

# Study Of Methods For Obtaining Potassium Sulfate

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**Abstract:** This article describes methods for obtaining potassium sulfate. Information on the physicochemical properties of potassium sulfate and some raw materials is also provided. Modern progress in agriculture, along with the introduction of new high-yielding varieties, increased mechanization of field work and irrigation, is largely determined by the degree of its chemicalization and, above all, the use of mineral fertilizers, plant growth and development stimulants, and chemical pesticides.

**Keywords:** Potassium sulfate, potassium fertilizer, conversion, potassium chloride, sulfuric acid.

## INTRODUCTION:

Modern progress in agriculture, along with the introduction of new high-yielding varieties, increased mechanization of field work and irrigation, is largely determined by the degree of its chemicalization and, above all, the use of mineral fertilizers, plant growth and development stimulants, and chemical pesticides. The production of mineral fertilizers in the republic is developing at an accelerated pace. This development has not only a quantitative but also a qualitative aspect: the raw material base is expanding, technology and equipment are being improved, the range of mineral fertilizers is increasing and the quality is improving. With the launch of the second stage of the potash fertilizer plant, Uzbekistan fully supplies its agriculture with its own potash fertilizers. Potassium sulfate is used for various crops and soil types, and primarily for crops that are sensitive to chlorine. The production of potassium sulfate by conversion of potassium chloride with sodium sulfate is the most acceptable method. Previously, studies were conducted on the conversion of potassium chloride by mirabilite from the Tumryuk deposit, the rheological properties of the solutions were determined, and the main parameters of the

technological process were established. [1–3] Potassium sulfate  $K_2SO_4$  is a highly concentrated, chlorine-free potassium fertilizer. Potassium sulfate is highly soluble in water. It is most often used in conjunction with phosphorus or nitrogen fertilizers. The highest increases in agricultural crop yields were found on soils poor in mobile potassium: peat, floodplain, sandy loam and light loamy sod-podzolic soils. The effectiveness of potassium fertilizers depends on the content of accompanying elements – sodium, chlorine, etc. In addition, potassium sulfate is used to obtain alum, in metallurgy – as part of 99 A.V.Ovsyannikova, D.V.Krutikov, A.G.Starostin flux. It is used as a sulfonating agent in the production of dyes, in analytical chemistry to convert poorly soluble compounds into easily soluble ones, in medicine, photography, pyrotechnics, in the production of glass, soap, paints, leather and in the chemical industry [4–6]. Potassium sulfate occurs naturally in some salt lakes. The Great Salt Lake in Utah is a rich source of potassium sulfate. Potassium sulfate is also found in some volcanic lavas. In nature, it is usually found in association with salts containing magnesium, sodium, and chloride.

Potash fertilizers- are a type of mineral fertilizer used as a source of potassium for plant nutrition; in addition to increasing crop yields, they improve the quality characteristics of grown produce: they contribute to increased plant resistance to disease, increased shelf life of fruits during storage and durability during transportation, as well as improving their taste and aesthetic qualities.

Potassium fertilizers are usually used in combination with nitrogen and phosphorus fertilizers.[7]

Potassium increases the sugar and vitamin content of cultivated produce, and fertilizing in late August and September promotes better winter survival for fruit, berry, and ornamental trees and shrubs. It is used in various soils, for all crops, and for indoor and balcony gardening. Potassium sulfate is suitable for all application methods: as a primary fertilizer (during soil tillage in spring or fall) and as a top dressing during the growing season. It is primarily used for chlorine-sensitive crops (potatoes, tobacco, flax, grapes, citrus, etc.). The presence of sulfate ion in the fertilizer has a positive effect on the yield of plants of the cruciferous family (cabbage, rutabaga, turnip, etc.) and legumes, which consume a lot of sulfur. [7]

The primary raw materials for producing potassium chloride are natural potassium salts (sylvinite and carnallite, salts with a pure potassium content of 12-15% with admixtures of sodium and magnesium salts). Potassium chloride is used on all types of soil as a primary fertilizer.

Sylvinite is a sedimentary rock consisting of alternating layers of halite and sylvite ( $n\text{NaCl} + m\text{KCl}$ ) and some impurities (hematite, etc.). The ratio between potassium and sodium chlorides in sylvinite is variable. It usually contains small amounts of sand, clay, gypsum, and other impurities. It has a non-uniform color—red, pink, blue, and orange crystals are common. It is almost completely soluble in water (except for impurities). Sylvinite is the most important raw material for the production of potassium chloride, which is used as a potash fertilizer. Deposits of the rock are relatively rare, with the main production taking place in Canada, Russia, Belarus, Israel, Uzbekistan and Germany.

Carnallite is the main source of potassium and magnesium for potash fertilizers. Carnallite is one of the most important minerals in potash salt deposits. Just like sylvite and other potassium salts, it serves as a raw material for soil fertilizers.

Sylvinite and carnallite are two different substances, but both are potassium salts used as raw materials for the production of potash fertilizers. Sylvinite is a sedimentary rock consisting of a mixture of minerals, mainly halite (sodium chloride) and sylvite (potassium chloride). Carnallite is a separate mineral, which is a double salt of potassium and magnesium chlorides.

Potassium sulfate can be obtained by reacting potassium chloride with sulfuric acid at high temperature (Mannheim process). Another method involves the reaction of ammonium sulfate and potassium chloride at high temperatures (300-400°C) followed by separation of the reaction products. It is also possible to neutralize the potassium acid sulfate obtained in the first stage from potassium chloride and sulfuric acid using substances such as magnesite or precipitate.

Magnesite is a common mineral, magnesium carbonate  $\text{MgCO}_3$ . Named after the region of Magnesia (Thessaly, Greece), where it was first discovered, it has been known since ancient times. Magnesite is also a refractory material consisting of magnesium oxide  $\text{MgO}$  with 1–10% impurities.[8]

**Double decomposition of potassium sulfate and chloride.** In this method, potassium sulfate is produced by the double decomposition of calcium sulfate ( $\text{CaSO}_4$ ) and potassium chloride ( $\text{KCl}$ ) in an aqueous solution. During the reaction, calcium sulfate first dissolves in water, forming ions. It then reacts with potassium chloride to form potassium sulfate and calcium chloride ( $\text{CaCl}_2$ ). This typically requires specific temperatures and solution concentrations to ensure maximum yield and purity.

**Cooling crystallization method.** The cooling crystallization method exploits the difference in the solubility of potassium chloride and magnesium sulfate ( $\text{MgSO}_4$ ) depending on temperature. This method allows magnesium sulfate and potassium chloride to be obtained, respectively, from a raw solution extracted from a mine or a salt lake, after a series of evaporation and cooling steps. Potassium sulfate is separated from the mother liquor by further processing, such as crystallization upon cooling.

**Ion exchange method.** Ion exchange is a modern technology for producing potassium sulfate. It uses resin or other ion-exchange materials to adsorb potassium ions from potassium-containing solutions. After the resin is saturated, the potassium ions can be eluted from the resin using a concentrated sulfuric acid solution. This is how potassium sulfate is produced. This method allows for the efficient extraction of potassium from various sources, including wastewater and seawater.

**The process of burning sulfur ores.** In this process, sulfur-containing ores (such as pyrite  $\text{FeS}_2$ ) are mixed with potassium chloride and heated to high temperatures for combustion. The sulfuric acid and sulfuric gas produced by the reaction can react with potassium chloride to form potassium sulfate. This process also solves environmental problems associated with sulfur ore, as waste sulfur can be converted into useful chemical products.

**Electrolysis method for the production of potassium sulfate.** Electrolysis produces potassium sulfate by electrolyzing a solution containing sulfuric acid and potassium chloride. During electrolysis, the water in the solution dissociates into hydrogen ions and oxygen ions. They react at the cathode and anode, respectively. During this process, hydrogen ions can combine with sulfate ions to form potassium sulfate. Oxygen ions can combine with chloride ions to form chlorine gas.

Each method has its pros and cons. For example, the Mannheim process is capable of producing high-purity potassium sulfate. However, energy consumption is high, costs are high, and the equipment requires rigorous materials. The double decomposition process is relatively simple. However, byproducts (such as calcium chloride) may form, which are difficult to handle. Cooling crystallization is suitable for processing potassium and magnesium salts in natural mineral water or seawater. Ion exchange and electrolysis are generally suitable for developing high-purity potassium sources.

Mineral forms of pure potassium sulfate are relatively rare. The mineral arcanite consists of pure  $K_2SO_4$  and occurs as white or transparent crystals. It is found in California, USA.

There are many minerals that contain potassium salts:

- $Cainite—MgSO_4 \cdot KCl \cdot H_2O$
- $Glaserite—2K_2SO_4 \cdot Na_2SO_4$
- $Schönite—K_2SO_4 \cdot MgSO_4 \cdot 6H_2O$
- $Leonite—K_2SO_4 \cdot MgSO_4 \cdot 4H_2O$
- $Langbeinite—K_2SO_4 \cdot 2MgSO_4$
- $Polyhalite—K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$
- $Syngenite—K_2SO_4 \cdot CaSO_4 \cdot H_2O$

Industrial production methods are based on exchange reactions of KCl with various sulfates and as a result potassium sulfate is usually heavily contaminated with by-products:

The purest product is obtained by treating solid potassium chloride with concentrated sulfuric acid:

By calcining the mineral langbeinite with coal:

The following methods are used in laboratory practice:

From potassium oxide:

- displacement from weak or unstable acids:
- from alkali and dilute acid:
- from potassium hydrosulfate
- oxidation of potassium sulfide:
- from potassium peroxide:

Potassium sulfate is obtained by heating potassium sulfite to a temperature of  $600^\circ C$ :

Oxidation of sulfur with potassium dichromate:

Interaction of ammonium sulfate and potassium hydroxide:

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