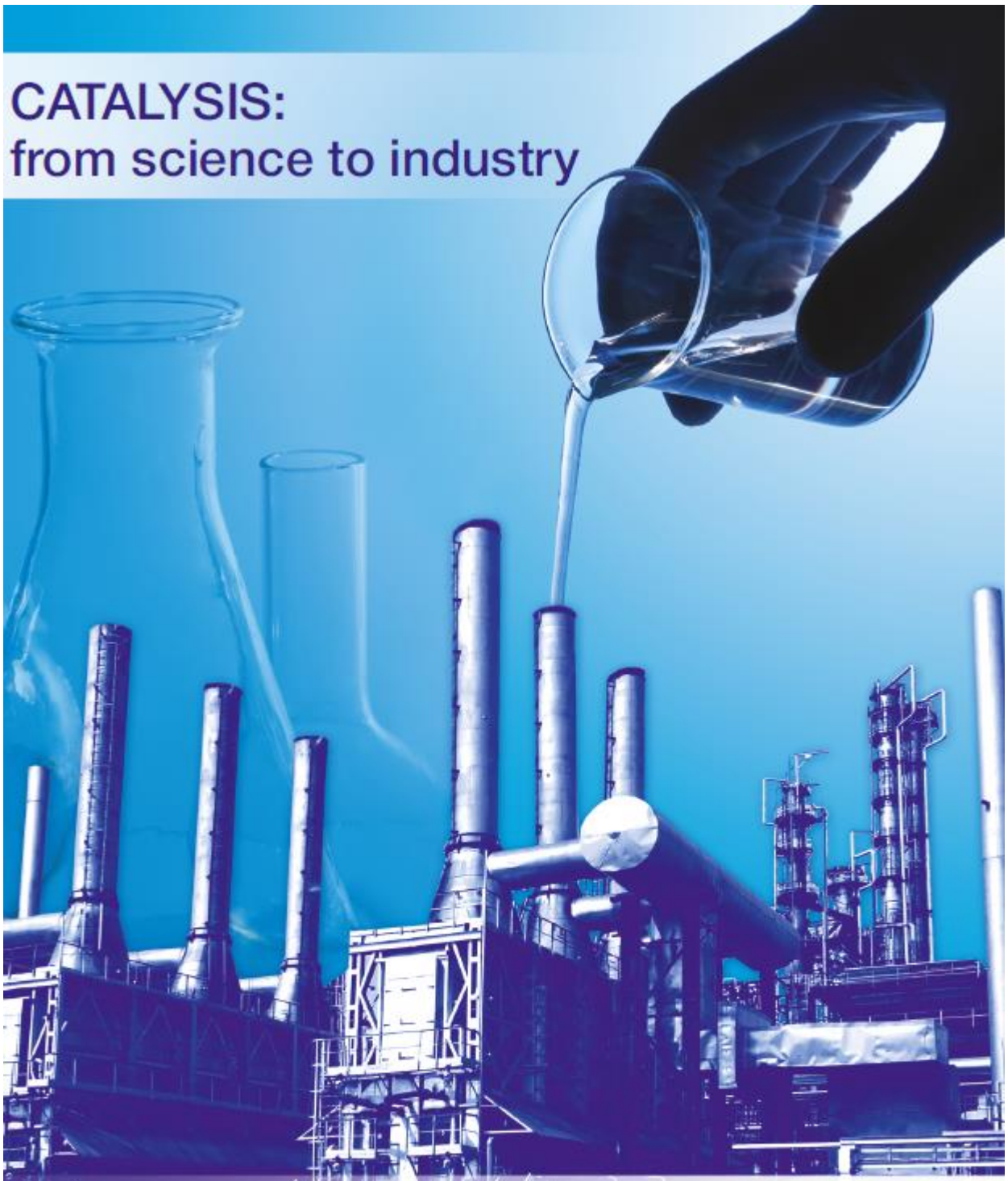
CATALYSIS:
from science to industry



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Bismuth silicates nanoparticles synthesized by pulsed laser ablation for photocatalytic applications

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Bismuth silicate (BSO) belong to new promising classes of materials for photocatalytic technologies applied in water purifying and hydrogen generation. BSO-based photocatalysts have the ability to act under the visible light irradiation, so these compounds have been actively studied in recent years [1-3]. Such materials are usually produced via hydrothermal methods, sol-gel or mechanical activation with the help of a planetary ball mill. As a result of such synthesis, particles of micron and submicron sizes are usually obtained. In this work, it is proposed to synthesize bismuth silicates by laser ablation in a liquid, which will reduce the particle size and also affect the phase composition.

The synthesis of bismuth silicates was carried out as follows. Initially, a stable colloidal silicon solution was obtained by ablation of a silicon target in water by Q-switch Nd: YAG laser with following parameters (1064 nm, 7ns, 20 Hz, 160 mJ/puls). Then, a freshly prepared solution of colloidal bismuth was mixed with a silicon solution with molar ratio 2:1, respectively. After that, the process of treatment of mixed solution was divided into 2 parts. First part was mixed and subjected to ultrasonic treatment about 30 min. Part 2 was additionally irradiated with laser beam with parameters mentioned above under stirring for 2 hours. Then the colloidal solutions were dried in open glass containers until completely dry, the obtained powder materials were annealed at 400 and 600 ºC. The following conventions were adopted for materials: BSO1 (ultrasonic treatment) and BSO2 (extra irradiation treatment).

BSO1 nanopowder has specific surface 41 m^2/g and consists of spherical particles with an average size of 40 nm. According to X-ray diffraction and diffuse reflection spectroscopy data the initial material contain metallic Bi and amorphous silica and absorbs in the entire range. After annealing at 400 ºC the main phase of α-Bi_2O_3 with an impurity metasilicate phase Bi_2SiO_5 are formed, and after 600 ºC Bi_2SiO_5 the main phase is metasilicate. Samples annealing at 400 and 600 ºC have a wide absorption spectrum consisting of the absorption of bismuth oxide and metasilicate phases.

BSO2 nanopowder is X-ray amorphous and consists of spherical particles with an average size of 30 nm and has a specific surface area 52 m^2/g. Extra irradiation treatment leads to homogenization of structure and bismuth metasilicate structure Bi_2SiO_5 appear after annealing at 600 ºC. The sample BSO2 absorb in the entire range and after annealing at 400 ºC has one distinct edge at 430 nm. After annealing at 600ºC the sample has absorption edge at 380 nm which can be associated with the structure of bismuth metasilicate.

The materials were tested for photocatalytic activity upon decomposition of the Rhodamine B dye under LED source (λ=378 nm). BSO2 material shows better activity in this process, which can be associated with a homogeneous phase composition and smaller particle size.

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