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FULL CYCLE TECHNOLOGY OF LITHIUM ELECTRODE MATERIALS FOR LIB FROM DOMESTIC RAW MATERIALS

Abstract. In recent years, there has been a steady increase in lithium consumption in high technology. Therefore, new methods for the extraction of lithium are becoming increasingly important. The distribution of lithium stocks in the world is uneven, access to its stocks plays a significant role and affects technological development. Rare-metal pegmatites and lithium-bearing brine are used as the main industrial sources of lithium.

This paper discusses the development trends of lithium production from spodumene ore to produce high purity lithium carbonate. The geological characteristics of the main lithium deposits of East Kazakhstan, as well as the possibility of their industrial development, are analyzed. A technology has been developed to produce battery grade lithium carbonate from Kazakhstan spodumene concentrate. Based on high purity lithium carbonate (99.5%), the efficient cathode material $LiFePO_4$ for lithium-ion batteries was synthesized. The technology of a full cycle of processing domestic lithium-containing mineral and industrial raw materials into lithium carbonate for the production of high-tech products: anode and cathode materials for modern LIB is presented. An efficient technology of lithium electrode materials based on high-purity lithium carbonate from domestic spodumene raw materials has been developed. The fundamental possibility of creating a lithium cluster in Kazakhstan for the production of products with a high degree of readiness for the final consumer is shown according to the scheme: Sodumene ores → Lithium concentrate → Lithium carbonate → Lithium cathode materials → Batteries.

Key words: lithium, extraction, ore, spodumene, technology, lithium carbonate, lithium iron phosphate, lithium-ion battery.

Today, lithium is becoming increasingly popular in high-tech industries such as aircraft manufacturing, space industry, automotive, nuclear, energy, as well as in energy storage systems. In connection with the sharp increase in the production of electric vehicles in the world, lithium has come to be called “future gasoline” and “white oil”. Lithium-ion batteries (LIB) are the market leaders among all available battery technologies. Due to their high energy density, stability and duration of charge-discharge circulation, LIBs are the most promising sources for the needs of alternative energy. The trend towards green energy due to the exhaustibility of hydrocarbons in recent decades has given a great impetus to the development and use of lithium-ion batteries (LIBs). The rapid development of the market for battery devices, especially electric and hybrid cars and renewable energy, over the past 10 years has led to a sharp demand for higher-capacity materials for LIB. All this, as well as the development of technologies in portable electronics (phones and laptops / tablets) and electric vehicles, has led to the fact that lithium is becoming a new strategic material that can influence the sustainable development of the global economy. The market has an urgent task to produce lithium salts, in particular lithium carbonate as the main precursor of lithium electrode materials. The main lithium minerals suitable for producing lithium concentrates, as a rule, are part of rare-metal granite pegmatites. Pegmatite mineral concentrates account for> 60% of lithium production; of these, spodumene is the main raw material for producing lithium carbonate. High purity lithium carbonate of battery quality is the main precursor of lithium electrode materials [1].

The analysis shows that the current global lithium consumption environment is favorable for the emergence of a new producer of lithium compounds, such as Kazakhstan, which has investment-attractive proven large reserves of lithium-containing ores in the Eastern region. Kazakhstan has large reserves of various rare-earth metals and their accompanying lithium. According to the degree of readiness for development and development costs, lithium deposits of the East Kazakhstan region can be divided into two groups. The first group includes mineral deposits of lithium, in which more than 23 thousand tons of lithium oxide and other useful components are concentrated. Given the forecast for the intensive development of the lithium economy, these lithium reserves are of practical interest for their development.

A promising lithium-containing technogenic object is dumps after ore beneficiation of the deposit, formed as a result of their processing at the Belogorsk mining and processing plant. Over the period of his work, more than 32 thousand tons of lithium are in the dumps of processing plants.

All this sets the task of creating a new lithium industry in Kazakhstan in order to become an important player in the world market of storage systems and energy sources, renewable energy, and electronics.

The objective of the proposed technology is the development of a method for obtaining high-grade lithium carbonate directly from spodumene, by passing the stage of obtaining a technical grade product, simplifying the process of cleaning a lithium-containing solution from impurities.

The technical result is to obtain high-grade lithium carbonate in a single technological process of processing spodumene, reducing the number of technological operations of cleaning from impurities, eliminating the expensive operation of concentrating a solution of lithium sulfate by the method of evaporation [2].

The technical result is achieved by a method of obtaining high-grade lithium carbonate from spodumene concentrate, including spodumen calcining, sulfation, water leaching, purification of lithium sulfate from impurities, lithium concentration in solution, reagent lithium carbonate precipitation, washing of lithium carbonate, characterized in that lithium concentration is carried out by a membrane method reverse osmosis, cleaning of metal and anions from impurities is carried out by causification of lithium sulfate, lithium carbonate is deposited by ammonium carbonate salt at a temperature not more than 40 °C, followed by heating to 90 °C. An essential feature of the method is the use of reverse osmosis membranes for the concentration of a solution of lithium sulfate, which makes it possible to exclude from the technology a very laborious and expensive method of evaporation of a solution of lithium sulfate [3].

Further purification, including caustification of lithium carbonate, ultrafiltration and ion-exchange sorption of a lithium hydroxide solution followed by precipitation with ammonium carbonate salt, bicarbonization and decarbonization of lithium carbonate, made it possible to obtain high purity lithium carbonate 99.5% [4].

Innovative electrode materials for LIB were obtained from high purity lithium carbonate on the basis of domestic spodumene raw materials by synthesis using method of aerosol pyrolysis (MAP) and sol-gel method (ZGM). Thus obtained lithium- iron- phosphate showed quite satisfactory electrochemical properties [5].

The end result is a new generation of innovative cathode and anode materials for modern LIBs with significantly increased capacity and stability, obtained from lithium precursors - battery grade lithium carbonate based on domestic spodumene raw materials.

Thus, technologies have been developed for producing innovative electrode materials for modern lithium batteries with the creation of a full cycle of the production line from lithium extraction from domestic mineral raw materials to high-tech products - cathode and anode materials of modern lithium-ion batteries.

Scientific and technological foundations have been created for the development in Kazakhstan of a high-tech lithium cluster for the production of products with a high degree of readiness for the final consumer according to the scheme: Spodumene ores → Lithium concentrate → Lithium carbonate → Lithium cathode materials → Batteries. Developed a business plan for the creation of cluster-oriented lithium production.

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ОТАНДЫҚ ШИКІЗАТТАН АЛЫНГАН ЛИБ-КЕ АРНАЛГАН ЛИТИЙЛІ ЭЛЕКТРОДТЫ МАТЕРИАЛДАР ТЕХНОЛОГИЯСЫНЫҢ ТОЛЫҚ ЦИКЛІ

Аннотация. Соңгы жылдары жогары технологияда литийді тұтынудың тұрақты өсу қарқыны байқалады. Сондықтан литий алудың жаңа әдістері барган сайын маңызды бола түсуде. Әлемде литий қорларының таралуы біркелкі емес, оның қорларына қол жеткізу маңызды болып саналады және технологиялық дамуга әсер етеді.

Бұл жұмыста жогары таза литий карбонатын алу үшін сподумен кендерінен литийді өндірудің даму тенденциялары қарастырылды. Шыгыс Қазақстанның негізгі литий кен орындарының геологиялық сипаттамалары, сондай-ақ олардың өнеркәсіптік даму мүмкіндігі талданды. Қазақстандық сподумен концентратынан батарея сапасындағы литий карбонатын алу технологиясы әзірленді. Жогары таза литий карбонатынан (99,5%) литий-ионды аккумуляторлар үшін тиімді $LiFePO_4$ катодты материалы синтезделді. Жогары технологиялық өнім: заманауи литий-ионды батареяларга (ЛИБ) арналған анод және катод материалдарын алу үшін отандық литий құрамды минералды және техногенді шикізатты литий карбонатына өңдеудің технологиясының толық циклі ұсынылды. Отандық сподумен шикізатынан литий карбонат негізіндегі литий электродты материалдарын алудың тиімді технологиясы әзірленді. Соңгы тұтынушыга жогары дәрежедегі дайын өнім шыгаруга арналган Қазақстанда литий кластерін құрудың негізгі мүмкіндігі келесі схемага сәйкес көрсетілген: Сподуменді кендер → Литийді концентрат → литий карбонаты → Литийді катодтық материалдар → Аккумуляторлар.

Түйін сөздер: литий, экстракция, кен, сподумен, технология, литий карбонаты, литий темір фосфаты, литий-ионды аккумулятор.

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ТЕХНОЛОГИЯ ПОЛНОГО ЦИКЛА ЛИТИЕВЫХ ЭЛЕКТРОДНЫХ МАТЕРИАЛОВ ДЛЯ ЛИБ ИЗ ОТЕЧЕСТВЕННОГО СЫРЬЯ

Аннотация. В последние годы наблюдается устойчивый рост потребления лития в области высоких технологий. Поэтому все большее значение имеют новые методы извлечения лития. Распределение запасов лития в мире неравномерно, доступ к его запасам играет значительную роль и влияет на технологическое развитие. В качестве основных промышленных источников лития используют редкометальные пегматиты и литиеносную рапу.

В настоящей работе рассмотрены тенденции развития производства лития из сподуменовой руды для получения карбоната лития высокой чистоты. Проанализированы геологические характеристики основных литиевых месторождений Восточного Казахстана, а также возможности их промышленного освоения. Разработана технология получения карбоната лития аккумуляторного сорта из казахстанского сподуменового концентрата. На основе карбоната лития высокой чистоты (99,5%) синтезирован эффективный катодный материал $LiFePO_4$ для литий-ионных батарей (ЛИБ). Представлена технология полного цикла переработки отечественного литийсодержащего минерального и техногенного сырья в карбонат лития для производства высокотехнологичной продукции: анодных и катодных материалов для современных ЛИБ. Разработана эффективная технология литиевых электродных материалов на основе высокочистого карбоната лития из отечественного сподуменового сырья. Показана принципиальная

возможность создания в Казахстане литиевого кластера для производства продуктов с высокой степенью готовности для конечного потребителя по схеме: сподуменовые руды → литиевый концентрат → литиевый карбонат → литиевые катодные материалы → аккумуляторы.

Ключевые слова: литий, извлечение, руда, сподумен, технология, карбонат лития, литий-железо-фосфат, литий-ионный аккумулятор.

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