Photocatalytic properties of K_2TiO_3

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Abstract

In this work, the possibility of using potassium titanate for the photocatalysis process of methylene blue is studied. K_2TiO_3 is obtained by alkaline melting of ilmenite from the Irshan deposit (Ukraine) with *KOH* at a molar ratio of 1:2 at temperature 453 *K*. The obtained potassium titanate structure is analyzed by IR spectroscopy and X-ray diffraction methods.

It is found that the potassium titanate has greater photocatalytic activity compared with unmodified titanium (IV) oxide.

It is established that the photocatalysis degree for TiO_2 and K_2TiO_3 is 19.29% and 81.91% under 10 minutes of UV irradiation of the catalyst-solution reaction mixture at a maximum concentration of methylene blue 10 mg / L. Experimental data indicate the promising use of potassium titanate as a catalyst for dye decomposition.

Keywords: ilmenite, potassium titanate, photocatalysis, dyes, methylene blue

I. Introduction

Modern industry requires the use of a large variety of synthetic dyes.However, artificial dyes that are getting into the environment with production wastes, cause significant damage to living organisms of water bodies, soils, and air due to the presence of certain toxic properties (Dina,2021).Today there is a significant number of ways to clean the environment from industrial pollutants, including dyes, the principle of which is based on certain physical and chemical processes (Tichapondwa, 2020).

Photocatalysis is one of the promising methods of cleaning water bodies and soils from dyes, the main advantages of which are considerable speed and efficiency of this process, high biocompatibility of the catalyst with the environment, and a relatively low cost of the technological process as a whole. Such photocatalysts can be titanium compounds of different chemical nature, in particular, potassium titanate (Al-Mamun, 2019).

II. Experimental Set-up and Procedure

To study the photocatalytic properties, potassium titanate is synthesized by fusing ilmenite from the Irshan deposit (Ukraine) with potassium hydroxide at a molar ratio of 1:2 according to the reaction stoichiometry:

$$4FeTiO_3 + 8KOH + O_2 \xrightarrow{T,453K} 4K_2TiO_3 + 2Fe_2O_3 + 4H_2O$$

The reaction mixture is heated in a glycerine bath for 3 hours at 453 K. After cooling, the melt is washed with distilled water and filtered from unreacted impurities. Potassium titanate is obtained by precipitation with three times methanol excess (puriss.p.a.). The obtained precipitate K_2TiO_3 is washed with methanol on a filter to pH ~ 7 and dried in a baker at 335 K for 30 min.

The obtained sample K_2TiO_3 was studied by IR spectroscopy on the "AGILENT CARY 630" FTIR Spectrometer (λ = 400 – 4000 cm^{-1}) and by the Automatic X-ray diffractometer DRON-3M (Kα (Cu), λ = 0,1540 nm).

To study the photocatalytic activity of K_2TiO_3, a series of aqueous solutions of methylene blue dye in the concentration range 2 -10 mg/L was prepared. Photocatalysis is performed using a 40 W UV lamp with constant stirring (catalyst mass 5 mg, dye solution volume 20 ml). The concentration before and after photocatalysis is set on a photocolorimeter KPK-2 (λ = 670 nm; l = 1.0 cm).

III. Analysis

The photocatalysis degree (*X, %)* is determined by the formula:

$$X = \frac{(C_0 - C_{eq})}{C_0} \cdot 100\%$$

where C_0 is the initial concentration of dye, mg/L;

C_{eq} – equilibrium concentration after photocatalysis, mg/L.

IV. Results and discussions

Fig.1 shows the curves of dye photocatalysis by TiO_2 (fig.1, a) and K_2TiO_3 (fig.1, b) surfaces.

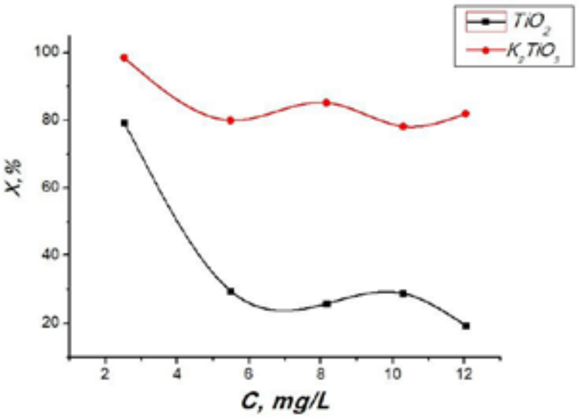

Fig.1 Dependence of the photocatalysis degree on the concentration of methylene blue

It is found that synthesized K_2TiO_3 has greater photocatalytic activity compared with unmodified TiO_2.Thus, during 10 minutes of UV irradiation of the catalyst-solution reaction mixture (C_{max} = 10 mg/L) the photocatalysis degree for TiO_2 is 19.29% and for K_2TiO_3 is 81.91%. Experimental data indicate the promising use of potassium titanate as a catalyst for dye decomposition.

V. Conclusions

Potassium titanate obtained by alkaline melting from ilmenite is a promising photocalase agent, particularly for adsorption-destruction processes of methylene blue conversion in aqueous solutions.

References

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