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STUDYING THE RED MUD PROPERTIES AS SORBENT

The problem of recycling alumina wastes is a serious test for many countries around the world. According to various sources, it has been established that for every tone of the produced aluminum there is formed from one to two tons of waste "red mud". In the world, about 750 million tons of aluminum were made over the past 20 years (Fig. 1).Accordingly, red mud already accumulated from 750 to 1500 million tons which are practically not used but just stored in the sludge storages, which determines the urgent need for its utilization and recycling.

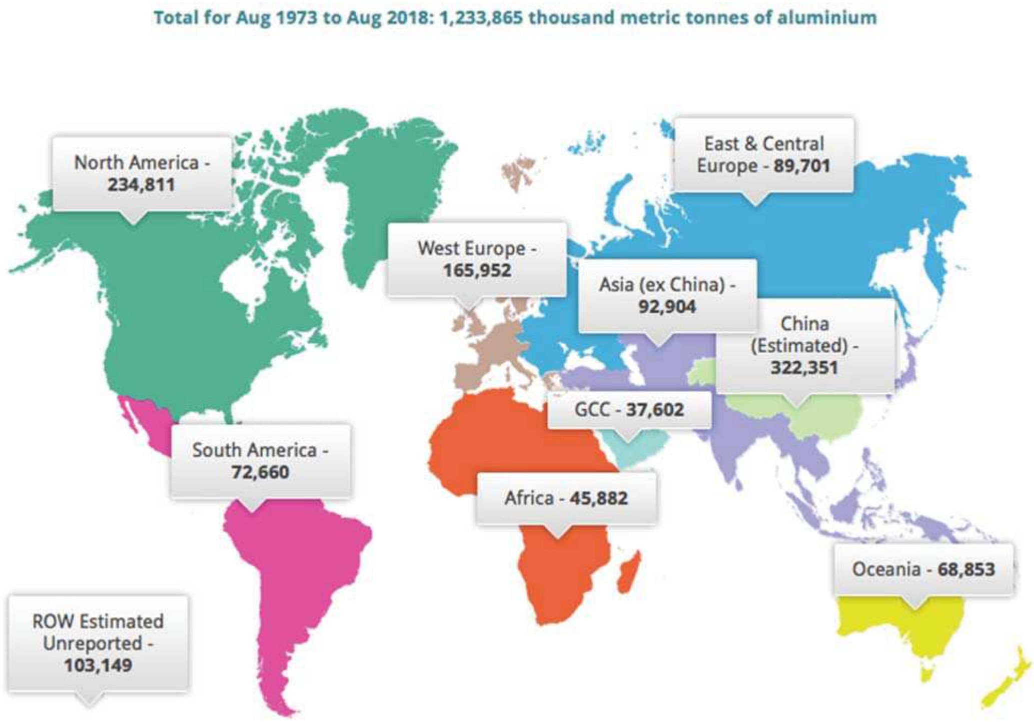

Figure 1. Total amount of aluminum produced in the world from 1997 to 2018 [1]

In Ukraine, there are two enterprises that produced aluminum: Nikolaev alumina plant, LTD (NAP) and ZaporizhzhyaAluminium Plant, PJSC (ZALK).Bauxite, that processed by NAP, basically consists of goethite, gibbsite, boehmite, amorphous aluminum hydroxide and, to a lesser extent, kaolinite, quartz, rutile etc. By-products (red mud) in their composition contain from 40 to 55% of ferric oxides, from 14 to 18% of aluminum oxides, from 4 to 6% of titanium oxides, from 5 to 10% of silicon and calcium oxides, etc.[2].

The diverse composition of the valuable components of red mud allows to use it as a raw material for creating a wide range of products that can be used in various fields. Thus, in particular, red mud is used as raw material for the production of building materials (cement, brick, ceramic tile, foam blocks, etc.); for extraction of useful components (metals) and in environmental processes as reagents for water treatment.

The using of red mud as a raw material for the reagents production for the removal of impurities of various origins from wastewaters is quite promising [2,3].

The purpose of this work is to check the kinetic patterns in order to determine the composition and characteristics of the red mud and sorption materials based on it, to verify the sorption properties of the samples on the example of the dye of methylene blue. To solve this goal, it was necessary to solve the following tasks: to synthesize samples of sorption materials that based on red mud; investigate the effect of storage conditions on the properties stability of red mud and sorption materials that based on it; verify the application efficiency of the obtained sorption materials in the water treatment technology.

In the work process, 3 samples of sorption materials were checked: raw red mud, taken directly from the sludge storage facility, dried at 105°C (RM); heat treated red mud at 600 °C(RMT) for 2.5 hours and with the addition of a magnetic fluid (RMM).RMM was prepared as follows: the magnetic fluid was first synthesized, which was injected into the prepared sample of red mud with constant stirring for 30–40 minutes and heated to a temperature of 60°C, followed by drying the sample to a constant mass at a temperature of 80°C, ensuring uniform distribution of magnetic particles fluid in the structure of red mud[4].

Synthesis of the magnetic fluid was carried out as follows: the weights of the iron (III) and iron (II) were dissolved in a 2M solution of hydrochloric acid with a molar ratio $Fe^{2+:}$ HCl = 1: 6, stirred and added distilled water. The thus obtained solution was transferred to a chemical glass and, at constant stirring and pH control, it was neutralized with a concentrated solution of ammonium hydroxide to a pH of 9-9.1 at a feed rate 1-2 drops per second. The resulting solution was washed three times and separated from the liquid phase by a magnetic field.

For the obtained sorption samples kinetic regularities were investigated. The results of pH changing of sorption materials over time are shown in Fig. 2. So, with time increasing for the first 30 seconds for all samples there is a dramatic increase in pH, then the curve goes to the plateau.

The water extract pH of the RM sample varies from 8.4 to 10 due to the partial dissolution of the alkaline components of the raw red mud. The slight decrease in the pH range for RMM from 7.9 to 9.6 is caused by the pH of the medium of magnetic fluid. For the water extract of RMT there is a significant increase in the pH reaching 11.8 at the contact time 600 sec due to the transition of $CaCO_3$ as a part of the red mud content in CaO, followed by a washout in the form of Ca $(OH)_2$.

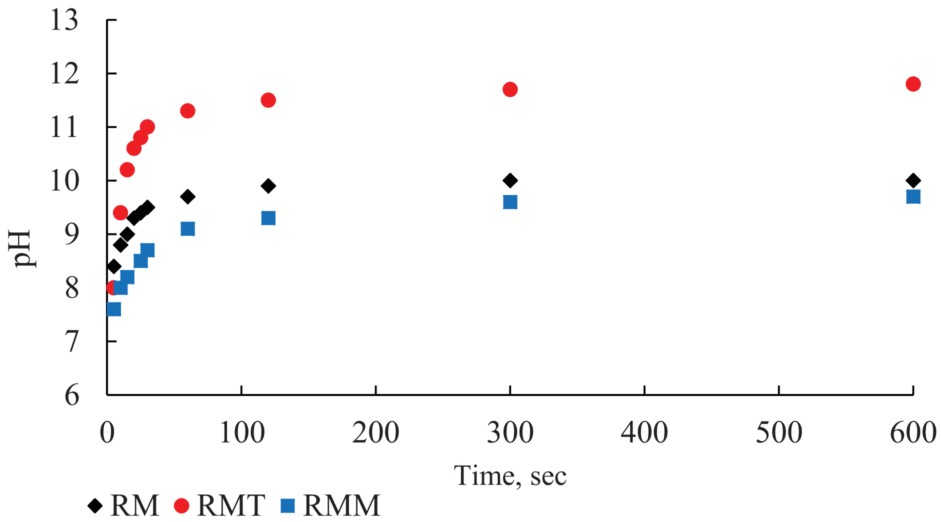

Figure 2. Kinetic patterns of sorption materials

At the temperature processing of the RMT, an increase in the pH of the aqueous extract was observed due to the transition of $CaCO_3$ as a part of the red mud into CaO, followed by washing-out in the $Ca(OH)_2$ form. When led into the sample of a magnetic fluid, we observe a slight decrease in the pH that associated with the pH of the medium of the magnetic fluid.

The effectiveness of the sorption materials using was checked on model water containing methylene blue dye with a concentration 10 mg/l, the dose of the sorbent was 2 g/l, the sorption duration for 5 hours, the pH of the medium 5.5 - 7 (Fig. 3).

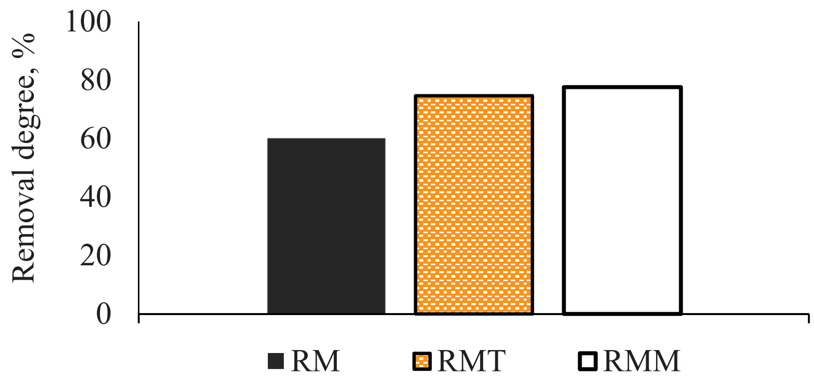

Figure 3. Removal efficiency of the dye methylene blue
with different samples of sorbents

It was established that using of an initial RM allows to treat wastewater from dye for 60%, the efficiency of using of RMT and RMM is higher and takes 74.5% and 77.5% respectively, which correlates with the using of commercial sorption materials.The advantage of RMM using is the simplicity of separation due to the introduction of a magnetic fluid into the sample. However, this does not significantly affect the sorption properties of RMM, but only make more expensive compared to RMT.

Consequently, waste from alumina production red mud is a promising raw material for the sorption materials production.However, it is promising to create sorption materials thermally activated RMT, which have high efficiency and are cheaper when received.

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