Hydrogen peroxide decomposition by kaolin clay modified with nanoceria

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Nanoceria attracted attention due to it's unique redox properties, which are determined by surface defects - the presence of cerium atoms in two degrees of oxidation. For the nanoscale particles it's surface, and hence the number of defects (Ce^{3+} / Ce^{4+} ratio), increases. The aim of this work is synthesis of a number of new nanocomposites kaolin / cerium oxide with decorator different content, identification their physical and chemical properties, experimental determination of both: the synthesized materials catalytic activity and activation energy (E_a) for the model reaction of hydrogen peroxide (HP) decomposition.

A series of nanocomposites kaolin / cerium oxide were synthesized by reaction of cerium nitrate deposition in an aqueous medium without stabilizers at room temperature: $4Ce(NO_3)_3 + 12NaOH + O_2 = 4CeO_2 + 12NaNO_3 + 6H_2O$.

Atomic emission spectrometry, TEM, SEM, IR- and UV diffuse reflection spectroscopy, electron- and X–ray diffraction methods were used for properties characterization of the kaolin nanomaterials with CeO_2 different content.

Catalytic activity of investigated materials was estimated by monitoring the reaction of hydrogen peroxide decomposition. Volumetric method was used to determine the kinetic of HP decomposition. Maximal reaction rate was calculated from kinetic curves for different HP concentration (1–11 %). The catalytic activity of the synthesized nanocomposites, pristine kaolin and pure nanoceria was investigated in a model reaction of H_2O_2 decomposition in pH range 8.5 – 10.5 and compared with the enzyme catalase activity. To determine the activation energy of the reaction, the reactions of HP decomposition were done at five different temperatures: 20, 25, 30, 35, 40 °C (pH 10.0). The graph of logarithm of reaction constant dependence $1/T$ (K) allows to calculate E_a.

It was shown that the catalytic activity of nanocomposites kaolin / cerium oxide correlates with modifier content. The dependence of the synthesized nanocomposites activity on pH is extreme with maximum at pH 9.5-10.0. Catalase mimetic activity of studied materials in terms of 100 % content of cerium oxide and activation energy of the hydrogen peroxide decomposition reaction by them correlate with nanooxide particle dispersion and ceria surface defects, evaluated as $I_{UVSCe}{}^{4+}/I_{UVSCe}{}^{3+}$ ratio. Increasing the amount of modifier, the size of nanocrystallites and defect of their surface reduces the activation energy.