Combustion Synthesis of Layered Ternary Carbides

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ABSTRACT

Formation of ternary carbide Ti3SiC2, Ti3AlC2, Ti2AlC and Ta2AlC was conducted by self-propagating high-temperature synthesis (SHS). Effects of the carbon source and sample density on flame-front propagation velocity, combustion temperature and phase composition of the product were studied. The carbon source employed in the starting mixture includes carbon black (Cb), graphite (Cg), titanium carbide (TiC), silicon carbide (SiC) and aluminum carbide (Al4C3), and their influence on combustion behavior and product composition was also explored. When ternary carbides were synthesized from the elemental powder compacts with carbon black, the reactant compact was subjected to considerable deformation, including axial elongation and radial contraction. On the contrary, the sample using graphite was slightly shrunk during the SHS process. For the elemental powder compacts containing carbon black, the flame propagation velocity and combustion temperature increase with sample density, reach maximum values and then decrease with further increase of sample density. When compared with samples using carbon black as the source of carbon, the reactant compacts with the use of graphite or addition of TiC, SiC, and Al4C3 exhibited slower reaction fronts and lower combustion temperatures. From the SEM observations, Ti3SiC2 and Ta2AlC are typically elongated grains, and Ti3AlC2 and Ti2AlC are plate grains with a closely packed pattern. Based upon the XRD analysis, formation of Ti3SiC2 along with a major impurity TiC and a small amount of Ti5Si3 was identified. According to the XRD profile, an improvement in the yield of Ti3SiC2 was observed with the addition of TiC and SiC and optimal conversions reaching 84.8 and 83.8 vol% were achieved by the samples with 20 mol% TiC and SiC, respectively. For the synthesis of Ti3AlC2, an optimal conversion yielding a product with 84.6 wt% Ti3AlC2 was obtained from the sample composed initially of 20 mol% TiC. When producing Ti2AlC, the best conversion of 89.2 wt% was attained in the sample containing 14.3 mol% TiC. However, in the case of forming Ta2AlC, the purity of Ta2AlC increases with the mole fraction of Al and the product is composed only of Ta2AlC and Ta4AlC3 as the sample contains 42.3 mol% Al. In addition, TiAl-Ti2AlC in situ composites were produced by self-propagating high-temperature synthesis from the mixed powders of Ti, Al and Cb. The XRD patterns showed that the synthesized products mainly consisted of TiAl, Ti3Al, Ti2AlC and TiC. When the mole fraction of TiAl was varied from 40 to 60 mol%, however, the products contained only TiAl and Ti2AlC.

Keywords : Ti3SiC2 ; Ti3AlC2 ; Ti2AlC ; Ta2AlC ; TiAl-Ti2AlC ; SHS ; flame-front velocity ; combustion temperature

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