COMBUSTION SCIENCE AND TECHNOLOGY
https://doi.org/10.1080/00102202.2024.2317861

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Combustion Behavior of Fuel Droplets with Metallic, Non-Metallic and Organo-Metallic Boron Additives

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ABSTRACT

There is considerable interest in the utilization of fuels derived from boron materials, with their high calorific value, in various applications ranging from propellants to pyrotechnics. Conversely, their impact on the combustion behavior of conventional hydrocarbon fuels remains largely unclear. In this study, ignition, combustion, micro-explosion and simultaneous atomization behaviors of gasoline-based alternative fuels containing metallic (28–35 µm MgB_2), nonmetallic (1 µm amorphous boron, 10 µm AlB_{12} with 86–88% and 95–97% purity) and organo-metallic boron derivatives (triethyl borate (TEB) containing C_2H_5 groups and trimethyl borate (TMB) containing CH_3 groups) were investigated. The experiments were carried out at droplet scale and recorded using a high-speed camera and a thermal camera. The findings revealed a systematic reduction in ignition delay for each gasoline fuel enriched with boron derivatives. 2.5%AlB_{12}/G and pure TMB droplets were the fastest extincting fuel droplets (0.9678 s and 1.245 s, respectively). The highest maximum flame temperature was recorded as 626 K and 610 K for pure TMB and 80%TEB/G, respectively. Droplet diameter regression analyses showed that the diameters of fuel droplets containing predominantly metallic and nonmetallic boron derivatives decreased in accordance with the d^2-law. This study demonstrated that cost-effective and easily producible amorphous boron and organometallic boron derivatives are promising energy carriers for hydrocarbon fuels.

ARTICLE HISTORY
Received 30 December 2023
Revised 1 February 2024
Accepted 8 February 2024

KEYWORDS
Trimethylborate; triethylborate; amorphous boron; aluminum dodecaboride; gasoline; magnesium diboride

Introduction

Boron's combustion characteristics during the whole extinction time process remain a mystery, and its potential for the combustion process has not yet been fully explored through experiments. Additionally, the volumetric and gravimetric heating capabilities of boron have captured the interest of numerous combustion investigators. This underscores the attractive and great potential of boron for the development of high-energy fuels (Hashim, Karmakar, and Roy 2019; Hashim et al. 2019; Sullivan, Young, and Zachariah 2009).

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