Mendeleev 2024

XIII International Conference on Chemistry for Young Scientists

BOOK OF ABSTRACTS

St Petersburg University

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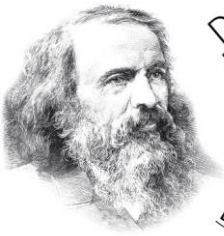

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MULTIFUNCTIONAL SORBENT/PHOTOCATALYST MATERIALS BASED ON Mg-Al LAYERED DOUBLE HYDROXIDES

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The purification of industrial wastewater containing ions of toxic heavy metals (Cu^{2+}, Co^{2+}, Ni^{2+}, Fe^{3+} and Pb^{2+}), as well as various cyclic organic compounds, remains a great challenge in the point of view of modern pollution rates of natural objects. This problem leads to a decrease of the surface waters ecological status and a decrease in the quality of drinking water.

To solve the stated problem various strategies were proposed such as membrane technologies, ion exchange and chemical precipitation followed by filtration are used to remove heavy metal ions from wastewater. However, these approaches are either too expensive or not effective enough at low concentrations of metal cations. In this regard, the use of cheap and effective sorbents for ion removal becomes a promising alternative.

Nowadays, photocatalysis is considered one of the optimal methods for the decomposition of organic pollutants in water. Its advantages include cost-effectiveness, high efficiency and the ability to purify water without additional waste. However, most of the modern researches are devoted to studying materials photocatalytic efficiency on model systems. With transferring the proposed technology to real objects, it turns out that developed photocatalysts show low efficiency due to rapid contamination of the material surface with various ions, since real samples are complex multi-component systems.

To solve the problem of removing heavy metal ions and cyclic organic compounds from wastewater, we propose the use of layered double hydroxides (LDHs) as a multifunctional material that combines the functions of a sorbent and a photocatalyst. LDHs consist of the positively charged brucite-like layers and charge-compensating anions in the interlayer space. Due to their structure, LDHs can sorb ions in their interlayer space, preventing contamination of the surface of the photocatalyst, what is increasing the efficiency of wastewater treatment.

This work is devoted to the development of new multifunctional sorbents and photocatalysts; for this purpose, 3 samples of bare and copper and chromium doped layered double hydroxides MgAl, CuMgAl and CrMgAl were synthesized. The synthesis was carried out by co-precipitation at pH 10, followed by aging of the precipitate. X-ray diffraction (XRD) patterns show that all samples are crystalline phases of $Mg_2Al(OH)_7$. It has been shown that doping leads to an increase in the distance between layers. FTIR spectra represents characteristic peaks of LDH with NO_3^- in the interlayer space. SEM micrographs with EDX element distribution maps and X-ray photoelectron spectroscopy results proved the uniform distribution of the dopant in the structure of the samples. The optical absorbance and transmittance spectra were used to evaluate the bandgap values of the samples.

Sorption of Cu^{2+}, Co^{2+}, Ni^{2+}, Fe^{3+} and Pb^{2+} on LDH samples and the influence of various parameters (pollutants nature and concentration, pH, temperature, incubation time) on this process was studied. Optimal sorption conditions allow to achieved 90% removal of pollutants in an hour.

The screening of MgAl, CuMgAl and CrMgAl samples photocatalytic activity was conducted using the widely used model dyes under Vis irradiation. The process optimization (temperature, time, amount of photocatalyst) for CuMgAl sample, demonstrated the best result of dyes decomposition, demonstrated 58% of degradation through 60 min of irradiation.

Additionally, we demonstrated a possibility of simultaneous sorption of heavy metals and photocatalytic decomposition of an organic dyes.

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