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ҚАЙЫРЫМДЫЛЫҚ ҚОРЫ
HALYK
CHARITY FOUNDATION

«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
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ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ КАЗАХСТАН»
ЧФ «Халық»

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ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»

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Адрес редакции: 050100, г. Алматы, ул. Кунаева, 142, АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского», каб. 310, тел. 291-62-80, факс 291-57-22, e-mail:orgcat@nursat.kz

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Editorial address: JSC «D.V. Sokolsky institute of fuel, catalysis and electrochemistry», 142, Kunayev str., of. 310, Almaty, 050100, tel. 291-62-80, fax 291-57-22, e-mail: orgcat@nursat.kz

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A. Tukibayeva[1]*, A. Bayeshov[2], R. Abzhalov[1], Asylbekova D.D.[1],
A. Yessentayeva[1], 2023

[1]M. Auezov South Kazakhstan University, Shymkent, Kazakhstan;
[2]JSC „Institute of Fuel, Organic Catalysis and Electrochemistry named after
D.V. Sokolsky”, Almaty, Kazakhstan.
E-mail: ainur_tukibaeva@mail.ru

THE ROLE OF COPPER (II) IONS IN THE PROCESS OF ANODIC OXIDATION OF PHOSPHINE IN AN ACIDIC MEDIUM

Tukibayeva Ainur – candidate of Chemistry, associate professor. M. Auezov South Kazakhstan University, Shymkent, Kazakhstan.
E-mail: ainur_tukibaeva@mail.ru, http://orcid.org/0000-0002-6648-5253;
Bayeshov Abduali – academic of NAS of RK, doctor of Chemistry, professor. Institute of Fuel, Organic Catalysis and Electrochemistry named after D.V. Sokolsky, Almaty, Kazakhstan.
E-mail: bayeshov@mail.ru, https://orcid.org/0000-0003-0745-039X;
Abzhalov Ramshad - postdoctoral student. M.Auezov South Kazakhstan University, Shymkent, Kazakhstan.
E-mail: ars.es_84@mail.ru; https://orcid.org/0000-0002-2070-0843;
Asylbekova Dina – candidate of Chemistry, associate professor, M. Auezov South Kazakhstan university, Shymkent, Kazakhstan.
E-mail: asylbekova.dina@inbox.ru, http://orcid.org/0000-0001-8099-0662;
Yessentayeva Aizhan – PhD, senior lecturer. M. Auezov South Kazakhstan University, Shymkent, Kazakhstan.
E-mail: aijan_01-84@mail.ru; https://orcid.org/0000-0002-5006-2707.

Abstract. The production of phosphorus is the basis of the chemical production in Kazakhstan. Furnace gas of phosphorus production contains mainly carbon monoxide (85-95 vol.%), and as concomitant impurities phosphine PH_3, phosphorus pentoxide P_2O_5 and acid gases H_2S, HF (0.1-2.0 vol.%). The most harmful components of furnace gas are phosphine and phosphoric anhydride. The aim of the research is the investigation of the influence of copper (II) ions on the electrochemical behavior of phosphine and elaboration of processing methods of phosphine by electrochemical methods. Electrochemical studies were carried out in thermostatic electrolyzers under galvanostatic conditions. The influence of the current density, electrolyte concentration, and the thickness of the layer of a lump graphite electrode on the degree of phosphine oxidation and the current efficiency of oxidation has been studied. The optimal conditions for the anodic oxidation of phosphine on a lump graphite electrode in a sulfuric acid solution are determined. The effect of divalent copper ions on the anodic oxidation of phosphine has also been studied. The optimal conditions for the electrochemical oxidation of phosphine on graphite lump electrodes in the presence of divalent copper ions are determined and current efficiency and the degree of oxidation of phosphine increases by 1.5 times. It was established that the catalytical action of copper (II) ions to phosphine anode oxidation. Analysis of the composition of phosphide, established by a scanning electron microscope with systems of energy dispersive microanalysis INSAEnergu and structural analysis HKL - Basicc with a useful magnification of 300,000, makes it possible to establish the content of the main components and impurities in the composition of products.

Keywords: phosphine, electrolysis, lumpy electrodes, current efficiency, oxidation degree, phosphate-ions, SEM analysis

А.С. Тукибаева[1]*, А. Баешов[2], Р. Абжалов[1], Д. Асылбекова[1], А. Есентаева[1], 2023

[1]М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан;
[2] «Д.В.Сокольский атындағы отын, органикалық катализ және электрохимия институты» АҚ, Алматы, Қазақстан.
E-mail: ainur_tukibaeva@mail.ru

ҚЫШҚЫЛ ОРТАДА ФОСФИННІҢ АНОДТЫ ТОТЫҒУ ПРОЦЕСІНЕ МЫС (ІІ) ИОНДАРЫНЫҢ РӨЛІ

Түкібаева Айнур – химия ғылымдарының кандидаты, доцент. М.Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан.
E-mail: ainur_tukibaeva@mail.ru, orcid.org/0000-0002-6648-5253;
Баешов Әбдуәлі – ҚР ҰҒА академигі, химия ғылымдарының докторы, профессор. Д.В. Сокольский атындағы отын, органикалық катализ және электрохимия институты, Алматы, Қазақстан**.**
E-mail: bayeshov@mail.ru, https://orcid.org/0000-0003-0745-039X;
Абжалов Рамшад – пост-докторант. М.Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан.
E-mail: ars.es_84@mail.ru; https://orcid.org/0000-0002-2070-0843;
Асылбекова Дина – химия ғылымдарының кандидаты, доцент, М.Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан.
E-mail: asylbekova.dina@inbox.ru, http://orcid.org/0000-0001-8099-0662;

Есентаева Айжан – PhD, аға оқытушы. М.Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан.
E-mail: aijan_01-84@mail.ru; https://orcid.org/0000-0002-5006-2707.

Аннотация. Фосфор өндірісі Қазақстандағы химия өндірісінің негізі болып табылады. Фосфор өндірісінің пеш газының құрамында негізінен көміртек оксиді (85-95 көлем %), ал ілеспе қоспалар ретінде фосфин PH_3, фосфор пентоксиді P_2O_5 және қышқыл газдары H_2S, HF (0,1-2,0 көлем) болады. Пеш газының ең зиянды компоненттері - фосфин және фосфор ангидриді. Зерттеудің мақсаты – мыс (ІІ) иондарының фосфиннің электрохимиялық қасиетіне әсерін зерттеу және фосфинді электрохимиялық әдіспен өңдеу әдістерін жасау. Электрохимиялық зерттеулер термостатикалық электролизерлерде гальваностатикалық жағдайда жүргізілді. Фосфин тотығуының тотығу дәрежесі мен ток бойынша шығымына түйіршікті графит электроды ток тығыздығының, электролит концентрациясының және түйіршікті қабат қалыңдығының әсері зерттелді. Күкірт қышқылы ерітіндісіндегі түйіршікті графит электродында фосфиннің анодты тотығуының оңтайлы шарттары анықталды. Фосфиннің анодты тотығуына екі валентті мыс иондарының әсері зерттелді. Екі валентті мыс иондарының қатысуымен графит кесек электродтарында фосфинді электрохимиялық тотығудың оңтайлы шарттары анықталды, токтың ПӘК және фосфиннің тотығу дәрежесі 1,5 есе артады. Мыс (II) иондарының фосфиннің анодты тотығуына каталиттік әсері анықталды. INSAEnergu энергетикалық дисперсиялық микроанализ және HKL - Basicc құрылымдық талдау жүйелері бар сканерлеуші электронды микроскопта алынған фосфид құрамын талдау пайдалы 300 000 ұлғайту арқылы фосфидті құрамдағы негізгі компоненттер мен қоспалардың мазмұнын анықтауға мүмкіндік береді.

Түйін сөздер: фосфин, электролиз, түіршікті электродтар, ток бойынша шығым, тотығу дәрежесі, фосфат-иондары, РЭМ талдау

А. Тукибаева[1]*, А. Баешов[2], Р. Абжалов[1], Д. Асылбекова[1],
А. Есентаева[1], 2023

[1]М. Южно-Казахстанский университет имени М. Ауэзова, Шымкент, Казахстан;
[2]АО «Институт топлива, органического катализа и электрохимии им.Д.В.Сокольского», Алматы, Казахстан.
E-mail: ainur_tukibaeva@mail.ru

РОЛЬ ИОНОВ МЕДИ (II) В ПРОЦЕССЕ АНОДНОГО ОКИСЛЕНИЯ ФОСФИНА В КИСЛОЙ СРЕДЕ

Тукибаева А.С. – к.х.н., доцент. Южно-Казахстанский университет им. М.Ауэзова, г. Шымкент, Казахстан
E-mail: ainur_tukibaeva@mail.ru, orcid.org/0000-0002-6648-5253;
Баешов Абдуали - академик НАН РК, доктор химических наук, профессор. АО «Институт топлива, органического катализа и электрохимии им.Д.В.Сокольского», Алматы, Казахстан
E-mail: bayeshov@mail.ru, https://orcid.org/0000-0003-0745-039X;
Абжалов Рамшад – пост-докторант. Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан.
E-mail: ars.es_84@mail.ru; https://orcid.org/0000-0002-2070-0843
Асылбекова Дина – кандидат химических наук, доцент. Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан.
E-mail: asylbekova.dina@inbox.ru, http://orcid.org/0000-0001-8099-0662;
Есентаева Айжан - PhD, старший преподаватель. Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан.
E-mail: aijan_01-84@mail.ru; https://orcid.org/0000-0002-5006-2707.

Аннотация. Производство фосфора является основой химического производства Казахстана. Печной газ фосфорного производства содержит в основном оксид углерода(85-95 об. %), а в качестве сопутствующих примесей фосфин PH_3, пятиокись фосфора P_2O_5 и кислые газы H_2S, HF (0,1-2,0 об. %). Наиболее вредными компонентами печного газа являются фосфин и фосфорный ангидрид. Цель исследования - изучение влияния ионов меди (II) на электрохимическое поведение фосфина и разработка способов переработки фосфина электрохимическим методом. Электрохимические исследования проводились в термостатических электролизерах в гальваностатических условиях. Изучено влияние плотности тока, концентрации электролита и толщины слоя кускового графитового электрода на степень окисления и выход по току окисления фосфина. Определены оптимальные условия анодного окисления фосфина на кусковом графитовом электроде в растворе серной кислоты. Изучено влияние ионов двухвалентной меди на анодное окисление фосфина. Определены оптимальные условия электрохимического окисления фосфина на графитовых кусковых электродах в присутствии ионов двухвалентной меди, при этом выход по току и степень окисления фосфина увеличиваются в 1,5 раза. Установлено каталитическое действие ионов меди (II) на анодное окисление фосфина. Анализ состава фосфида, установленный на сканирующем электронном микроскопе с системами энергодисперсионного микроанализа INSAEnergu и структурного анализа HKL - Basicc с полезным увеличением 300 000, позволяет установить содержание основных компонентов и примесей в составе фосфида. Продукты.

Ключевые слова: фосфин, электролиз, кусковые электроды, выход по току, степень окисления, фосфат-ионы, РЭМ анализ

Introduction

The production of phosphorus is the basis of the chemical production in Kazakhstan. It is known that over the years, about 450,000 tons of solid residue of boiler milk have accumulated in boiler milk tanks in the territory of Kazphosphate LLP. Kazphosphate LLP is represented by the following enterprises: Karatau Mining and Processing Complex, Chulaktau Mining and Processing Complex, NDFZ LLP, ZMU, Railway Transport Complex, Stepnogorsk Chemical Plant, Shymkent Detergent Plant (Novodzhambul phosphorus plant…, 2021). These institutions are engaged in the neutralization of these wastes, and according to the calculations of specialists, it is assumed that the processing and neutralization of the entire amount of phosphorus sludge accumulated in the form of waste will take an average of 30-40 years (Arystanova, 2021).

Nowadays, NDFZ LLP is the only supplier in the CIS and the EU of phosphorus to the Czech Republic, Poland, Switzerland, England, America, Italy - practically to all European companies that consume phosphorus. Tripolyphosphate is mainly sold to Russian companies, thermal phosphoric acid - to the CIS countries, hexametaphosphate is bought by Russia and the USA (Handboo, 2021).

The maximum concentration of phosphine is observed in the production of phosphorus-potassium fertilizer. To date, in the production of phosphorus-potassium fertilizer for the purification of industrial emissions, dust-cleaning equipment is used, which does not provide gas purification. To reduce the concentration of phosphine in the exhaust gas, it is necessary to modernize the gas cleaning equipment. Hydrogen sulphide is formed when an acid is treated with a solution of sodium sulphide.

The existing chemical methods for cleaning waste gases from phosphine are based on systems containing various oxygen chlorine compounds (HClO, NaClO, $NaClO_3$), manganese peroxide, phosphoric acid with dissolved ozone, etc. For practical use, these solutions are not used, since they are not regenerated and must be replaced after working out (Proceedings of IOKE, 1980; Dorfman et al., 1991; Polimbetova et al., 2016; Ibraimova et al., 2021).

Complex utilization of solid, liquid and gaseous wastes from the electrothermal production of phosphorus proceeds at temperatures of 1300-1600°C. To remove impurities from gases, they are usually either adsorbed or converted by oxidation into other products. Phosphine, in contrast to the accompanying acidic impurities of furnace gas, which are removed by liquid or acid-base sorbents, phosphorus and phosphine are oxidized by oxygen only in the presence of metal-complex catalysts. Also, phosphine is characterized by inertness in acid-base reactions; it is not absorbed by alkali solutions, but is neutralized only by oxidation (Polimbetova et al., 2007). Currently, there are a number of works devoted to the purification of furnace gas and solid waste from phosphorus production, as well as the study of the reactivity of phosphorus and its compounds. These works are based on chemical methods, the use of expensive catalysts, oxidizing agents, etc., for example, the adsorption characteristics of phosphorus and hydrogen sulfide on catalysts were studied in a fixed bed system at various temperatures from 20 to 140 □ at atmospheric pressure (Ning Ping et.al, 2005), the reaction mechanism of simultaneous removal H_2S and PH_3 with modified manganese slag were studied in (Jiacheng Bao et al., 2020).

In the work (Kabulov, 2015) developed technologies for the production of carbon-containing composite materials for the purification of gas-air mixtures from toxic compounds. As a result of the conducted research, optimal compositions of composite materials for the purification of gas-air mixtures from cyclohexane, ammonia, hydrogen sulfide and phosphine were established: composite material based on shungite concentrate (KM1) with mass content of nickel chloride – 3%, copper sulphate - 10%; composite material based on saxaul wood (KM2) with mass content of nickel chloride – 3%, copper sulphate – 7 %; composite material based on apricot seed shell (CM3) with mass content of nickel chloride is 3%, copper sulphate is 5%.

There are also a lot of works on the purification of phosphine by the adsorption method from literary sources. T. Rakitskaya and her colleagues prepared metal-complex catalysts based on silicon oxide for purification from phosphine, where Cu^{2+}, Fe^{3+}, Pd^{2+}, Hg^{2+} were used as the active metal (Rakitskaya et al., 2021, Gagieva, 2014). The disadvantage of metal-complex catalysts based on silicon oxide is that the specific surface area of the carrier is relatively low compared to porous carbon materials, and expensive palladium is also used.

The result and quality of phosphating depend on a large number of influencing factors — primary material, surface pre-cleaning, rinsing process, temperature and composition of the solution, duration of the process. In work (Starikova et al., 2020), an overview of the types of phosphating is given. The authors conducted experimental studies of various phosphating processes. The results of corrosion tests of phosphate coatings obtained by us in solutions of different composition under different conditions are presented.

The authors [Sandu, Andrei Victor et al., 2013) researched the production and characterization of new anticorrosion phosphate layers deposited on steel substrate. The layers are obtained by co-precipitation in acid aqueous medium with addition of metallic cations, which influence the formation of crystallites and the uniformity of the layers.

Authors [Koshkarbaeva et al., 2012) developed the technology of applying the conductive films of copper phosphide on the dielectric materials in order to obtain a basis for further metallization. This technology is based on use of phosphine as reducing agent, which can restore the connections of copper to phosphide. Obtained copper phosphide belongs to the metal-phosphide, and a good conduct the electricity.

Based on a literature review, it is our goal to substitute lengthy chemical and purification processes with time and cost-efficient ones. This fits the term of "Click Chemistry" and ideas attached to it quite well [Kolb et al., 2001]. Electrochemical research methods, in particular, require minimal reagents, produce high results, and have few, if any, by-products. The second point that we would like to clarify in our study is the concept of "Green Chemistry". Reducing the use of expensive catalysts, halogenated oxidizers and replacing with various reagents seems to be acceptable for a project primarily and generally dealing with environmental pollutants. It is our understanding that the easier, cheaper and cleaner the process is, the more likely that substances obtained from it will find their way to the practical application, be it scientific or industrial. We believe that this approach gives us a complete picture of the behavior of phosphorus and some of its compounds.

The aim of the research is the investigation of the influence of copper (II) ions on the electrochemical behavior of phosphine and elaboration of processing methods of phosphin by electrochemical methods.

The novelty of results obtained is the phosphine was oxidized by electrochemical way in acidic solutions and the resulting product is phosphate-ions.

Methods and materials

Electrochemical studies were carried out in thermostatic electrolyzers under galvanostatic conditions. The phosphine used for the study was obtained in the laboratory, as a result of the oxidation of 30% sulfuric acid with zinc phosphide:

$$Zn_3P_2 + 3H_2SO_4 \rightarrow 3ZnSO_4 + 2PH_3 \uparrow \qquad (1)$$

As a result of a chemical reaction, the released gas enters a burette filled with distilled water, and with pressure the gas is pushed into a storage burette controlled by a three-way valve. After the desired concentration of phosphine is collected in the measuring burette, close the tap. Phosphine is supplied into the electrolysis cell using a bubbler unit, which is located in the lower part of the cell. The bubbler ensures uniform distribution of gas in the volume of the electrolyzer. In order to trap the unreacted phosphine, absorption mixtures are used that contain oxidizing mixtures (the mixture is prepared from equal volumes of 0.5 potassium permanganate and sulfuric acid), it is connected to the top of the electrolyzer using a conductive tube. The gas velocity is controlled by a three-way valve, and is fed into the electrolyzer at a certain speed. The electrolyzer is equipped with electrodes made of different materials. The current was supplied to the electrodes under study using a current rectifier brand B-24. In the studies, lump electrodes were used instead of anodes and they are folded to the bottom of the electrolyzer. The advantage of these electrodes is that they ensure the passage of the process throughout the entire volume of the electrolyzer.

Graphite lumpy electrodes with a diameter of 1.5 mm and a length of 3 mm were used as anodes. They are folded onto the surface of the down conductor. The thickness of the lump electrode was measured in the range from 1 to 7 cm. The electrode-cathode is located on the top of the cell. The distance between the front surface of the anode and the cathode is 50 mm, electrolysis is carried out within the anode current density of 200-1000 A/m^2.

Since it is very difficult to calculate the surface of the electrodes, the known volumes of the cylindrical cell are used, and the areas of the lumpy electrodes are calculated as the cylindrical surface of the electrode.

For carrying out under normal conditions, the volume of gas to be passed was calculated using the Boyle-Mariotte and Gay-Lusacque equation:

$$\frac{V_0P_0}{T_0} = \frac{V_1P_1}{T_1};\ V_0 = \frac{T_0P_1V_1}{T_1P_0}; \qquad (2)$$

After electrolysis, the resulting phosphate ions were determined by the known photocolorimetric method. The analysis was carried out according to the linear dependence of the concentrations of phosphate ions on the optical density of the solution (D=f(C)).

Analysis of the composition of the resulting copper phosphide was carried out on an electron microscope with INSAEnergu energy-dispersive microanalysis and HKL-Basic structural analysis systems with a useful magnification of 300,000, which made it possible to see the picture of the appearance of the phosphide in the photographs, as well as the content of the main component and impurities in the coating in %.

The influence of the current density, electrolyte concentration, and the thickness of the layer of a lumpy graphite electrode on the degree of phosphine oxidation and the current efficiency of oxidation has been studied.

Results and discussion

The volume of gas supplied to the electrolyzer is 500 ml. The gas velocity was controlled by a three-way valve, electrolysis was carried out in all cases for 1 hour.

The oxidation degree and current efficiency of phosphine are significantly affected by the current density at the electrode. With an increase in current density to 200-1000 A/m^2, the phosphine degree of oxidation steadily increases to 600 A/m^2, and at higher current densities, it decreases due to an increase in the proportion of the oxygen evolution process along with the oxidation of phosphine at the anode (Fig. 1):

$$2H_2O - 4e^- \rightarrow O_2 + 4H^+ \quad E^\circ = +1.23\ B \tag{3}$$

The current efficiency of phosphine oxidation naturally decreases due to an increase in the proportion of side reactions.

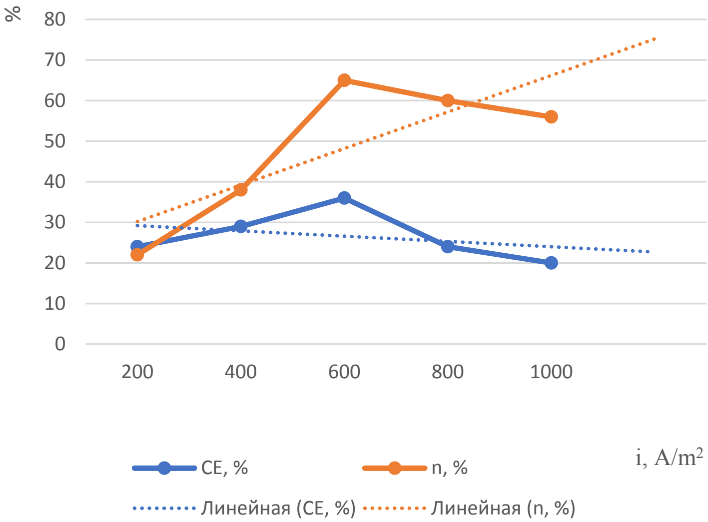


Fig. 1. The influence of current density on the oxidation degree (n) and current efficiency (CE) of phosphine anodic oxidation

When studying the influence of the height of the graphite electrode layer up to 4 cm, the oxidation degree of phosphine is 73%, and the current efficiency is 30%. A further increase in the layer height leads to a decrease in the oxidation degree. Apparently, in the volume of lumpy electrodes of great height, clumps of particles can form, acquiring the functions of a biopolar electrode. As is known from the literature, zones of maximum polarization and electrically inactive zones can appear (Ugorets et al., 1989; Tomilov at el., 1988). Thus, our assumptions are confirmed by experimental data. When electrolysis was carried out only on a current collector without a lump electrode, the degree of phosphine oxidation did not exceed 15%, and the current efficiency did not exceed 8%.

Table 1. The influence of the height of graphite electrode layer on the current efficiency (CE) and oxidation degree (n) of phosphine oxidation

, cm	0	2	4	6	8
Oxidation degree (n) of phosphine, %	15	40	73	68	55
Current efficiency, %	8	17	30	26	21

The result of experiments that were conducted to study the dependence of the change in the concentration of a sulfuric acid solution showed that at first the current efficiency and the degree of oxidation of phosphine increase in the concentration range of 0.25-0.75 mol/L (Figure 2). With an increase in the concentration of sulfuric acid in the solution, the concentration (content) of sulfate ions increases, and the anode space is saturated with sulfate ions and the solubility of phosphine in the solution decreases, as a result, the oxidation degree and current efficiency of phosphine oxidation. This makes it possible once again to judge that phosphine is oxidized in solution due to solubility. As is known from the literature data, with an increase in the concentration of sulfuric acid, the solubility of gases decreases ().

As a rule, in concentrated solutions of oxyacids at high current densities, acid anions also begin to take a direct part in oxygen evolution reactions. Such a mechanism was proved by Gerovich and his collaborators (Antropov, 1984). In our case, with an increase in the concentration of sulfate ions, the rate of oxygen evolution also increases, which leads to a decrease in the rate of the main process:

$$2SO_4^{2-} = 2SO_3 + O_2 + 4e^- \qquad (4)$$

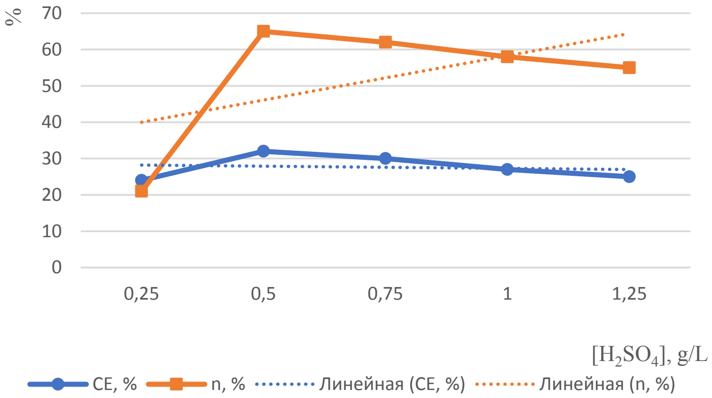


Fig.2. The influence of electrolyte concentration on the oxidation degree (n) and current efficiency (CE) of phosphine anodic oxidation

In our studies, we researched the effect of the concentration of divalent copper ions on the oxidation process of phosphine. When passing phosphine through a sulfuric acid solution containing 10 g/L of copper (II) ions, it was found that only 22% of the phosphine precipitated according to the 5-reaction. In this regard, we considered the oxidation of phosphine in the presence of copper (II) ions by passing it through anodic polarized lumpy graphite electrodes.

In the presence of copper (II) ions, the rate of phosphine oxidation sharply increases. The results of the study are shown in Figure 4.

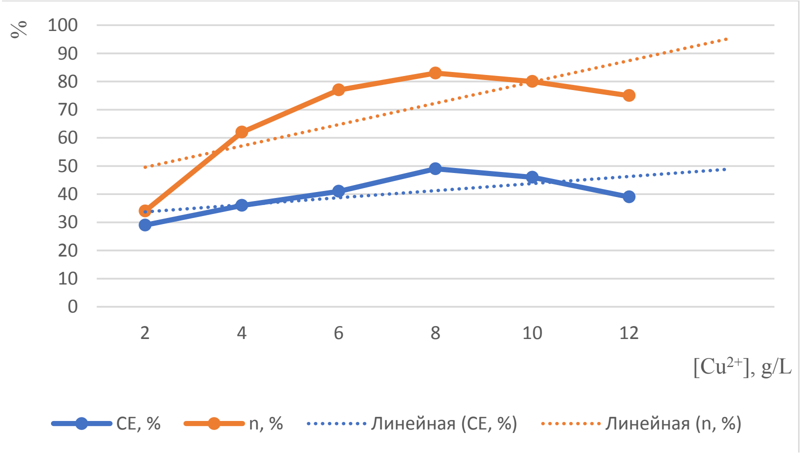
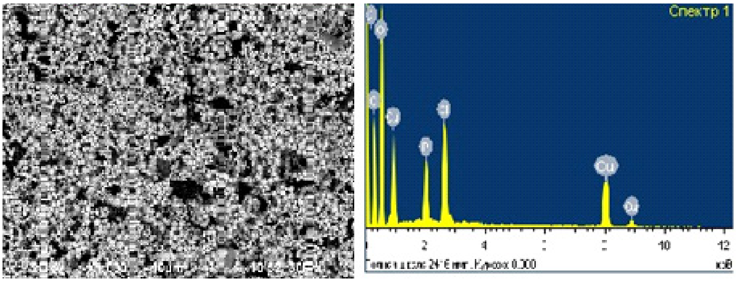


Fig.3. The influence of copper (II) ions concentration on the oxidation degree (n) and current efficiency (CE) of phosphine anodic oxidation

As a result of electrolysis, a layer of copper 3.5-4.5 microns thick was obtained on the surface of the granular electrode and in the electrolyte. A scanning electron microscope was used to analyze the elemental composition, percentage and weight indicators of the resulting packages. The results of the SEM analysis are presented in Figure 4.



Элемент	Салмақтық %	Атомдық %
C	38.88	53.79
O	36.61	38.03
P	2.82	1.51
Cl	4.81	2.25
Cu	16.88	4.41
Қорытынды	100.00	

Fig.4. Spectra and elemental composition of the resulting copper phosphide

The effect of copper (II) ions on the process of anodic phosphine oxidation can be explained as follows: during the anodic polarization of a graphite electrode in a solution of sulfuric acid, oxygen is released (6 - reaction). At the anode, the released active oxygen reacts with copper phosphide, formed as a result of the 5 - reaction, and phosphoric acid and copper (II) ions are formed (7-reaction). Copper (II) ions formed by the latter reaction react with phosphine, which passes through the solution according to the 5-reaction, forming metal phosphides and phosphoric acid. Copper phosphide reacts with active oxygen and again copper (II) ions are formed according to the 7-reaction. So, it can be assumed that during the electrochemical oxidation of phosphine, copper (II) ions play the role of a catalyst:

$$2H_3P + 8Cu^{2+} + 4H_2O \rightarrow Cu_3P + H_3PO_4 + 11\,H^+ + 5Cu^+ \tag{5}$$

$$2H_2O - 4e^- \rightarrow O_2 + 4H^+ \tag{6}$$

$$Cu_3P + 2.75\,O_2 + 6\mathrm{H}^+ \rightarrow 3Cu^{2+} + \mathrm{H}_3PO_4 + 1.5\,\mathrm{H_2O} \tag{7}$$

$$H_3P + 2.75O_2 + 3\mathrm{H}^+ \xrightarrow{Cu^{2+}} \mathrm{H}_3PO_4 + 1.5\,\mathrm{H_2O}$$

It should be noted that the electrode space is not divided, therefore, the reduction of copper (II) ions proceeds on the cathode according to reactions (8-10):

$Cu^{2+} + 2e^- \rightarrow Cu^0$ $E^\circ = +0.34$ B (8)

$Cu^{2+} + e^- \rightarrow Cu^+$ $E^\circ = +0.15$ B (9)

$Cu^+ + e^- \rightarrow Cu^0$ $E^\circ = +0.50$ B (10)

consequently, the concentration of cuproions decreases and leads to a decrease in the oxidation state of phosphine. In this regard, subsequent experiments were carried out with the separation of the electrode spaces by an anion exchange membrane MA-40. Thus, the results of the studies performed showed that the oxidation state of phosphine is significantly affected by divalent copper ions.

Conclusions

In this work, the electrochemical oxidation of phosphine on graphite lump electrodes in a sulfuric acid solution was studied. The influence of electrochemical parameters: current density, electrolyte concentration, layer height of a graphite lump electrode on the degree of oxidation and current efficiency of phosphine oxidation was studied. The optimal conditions for the anodic oxidation of phosphine on a lump graphite electrode in a sulfuric acid solution are determined. The effect of divalent copper ions on the anodic oxidation of phosphine has also been studied. The optimal conditions for the electrochemical oxidation of phosphine on graphite lump electrodes in the presence of divalent copper ions are determined and the degree of oxidation is 83%, the current efficiency is 49%.

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REFERENCES

Novodzhambul phosphorus plant, 2021 - *Novodzhambul phosphorus plant*, http://www.kpp.kz/stru_podr/ndfz/. Access date 07/21/2021 (in Russ.)

Arystanova S., 2018 - *Arystanova S.* Development of a technology for the extraction of sorbents from natural mineral raw materials for the purification of phosphorus-containing sediments [Fosforquramdas şlamdardı tazalaw üşin tabïğï mïneraldı şïkizattardan sorbentterdi alw texnologïyasın jasaqtaw]. Diss. 6D072000 Chemical technology of inorganic substances, 152. (in Kaz.)

Handbook of Best Available Techniques for the Production of Inorganic Chemicals, 2021 - *Handbook of Best Available Techniques for the Production of Inorganic Chemicals*, Nur-Sultan, 625 (in Russ.)

Complex compounds in catalysis. Proceedings of IOKE, 1980 - *Complex compounds in catalysis. Proceedings of IOKE,* Almaty, Science of the Kazakh SSR, 144 (in Russ.)

Dorfman Ya.A., Yukht I.M., Levina L.V., Polimbegova G.S., Petrova T.V., Emelyanova V.S., 1991 - *Dorfman Ya.A., Yukht I.M., Levina L.V., Polimbegova G.S., Petrova T.V., Emelyanova V.S.* Oxidation of phosphine and arsine by metal complexes, free and bound oxygen, Usp. chem. 60, 6: 190-1228 (in Russ.)

Polimbetova G.S., Borangazieva A.K., Abdreimova R.R., Akbaeva D.N., Ibraimova Zh.U., Bugubaeva G.O., 2016 - *Polimbetova G.S., Borangazieva A.K., Abdreimova R.R., Akbaeva D.N., Ibraimova Zh.U., Bugubaeva G.O.* The kinetics and mechanism of phosphine oxidation by oxygen in solutions of copper (I, II) complexes, Proceedings of the National Academy of Sciences of the Republic of Kazakhstan. Chemistry and Technology Series, 4(418): 42-47(in Russ.) https://journals.nauka-nanrk.kz/chemistry-technology/issue/view/297

Ibraimova Z.U., Polimbetova G.S., Borangazieva A.K., Itkulova S.S., Boleubaev E.A., 2021 - *Ibraimova Z.U., Polimbetova G.S., Borangazieva A.K., Itkulova S.S., Boleubaev E.A.* Catalytic purification and ways for utilization of furnace gas of phosphorus production, Reports of the NAS of the Republic of Kazakhstan, 5, 339: 136 – 143. https://doi.org/10.32014/2021.2518-1483.92

Polimbetova G.S., Abdreimova R.R., Borangazieva A.K., 2007 - *Polimbetova G.S., Abdreimova R.R., Borangazieva A.K.* Catalytic processing of phosphorus and wastes of the phosphorus industry, Proceedings of the National Academy of Sciences of the Republic of Kazakhstan. chemical series, 2(362): 6-9 (in Russ.)

Ning Ping, Hans-Jörg Bart, Wang Xueqian, MaLiping, Chen Liang, 2005 - *Ning Ping, Hans-Jörg Bart, Wang Xueqian, MaLiping, Chen Liang*. Removal of P_4, PH_3 and H_2S from Yellow Phosphoric Tail Gas by a Catalytic Oxidation Process, Strategic Study of Chinese Academy of Engineering, 7, 6: 27-35.

Jiacheng Bao, Xialing Wang, Kai Li, Fei Wang, Chi Wang, Xin Song, Xin Sun and Ping Ning, 2020 - *Jiacheng Bao, Xialing Wang, Kai Li, Fei Wang, Chi Wang, Xin Song, Xin Sun and Ping Ning.* Reaction Mechanism of Simultaneous Removal of H_2S and PH_3 Using Modified Manganese Slag Slurry, Catalysts, 10(1384), doi:10.3390/catal10121384

Kabulov A.T., 2015 - *Kabulov A.T.* Technology for producing composite carbon-containing materials based on carbon raw materials from Kazakhstan [Tekhnologiya polucheniya kompozitsionnykh uglerodsoderzhashchikh materialov na osnove uglerodnogo syr'ya Kazakhstana], PhD thesis, Almaty, 114 (in Russ.)

Rakitskaya T.L., Ennan A.A., 2012 - *Rakitskaya T.L., Ennan A.A.* Phosphine. Physicochemical properties and practical aspects of capture, Odessa, Astroprint, 208 (in Russ.)

Gagieva F.A., 2014 - *Gagieva F.A.* Intensification of sorption extraction of rhenium, molybdenum and tungsten ions from aqueous solutions of complex composition: PhD thesis, Vladikavkaz, 177 (in Russ.)

Starikova E.Yu., Feiler L.A., 2020 - *Starikova E.Yu., Feiler L.A.* Protective phosphate coatings of metals, Bulletin of the Kuzbass State Technical University, 6: 46-50 https://dx.doi.org/10.26730/1999-4125-2020-6-46-50

Sandu, Andrei Victor & Bejinariu, Costica & Nemtoi, Gh & Vizureanu, Petrica & Ionita, Iulian & Constantin, Baciu, 2013 - *Sandu, Andrei Victor & Bejinariu, Costica & Nemtoi, Gh & Vizureanu, Petrica & Ionita, Iulian & Constantin, Baciu*. New Anticorrosion Layers Obtained by Chemical Phosphatation. Revista de Chimie -Bucharest- Original Edition, 64: 825-827 http://www.revistadechimie.ro

Koshkarbaeva T. Sh., Nauryzova S.Z., Sataev M.S. and Tleuova A.B., 2012 - *Koshkarbaeva T. SH., Nauryzova S.Z., Sataev M.S. and Tleuova A.B.* Low-temperature Gas-phase Metallization of Dielectrics, Oriental journal of chemistry, 28, 3: 1281-1283

Kolb H. C., Finn M. G. and Sharpless K. B., Angew, 2001 - *Kolb H. C., Finn M. G. and Sharpless K. B., Angew*. Chem. Int.l Edit., 40 (11): 2004–2021.

Ugorets M.Z., Shalayeva T.S., Pivovarova P.S., 1989 - *Ugorets M.Z., Shalayeva T.S., Pivovarova P.S.* Electrolysis of powdered inorganic materials in an aqueous environment, Alma-Ata, 213 (in Russ.)

Tomilov A.P., 1989 - *Tomilov A.P.* Intensification of electrochemical processes, Collection of scientific works, Science, 213 (in Russ.)

Chemist's Handbook, 1964 - *Chemist's Handbook.* Leningrad department, 3, 1008 (in Russ.)

Antropov L.I., 1984 - *Antropov L.I.* Theoretical electrochemistry, Higher School, 519 (in Russ.)

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