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THE EFFECT OF SEPARATING LAYER BETWEEN REACTING MEDIA AND MOLDING TEMPLATE ON THE POROUS STRUCTURE OF COMBUSTION SYNTHESIZED NI-AL INTERMETALLICS

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This research focuses on identifying conditions under which porous intermetallics with a welded granular structure comprised of mm-sized spheroidal alloy elements can be directly obtained by combustion synthesis using μm-sized metal powders as starting reagents. The main question is whether the porous structure can be controlled by modifying the interface between the reacting mixture and the molding template with a separating layer. In the present work we consider the effect of two types of separating layers: (i) chemically inert having low thermal conductivity to suppress the heat loss rate, and (ii) chemically active to stimulate the eutectic melting of the reacting system.

85 wt% Ni + 15 wt% Al porous intermetallics were synthesized and examined. The green mixture was placed in a cylindrical molding tool made of stainless steel with inner diameter of 32 mm, wall thickness 3 mm, height 60 mm. The SHS was performed in the argon atmosphere with the initial preheating of 320 °C. Two types of separating layers between the reacting mixture and the molding template were considered: (i) chemically inert layers made on the surface of the template cavity via a dip-coating process using the water-based slurries of ceramic powders (Al_2O_3, SiO_2, ZrO_2, or porous mullite microspheres), and (ii) chemically active cellulose-based layers made of microcrystalline cellulose powder (dip-coating process) or rolled paper (CaO coated paper, 90 g/m^2, 70 μm thick).

Intermetallics synthesized without separating layer has a microporous crust over the exterior layer. We assumed that applying ceramic powder coating on the inner surface of the steel molding template should decrease the heat loss rate of reacting medium and suppress the crust formation. However, the experiments had shown that microporous crust remains almost unchanged even when a 1.5 mm thick coating from porous microspheres was used.

As for the cellulose-based layers, even a thin separating layer with a thickness of 70 μm suppresses the crust formation. The average size of alloy elements in the exterior layer of synthesized materials D_E increases with the thickness of separating layer h (Fig. 1a). This effect is presumably attributed to the chemical interaction of the cellulose with the reacting medium. The decomposition of cellulose mainly occurs at the temperature range of 280 – 400 °C and generates carbon-containing tar, char, and light gases in the preheating zone of the combustion wave. According to the Ni-C phase diagram (Fig. 1c), the melting temperature of nickel gradually decreases in the presence of carbon, attaining a minimum of 1326 °C for 0.5 wt% C [1]. Therefore, the coarsening mechanism suggested here is that products of cellulose pyrolysis saturate the reacting metals with carbon, leading to an increase in the volume of media that melts near the template surface, providing the coalescence of large droplets. Argument for coarsening effect of carbon is that the artificial addition of carbon black to the Ni-Al mixture of more than 0.3 wt% significantly increases the average size of alloy elements (Fig. 1b)

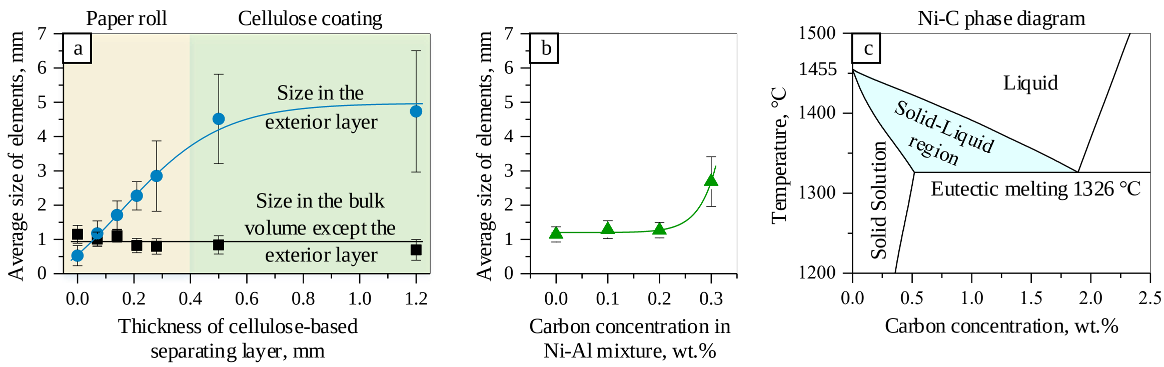

Fig.1. Average size of Ni-Al alloy elements versus the thickness of cellulose-based separating layers (a), and the concentration of carbon black in the Ni-Al reaction mixture (b). Ni-C phase diagram (c), adapted from [1].

REFERENCES

[1] M. Singleton and P. Nash, "The C-Ni (Carbon-Nickel) system," *Bull. Alloy Phase Diagrams*, vol. 10, no. 2, pp. 121–126, 1989.