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Optimization of Energy and Production Process Modeling of Zinc

Mansour Kalbasi, Abbas Hedayati and Amin Ahmadpour

Che. Eng Department of Amirkabir University of Tehran (Poly Technic), Iran

Abstract: Zinc is white, bluish or silver metal, very soft which is brittle in normal temperatures, easily breaks with hammer blows and could not be roll in ambient temperatures and could easily roll into sheets at 100- 150 degrees centigrade. Considering the importance of electrical energy consumption in electrical refining processes, electrowining, its great effect on production cost and other products parameters, including zinc and modeling process with SPSS software that have high credit grade model result, respectively. In this study, by using test equipment indicated that rising temperature causes reduce efficiency and increase consumed energy and the most optimal flow density value for this process is 2400-300 A/m and electrolyte solution optimum concentration as: 60-50 zinc 140-120 Sulfuric acid, 200ppm manganese sulfate, 500ppm permanganate and gum are 500ppm. Also, energy consumption in Iran's zinc production industry is 4.5 kwh/kgZ_n and in developed countries industry is 3.3 kwh/kgZ_n. In this study, consumption energy reduced to 2.75 kwh/kgZ , $_n$which, reduction in energy consumption is about 17 percent of advanced industrial countries and about 40 percent of Iran's industry.

Key words: Energy · Modeling · Zinc · Electrical treatment · Electrovining

INTRODUCTION

Hardness and strength of pure zinc is higher than tin and lead but is lower than aluminum and copper. In such places that tensions occurred into metal, zinc should not be used because zinc shows a little resistance on creeps. Consumption of this metal is function of its plasticity. When this metal alloyed with 4 percent aluminum, strength and hardness resistance increase significantly. Such alloys have casting capabilities especially pressure casting is common. Other casting ways are less consumption. Zinc with high elasticity properties has very good plasticity. Zinc electro negativity property causes widespread use it on dry batteries. Zinc important technical property in industry is its very good coverage protection against corrosion. Also warm and thick Sulfuric acid will effect on zinc and reacts SO2 gas. Zinc salts Reactivity on other compounds like: alkaline carbonate, BASICITY phosphate, ammonia, ammonium carbonate, sulfide ammonium and cyanide potassium could note. Zinc industry Production base on hydro mythology method obtained zinc sulfate solution after acid dissolution stage [1]. Concentrations measured on this solution done with complex metric titration method and disodium salt EDTA standard solution. Amine tetra-acetic acid ethylene (EDTA) is an amino acid is insoluble in water so used sodium salt solution which is soluble in water. Zinc produced in variety business forms, including ingot, lump, sheet, wire bulleted lists, bar, Cornish and Polk. Compounds and alloys of zinc in the most cases prepared form above forms or scrap containing zinc or in some cases directly from zinc concentrate [2, 3]. Zinc properties in terms of applications have been various uses including: Reactivity with iron, corrosion resistance, electrochemical, low melting point, fluidity, the capacity for curing level; strength; alloy ability, Plasticity, high tensile strength, be nutritional, recovery and heal. Including cover for metals to prevent corrosion, such as: construction and use of instruments, accessories and furniture, automotive, ship building etc. to dicasting and casting equipment for consumption in heavy vehicles, accessories and furniture home, toys, tools, etc. to the alloy used in construction and building instruments, automotive equipment, electrical accessories, etc. for consumption in the battery making cars, computers, medical equipment, consumer products and components etc. and various use in industries, such as rubber, pigment, ceramic enamels, paper, food industry, livestock, fertilizers, pharmaceutical industry, cosmetics industry and many other applications include [4, 5]. A specialized branch of extractive metallurgy related to metal ore recovery, the concentrate and other intermediate products

Corresponding Author: Hedayati-Amin Ahmadpour, Che. Eng Department of Amirkabir University of Tehran (Poly Technic) Iran
E-mail: a.ahmadpoor@npc-rt.ir.

metallurgy method "wet" is Hydro metallurgy. Leaching, treatment; high grade solution and finally metal recovery solution are different stages of Hydro metallurgy operation [6]. In zinc hydro metallurgy sulfate the goal is producing net zinc that ultimately used for produced net zinc recovery with Electrovining method (Electro-metallurgy process). Electro-metallurgy is a specialized branch of Extractive metallurgy that placed use of electro-chemical methods in extracting metals studied. In this knowledge to achieve process objectives, two types of reaction, i.e. establishing spontaneous flow and utilizing external potential will be operating. An advantage of using electrical energy to promote chemical reaction is that the electric force makes no unwanted impurities inside the cell. Electrovining is producing a metal from molten salt electrolytes or its aqueous solution with using general electricity. Common name for this operation is electrolysis. Many metals, including zinc, can retrieve by electrolysis in cathode of a cell [7].

SPSS software Modeling: In this study, relationship between changes in energy consumption, acid concentration, zinc, gum, permanganate, iron, flow, temperature and efficiency with SPSS software investigated. Obtained model diagnosis coefficient is 97% which validated research is successful.

Analytical Results:

- According to acid concentration per energy and acid concentration per efficiency charts, determined that with increasing in acid concentration, efficiency decrease and energy consumption increase.
- According to zinc sulfate per energy charts indicate that with increasing zinc concentrations to 50*gr*/*lit*, efficiency increased but at concentration more than 50*gr*/*lit*, efficiency reduced with partial energy increasing. Therefore, concentration more than 50 is useless and harmful.
- Adding gum improved operating structure and changing sediment structure from dendrite to clog and cause zinc to deposit uniformly but if more electrolytes solution added, efficiency reduce and energy consumption increase. Gum effect charts shows efficiency reduction. In this chart, if gum concentration increases more than 50ppm the efficiency reduced intensity and at gum concentration more than 150ppm efficiency remains almost constant but gum with low permanganate concentrations can be increased efficiency partially.
- Low manganese sulfate concentrations causes partial efficiency increase rate. This partial increased (a rate of about 7%) shows at 200ppm concentration. However, in this process energy consumption increased so efficiency increasing is useless. Increased manganese sulfate causes sediment separated from aluminum sheet surface easier.
- Gum makes some complex reactions with impurities in solution and may cause changes in the efficiency or energy consumption. Adding 200ppm manganese sulfate to electrolyte solution with 10-2000*ppm* gum will reduce efficiency, but when only gum added to solution, efficiency is more. It observed that with increasing gum concentration more than 50ppm, flow efficiency decreases and at concentration more than 200ppm, efficiency remains almost constant.
- Permanganate cause separate deposition easier from aluminum surface and charts show that an increase in permanganate concentration (about 350ppm) causes efficiency partial increased (approximately 5 percent), but it remains nearly constant at higher permanganate concentration. At 200ppm efficiency decrease and energy consumption increased which should be avoiding extract at this concentration. Permanganate critical point was considered 350ppm.
- At ppm100 gum with presence of permanganate a partial increase at gum concentration causes efficiency reduced and energy consumption increased so combination of 350ppm permanganate with 100ppm gum is recommended.
- Turbulence: experiments conducted at 120*gr*/*lit* and 160*gr*/*lit* acid concentrations (20*gr*/*lit* more acid and less than the critical point 140*gr*/*lit*). Showed that turbulence can increase efficiency and reduce energy consumption in addition sediment got denser structure.
- Increased iron II (sulfate) concentration till 100ppm is ineffective but at more concentration decrease efficiency and increase energy so iron II (sulfate) concentration should not be more than100ppm.
- Flow density: flow density increased with the increase of flow from 0.25 Amp to 1.5 Amp at fixed level and results that with of the increase flow density from 125 to 300A/m^2 efficiency is increased greatly and reaches about% 50 and energy consumption reduced. Increasing flow density to more than 750A/m^2 increased efficiency but at flow density from 400 to 750 A/m^2 efficiency increase only d 10%.

Flow density causes increased efficiency first from 125 to300 A/m^2 with high rate and from 300 to 750 A/m^2 increased with lower rate and will not reach more than one extent point. At 125A/m^2 a maximum density at 50 is clearly visible that shows the correct zinc selected concentration is 50gr/lit^{-1}.

Increasing flow density in the solution containing permanganate indicates that the efficiency till 350 increase intensity but with increasing flow density, increasing efficiency reduced is low and at 750A/m^2, efficiency decrease with increasing energy consumption.

With increasing flow density, energy consumption decreased regularly from 125 to 250 with high intensity and then from 250 to 750 decreases with lower intensity. With increasing flow density, increasing energy consumption reduces and efficiency increase.

Flow density test contains in solution 350ppm permanganate / 50 zinc / 100ppm acid on two concentrations of Arabic gum 140 and 50ppm showed that increasing flow density to 250A/m^2 efficiency increased with high intensity and reduces energy consumption, but at flows more than This amount, increasing efficiency is high while for 125 to 250 A/m^2 for the solution increased efficiency is 45%. Energy consumption rate decrease lower after 250 A/m^2 that indicates optimal electrolytes solution is 140 acid, 50 salt, 350ppm permanganate, 100 and 50ppm gum concentrations and 500A/m^2flow density.

Temperature Effect: temperature rise from 25 to 80°C causes reduced efficiency and increased energy consumption. Graphs of 120, 140 and 160*gr/lit* acid concentrations in temperatures 40, 60 and 80°C were compared with 25°C.curves indicate that temperature rise is harmful agent. At 80 and 60°C zinc sediment samples were crystallized and at 80 were more which indicates that Crystal sediment growth with temperature and in 80°C sediment formation was completely dendrite which reduced efficiency.

Because of evaporation at high temperature, solution volume reduces so experiments accuracy is not high and results accurate of 80 are less than 60, but which reduce efficiency.

Rising temperature at permanganate solution reduces efficiency and increase energy consumption. At 80°C efficiency increased and energy consumption reduced which do not use.

In 350ppm permanganate solution containing gum 50 and 100ppm was observed with increasing temperature, efficiency decreased and energy consumption increased but at 80 efficiency increased and energy consumption decreased that indicates ambient temperature is suitable condition for tests.

CONCLUSION

Materials required for testing this process are: Sulfuric acid98%, zinc sulfate M = 287.54, distilled water, a distillation of Arabic gum and permanganate and one gram per liter iron sulfate solution. Equipment used in this experiment are Aluminum and lead sheets with dimensions of 5 * 8 cm, copper bars, balance digital rectifier current (Rectifiers), Multi meters, wire, bashers 600 CC and one-liter and 250 ml balloons, stopwatch, Pithy 10, 25 and 100 cc. The following results are obtained in different tests:

Effect of Sulfuric Acid Concentration on Efficiency and Energy Consumption: With assessment charts 1 and 2 indicate that by increasing acid concentration, efficiency decrease and energy consumption increases. Also in chart 1, efficiency decreased with lower slope till acid concentrations 140 *gr/lit* and after that efficiency decreased with more slope. Due to high acid concentration about 140 *gr/lit*, Leaching operations in the electrolysis process is required.

Effect of Concentration on Efficiency and Energy Consumption: According to charts 3 and 4 is specified that with more zinc concentration, efficiency is larger and less energy consumption needed. The relevant charts, if zinc concentration is less than 50*gr/lit*, energy consumption rate increased. Relevant diagrams show that till zinc concentration is 50*gr/lit* efficiency increased and at concentration about 50 to 60*gr/lit* efficiency decreased and at concentration more than 60 *gr/lit*, efficiency again increased and for energy consumption is vice versa of efficiency.

Effect of Arabic Gum Concentration on Efficiency and Energy Consumption: In chart 5, when the gum concentration is between zero to 50*gr/lit* efficiency reduction and increasing in energy consumption rate is not high but at gum concentration between 50 to 100*gr/lit* this rate increased and at concentration between 100 to 200*gr/lit*, curve's slope reduced that at concentrations

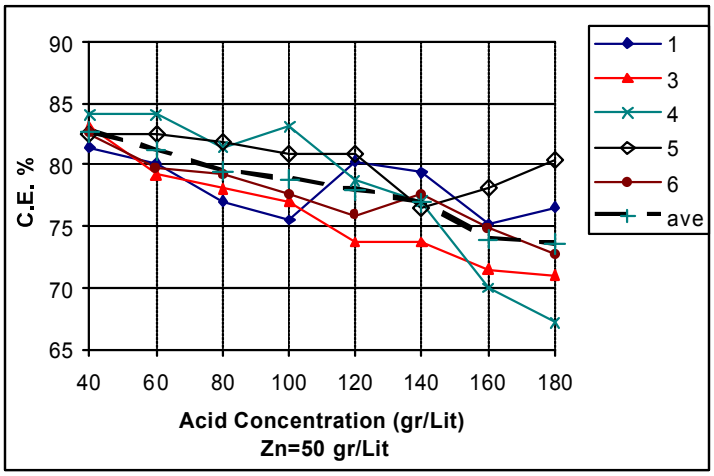

Chart 1: Flow efficiency changes according to changes in acid concentration

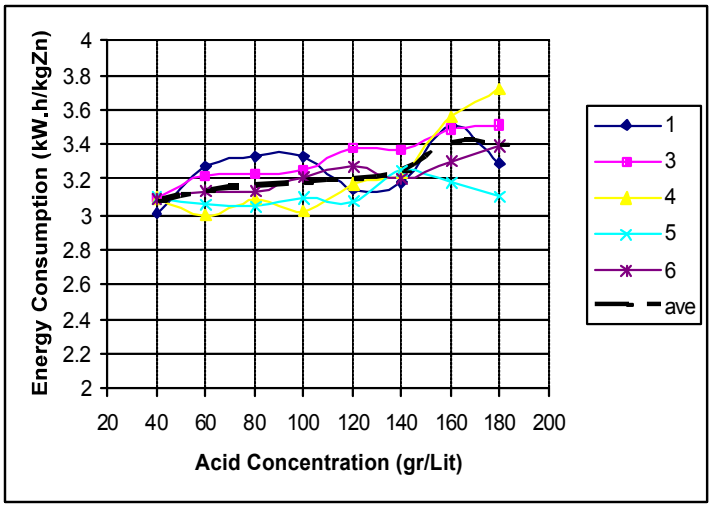

Chart 2: Energy consumption changes according to changes in acid concentration

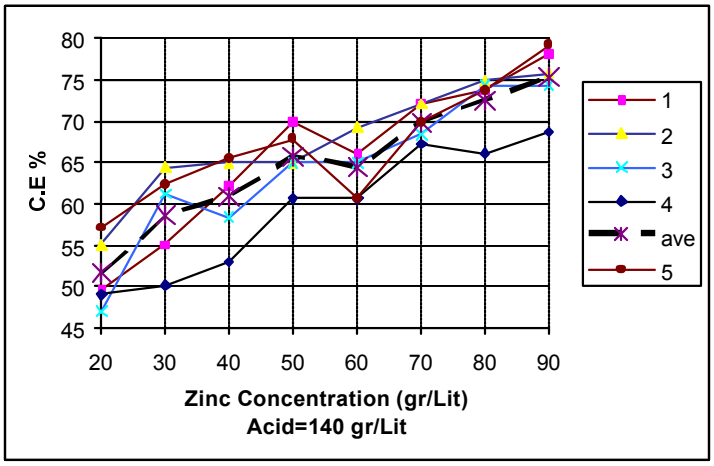

Chart 3: Flow efficiency changes according to changes in zinc concentration

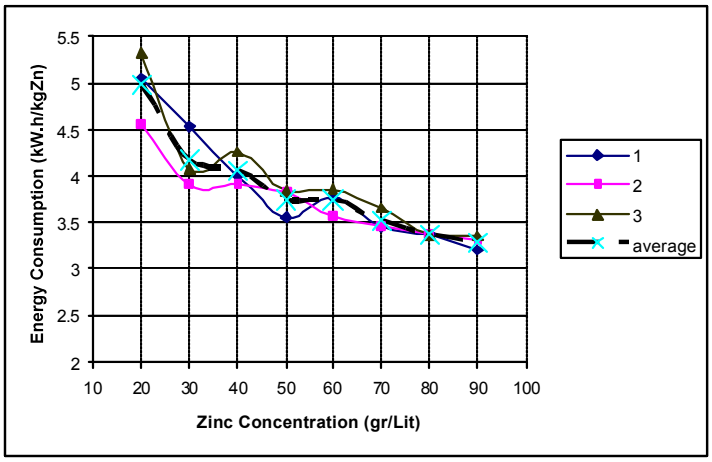

Chart 4: Energy consumption changes according to changes in zinc concentration

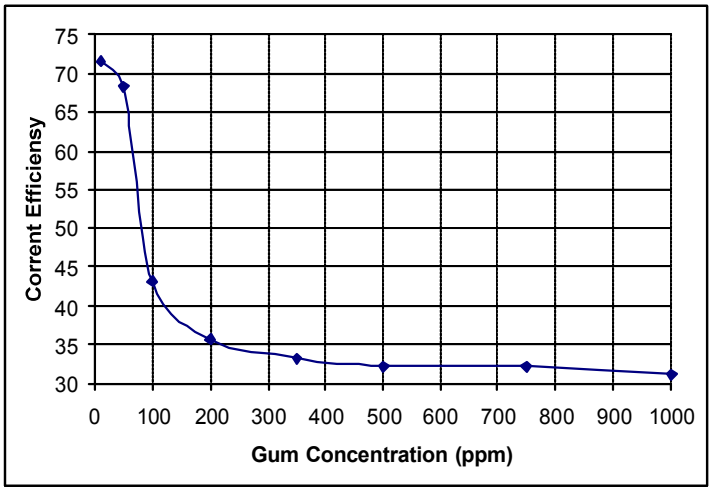

Chart 5: Flow efficiency changes according to changes in gum concentration

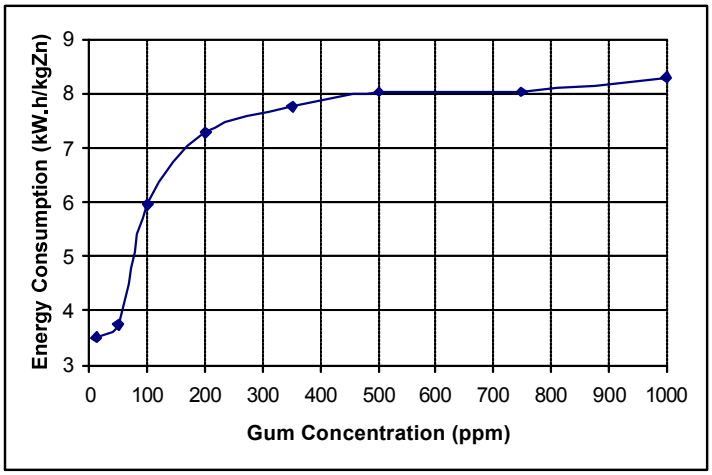

Chart 6: Energy consumption changes according to changes in gum concentration

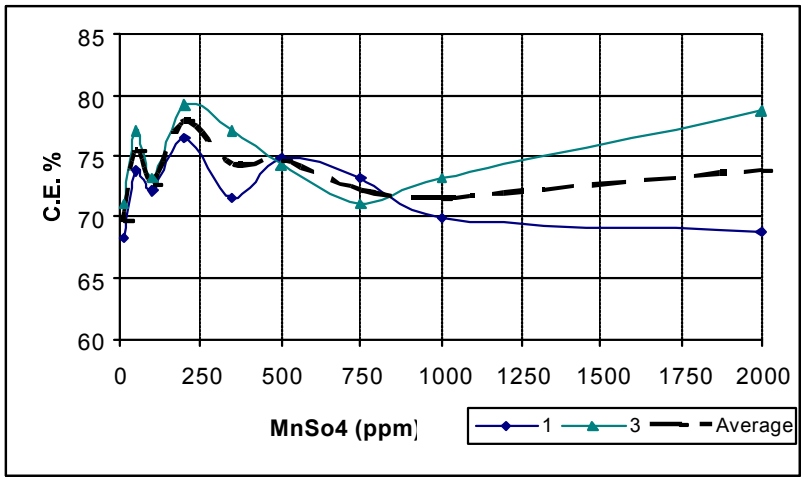

Chart 7: Flow efficiency changes according to changes in manganese sulfate concentration

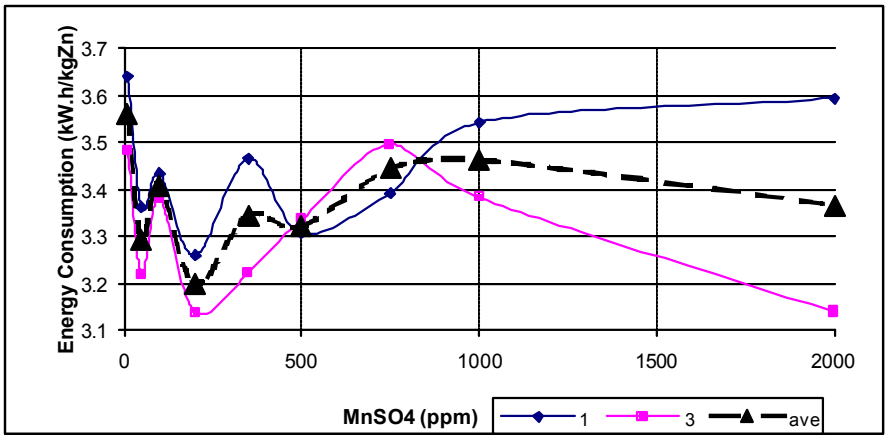

Chart 8: Energy consumption changes according to changes in manganese sulfate concentration

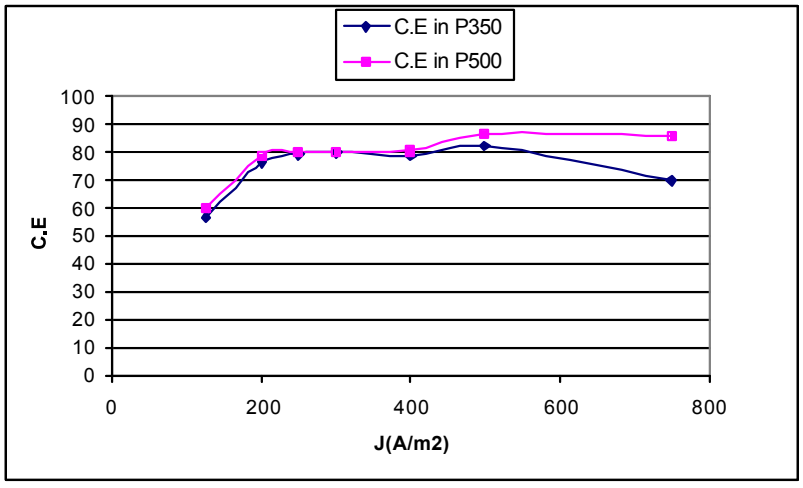

Chart 9: Efficiency changes per flow density in different permanganate concentration on 50 g /l and 140 g /l acid

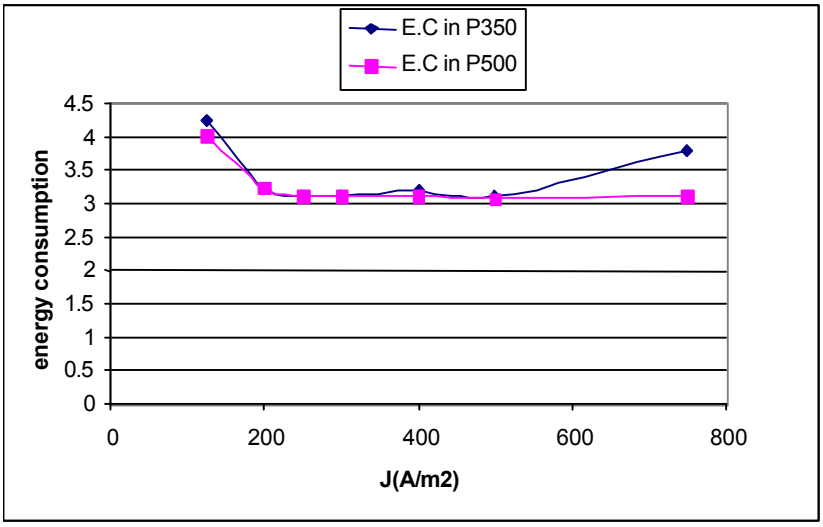

Chart 10: Energy consumption changes per flow density in different permanganate concentration on 50 g /l and 140 g /l acid

more than 300*gr/lit*, curve slope remains almost constant. Charts 5 and 6 indicate that suitable concentration of gum is 10-50ppm. Also gum improved zinc structure and changed zinc sediment structure into of a conglomerate or dendrite and makes uniform and continuous zinc precipitation, but if gums concentration rose in electrolyte solution, efficiency reduced and energy consumption increased.

Effect of Manganese Sulfate Concentration on Efficiency and Energy Consumption: Study on charts 9 and 10 indicate that efficiency at 500ppm permanganate is more than when 35ppm permanganate. Also increase in current density causes increase in efficiency and reduce in energy consumption. In addition, with increasing current density more than 500, efficiency decreases. The highest efficiency reached at 50ppm.

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