MECHANICAL ACTIVATION OF THE SURFACE OF ALUMINUM POWDERS AND REGULARITIES OF THEIR HYDROLYSIS

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The activated aluminum powders are promising materials for the hydrogen production in hydrolysis type H_2-generators, which can be autonomous and convenient for the generation of hydrogen directly at the site of its use. It is known that aluminum activated with low-melting metals and their alloys is able to react with water already at room temperature. In the present work, aluminum powders of PA-4 and ASD-1 grades were activated with Ga-In-Sn eutectic by grinding in a planetary ball mill or in a ceramic mortar and regularities of the obtained powders hydrolysis were studied.

Experiment description

Aluminum powders:
PA-4: nonspherical, particle sizes < 100 μm;
ASD-1: spherical, particle sizes < 30 μm.

Ga-In-Sn eutectic alloy:
Composition (wt.%): Ga – 67, In – 22, Sn – 11.
Melting point: 10.7 ± 0.3 °C.
Content in the initial mixture: 5 wt.%

Aluminum powders were grinding together with Ga-In-Sn eutectic in a planetary ball mill (Fritsch Pulverisette P6 mill with steel balls, 400 rpm for 1 hour [PA-4] or for 4 hours [ASD-1]) or in a ceramic mortar manually.

Morphology and surface composition studies of obtained powders performed using EVO 40XVP scanning electron microscope with INCA Energy microanalysis system.

Regularities of the hydrolysis of obtained powders were studied by periodic determining the volume of hydrogen released during hydrolysis in a volumetric setup at 25 °C. The sample mass of activated powders was 0.15 g, and the water volume was 100 ml. Measured hydrogen volumes were brought to the normal conditions (T = 273.15 K, P = 760 mm Hg).

Fig. 1. Photo of lump formed by Al powder PA-4 and Ga-In-Sn eutectic in mill.

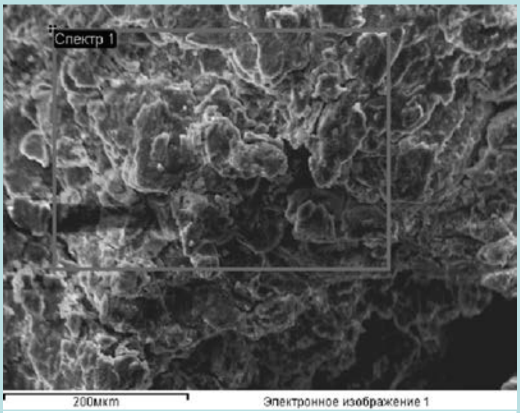

Fig. 2. SEM micrograph of PA-4 powder activated in a planetary mill and formed lump. Composition in selected area (wt.%): Al – 89.46, Ga – 4.84, In – 3.42, Sn – 2.28.

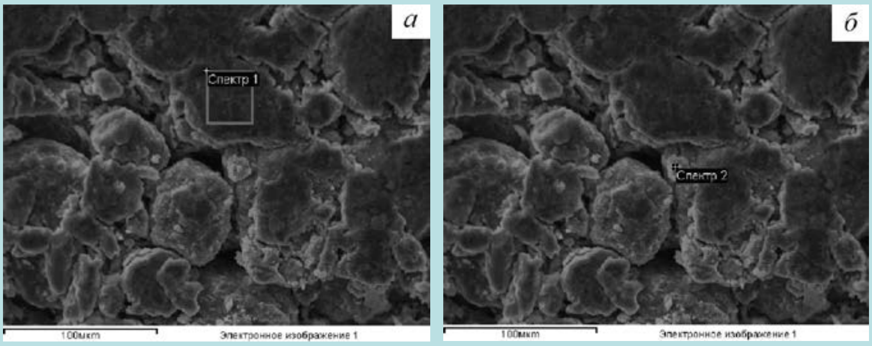

Fig. 3. SEM micrograph of ASD-1 powder activated in a planetary mill and formed lump. Composition in selected area (wt.%): (*a*): Al – 83.53, Ga – 8.89, In – 4.84, Sn – 2.74; (*б*): Al – 79.21, Ga – 9.24, In – 6.72, Sn – 4.83.

Results

In the planetary mill only part of the activated powders formed a lump with Ga-In-Sn eutectic which was adhered to the wall of the mill (see Fig. 1). The remaining parts of the powders were at the bottom of the mill.

These lumps were enriched with eutectic alloy (≫ 5 wt.%) localized on the surface of aluminum grains but distributed very unevenly (see Fig. 2, 3). In the ceramic mortar the lumps of aluminum powder with eutectic were not formed.

Aluminum powders which formed the lumps in the mill reacted with water faster than the powder ground in the mortar, but the hydrogen yield from the hydrolysis of latter powder was higher than from hydrolysis of the former ones (see Fig. 4).

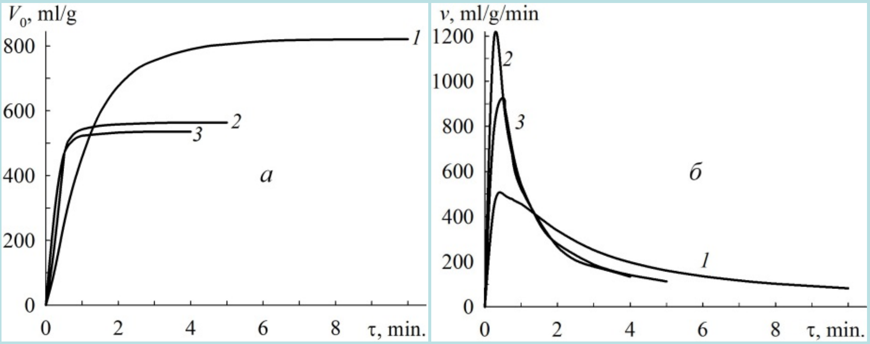

Fig. 4. Dependences of evolved hydrogen volume (*a*) and average rate of its evolution (*б*) on the duration of hydrolysis of following powders: *1* – PA-4 activated in mortar; *2* – ASD-1 activated in mill; *3* – PA-4 activated in mill.

Conclusion: Mechanical activation of aluminum powders with Ga-In-Sn eutectic (5 wt.%) in the planetary ball mill and in the ceramic mortar allows to obtain materials capable to evolve the hydrogen from water with high rate at the temperature of 25°C but the distribution of the eutectic alloy in the materials obtained in the mill is very uneven.