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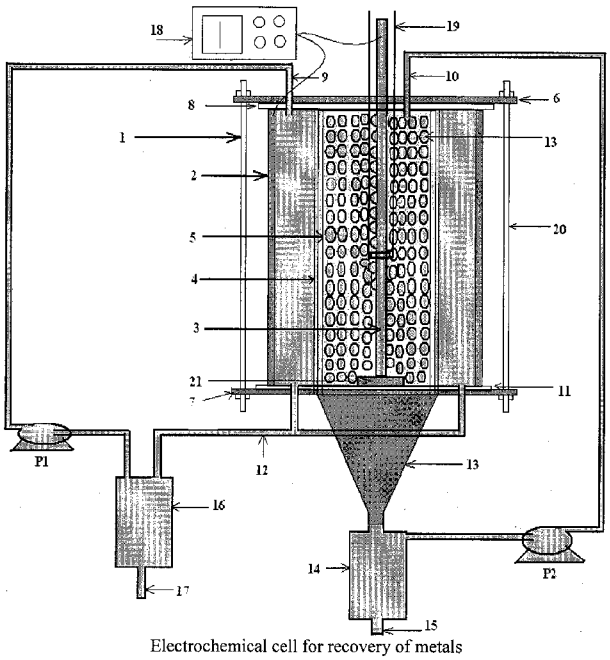
(54) Title: ELECTROCHEMICAL CELL USED IN PRODUCTION OF HYDROGEN USING CU-CL THERMOCHEMICAL CYCLE




Electrochemical cell for recovery of metals

(57) Abstract: The electrochemical cell consists of hollow tube and centralized copper rod. The tubes have first and second ends. The first end cap is used to close the first open end. The anolyte inlet is extended through the first end cap in anolyte compartment and catholyte inlet is extended through the first end cap in catholyte compartment. The anolyte and catholyte compartments are separated by ion exchange membrane fixed over inner hollow tube having holes on the surface. A first Teflon gasket has provision for inlet of anolyte and catholyte tube is secured between first tubes end and first end cap. The copper rod is placed at the centre of the tubes acts as cathode. The circular ring works as scrapper to take out deposited copper is provided. A second end cap is used to close the second open. A second Teflon gasket is secured between second tubes end and second end cap. The second end cap has provision for anolyte outlet and comprises a conical dome to collect the deposited copper and transport it along with catholyte. The anolyte trappers and catholyte trappers are connected through the tubes to anolyte and catholyte half cells. The anolyte and catholyte are re-circulated through peristaltic pumps, one on each side.

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AMENDED CLAIMS
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We claim,

1. An electrochemical cell for recovery of metals comprising of;
   a) at least one anode disposed in electrolyte;
   b) at least one cathode disposed in electrolyte;
   c) at least one ion exchange membrane disposed between anode compartment and cathode compartment;
   d) a corrosion resistant material as a support to ion exchange membrane;
   e) at least one scrapper to remove deposited metal from the cathode;
   f) at least one catholyte trapper to collect scrapped metal powder;

   characterized that cathode and anode have surface area ratio in the range of 1:6 to 1:50 and said support with openings of any geometrical shape having surface area covered in the range of 10% to 95% of total area of said support.

2. An electrochemical cell according to claim 1, wherein a cathode is coaxial and at the center of an anode.

3. An electrochemical cell according to claim 1, wherein an anode is composed of corrosion resistant conductive metals, conductive carbon material and any non-conductive material coated by conductive materials.

4. An electrochemical cell according to claim 1, wherein an anode is graphite.

5. An electrochemical cell according to claim 1, wherein an anode is hollow.

6. An electrochemical cell according to claim 1, wherein a cathode is composed of corrosion resistant conductive metals, conductive carbon material and any non-conductive material coated by conductive materials.

7. An electrochemical cell according to claim 1, wherein a cathode is copper.

8. An electrochemical cell according to claim 1, wherein an anode is of any geometry.

9. An electrochemical cell according to claim 1, wherein both ends of anode are kept open.

10. An electrochemical cell according to claim 1, wherein cathode and anode have surface area ratio preferably in the range of 1:6 to 1:15.

11. An electrochemical cell according to claim 1, wherein support is made of corrosion resistant and non-conductive material.

12. An electrochemical cell according to claim 1, wherein support is composed of a ceramic, thermoplastic or thermoset polymeric material.

13. An electrochemical cell according to claim 1, wherein openings of any size and shape on the support are uniformly distributed.

14. An electrochemical cell according to claim 1, wherein in the scrapper provided is composed of corrosion resistant and non-conductive material.

15. An electrochemical cell according to claim 1, wherein support is composed of a ceramic, thermoplastic or thermoset polymeric material.

16. An electrochemical cell according to claim 1, wherein the deposited particles size of copper powder obtained has particle size in the range of 0.001-1000 μm.

17. An electrochemical cell according to claim 1, wherein said scrapped metal powder are copper, silver, zinc, and lead.

18. An electrochemical cell according to claim 17, wherein scrapped metal powder is copper.

19. An electrochemical cell according to claim 1, wherein anode and cathode are partially coated with corrosion resistant and non-conductive material.

20. An electrochemical cell according to claim 1, wherein cathode is partially coated with corrosion resistant and non-conductive material.

21. An electrochemical cell according to claim 1, wherein anode is partially coated with corrosion resistant and non-conductive material.

22. An electrochemical cell according to claim 1, wherein cathode is partially coated with non-conductive material.

23. An electrochemical cell according to claim 1, wherein cathode is partially coated with non-conductive material at least in one plane.

# STATEMENT UNDER ARTICLE 19 (1)

Re: PCT International Application No. PCT/IN2012/000486
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Applicant: **YADAV, GANAPATIDADASAHEB**
Title: ELECTROCHEMICAL CELL USED IN PRODUCTION OF HYDROGEN USING CU-CL THERMOCHEMICAL CYCLE
Priority: 1975/MUM/2011 8.07.2011 IN
Agent's File Ref.: PIICP 1303

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The present invention relates to tubular electrochemical cell for electrolysis of cuprous chloride and copper powder. The material used for fabrication of cell is dense graphite tube as anode and dense copper rod as cathode, separated by ion exchange membrane supported by acrylic tube. This electrochemical cell is characterized by the surface area ratio of cathode and anode, that cathode and anode have surface area ratio in the range of 1:6 to 1:50 and said support with openings of any geometrical shape having surface area covered in the range of 10% to 95% of total area of said support.

**With reference to item V, point 1, 2 and 3 and Item VIII:** Claim 1 has been suitably amended by merging dependent claim13,14 and 16 in claim 1 supported by specification on page 8 para 2 as mentioned below;

Claim 1: An electrochemical cell for recovery of metals comprising of;

a) at least one anode disposed in electrolyte;
b) at least one cathode disposed in electrolyte;
c) at least one ion exchange membrane disposed between anode compartment and cathode compartment;
d) a corrosion resistant material as a support to ion exchange membrane;
e) at least one scrapper to remove deposited metal from the cathode;
f) at least one catholyte trapper to collect scrapped metal powder;

characterized that cathode and anode have surface area ratio in the range of 1:6 to 1:50 and said support with openings of any geometrical shape having surface area covered in the range of 10% to 95% of total area of said support.

D1: US 4,028,199 discloses a method for producing a metal powder from a dilute aqueous solution of metal by using electrolytic cell preferably diaphragm cell. The electrolytic cell includes a rotating cylinder cathode. The peripheral speed of rotating cylindrical cathode affects the cathodic current density. Whereas our invention discloses the electrochemical cell comprising of hollow tube acting as anode and in the center of hollow tube a fixed copper rod acting as a cathode. The anolyte and catholyte compartment are separated by ion exchange membrane. Two separate pumps are used for recirculation of the anolyte and catholyte solution in respective compartment. The flow rate of electrolyte affects the cathodic current density. Surface area ratio of cathode and anode which influences voltage and current density is not disclosed in D1.

D2: US 2005/0067291 A1 discloses a method of producing high purity electrolytic copper by electrowinning process. Electrochemical cell comprises plate type anode and cathode. It teaches that leach liquor obtained from chloride leaching chalcopyrite is fed as electrolyte in the cathode compartment and copper is electrowon through electrolytic reduction carried out on cathode surface. After the copper concentration decreases in the cathode compartment the electrolyte permeates to the anode compartment. Electrolytic oxidation is then carried out in the anode compartment and the electrolyte is removed from anode compartment. The electrochemical cell design disclosed in US 2005/0067291 A1 is different from the design mentioned in present invention. The present invention is based on cylindrical anode and cathode which involves electrolysis of acidic cuprous chloride solution obtained from other reactions of Cu-Cl cycle, which is oxidized and reduced simultaneously at anode and cathode respectively.

D3: US 2006/0016696 A1 discloses a system and method for producing a metal powder product using conventional electrowinning chemistry i.e. using oxygen evolution at anode in a flow through electrowinning cell, wherein anode and cathode are not separated by any means. The present invention discloses the electrolytic cell design for electrochemical production of metal with no evolution of any oxygen at anode. US 2006/0016696 A1 discloses anode and cathode are not separated by any means and displacement of metal

deposited is done by mechanical vibration or pulsed flow system. Whereas our invention comprises anode and cathode separated from each other by ion exchange membrane and mechanical scrapper is attached to cathode for displacement of deposited metal powder.
By the way of explanation we have made amendment in claims such that dependent claims are clear and supported by independent claims.

The present invention claimed under the amended set of claims in particular the amended principal claim 1 and claim**10, 15, 19, 20 and 21** are now directed to the electrochemical cell with surface area ratio of cathode to anode, this surface area ratio utilizes minimum voltage and gives maximum cathodic current density and minimum particle size which is achieved by invention of ours and is not disclosed in any of the prior art for D1 to D3.D1 discloses rotating cathode offering better mass transfer due to which desired particle size is not achieved. D1 also discloses very high cell voltage requirement. Whereas D2 utilizes more voltage and hence gives higher current density. Anode and cathode are not concentric and there is no correlation of cathode and anode surface area ratio.

Further referring to point 1.1, the mentioned "corrosion resistant and non-conductive material" is explained in the specification on page 8 para 3, as said it is found that support is made of corrosion resistant and non-conductive material and can be selected from a ceramic, thermoplastic or thermoset polymeric material. Further 1.2 and point 2, the scale is amended and the deposited particle size particularly refers to figure 5, wherein the particle scale from micron is amended to micrometer.

As suggested the statement of claims has been amended. This may kindly be taken as amended claims under Article 19 of the PCT.