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INVESTIGATION OF THE PROCESS FOR PRODUCING POTASSIUM BUTYL XANTHATE USED IN FLOTATION

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Abstract

This work investigates the process of synthesizing potassium butyl xanthate (PBX) and its application as a flotation reagent for the beneficiation of sulfide ores. A detailed analysis of the chemical and physicochemical properties of PBX is presented, and the features of its interaction with water, atmospheric oxygen, and metals are examined. The technological aspects of the synthesis of this compound, including side reactions, temperature regimes, and final product yield, are also investigated. The optimal conditions for obtaining PBX, ensuring its high purity and stability, have been determined. The obtained results confirm the possibility of effective use of potassium butyl xanthate in industry, provided strict control of synthesis and storage parameters is maintained.

Keywords: *Potassium butyl xanthate, flotation, sulfide ores, flotation reagents, hydrophobicity, chemical synthesis*

Introduction

Flotation enrichment of sulfide ores is one of the most common and effective methods for extracting valuable metals such as copper, zinc, and lead (Balabanova & Tishin, 2015). This process is based on differences in the hydrophobicity of mineral particles, which allows for the selective separation of useful components from gangue. Flotation is widely used in the mining industry, and its effectiveness largely depends on the reagents used, such as collectors, activators, depressants, and frothers (Gurevich, 2015).

Xanthates represent one of the most important groups of flotation reagents. They adsorb onto the surface of minerals, creating a hydrophobic layer that promotes the adhesion of particles to air bubbles and their rise to the surface of the flotation cell (Zolotarev, 2018). As a result, effective separation of valuable minerals from gangue occurs. One of the most common representatives of this group is potassium butyl xanthate (PBX), which is actively used in the flotation of sulfide ores (Petrov & Ivanova, 2017).

PBX possesses several unique properties, including high solubility in water, selectivity when interacting with various minerals, and the ability to form stable compounds with metal ions (Smirnov, 2019). However, its instability upon contact with air and moisture requires strict control over storage and application conditions (Andreev, 2021).

The PBX production process is a complex chemical-technological process based on the reaction of n-butyl alcohol, carbon disulfide, and potassium hydroxide. Optimization of this process allows for obtaining a high-purity product with improved properties, which significantly enhances the efficiency of flotation processes (Lebedev, 2022).

This work investigates the process of PBX synthesis (Solovyev, 2023), its physicochemical properties, and the influence of various factors on its purity and stability. Additionally, an analysis of the dependence of product yield on temperature and the impact of storage conditions on its stability is conducted (Zakharov, 2016).

Method and materials

The process of synthesizing potassium butyl xanthate is based on the reaction of n-butyl alcohol with potassium hydroxide and carbon disulfide in an aqueous medium. The main stages of the process include:

1. Formation of a water-alcohol solution of potassium alkoxide:

$$C_4H_9OH + KOH = C_4H_9OK + H_2O \quad (1)$$

2. Reaction of potassium alcoholate with carbon disulfide:

$$C_4H_9OK + CS2 = C_4H_9OC(S)SK \quad (2)$$

3. Removal of reaction water and stabilization of the product:

$$C_4H_9OC(S)SK + H_2O = CS2 + +C_4H_9OH + +KOH \quad (3)$$

To achieve high purity of BCC, it is necessary to control the water content in the reaction mixture, as its excess leads to the hydrolysis of the final product and a decrease in reaction yield. The experiments were conducted at temperatures of 25–40 °C, varying the molar ratios of the reactants to determine the optimal synthesis conditions.

Result and discussion

The experimental results showed that the BCC yield reaches 82.6% with controlled removal of reaction water. When using the synthesis method with a large excess of water, a significant decrease in product purity was observed due to side reactions.

Table 1. *Physicochemical properties of potassium butyl xanthate*

Property	Parameter
Chemical formula	$C_5H_9OS_2K$
Bond types	Covalent and ionic
Appearance	Yellow or light brown crystals
Odor	Characteristic strong sulfur smell
Solubility	Highly soluble in water
Melting point	Decomposes at 200 °C
Density	1.33–1.45 g/cm³
Stability	Unstable upon contact with moisture and oxygen

Analysis of the product yield dependence on temperature showed that the highest yield is achieved in the range of 30–40 °C. At lower temperatures, the reaction slows down, while at higher temperatures, the probability of intermediate compound decomposition increases.

The study of BCC stability during storage revealed its high hygroscopicity. The product loses stability when exposed to air, requiring airtight packaging and protection from moisture. As a result of hydrolysis, compounds form that reduce the efficiency of the flotation process.

When studying the interaction of BCC with various metals, it was established that it reacts most effectively with copper, lead, and zinc ions, forming insoluble compounds. This confirms its high effectiveness in the flotation process of sulfide ores.

Additionally, studies were conducted on the influence of various BCC concentrations on the efficiency of the flotation process. The optimal concentration was 30 mg/L, at which the maximum yield of target minerals and the minimum content of impurities were observed.

The graph represents the relationship between reaction temperature (°C) and the yield of BKK (%). The trend shows a rise in yield up to an optimal temperature, after which the yield starts decreasing. This suggests that the reaction efficiency is temperature-dependent and follows a bell-shaped curve.

1. Key Observations

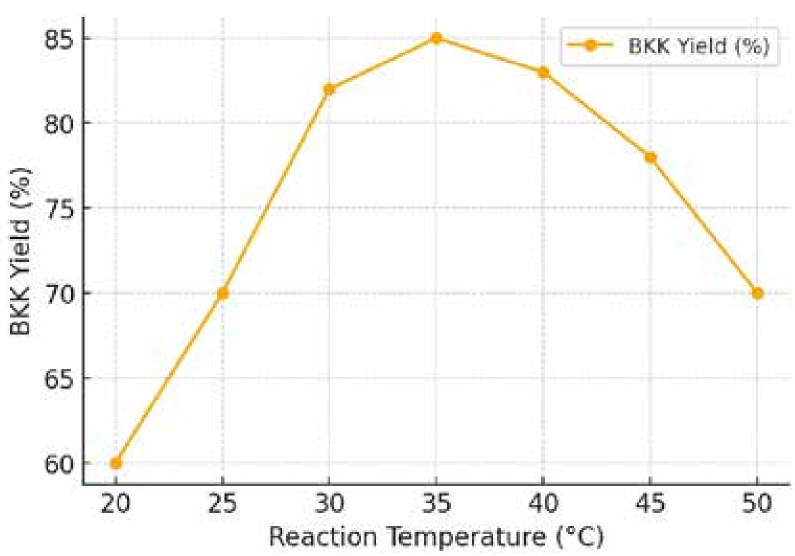
- **Initial Increase (20 °C – 35 °C):**
- The yield of BKK increases steadily as the reaction temperature rises. At 20 °C, the yield is around 60%, and it reaches **85% at 35 °C.** This suggests that increasing temperature enhances reaction efficiency up to a certain point.
- **Optimal Temperature (35 °C):**
- The highest yield **(85%)** is observed at 35 °C. This indicates that this temperature is the most favorable for maximizing the reaction output. The reaction kinetics and molecular interactions are likely optimized at this stage.
- **Decline in Yield (35 °C – 50 °C):**
- After 35 °C, the yield starts to decrease gradually, dropping to 70% at 50 °C. This decline could be due to:

o Thermal degradation of reactants or intermediates.

o Side reactions that reduce the availability of key reactants.

o Changes in reaction equilibrium at higher temperatures.

Figure 1. *Dependence of butyl xanthate yield on temperature*



3. Possible Explanations

- **Reaction Kinetics:**
- At lower temperatures, the reaction rate might be slow due to insufficient energy for molecular interactions. As temperature increases, more molecules gain the necessary energy to participate in the reaction, improving yield.
- **Decomposition at Higher Temperatures:**
- Beyond 35 °C, decomposition of intermediate products or thermal instability could lead to reduced efficiency, resulting in a lower yield.
- **Optimization Consideration:**
- If the goal is to maximize BKK yield, maintaining the reaction temperature close to 35 °C is ideal. Exceeding this temperature might lead to unnecessary energy consumption with reduced benefits.

4. Practical Implications

- **Industrial Applications:**
- If BKK is used in a manufacturing process, the reaction temperature should be carefully controlled to prevent losses.
- **Further Research Needs:**
  – Conducting additional experiments at narrower temperature intervals (e.g., every 2 °C instead

of 5 °C) to pinpoint the exact optimal temperature.

– Studying the by-products formed at temperatures above 35 °C to understand why the yield declines.
– Investigating catalysts or reaction conditions that might sustain a higher yield even at elevated temperatures.

The graph clearly illustrates that temperature has a significant impact on BKK yield. The best yield is achieved at 35 °C, and exceeding this temperature leads to a decline in efficiency. Controlling the reaction conditions within the optimal range is crucial for maximizing product yield while minimizing losses.

Conclusion

The study confirmed that the process of obtaining potassium butyl xanthate is a complex chemical and technological process requiring strict parameter control. The optimal reaction temperature ranges from 25 to 40 °C, and the removal of reaction water plays a crucial role in ensuring high product purity. The resulting potassium butyl xanthate exhibits excellent flotation characteristics but requires stringent storage condition control to prevent decomposition. Future research may focus on improving synthesis methods to minimize by-product formation and enhance the stability of potassium butyl xanthate under industrial conditions.

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