Nanopurimon

Newsletter, Issue 1

JOINT OPERATIONAL PROGRAMME
ROMANIA-MOLDOVA 2014-2020

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GA3 Research activities.

Activity 3.1 Development and realization of synthesis of a photocatalyst on the base of diatomite and nanosized TiO_2 particles (NTD).

Executive summary of the Action.

Wastewater containing phenolic compounds is particularly difficult to clean due to their poor biodegradability and high toxicity. Phenols are considered one of the major hazardous materials because of their toxicity, endocrine disrupting ability, persistence and carcinogenic behavior. Therefore, the increasing presence of phenol represents significant hazardous environmental toxicity. The World Health Organization (WHO) has limited phenol concentration in drinking water to 1 µg/L.

Wastewaters containing phenols and other toxic compounds need careful treatment before discharge into the receiving bodies of water.

Activated carbon adsorption, solvent extraction, chemical oxidation and electrochemical methods are the most widely used methods for removing phenol and phenolic compounds from wastewaters.

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These approaches are often ineffective because they merely transfer the organic pollutants from water to another medium without degrading or mineralizing the organic pollutants.

Nanotechnology offers original approaches for the destruction of organic substances in water and presents several environmental benefits. The method of heterogeneous photocatalysis, one of the measures employed in modern advanced oxidation processes (AOPs), has been used to remove or mineralize a wide range of organic pollutants.

Several semiconductors can act as photocatalysts but TiO_2 stands out as the most effective photocatalyst and has been extensively used in water and wastewater treatment studies because it is cost effective, thermally stable, non-toxic, chemically and biologically inert, strong photoactive and is capable of promoting oxidation of organic compounds.

However, the large scale application of this treatment technology is constrained by several factors such as: low adsorption capacity, strong tendency to agglomeration of nano sized TiO_2 particles resulting in reduction or even complete loss of photocatalytic activity; problem of separation of nanosized particle powder in the aqueous media after the photocatalytic process.

Many techniques of immobilization have been developed to attach the TiO_2 powder to simplify the cleaning stage after the photocatalytic process. The dispersion of TiO_2 nanosized particles into porous material is the solution of the problem.
Diatomite is an important porous non-metallic resource with nontoxic and good chemical stability. Application of diatomite as carrier material may enhance the TiO_2 nanosized particles distribution in suspension which enables to adsorb and concentrate the target substances.

There are a number of methods for preparing hybrid photocatalysts based on nanosized titanium dioxide and a mineral substrate, in particular, diatomite. Basically, this is a heterogeneous chemical deposition of titanium dioxide from titanium alkoxides or titanium tetrachloride as a precursor of nanosized titanium dioxide.

A common disadvantage of the described methods is the use of chemical reagents, the multistage and long duration of the process of obtaining titanium dioxide in the composite.
One of the methods without these disadvantages is the electrochemical method for producing titanium dioxide.

The electrochemical method developed by us for the preparation of a hybrid photocatalyst based on nanosized titanium dioxide and diatomite (NTD) as a substrate is free from these drawbacks.

In the period of Activity 3.1. the procedure for obtaining the hybrid photocatalyst has been developed and hybrid photocatalyst on the base of nanocrystalline titanium dioxide and local raw material, diatomite, as a substrate was manufactured.

Patent application on the developed method for preparation of a composite photocatalyst "nano-TiO2 - diatomite (NTD)" has been filed, including the following steps:

- Patent search;
- Patent writing;
- Patent pending.

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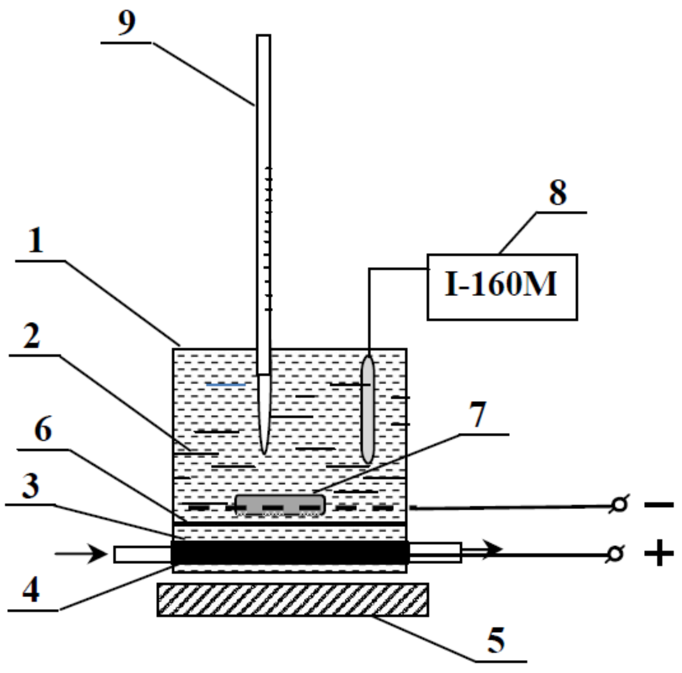
Institute of Applied Physics

Patent application Nr. s 2021 0046, 20210531. Datko T., Zelentov V., i Dvornikov D., Sainsus I.

The process for obtaining the hybrid photocatalyst on the base of nanocrystalline TiO2 and diatomite by electrolysis.



4 - Carbon anode
5 - Magnetic stirrer
6 – Cathode, Pt grid.
7 – Magnet.
8 - pH meter I-160M.
9 – Thermometer.

The invention relates to the field of renewable alternative solar energy, photocatalytic purification of water and air from organic and inorganic pollutants using a photocatalyst based on nanosized titanium dioxide grafted on the surface of a porous carrier and can be used for purification of aqueous media from organic pollutants and degradable toxic inorganics, in devices that convert radiant energy, including solar energy, to produce hydrogen from water into electrochemical cells, or heterogeneous photocatalytic conversion of carbon dioxide to produce new compounds.

Fig.1 Diagram of the experimental installation for the synthesis of the photocatalyst.

1 – Electrolizer
2 – Suspension: diatomite + TiC14 solution
3 - MK-40 cation exchange membrane

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A method for producing a hybrid photocatalyst based on nanodimensional titanium dioxide and local diatomite. The method consists in processing the mixture of diatomite and titanium dioxide precursor in the cathode chamber of the two-chamber electrolyzer by passing an electric current with a density of 30-100 mA/cm2 through an aqueous suspension of diatomite and titanium dioxide precursor. The method is characterized in that the heterogeneous hydrolysis of the precursor by electrolysis products is carried out directly in the presence of diatomite in a single step.

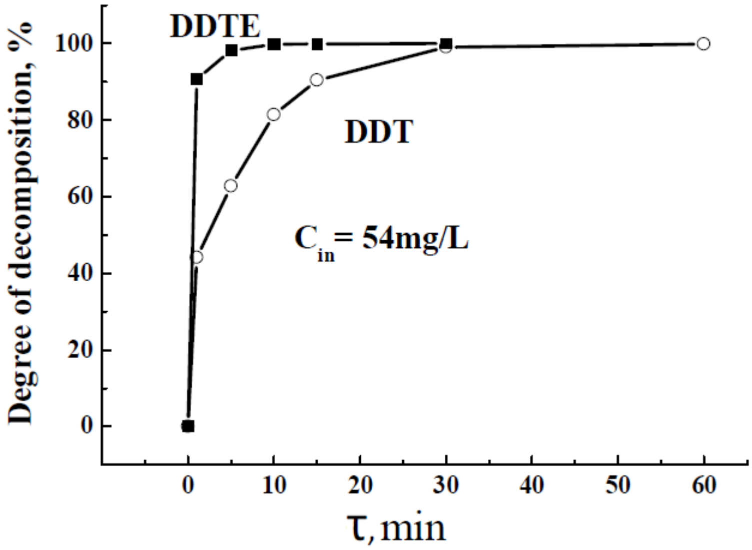

Fig.2 Comparison of methylene blue degradation rates by chemically deposited (DDT) and electrochemically synthesized (DDTE) photocatalysts.

Advantages of the proposed process compared to the classical procedures:

- Increasing the synthesis productivity by reducing the number of operations and the amount of reagents used (the synthesis takes 30 minutes instead of 20 hours).
- A product with the following new properties was obtained: increased specific surface area, anatase crystallite size of 8.0 nm instead of 15.3 nm, adsorption value of standard dye - methylene blue of 64.9 mg/g instead of 37.5 mg/g.
- Application of the obtained product in the photocatalytic degradation of organic pollutants will result in:
    1. Intensification of the process of photodegradation of the organic substances: the time to achieve the discoloration of 99.9% with an initial concentration of methylene blue of 54 mg/l is reduced by a few times (for example, 5 minutes instead of 30);
    2. Reduction of the dose of photocatalyst for the decomposition of the same mass of organic substances (for example, 1g/l instead of 6g/l);

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