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ULTRASONIC AND STEAM EXFOLIATION OF g-C_3N_4 NANOPOWDERS

Currently, hydrogen technology is one of the most discussed topics in the energy sector. The active usage of fossil energy sources (coal, oil and gas) inevitably leads to an increase in the greenhouse effect, and, as a result, climate change. Abstention from burning fuels in order to reduce the carbon footprint can be achieved by alternative energy sources obtained using low-carbon technologies. The use of wind turbines and solar panels cannot fully cope with this task due to the difficulties with long-term storage of the energy received. Therefore, the use of hydrogen today seems to be the only universal way to overcome problems that cannot be solved with the help of other renewable energy sources. It is possible to produce green hydrogen using electrolysis of water, as well as photocatalytic reforming of water, however, due to the lack of effective catalytic materials, this method has not yet received industrial application. Therefore, the search and development of environmentally friendly and highly efficient catalysts is an urgent and important task.

Graphite-like carbon nitride (g-C_3N_4) is widely known as an effective bifunctional catalytic material for photo- and electrocatalytic hydrogen production processes. It does not contain rare or noble elements in its composition, it is easily synthesized by thermolysis of nitrogen-rich precursors (melamine, urea, thiourea, dicyandiamide, etc.). The catalytic efficiency of g-C_3N_4 can be increased by modifying the morphology of its 2D nanocrystals and reducing their aggregation. Exfoliation of graphite-like carbon nitride makes it possible to obtain g-C_3N_4 monolayers, which leads to a significant increase in the specific surface area. The specific surface area is an important characteristic of catalytic materials, since it determines the specific amount of active sites on the g-C_3N_4 surface.

At present, methods of thermal, chemical, and electrochemical exfoliation are known, but template synthesis remains the most effective way to increase the specific surface area of g-C_3N_4. The use of a template makes it possible to obtain developed macroporous structures, but additional washing stage is necessary.

Therefore, this work is aimed at developing simple and effective method for the exfoliation of graphite-like carbon nitride (g-C_3N_4) nanopowders, as well as studying the structural features of exfoliation products in order to determine the prospects for their practical use as the basis for effective and affordable photo- and electrocatalytic materials.

Initial graphite-like caкbon nitride was obtained by thermal treatment of urea at 550°C in air for 2 hours.

Two ways were used to carry out exfoliation process:

1. Using alternating ultrasonic and thermal treatments of the initial g-C_3N_4 nanopowder.
2. Using steam treatment of initial g-C_3N_4 nanopowder.

The phase composition of the synthesized products was determined by X-ray diffractometry, the morphology was analyzed by scanning electron microscopy, specific surface area and porosity were determined by low-temperature nitrogen adsorption-desorption, and diffusion reflection spectroscopy was used to evaluate the band gap.

As a result of the synthesis, a pale-yellow powder was obtained, the X-ray diffraction pattern of which corresponded to graphite-like carbon nitride. It was shown that ultrasonic exfoliation of the initial powder of graphite-like carbon nitride led to a decrease in the band gap from 2.93 eV to 2.85 eV and an increase in the specific surface area from 58.6 m2/g to 136.7 m2/g. The exfoliation of the initial powder using steam reforming was carried out at 400°C. The band gap of the obtained nanocrystalline graphite-like carbon nitride was 3.06 eV, and the specific surface area increased to 156.6 m2/g.

An increase in the specific surface area of the catalytic material and a shift of the absorption band edge to the visible region allows us to conclude that g-C3N4 exfoliated by the proposed methods can be considered as a promising basis for photo- and electrocatalytic materials.

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