TECHNOLOGY FOR OBTAINING POTASSIUM TITANATE BY ILMENITE ALKALINE LEACHING

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Introduction. Potassium titanates are promising materials for the electronic, ceramic, and catalytic industries. Traditional acid methods for processing titanium-bearing raw materials involve significant environmental risks and high energy consumption. Alkaline leaching serves as a competitive alternative, ensuring rapid conversion of titanium into soluble forms without requiring expensive, corrosion-resistant equipment. However, process efficiency depends heavily on the mineralogical composition of a specific deposit. The purpose of this work is to optimize the conditions for the solid-phase synthesis of potassium titanate (K_2TiO_3) from the ilmenite concentrate of the Irshansky deposit (Zhytomyr region).

Methodology and Materials. A 96% ilmenite concentrate was used in this study. The morphology and phase composition of the initial raw material and the resulting products were investigated using scanning electron microscopy (SEM) and X-ray diffractometry (XRD) on a DRON-3M diffractometer. The solid-phase alkaline interaction was carried out under controlled temperatures (453–573 K) and varying component molar ratios.

Results and Discussion. According to the XRD data, the initial concentrate contains 70 % of ilmenite ($FeTiO_3$) and 20 % of rutile (TiO_2). The average crystallite size of the ilmenite phase calculated via the Scherrer formula is 26.62 nm. Thermodynamic calculations performed by the Tiomkin-Schwartzman method confirmed the energetic feasibility and spontaneous course of the alkaline leaching reaction:

$$4FeTiO_3 + 8KOH + O_2 \rightarrow 4K_2TiO_3 + 2Fe_2O_3 + 4H_2O$$

The optimal process parameters were experimentally determined (Table 1), providing a titanium(IV) extraction degree of 86.7%.

Process Parameter	Parameter Value	Extraction Rate (X), %
Ilmenite particle size	≤ 71 µm	86.10
Molar ratio $FeTiO_3$: KOH	1 : 2	86.7
Interaction time (τ)	180 min	86.13
Process temperature (T)	453 K	86.5

Further increases in temperature or an excess alkali content result in only a slight increase in extraction efficiency (up to 89.7%), which is deemed economically unfeasible. Mathematical modeling of the kinetics showed that the process is most accurately described by the compressed sphere model (R^2 = 0,9728) with a chemical reaction at the limiting stage. The calculated apparent activation energy is 22 kJ/mol, indicating a kinetic regime of the process with low activation energy.

The obtained potassium titanate was purified by dissolving the melt in water followed by coagulation and precipitation with a fivefold excess of 96% ethanol. According to SEM and XRD data, the product possesses an orthorhombic structure with an average particle size under 200 nm (X-ray diffraction data shows 31.53 nm). Based on these research findings, a closed technological scheme for the production of K_2TiO_3 with integrated alcohol and alkali recycling has been proposed.

Conclusions. The optimal conditions for synthesizing potassium titanate from Irshansk ilmenite were established (≤ 71 μm, $FeTiO_3$:KOH = 1:2, 453 K, 3 h). These parameters significantly lower the reaction temperature compared to traditional industrial analogues and ensure a high level of environmental safety for the technology.

References

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