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DISSOLUTION BEHAVIOR OF BRASS POLARIZED BY ALTERNATING CURRENT IN SODIUM PHOSPHATE AQUEOUS SOLUTION

Abstract. The electrochemical behavior of Cu-Zn alloy (brass) polarized with industrial - frequency alternating current has been studied for the first time in aqueous sodium phosphate solution. The effects of current density in brass (200-1200 A/m^2) and titanium (20-120 kA/m^2) electrodes, sodium phosphate solution concentration (0,5-2,0 M), alternating current (AC) frequency (30-180 Hz) and electrolysis duration (0,25-1,5 h) on the alloy dissolution current efficiency were considered.

Intensive brass dissolution by forming copper (II) and zinc (II) ions during the electrolysis in alternating current mode was shown for the first time. In the case of direct current (DC) electrolysis, the current output value of alloy electrochemical dissolution was very low. As the current density of the alternating current polarized brass electrode was increased, the current output rate of the alloy dissolution increased initially and decreased to 400 A/m^2, where (400 A/m^2) alternating current value comprised 80% in an optimal condition. When the titanium electrode current density was increased, the brass dissolution current efficiency showed a maximum value; the current output of Cu (II) and Zn (II) ions formation at current 60 кA/m^2 density was 50% and 30%, respectively. As the electrolysis duration and the AC frequency are increased, the brass electrode current efficiency is reduced.

On the basis of obtained results, the potential of copper and zinc phosphate synthesis was shown.

Key words: brass, alternating current, electrolysis, sodium phosphate, titanium electrode.

At present, the use of alternating current in studying alloy electrochemical properties and in the synthesis of its important compounds is of great interest. Electrochemical processes are used to solve various topical issues in the field of production. Rather than direct current, alternating current allows to create simple, yet rational technological processes [1].

Alloys electrochemical dissolution is a very complicated process. An alloy of copper with zinc is called brass; by composition they may be red brass (containing less than 20% zinc), yellow brass (20-50% zinc), white brass (50-80% zinc) and special brass (containing lead, nickel manganese, iron, silicon, beryllium, etc. alongside with copper and zinc). The alloy electrochemical dissolution depends on dimensional ratio of its components and nature of the solution [2]. The more copper-based alloys are used, the more their residuals size in the environment increases as well. Digestion of metals from solid alloy wastes is an important source of production, since it reduces load on the environment [3, 4]. Subsequently, the demand for copper alloys, especially for brass (C38500) is great due to the development of automobile industry and the construction industry. Therefore, a thorough study of copper alloy properties is one of the main tasks today [5].

In this regard, it is important to develop different methods of processing solid alloy residuals on the basis of copper and zinc.

As the copper contains Cu 87%, Zn 13.67% and other impurities 0.33%, the brass electrochemical dissolution is similar to the copper electrochemical dissolution properties. Therefore, the copper electrochemical properties can be applied to the Cu-Zn alloy [2].

A.B. Bayeshov and et al. developed a method of obtaining copper (II) sulfate by the industrial alternating current polarization [6]; while the method of obtaining copper (I) chloride and copper bromide, inorganic copper and zinc compounds was developed by A.S. Kadirbayeva and R.N. Nurdillayeva [7-9].

With a view of obtaining copper salts, the electrochemical properties of copper were studied in sodium carbonate, sulfuric acid, potassium iodide, potassium bromide, and sodium sulfate, neutral and acidic media [10-15].

Corrosive [16-17] and electrochemical [18-21] properties of brass in aqueous solutions have been studied in a number of works. The electrochemical dissolution of brass was investigated by potentiodynamic polarization and cyclic voltammetry methods with and without the presence of Cl^- ions in $NaHSO_3$ solution. The results of this work indicated that brass dissolution was accelerated by increasing HSO_3^- concentration [18]. The electrochemical properties and passivation of Cu-30Zn alloy in the alkaline medium have been considered, increasing the NaOH concentration on the potentiodynamic curves basis has led to an increase in corrosion current density [19]. In the following study, the electrodisolution brass (60.8Cu-36.3Zn-2.9Pb) and pure copper were comparatively studied in 0.1 M HCl using cyclic voltammetry and a rotating ring-disc electrode and similarity of dissolution mechanism of copper and pure copper in the brass composition was discovered [20]. The electrochemical properties of α, β'-brass ($CuZn_{40}Pb_2$) were investigated at different pH values in basic nitrate solutions. The study indicated that the extent of the dezincification was affected by presence of Pb in the alloy but the pH value was determined to be a key parameter [21].

Literature data show that brass electrode electrochemical properties in aqueous sodium phosphate solution have not been investigated.

Results and discussion

In the present work, the brass electrode electrochemical properties were studied in aqueous sodium phosphate solution polarized with industrial-frequency alternating current. Due to the slow electrochemical reactions in the polarization of the brass electrode by direct current, an alternating current was used in our study. The achievement of using alternating current during the electrolysis was noted by the authors of [22] work.

During the alternating current polarization, the electrochemical dissolution of Cu-Zn alloy in the sodium phosphate aqueous solution was investigated at the range of 200 to 1200 A/m^2 (Fig. 1). When the current density is increased up to 400 A/m^2, the current efficiency in Cu (II), Zn (II) ions formation and brass dissolution gradually increases. When the current density increased up to 1200 A/m^2, the decrease in the alloy dissolution current output occurred. This can be explained by the increase in the additional reactions rate due to the current density increase.

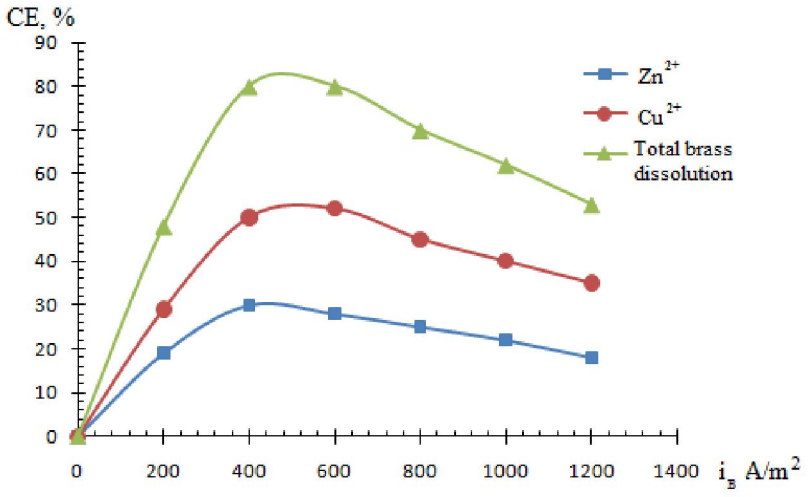

Figure 1 - The effect of the brass electrode current density on the current efficiency of the AC polarized Cu-Zn alloy dissolution: i_{Ti}=60 kA/m^2, [Na_3PO_4]=1.0 M, τ=0.5 h.

The effect of the additional titanium electrode current density on the electrochemical dissolution of the brass electrode polarized with alternating current in a neutral medium was investigated (Figure 2). An increase in the current efficiency rate of Cu (II) ions formation and the total brass dissolution by increasing the current density of titanium electrods from 20 kA/m^2 to 60 kA/m^2 can be explained by an occurrence of an oxide layer with a valve property on the titanium electrode surface in the anodic half-period. Further increase in the titanium electrode current density has led to a reduction in the current output. This is because the oxide layer surface structure in the titanium electrode changes due to the current density increase and its current correction property decreases.

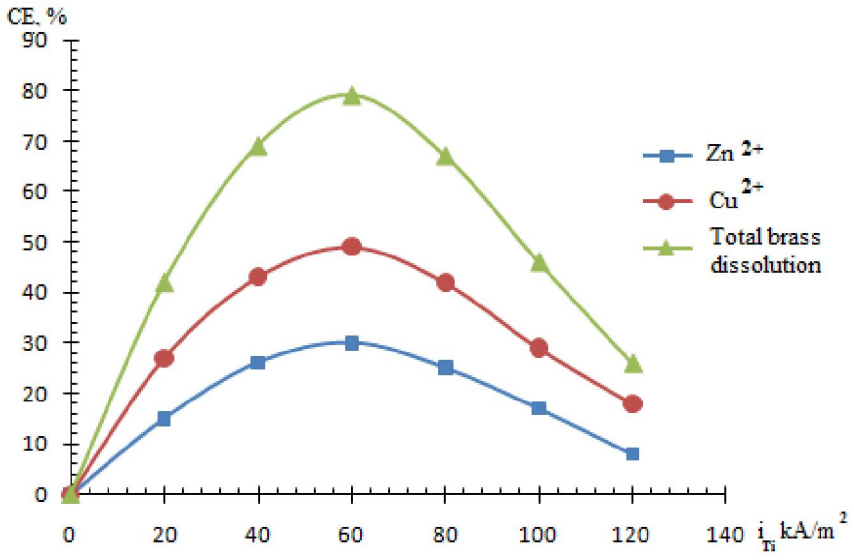

Figure 2 - Effect of titanium electrode current density on the current efficiency of the brass electrode dissolution polarized with alternating current: i_B=400 A/m^2, [Na_3PO_4]=1.0 M, τ=0.5h.

The effect of sodium phosphate solution concentration on the current efficiency of brass electrode dissolution polarized with alternating current was studied in a range 0.25 and 1.5 M (Fig. 3). As the sodium phosphate concentration increases, the current output of the brass electrode dissolution increases, but it decreases from 1.0 M. The reason is that as the electrolyte concentration increases, the brass electrode surface area is covered with saline coating and the brass electrode passivation takes place.

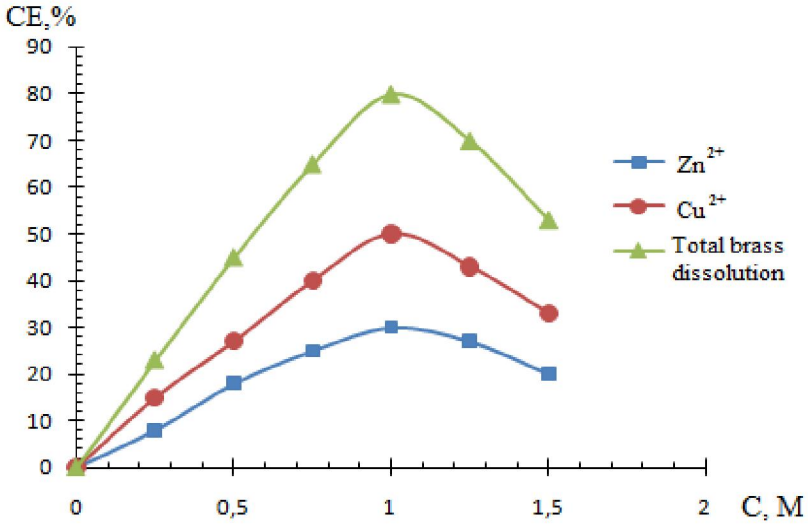

Figure 3 - Effect of sodium phosphate concentration on the current efficiency of brass electrode dissolution polarized with alternating current: i_{Ti} = 60 kA/m^2, i_B = 400 A/ m^2, τ = 0.5h.

The current efficiency decrease of copper, zinc ions formation and brass electrode dissolution due to the alternating current frequency increase can be observed in Figure 4. It can be assumed that the required time for the occurrence of the alloy oxidation reaction by forming copper and zinc ions can not be provided due to the rapid periods changes at high current frequencies.

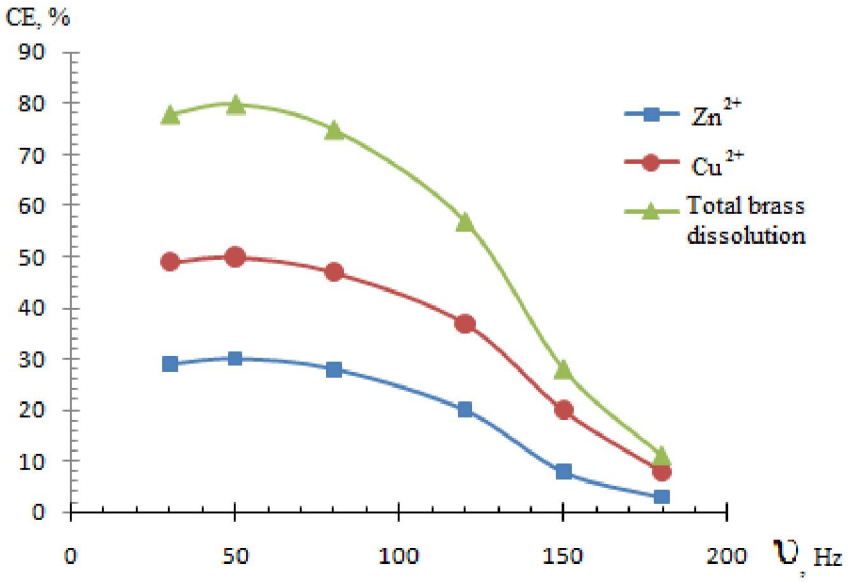

Figure 4 - AC frequencies effect on the current efficiency of brass electrode dissolution polarized with alternating current: i_{Ti}=60 kA/ m^2, i_B=400 A/m^2, [Na_3PO_4]=1.0 M, τ=0.5 h.

Figure 5 shows the electrolysis duration effect on the brass electrode current current efficiency. As the, electrolysis duration increases, the brass electrode current output decreases. As the electrolysis duration increases, electrodes electrolysis products begin to passivate with poorly soluble copper and zinc products. It is explained by the formation of blue saline coat on the electrode surface.

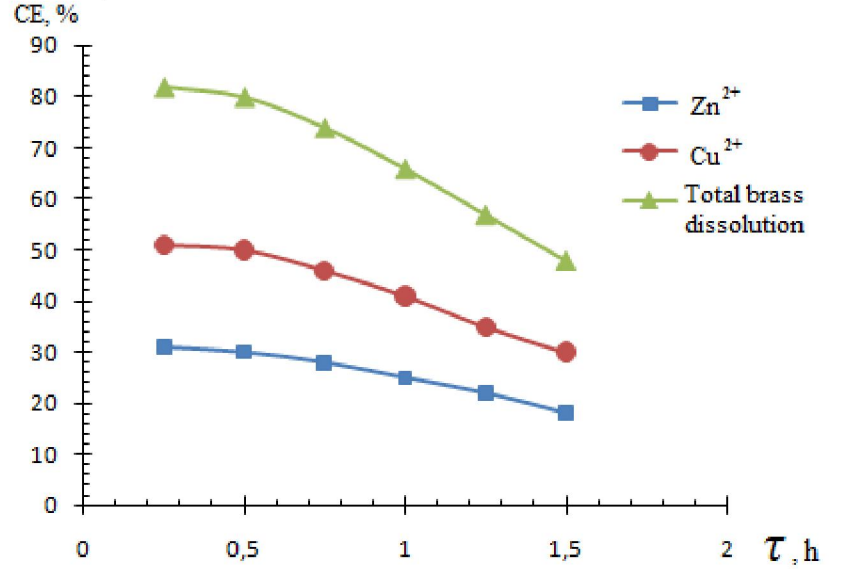

Figure 5 - The electrolysis duration effect on the current efficiency of brass electrode dissolution polarized with alternating current: i_{Ti}=60 A/ m^2, i_B=400 A/m^2, [Na_3PO_4]=1.0 M

Figure 6 shows the solution temperature effect on the brass electrode current efficiency. In our study, a decrease in current efficiency value of Cu (II) ions formation beginning from 30 °C was observed due to the increase in electrolyte temperature and the linear increase in the current efficiency value of Zn (II) ions formation took place. As the solution temperature increases, zinc chemically interacts with the

hydrogen ions and thereby its ionization potential is facilitated. The total current output of the alloy dissolution increased up to 40 °C and slowed down at higher temperatures.

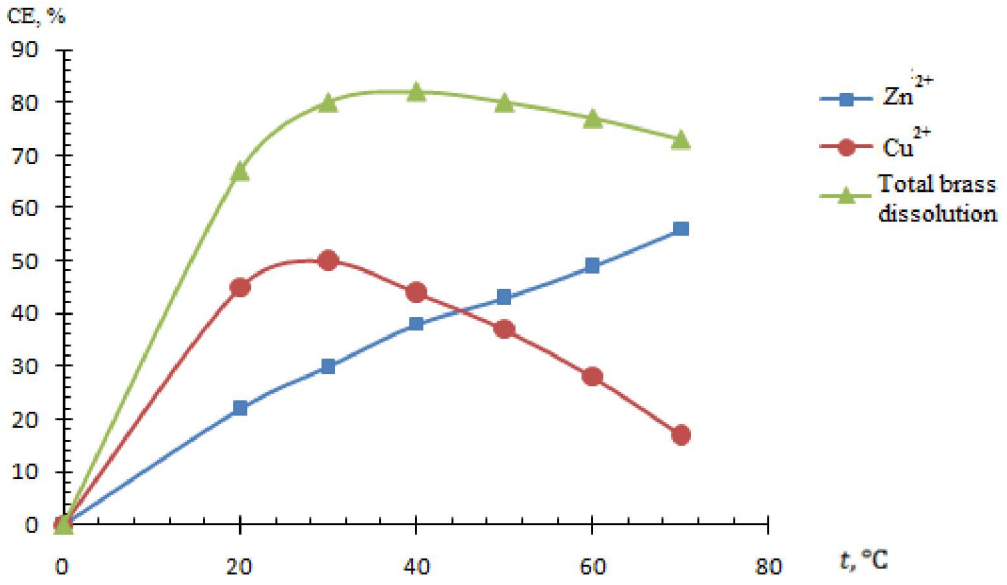

Figure 6 - The electrolyte temperature effect on the current efficiency of brass electrode dissolution polarized alternating current: i_{Ti}=60 A/m^2, i_B=400 A/m^2, [Na_3PO_4]=1.0 M, τ=0.5 h.

Summing up, the electrochemical dissolution laws of the brass electrode polarized with alternating current in a neutral medium - sodium phosphate aqueous solution have been systematically studied for the first time. The study results showed that the electrochemical process was intensified when replacing one of the two brass electrodes into the titanium wire. The basic electrochemical parameters effect on the brass electrode dissolution by forming copper and zinc ions in (Na_3PO_4) sodium phosphate solution were investigated and the effective alloy dissolution conditions were considered: (i_B=400 A/m^2, i_{Ti}=60 kA/m^2, [Na_3PO_4]=1.0 M, ν=50 Hz, t=30°C).

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АЙНЫМАЛЫ ТОКПЕН ПОЛЯРИЗАЦИЯЛАНҒАН ЖЕЗДІҢ НАТРИЙ ФОСФАТЫ СУЛЫ ЕРІТІНДІСІНДЕГІ ЕРУ ЗАҢДЫЛЫҚТАРЫ

Аннотация. Өндірістік жиіліктегі айнымалы токпен поляризацияланған Cu-Zn құймасы - жездің электрохимиялық қасиеті натрий фосфаты сулы ерітіндісінде алғаш рет зерттелді. Құйма еруінің ток бойынша шығымына (ТШ) жез (200-1200 А/м^2) және титан (20-120 кА/м^2) электродтарындағы ток тығыздықтарының, натрий фосфаты ерітіндісі концентрациясының (0,5-2,0 М), айнымалы ток жиілігінің (30-180 Гц), электролиз ұзақтығының (0,25-1,5 сағ.) әсерлері қарастырылды.

Айнымалы ток режиміндегі электролиз кезінде жездің мыс (II) және мырыш (II) иондарын түзе қарқынды еритіндігі алғаш рет көрсетілді. Ал, тұрақты ток электролиз барысында құйманың электрохимиялық еруінің ТШ мәні өте төмен болды. Айнымалы токпен поляризацияланған жез электродындағы ток тығыздығын жоғарылатқан сайын құйма еруінің ток бойынша шығымы алғашында жоғарылап, 400 А/м^2-бастап біркелкі төмендеп, оңтайлы жағдайда (400 А/м^2) ТШ мәні 80% құрады. Титан электродындағы ток тығыздығын арттырғанда құйма еруінің ТШ максимум арқылы өтіп, ток тығыздығы 60 кА/м^2 кезінде Cu (II) және Zn (II) иондары түзілуінің ТШ сәйкесінше 50% және 30% құрады. Жез еруінің ток бойынша шығымы 1,0 М натрий фосфаты ерітіндісінде максималды мәнді көрсетті. Электролиз ұзақтығы

мен айнымалы ток жиілігін арттырған сайын жез электродының ток бойынша шығымы төмендейтіндігі анықталды.

Алынған нәтижелердің негізінде мыс және мырыш фосфатын синтездеудің мүмкіншіліктері көрсетілді.

Түйін сөздер: жез, айнымалы ток, электролиз, натрий фосфаты, титан электроды.

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ЗАКОНОМЕРНОСТИ РАСТВОРЕНИЯ ЛАТУНИ В ВОДНОМ РАСТВОРЕ ФОСФАТА НАТРИЯ ПРИ ПОЛЯРИЗАЦИИ ПЕРЕМЕННЫМ ТОКОМ

Аннотация. Впервые исследовано электрохимическое поведение сплава Cu-Zn - латуни при поляризации переменным током промышленной частоты в водном растворе фосфата натрия. Рассмотрено влияние плотности тока на латунном электроде (200-1200 А/м^2) и титановом электроде (20-120 кА/м^2), концентрации раствора фосфата натрия (0,5-2,0 М), частоты переменного тока (30-150 Гц) и продолжительности электролиза (0,25-1,5 час) на выход по току (ВТ) растворения сплава.

Впервые показано, что при переменнотоковом режиме электролиза происходит интенсивное растворение сплава с образованием ионов меди (II) и цинка (II). При электролизе с постоянным током значение ВТ электрохимического растворения сплава было значительно ниже. При повышении плотности тока на латунном электроде, поляризованном переменным током, выход по току растворения сплава плавно снижается и при оптимальных условиях (400 А/м^2) значение ВТ составило 80%. При изменении плотности тока на титановом электроде ВТ растворения сплава проходит через максимум и ВТ образования ионов Cu (II) и Zn (II) составляет, соответственно, 50% и 30% при плотности тока 60 кА/м^2.

Максимальное значение ВТ растворения латуни наблюдалось при 1,0 М концентрации раствора фосфата натрия. Установлено, что при увеличении продолжительности электролиза и частоты переменного тока значение ВТ латуни снижается.

На основе полученных результатов была показана вожможность синтеза фосфатов меди и цинка.

Ключевые слова: латунь, переменный ток, электролиз, фосфат натрия, титановый электрод.

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