vinegar take some powder and rub it on an object. Rinse well, brush with fine brass wire brush previously moistened with soapy water or stale beer, rinse again, dry and lacquer.
8. Coppering of iron and steel. Add tartaric acid until pH is 3,5!
9. Bronze finish for iron and steel.
10. Nickeling of copper. Temperature of the solution 100 C, objects must be hanged on aluminium or zinc wire.

ADDITIONAL EXPLANATIONS: Immersion plating/II

1. Coppering for zinc. Immerse objects. When copper coating is formed take it out and rinse well. 50 ccm ammonia.
2. Platinizing for copper and copper alloys. Dissolve salt in a hot water, add platinum chloride, add hydroxide, until pH is 9. Immerse objects in the hot solution.
3. Zincing of aluminium. Dissolve zinc sulphate in 1 lit. water, dissolve hydroxide in 1 lit water, mix solutions and immerse objects in the hot solution (50 C), objects must be moved in solution, duration 20 seconds.
4. Coppering of iron and steel. Immerse objects (4 seconds). Rinse well.
5. Coppering for tin and pewter. Dissolve tartarate in a half liter of water, add hydroxide, in another half liter of water dissolve sulphate, mix solutions and immerse objects hanged on aluminium or zinc wire. The temperature of solution 90 C.
6. Coppering for aluminium. The solution must be acidified with tartaric acid, pH 3,5/temp. 100 C.
7. Zincing of iron and steel. Immerse objects in hot solution.
8. Nickelizing of iron and steel. Correct pH to 9 (with ammonia), then acidify with tartaric acid, pH must be 3. Immerse objects hanged on aluminium or zinc wire.
9. Nickelizing by friction. The solution must be acidified with few drops of sulphuric acid. Moisten piece of cloth with solution, take some fine zinc fillings and rub it on an object. Rinse well and dry. For copper and coppered iron or steel.
10. Nickelizing of zinc. Immerse objects in heated solution. Dilute if works too fast.

INGREDIENTS,grams on
liter of water

ELECTROPLATING /I

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Copper sulphate	250									
Sulphuric acid	75					2,5				
Copper pyrophosphate		110								
Potassium pyrophosphate		400					100			
Zinc sulphate			200							
Sodium sulphate			50							
Tin chloride				17						
Sodium phosphate				35						75
Nickel sulphate					68					
Sodium citrate					35					
Chromic acid						250				
Silver pyrophosphate							25	20		
Ammonium carbonate							25			
Potassium ferrocyanide								40	15	
Potassium carbonate								40	15	
Gold chloride									4	1
Aluminium sulphate			30							
Sodium sulphite										2,5
Boric acid					1					
Dextrine			10							
Ammonia 25 %								1		

ADDITIONAL EXPLANATIONS: Electroplating/I

1. Acid copper plating. Can be used for electroforming. 3-5 A/dm². Voltage 2,6 v. Temperature 30-40 C. Copper anode.
2. Pyrophosphate coppering. Add 19 gm citric acid and 3 gm ammonia(25%). Copper anode.
3. Acid zinc plating. 2 A/dm², 3-4 V, temp. 20 C, anode electrolytic zinc.
4. Tin plating. Tin anode.
5. Nickel plating. 0,3-0,6 A/ dm², pH 5,6; 3 V, anode nickel.
6. Chromium plating. 10-20 A / dm², 35 °C - 40 °C, anode lead. The compounds used for chromium plating are carcinogenic and dangerous for environment! Imitation of chrome plating, based on cobalt and zinc alloy can be used instead.
7. Silver plating. Anode stainless steel.
8. Silver plating. Anode stainless steel, 0,5 A/dm², 2,3 V, 20 °C, ammonia 1 cm³.
Chemicals must be dissolved one by one(after previous compound is dissolved!) in boiling water, add silver chloride as last(fresh is the best-mix silver nitrate solution and kitchen salt solution). Must be boiled 30-180 minutes, filter when cold .Never try to mix solution and acids-it is deadly dangerous!
9. Gold plating. 4 V, 0,6 A/dm², 20 °C, anode stainless steel. Same process as 8. Never try to mix solution and acids-deadly dangerous!
10. Gold plating. Stainless steel anode.

INGREDIENTS,grams on
liter of water

ELECTROPLATING /II

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Nickel sulphate	50									
Ammonium tartrate	36									
Silver chloride								40		
Platinum chloride		4								
Sodium phosphate		100								
Ammonium phosphate		20								
Basic copper carbonate							8			
Zinc oxide							8			
Potassium sodium tartarate					200		260			180
Sodium hydroxide							40			50
Potassium ferrocyanide								200	200	
Potassium carbonate								20	40	
Gold chloride									50	
Tin chloride			9,4							
Copper sulphate						30				35
Rhodium sulphate				2						
Iron -II-sulphate					40					
Sodium pyrophosphate			75							
Citric acid						20				
Glycol						48				

ADDITIONAL EXPLANATIONS: Electroplating/II

1. Nickel plating. Dissolve chemicals in the half liter of water, add 0,5 gm tannin, when it is dissolved add another half liter of water, pH 7. Nickel anode.
2. Platinum plating, for copper, silver and gold. Dissolve sodium phosphate, add ammonium phosphate, add platinum chloride. Anode platinum or stainless steel.
3. Pyrophosphate tin plating. Add 6,26 gm dextrine. Temp. 60 C.
4. Rhodium plating. Rhodium sulphate 2-3 gm /metal content/, sulphuric acid 40-60 gm. 1,5-2 A/dm², temp. 15-25 C.
5. Iron plating. Dissolve in 0,6 lit water, and then add 0.4 lit ammonia (25%). Iron anode.
6. Copper plating. Sulphate 15,6-31,2 gm, glycol 16-48 gm. Temp. 18-25 C. Current density 0,5-1,5 A/dm².
7. Brass plating. 0,5-0,7 A /dm²; 50 °C, pH 13,2-13,6. Anode brass!
8. Silver plating. For copper and its alloys, tin, iron. Dissolve potassium ferrocyanide in the boiling water, add carbonate and when it is dissolved add silver chloride (fresh is the best). Boil 30-180 minutes. Filter when cooled. Anode stainless steel or fine silver. 12 ml ammonia can be added too. Plated object must be then scratch brushed with fine brass wire brush, previously dipped in soapy water or stale beer. Can be used for electroforming too. Never try to mix solution and acids. Deadly dangerous!
9. Gold plating. For copper and its alloys, silver, tin, iron. Same process as 8. Anode stainless steel or platinum. Plated objects must be scratch brushed with fine brass wire brush, previously immersed in soapy water or stale beer. Can be used for electroforming too. Never try to mix solution and acids. Deadly dangerous!
10. Copper plating. Copper sulphate 35-40 gm, tartarate 180-190 gm, hydroxide 50-60 gm. Temp. 20 C. Current density 0,3-1,5 A/dm².

SHORT INSTRUCTIONS FOR SUCCESSFUL AND SAFE COLOURING AND PLATING OF METALS

1. EVERY METAL OBJECT CAN BE COLOURED ONLY IF IT IS PREVIOUSLY CLEANED FROM GREASE, OXIDE AND OTHER IMPURITIES (STANDARD WORKING CYCLE-DEGREASE+ PICKLE+ RINSE+ COLOUR OR PLATE+ RINSE+ DRY+ WAX OR LACQUER+ IN SOME CASES NEUTRALIZATION STEP CAN BE INCLUDED TOO!). FOR THE BEST RESULTS USE ONLY DISTILLED WATER!

2. IF TREATED METAL CANNOT BE COLOURED TO DESIRED COLOUR WE MUST COVER THEM WITH METAL WHICH CAN BE COLOURED TO DESIRED COLOUR.

3. OBJECTS CAN BE SPRAYED OR BRUSHED WITH SOLUTION OR IMMERSSED IN SOLUTION FOR COLOURING. SAWDUST, PAPER OR TEXTILE CUTTINGS CAN BE MIXED WITH SOLUTION AND THEN APPLIED. THIS METHOD CANNOT BE USED WITH OXIDIZING COMPOUNDS BASED SOLUTIONS. IN SOME CASES COLOURING CAN BE SPEEDED WITH GAS TORCH OR HOT AIR GUN.

FINALLY OBJECTS CAN BE WAX OR LACQUER FINISHED.

4. SIMPLE CURRENT SOURCE FOR ELECTROPLATING IS A BATTERY. BEST CURRENT SOURCE IS PLATING RECTIFIER .AN OBJECT MUST BE CONNECTED TO THE NEGATIVE POLE AND ANODE TO THE POSITIVE POLE(EXCEPT IN THE CASE OF ANODIZING). WE CAN USE PLASTIC ,GLASS OR ENAMELLED IRON CONTAINERS.

5. ALL CHEMICALS USED IN COLOURING OR PLATING OF METALS ARE LESS OR MORE TOXIC ,SO WE MUST USE SAFETY GOGGLES, RUBBER GLOVES AND PROTECTIVE CLOTHING. IN SOME CASES WE MUST USE GAS MASK WITH APPROPRIATE FILTER. ALL FORMULAS BASED ON POTASSIUM OR SODIUM CYANIDE, ARSENE OR MERCURY COMPOUNDS ARE OMITTED! PROCESSES BASED ON CHROMIUM, ANTIMONY, SELENIUM AND LEAD ARE INCLUDED BUT AUTHOR CANNOT RECOMMEND THEIR USE!

6. STRONG OXIDIZING COMPOUNDS USED IN SOME OF THE FORMULAS MUST BE HANLED WITH CAUTION BECAUSE OF THE FIRE HAZARD AND

THEIR EXPLOSIVE NATURE. NEVER MIX THEM TOGETHER OR WITH ORGANIC MATERIALS OR SOLVENTS(POTASSIUM , SODIUM AND AMMONIUM NITRATE, CHLORATE , PERSULPHATE AND CHROMATE)!

7. ALL CHEMICALS MUST BE CLEARLY LABELED AND KEPT OUT OF REACH OF THE CHILDREN OR UNTRAINED PERSONS!

8.EXPIRED SOLUTIONS MUST BE DILUTED WITH AT LEAST 4 PARTS OF THE WATER TO THE ONE PART SOLUTION AND THEN NEUTRALIZED TO THE NEUTRAL PH. ONLY AFTER THAT STEP WE CAN THROW THEM AWAY.

EXPIRED SOLUTIONS BASED ON COMPOUNDS OF CHROMIUM, LEAD ,ANTIMONY, NICKEL, SELENIUM OR FERROCYANIDES MUST BE TREATED BY AUTHORIZED PERSONAL. BEFORE ANY FORM OF DISPOSAL, LOCAL LAW REGULATIONS MUST BE CONSULTED!

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RECOMMENDED WEBPAGES:

1. Finishing.com- best forum dedicated to electroplating, colouring of metals and metal finishing

www.finishing.com/

2. Products Finishing Online- very good site too

www.pfonline.com/

3. Internet Archive- excellent website, there you can find many 19-th century electroplating and electroforming handbooks + 3 books on colouring of metals (Hiorns, Kaup, Buchner)

www.archive.org/

4. Download free book on metal colouring Chemische Faerbung von Kupfer und Kupferlegierungen, publisher is Deutsches Kupfer Institut (German Copper Institute)

www.kupfer-institut.de/front_frame/pdf/chemische-Faerbungen.pdf

5. Russian site dedicated to electroplating and metal finishing, here you can download many old ex USSR plating handbooks

www.galvanicus.ru

6. Another Russian site dedicated to electroplating and surface finishing, many old download free plating handbooks too

www.galvanicworld.com

7. United States Patent and Trademark Office- there you can download hundreds of expired patents on electroplating, metal colouring, electroforming, corrosion inhibitors, anodizing, conversion coatings, rust converters etc.

www.uspto.gov

8. Searchable database dedicated to surface finishing

<http://surfacequery.com>

9. German website dedicated to surface finishing

www.galva-projekt.de

10. Patinas for copper, brass and bronze

www.sciencecompany.com/patinas/patinaformulas.htm

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