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Photocatalysts based on Bi-containing layer perovskites for dye photodegradation

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To date, the development of manufactures, in particular the textile and polygraphic, is growing rapidly. Plants release a numerous amounts of dyes in water that causes environmental pollution [1]. Photocatalysis is a perspective approach of dyes degradation since it occurs in the presence of photocatalysts and light at room temperature. Photocatalysts on basis of Bi-containing layer perovskites have advantages under other photocatalysts due to the ability to separate an electron-hole pair and absorb visible light that enhance the photocatalytic performance.

Thus, the aim of the report is to establish the influence of phase content of perovskite catalysts on their optical properties and photocatalytic activity in the reaction of Rhodamine B photodegradation.

The seria of 3 samples, namely Bi_2Si_1, $Bi_2Si_{0.5}Ti_{0.5}$, Bi_4Ti_3, was synthesized via sol-gel method. Phase composition was determined by X-ray diffraction analysis and IR-spectroscopy. Quantitative content of elements was detected with X-ray Fluorescent analysis. The value of specific surface area was measured by low temperature sorption of nitrogen. Diffuse reflectance spectroscopy was used to determine optical characteristics of the samples.

Photocatalytic activity of the samples prepared was evaluated in the reaction of Rhodamine B photodegradation, concentration of which was monitored by UV-Vis spectrophotometer.

According to XRD data, the sample Bi_4Ti_3 consists of layer $Bi_4Ti_3O_{12}$ phase, while the samples containing Si are multiphase with the prevalence of layer bismuth metasilicate phase Bi_2SiO_5. The sample Bi_2Si_1 possesses the highest value of S_{BET}, at the same time the content of silicon is in 1.5 higher than theoretically calculated one, so IR-spectroscopy was also used to confirm the phase composition of the samples. IR-spectroscopy data correlates with XRD data for each sample prepared. Additionally, in the IR-spectrum of the Bi_2Si_1 sample in region 1100–1200 cm^{-1} the vibrations of Si-O bond were detected which are characteristic for SiO_2. Obtained results specify the formation of amorphous silica due to partial hydrolysis of TEOS for Bi_2Si_1 sample.

DRS spectra demonstrate absorbance edges in region 378–395 nm for the samples containing bismuth titanates. Since the absorbance edge of Bi_2Si_1 sample is at 550 nm, the sample absorbs light in the visible area which is due to the presence of narrow-band semiconductor β-Bi_2O_3 in the composition of the photocatalyst.

Photocatalysts prepared show 100% conversion of Rhodamine B degradation via deethylation mechanism, while the reference photocatalyst α-Bi_2O_3 decomposes the dye only by 40%.

Thus, sol-gel approach allowed preparing the photocatalysts based on Bi-containing perovskite silicates and titanates which are able to decompose the Rhodamine B solution. Apart from that, the developed preparation technique let synthesize material absorbing the visible light. Though the highest photocatalytic activity was demonstrated due to separation of charge carriers inside the composite $Bi_2Si_{0.5}Ti_{0.5}$ consisted of Bi_2SiO_5, $Bi_{12}SiO_{20}$, $Bi_{12}TiO_{20}$ phases.

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References

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