Advanced Powder Technology 23 (2012) 387–392

Contents lists available at ScienceDirect

Advanced Powder Technology

journal homepage: www.elsevier.com/locate/apt

Original Research Paper

# Combustion characteristics of the heat pellet prepared from the Fe powders obtained by spray pyrolysis

J.H. Kim [a], H.Y. Koo [a,c], S.K. Hong [a], J.M. Han [a], H.C. Jang [a], Y.N. Ko [a], Y.J. Hong [a], Y.C. Kang [a,*], S.H. Kang [b], S.B. Cho [b]

[a] Department of Chemical Engineering, Konkuk University, 1 Hwayang-dong, Gwangjin-gu, Seoul 143-701, Republic of Korea
[b] The 4th R&D Institute-1, Agency for Defense Development, Yuseong P.O. Box 35-4, Daejeon 305-600, Republic of Korea
[c] Functional Materials Division, Korea Institute of Materials Science, 531 Changwonadaero, Changwon, Gyeongnam 641-831, Republic of Korea

ARTICLE INFO

*Article history:*
Received 27 November 2010
Received in revised form 10 May 2011
Accepted 12 May 2011
Available online 27 May 2011

*Keywords:*
Spray pyrolysis
Heat pellet
Thermal battery
Fe powders

ABSTRACT

Fe powders for thermal batteries were prepared by reduction of iron oxide powders obtained by spray pyrolysis. The iron oxide powders prepared by spray pyrolysis had fine size, spherical shape and high surface area. The morphologies of the Fe powders were affected by the preparation temperatures of the iron oxide powders. The Fe powders obtained from the iron oxide powders prepared by spray pyrolysis at 900 and 1000 °C had slightly aggregated structure of the primary powders with several microns sizes. The powders had pure Fe phases at reducing temperatures between 600 and 800 °C. The heat pellets with diameter of 18.2 mm were prepared using Fe powders and potassium perchlorate ($KClO_4$). The porosity of the prepared heat pellet was about 40%. The break strength of the heat pellet was 0.9 kgf. The ignition sensitivity of the heat pellet was 4 W. The maximum burn rate of the heat pellet obtained from the Fe powders were 8.6 cm $s^{-1}$.



## 1. Introduction

Thermal batteries are used in any application where there is a sudden demand in electric power. For many years, thermal batteries have the first choice of power supply for military purposes such as guided missiles and nuclear weapon. They are primary reserve batteries that are solid state at normal temperature. Thermal batteries consisting of series or series–parallel arrays of cells are thermally activated. Each cell comprises of an electrode, an anode, an electrolyte, a cathode and a heat source [1–6]. The material is completely inert and nonconductive until the battery is activated at which time it becomes molten and highly conductive. This allows the cathode to interact with anode. The heat source is mixture of high surface area iron (Fe) powder and potassium perchlorate ($KClO_4$). Ignition of the heat source supplies the energy to melt the solid electrolyte. Heat pellets prepared from Fe and $KClO_4$ powders should have high mechanical strength and high burn rate. The physical and combustion properties of the heat pellets are affected by morphology and size of Fe powders [7]. Fe powders with elongated and interlocking structure are mainly used as the heat source material.

Spray pyrolysis, which is one of the gas-phase reaction methods, is a useful method for the synthesis of pure metal and alloy powders [8,9]. The metal powders prepared by spray pyrolysis had spherical shape, high crystallinity, high density and low content of impurity due to the high preparation temperatures above 1000 °C. However, Fe powders with elongated and interlocking structure for thermal batteries were not studied in the spray pyrolysis.

In this study, Fe powders for thermal batteries were prepared by reduction of iron oxide powders. The iron oxide powders obtained by spray pyrolysis were reduced to the Fe powders by post-treatment at low temperatures under reducing atmosphere. The characteristics of heat pallet formed from the prepared Fe powers and $KClO_4$ were studied.

## 2. Experimental

The flow chart for the preparation and characterization of Fe powders was shown in Fig. 1. Iron oxide powders were prepared by spray pyrolysis from the spray solution with ferric nitrate. The iron oxide powders obtained by spray pyrolysis were reduced to the Fe powders. The heat pellets with diameter of 18.2 mm were prepared using Fe powders and potassium perchlorate (Sigma–Aldrich, $KClO_4$). The commercial $KClO_4$ powders were milled by planetary mill. Ignition sensitivity and burn rate of heat pellets

* Corresponding author. Tel.: +82 2 2049 6010; fax: +82 2 458 3504.
*E-mail address:* yckang@konkuk.ac.kr (Y.C. Kang).

0921-8831/$ - see front matter © 2011 The Society of Powder Technology Japan. Published by Elsevier B.V. and The Society of Powder Technology Japan. All rights reserved.
doi:10.1016/j.apt.2011.05.004