INFLUENCE OF ADDITIVES OF $CuSO_4 * 5H_2O$, $FeSO_4 * 10H_2O$, $Na_2B_4O_7 * 10H_2O$, AND $CuSO_4$ ON THE SPECIFIC FEATURES OF COMBUSTION OF MAGNESIUM POWDER IN AIR

V. G. Krupkin and G. N. Mokhin

N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation

Abstract: The specific features of combustion of cylindrical samples of magnesium powder of bulk density with different additives — anhydrous copper sulfate, iron oxide, and crystalline hydrates $CuSO_4 * 5H_2O$, $FeSO_4 * 10H_2O$, and $Na_2B_4O_7 * 10H_2O$ in air are studied experimentally. It has been shown that the introduction of an additive in the composition of magnesium powder in an amount exceeding 2 %(wt.) leads to sample combustion with a characteristic temperature of $\sim$ 1100 °C. The conversion of magnesium in the residue after combustion in this mode is close to 100%. The specific composition of the additive and its amount do not significantly affect the nature of time dependence of sample temperature during sample combustion. The residue after sample combustion in air consists of a mixture of magnesium oxide and magnesium nitride. The ratio between the mass of the original sample and the mass of the residue after sample combustion makes it possible to estimate the composition of the residue. The obtained results are explained by the appearance of hot spots in the heating zone during flame propagation along the sample caused by the reaction between the additive and magnesium, additional preheating of the sample by these hot spots, and the achievement of a plateau with a temperature of $\sim$ 1100 °C during sample combustion which corresponds to the boiling point of magnesium in the particles of the initial powder. The evaporation of magnesium in this mode stabilizes the combustion process.

Keywords: burning of metals; magnesium powder; crystal hydrates; anhydrous copper sulfate

DOI: 10.30826/CE20130410

Figure Captions

Figure 1 Images of Mg + 5% $CuSO_4$ powder sample burning in air: (*a*) $t = 35.5$ s; (*b*) 50.5; (*c*) 60.5; (*d*) 65.5; (*e*) 70.5; (*f*) 75.5; (*g*) 80.5; (*h*) $t = 257.1$ s; and 1 and 2 — thermocouples

Figure 2 Time histories of the Mg + 5% $CuSO_4$ sample temperature when burning in air: *1* — signal of the top thermocouple; and *2* — signal of the bottom thermocouple

Figure 3 Time histories of the Mg + $CuSO_4$ sample temperature when burning in air at different contents of $CuSO_4$ additive: *1* — 0%; *2* — 1%; *3* — 2,5%; and *4* — 5%. Record of thermocouple No. 2

Figure 4 Images of the Mg + 5% $CuSO_4*5H_2O$ powder sample burning in air: (*a*) $t = 50$ s; (*b*) 65; (*c*) 75; (*d*) 90; (*e*) 100; (*f*)120; (*g*) 130; and (*h*) $t = 260$ s

Figure 5 Time histories of the Mg + $CuSO_4 * 5H_2O$ sample temperature when burning in air at different contents of $CuSO_4 * 5H_2O$ additive: *1* — 0%; *2* — 1%; *3* — 2,5%; *4* — 5%; and *5* — 10%. Record of the thermocouple No. 2

Figure 6 Time histories of the Mg + $Na_2B_4O_7 * 10H_2O$ sample temperature when burning in air at different contents of $Na_2B_4O_7 * 10H_2O$ (borax) additive: *1* — 0%; *2* — 3%; *3* — 5%; *4* — 10%; and *5* — 15%

Figure 7 Time histories of the temperature of the magnesium powder burning in air without additive (*1*) and with 2.5% additive of $CuSO_4 * 5H_2O$ (*2*), $FeSO_4 * 7H_2O$ (*3*), and $CuSO_4$ (*4*)

Figure 8 Time histories of the magnesium powder temperature burning in air without additive (*1*) and with 5% additive of Fe_2O_3 (data from [6]) (*2*), $CuSO_4 * 5H_2O$ (*3*), and $CuSO_4$ (*4*)

Figure 9 Time histories of the magnesium powder temperature burning in air without additive (*1*) and with 10% additive of $CuSO_4 * 5H_2O$ (*2*), Fe_2O_3 (data from [6]) (*3*), and $Na_2B_4O_7 * 10H_2O$ (*4*)

Acknowledgments

The research was performed according to the subsidy given to N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences to implement the state assignment of the topic 44.8 "Foundation studies of conversion processes of energetic materials and development of scientific grounds of controlling these processes" (Registration No. AAAA-A21-121011990037-8).

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Received November 14, 2020

Contributors

Krupkin Vladimir G. (b. 1949) — Doctor of Science in physics and mathematics, head of laboratory, N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; krupkin49@mail.ru

Mokhin Grigory N. (b. 1964) — Candidate of Science in physics and mathematics, senior research scientist, N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; mokhin@gmail.com