

RAISING THERMAL STABILITY OF TITANIUM HYDRIDE

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Introduction

The relevance of metal hydride studies is attributed to their applications in different areas of science and engineering. One of the applications of metal hydrides is their use in manufacturing processes for making foams from aluminum and its alloys. Cellular metals are produced by gas foaming using the gas produced by thermal decomposition of a blowing agent. The most widely used blowing agents are titanium hydride and zirconium hydride [1,2]. Titanium and zirconium hydride powders are considered to be satisfactory blowing agents as applied to the manufacture of aluminum foams, because they actively produce hydrogen, when heated to temperatures of 400-600°C, which are close to the melting point of aluminum (660°C).

One of the directions in aluminum foam technology is research into the pretreatment processes and conditions for titanium hydride powders in order to raise their thermal stability under temperatures close to the melting point of aluminum.

This paper discusses the possibility of raising thermal stability of titanium hydride by application of copper metal on the particle surface using a chemical process.

Experiment

We used titanium hydride powder with a particle size of $\leq 40 \mu\text{m}$ produced from titanium sponge.

Application of copper layers onto titanium hydride powder particles was performed in a water solution, the composition of which is given in Table 1 [3]. This solution enables copper deposition at a slow rate of 0.8 to 1.0 $\mu\text{m/h}$, which in turn allows application of thin copper layers. In addition, the solution remains highly stable for the duration of the whole process.

The process of copper application on titanium hydride particles was as follows.

Table 1. Composition of the copper deposition solution.

No.	Components	Component concentration, g/l
1	Copper sulfate (crystalline hydrate)	10-15
2	Potassium sodium tartrate	50-60
3	Sodium hydroxide	10-15
4	Sodium carbonate	2-3
5	Formalin (40-percent solution)	15-20 ml/l
6	Sodium thiosulfate	0.005-0.010
7	Nickel chloride (crystalline hydrate)	2-3

A portion of about $\approx 5\text{g}$ of titanium hydride powder was placed into a glass, topped up with $\approx 50\text{cm}^3$ of fresh solution (see Table 1), and mixed for a fixed period of time (5 to 60 minutes) with a magnetic stirrer. After mixing, the powder suspension was transferred onto a glass filter, which was evacuated with the precipitate using a Kamovsky pump. The copper-coated titanium hydride powder left on the filter was washed repeatedly with distilled water and then dried in a vacuum drying cabinet for 2 hours at a temperature of 105°C.

The titanium hydride powder, the particles of which were coated with copper layers, was studied by different techniques.

Results and Discussion

Preliminary assessment of the copper layer thickness was performed using X-ray phase analysis. The average thickness of the copper coating after holding titanium hydride in the solution for 15 minutes was 0.5 μm , and after holding for 60 minutes, 1.1 μm .

As can be seen from Table 2, results of specific gas content analysis are approximately equal – to within the method's error – for all the titanium hydride samples held in water and in the copper deposition solution.

Table 2. Specific gas content in titanium hydride samples after holding in different media

Initial specific gas content, cm ³ /g	Specific gas content after holding, cm ³ /g				
	in water		in copper coating solution		
	15 min	60 min	5 min	15 min	60 min
419	414	416	404	421	423

The samples underwent thermal gravimetric (TG) analysis. The peak of hydrogen thermal desorption from the copper-coated titanium hydride powder sample is shifted relative to the peak of thermal desorption from the starting titanium hydride powder towards higher temperatures by ~ 60°C (see Figs. 1 and 2). Thus, the copper layer applied onto the titanium hydride surface raises thermal stability of titanium hydride.

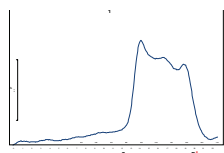


Fig. 1. Spectrum of hydrogen thermal desorption from starting titanium hydride.

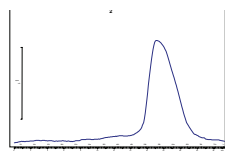


Fig. 2. Spectrum of hydrogen thermal desorption from copper-coated titanium hydride.

Kinetic curves for the copper-coated titanium hydride samples at the beginning are located below the corresponding thermal decomposition curve of the titanium hydride samples produced from titanium sponge (see Fig. 3). This fact indicates that the copper-coated titanium hydride powder has somewhat higher thermal stability than the starting titanium hydride powder. The growth of thermal stability of titanium hydride after its coating with copper can probably be related to the fact that the barrier layer of copper on titanium hydride reduces the rate of hydrogen atom recombination on the particle surface, if the associative desorption of hydrogen molecules is the limiting stage in the process of thermal decomposition [4].

Note that the kinetic curves of thermal decomposition of titanium hydride with copper coating deposited for 5 to 60 minutes differ slightly (see Fig. 3).

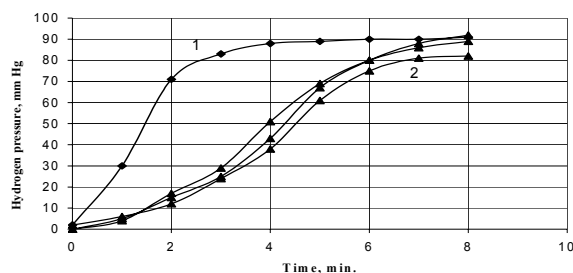


Fig. 3. Kinetics of thermal decomposition of titanium hydride produced from titanium sponge (1) and copper-coated titanium hydride (2).

Conclusions

1. Titanium hydride with copper-coated particles was produced by chemical deposition of copper metal.

2. Preliminary assessment of the copper layer thickness was made. The thickness was 0.5 μm for the titanium hydride samples held in the copper deposition solution for 15 minutes and 1.1 μm for the samples held in the solution for 60 minutes.

3. Application of the copper coating on titanium hydride particles was found to result in higher thermal stability of the material.

References

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