THERMODYNAMIC ASPECTS OF PIEZOPHOTOCATALYSIS AND DESIGN OF PIEZOPHOTOCATALYTIC MATERIALS

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In the report it will be discussed a new rapidly developing area that has shown its effectiveness in increasing the photocatalytic activity of oxide materials – using the piezoelectric properties of oxides and achieving a synergy of light and mechanical effects to enhance catalytic activity.

An overview of both the history of the development of the research area and the results of recent years for various classes of materials will be presented.

The approach to increasing photocatalytic activity is based on the introduction of an external field to reduce carrier recombination and accelerate their separation and migration [1,2]. In this case, the use of photoactive ferroelectric semiconductors opens the way for synergetic catalysis – piezophotocatalysis.

The report focuses on thermodynamic criteria for the possibility of photo– and piezophoto-catalytic processes of oxidation of organic pollutants in water and the production of hydrogen from water and aqueous solutions of organic substances including plant biomass derivatives.

Thermodynamic criteria use data on the band structure of a semiconductor oxide and data on the reduction potentials of semi-reactions involving ions and radicals participated in the photocatalytic process as a whole.

The main attention will be devoted to the prospects of perovskite-like materials, most of which contain bismuth cations, for piezophotocatalysis. As an example will be considered the Aurivillius phase of Bi_3NbTiO_9 and the results of testing their piezophotocatalytic activity under simultaneous exposure of light and ultrasound. It is shown how an internal piezoelectric field, suppressing the rapid recombination of charge carriers, activates additional pathways for the formation of superoxide anion radicals that are inaccessible under photocatalytic conditions, resulting in a pronounced synergistic effect when exposed to light and ultrasound simultaneously.

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