PHYSICOCHEMICAL PROPERTIES OF TITANIUM (IV) OXIDE AND ITS INDUSTRIAL SIGNIFICANCE

Davlatov Sukhrob Shavkatovich
Qoraeva Dilnavoz Kumakovna
Lead Engineers, Shurtan Oil and Gas Production Department
https://doi.org/10.5281/zenodo.17312264

ARTICLE INFO

Received: 01st October 2025
Accepted: 04th October 2025
Online: 10th October 2025

KEYWORDS

Titanium (IV) oxide, chemical, catalyst, reagent, technology, reaction, production, chemical

ABSTRACT

A brief overview is given on the use of Titanium (IV) oxide (TiO_2) and its place in industry.

Introduction: Titanium (IV) oxide is an amphoteric oxide composed of chemical elements, a compound of titanium with oxygen having the chemical formula TiO_2. It is considered one of the main products of the titanium industry. Due to its boiling point of 2972 °C, melting point of 1843 °C, density of 4.23 g/cm^3, molar mass of 79.866 g/mol, and permissible workplace concentration of 10 mg/m^3, it is one of the most widely used reagents in world industry. Its main advantages are high photocatalytic activity, chemical stability, and relative affordability.

Titanium (IV) oxide is widely used in cosmetology for preparing sunscreens that absorb ultraviolet rays, assisting in purification processes, water treatment, air filtration, decomposition of organic compounds in the oil and gas industry, and as a catalyst in chemical reactions. However, after use, its active centers become contaminated, covered, or structurally changed, leading to decreased activity. Titanium (IV) oxide is a white powder that, when heated, turns pale yellow but returns to its original color when cooled. It occurs naturally in three forms: rutile, anatase, and brookite. It is distinguished by resistance to H_2S and SO_2 and slight solubility in alkalis. It is also used in the production of synthetic fibers and paints. For these reasons, the development of technologies for regeneration and reuse of titanium (IV) oxide reagents is one of the important modern directions.

Methods of Titanium (IV) Oxide Regeneration:

- thermochemical treatment (calcination): Heating the catalyst at high temperatures (400–600 °C) burns off accumulated organic substances. This method helps restore the active centers of titanium (IV) oxide.

- chemical cleaning: Washing with acidic or alkaline solutions removes metal ions and various coatings. For example, treatment with H_2SO_4 or NaOH solutions.

- photocatalytic restoration: Under ultraviolet radiation, electron-hole pairs in titanium (IV) oxide activate, oxidizing contaminants and restoring catalyst activity.

Applications of Recycled Titanium (IV) Oxide:

- in the oil and gas industry — purification of gas mixtures, oxidation of organic substances;

- in water resource protection — treatment of polluted industrial water;

- in atmospheric air filtration — removal of harmful gases such as NO_2 and SO_2;

- in energy — used as a photocatalyst in hydrogen production processes.

Titanium (IV) oxide also exhibits acidic properties. When interacting with concentrated sulfuric acid, it slowly dissolves and forms corresponding tetravalent titanium salts:

$$TiO_2 + H_2SO_4 \longrightarrow Ti(SO_4)_2 + 2H_2O$$

Regeneration and reuse of titanium (IV) oxide reduce industrial waste volumes, conserve resources, and improve environmental safety. Additionally, restoring used titanium (IV) oxide catalysts reduces the costs of purchasing new materials and prevents environmental pollution. Research in this field paves the way for zero-waste production in the future.

References:

1.T. G. Akhmetov, R. T. Porfiryeva, L. G. Gaisin et al. Chemical Technology of Inorganic Substances, Vol. 1, Ed. T. G. Akhmetov. Moscow: Vysshaya Shkola, 2002.

2.B. V. Nekrasov. Fundamentals of General Chemistry, Vol. I, 3rd ed., revised and supplemented. Chemistry Publishing House, 1973.

3.Yu. N. Yuryev. Properties of Thin Films of Titanium Oxide (TiO_2) and Amorphous Carbon (a-C) Deposited Using Dual Magnetron Sputtering System, PhD Dissertation Abstract, Tomsk, 2016.

4.Chemical Encyclopedia (electronic version).