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Study of the Impact of Synthesis Method and Chemical Composition on Photocatalytic Properties of Cobalt Ferrite Catalysts

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Abstract : The nanostructured cobalt ferrite-type materials Sample A - Co0.25Fe2.75O4, Sample B - Co0.5Fe2.5O4, and Sample C - CoFe2O4 were prepared by co-precipitation in our previous investigations. The co-precipitated Sample B and Sample C were mechanochemically activated in order to produce Sample D - Co0.5Fe2.5O4 and Sample E- CoFe2O4. The PXRD, Moessbauer and FTIR spectroscopies, specific surface area determination by the BET method, thermal analysis, element chemical analysis and temperature-programmed reduction were used to investigate the prepared nano-sized samples. The changes of the Malachite green dye concentration during reaction of the photocatalytic decolorization using nanostructured cobalt ferrite-type catalysts with different chemical composition are included. The photocatalytic results show that the increase in the degree of incorporation of cobalt ions in the magnetite host structure for co-precipitated cobalt ferrite-type samples results in an increase of the photocatalytic activity: Sample A (4 x10-3 min-1) < Sample B (5 x10-3 min-1) < Sample C (7 x10-3 min-1). Mechanochemically activated photocatalysts showed a higher activity than the co-precipitated ferrite materials: Sample D (16 x10-3 min-1) > Sample E (14 x10-3 min-1) > Sample C (7 x10-3 min-1) > Sample B (5 x10-3 min-1) > Sample A (4 x10-3 min-1). On decreasing the degree of substitution of iron ions by cobalt ones a higher sorption ability of the dye after the dark period for the co-precipitated cobalt ferrite materials was observed: Sample C (72 %) < Sample B (78 %) < Sample A (80 %). Mechanochemically treated ferrite catalysts and co-precipitated Sample B possess similar sorption capacities, Sample D (78 %) ~ Sample E (78 %) ~ Sample B (78 %). The prepared nano-sized cobalt ferrite-type materials demonstrate good photocatalytic and sorption properties. Mechanochemically activated Sample D - Co0.5Fe2.5O4 (16x10-3 min-1) and Sample E-CoFe2O4 (14x10-3 min-1) possess higher photocatalytic activity than that of the most common used UV-light catalyst Degussa P25 (12x10-3 min-1). The dependence of the photo-catalytic activity and sorption properties on the preparation method and different degree of substitution of iron ions by cobalt ions in synthesized cobalt ferrite samples is established. The mechanochemical activation leads to formation of nano-structured cobalt ferrite-type catalysts (Sample D and Sample E) with higher rate constants than those of the ferrite materials (Sample A, Sample B, and Sample C) prepared by the co-precipitation procedure. The increase in the degree of substitution of iron ions by cobalt ones leads to improved photocatalytic properties and lower sorption capacities of the co-precipitated ferrite samples. The good sorption properties between 72 and 80% of the prepared ferrite-type materials show that they could be used as potential cheap absorbents for purification of polluted waters.

Keywords : nanodimensional cobalt ferrites, photocatalyst, synthesis, mechanochemical activation
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