ELECTROCHEMICAL HYDROGENATION OF THE Tb$_2$Ni$_{15}$LiMg PHASE

Kordan V. M., Nytka V. V., Tarasiuk I. I., Pavlyuk V. V.

Department of Inorganic Chemistry, Ivan Franko National University of Lviv,
6 Kyryla i Mefodiya St., 79005 Lviv, Ukraine
vasyl.kordan@lnu.edu.ua

Systematic studies of the solid solution Tb$_2$Ni$_{17-x-y}$Li$_x$Mg$_y$ ($0 < x \leq 1$; $0 < y \leq 1$) showed that the maximum solubility of these doping components ($x + y$) does not exceed 2 atoms per formula unit ($r_{Li} = 1.53$ Å, $r_{Mg} = 1.60$ Å) [1–3]; hydrogen sorption ability and corrosion stability increase for the electrode with the larger amount of doping components. Also, the specific resistance value $\rho_0 = 35.7$ μΩ·cm is lower than for other phases on the basis of 2:17 and 1:5 stoichiometry [4]. Low value of this parameter is required for creation of new electrode materials.

A sample with the nominal composition Tb$_2$Ni$_{15}$LiMg was synthesized by arc melting of a pressed pellet containing a mixture of pure metals (5 wt. % excess of Li and Mg), remelted two times for better homogenization. X-ray phase analysis (DRON-2.0M, Fe $K\alpha$-radiation) showed that the alloy consisted of an expected phase with Th$_2$Ni$_{17}$-type structure (space group $P6_3/mmc$, $a = 8.3352(2)$ Å, $c = 8.0624(3)$ Å, $V = 485.09(2)$ Å^3) and a trace amount of Ni. Energy dispersive X-ray spectroscopy confirmed the formation of these phases. Composition of the main phase is Tb$_{11.5(5)}$Ni$_{81.1(7)}$Mg$_{7.4(9)}$ (Li was not determined), composition of the solid solution based on Ni is Tb$_{2.2(7)}$Ni$_{95.9(8)}$Mg$_{1.9(9)}$ (Fig., a). Electrochemical hydrogenation of the investigated alloy was carried out in 2-electrode Swagelok-type cell. The battery prototype consisted of a negative electrode (studied alloy) and a positive electrode containing a mixture of dried Ni(OH)$_2$ with graphite. Chronopotentiograms of the Ni-MH battery prototype were obtained in galvanostatic mode over 50 cycles (Fig., b). The amount of deintercalated H-atoms of the investigated electrode was determined using Faraday's formula. It reached 3.45 H/f.u. and it is a good value taking into consideration the low content of the rare earth element (Tb) and the high content of nickel.
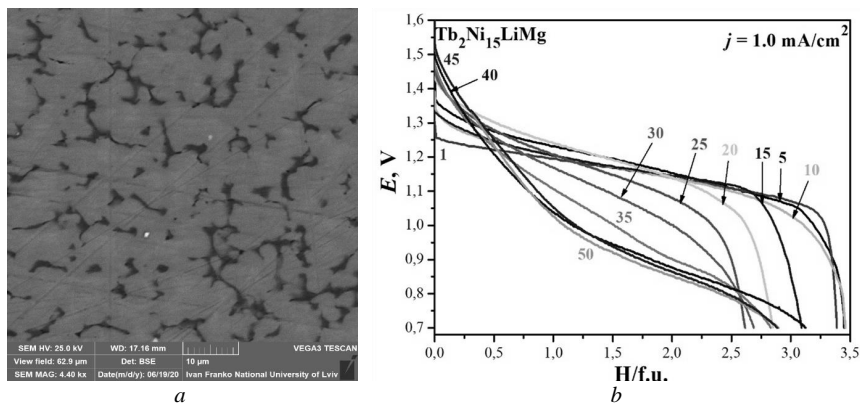

Fig. SEM-image (BSE-mode) of the Tb$_{10.5}$Ni$_{79.5}$Li$_5$Mg$_5$ alloy (a) and selected discharge
curves for the battery prototype with the Tb$_{10.5}$Ni$_{79.5}$Li$_5$Mg$_5$-based electrode (b)

[1] V. Kordan, O. Zelinska, V. Pavlyuk, V. Nytka, R. Serkiz. Chem. Met. Alloys, 2016, 9(3/4), 153–157.

[2] V. Kordan, V. Nytka, G. Kovalczyk, A. Balinska, O. Zelinska, R. Serkiz, V. Pavlyuk. Chem. Met. Alloys, 2017, 10(1/2), 61–68.

[3] V. M. Kordan, V. V. Nytka, I. I. Tarasiuk, O. Ya. Zelinska, V. V. Pavlyuk. Abs. III Int. (XIII Ukr.) Sci. Conf. Stud. Young Scient. "Current Chemistry Problems", Vinnytsia, 2020, 51.

[4] V. Kordan, V. Nytka, I. Stetskiv, I. Tarasiuk, O. Zelinska, V. Pavlyuk, H. Müller, E. Bauer. Abs. XXII Int. Sem. Phys. Chem. Solid. (eISPCS'20), Lviv, 2020, 55–56.