Experimental Study on Gases produced from Polymers Burning with Water Mist: Influence of droplet size of spray

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Bio[1]: Nicharee Thinnakornsutibutr is a student of master's degree in department of Global Fire Science and Technology at Tokyo University of Science. Her research topics are mainly relevant to the investigation of toxic gases from water-based fire suppression on polymers combustion.

Bio[2]: Masayuki Mizuno has mainly engaged in the research of human behaviour and egress safety in fire such as pedestrian flow in staircase, evacuation method for elderly people with help and analysis of toxic and irritant gases produced by combustion of flammable without versus with water spray, etc.

Abstract

[*Background*] These days, water mist systems have been commonly used for fire suppression in underground parking lot in Japan. With water mist application, fires can be extinguished by cooling effect and oxygen diluted by evaporation of water. Generally, water mist sprays were characterized in term of water droplet size, water droplet distribution and water flux density. Recently, few researches have been studied on toxic gases generated from combustion of polymeric materials with water sprays. [*Objective*] The aim of this study is to determine the produced toxic gases with the influence of the different sizes of water mists discharged for fire suppression from nozzle on natural and thermoplastic polymeric materials burning conducted in small-scale experiment. [*Method*] Internal temperatures of combustion chamber were measured by thermocouple, and the extinguish process were observed in the experiment (Fig.1). Fire produced toxic gas concentration was measured by nondispersive infrared (NDIR) and Fourier transform infrared (FTIR) gas analyzers. Wood, polypropylene (PP) and polyethylene (PE) were used as test samples. There were two nozzle models in this experiment from Ikeuchi company

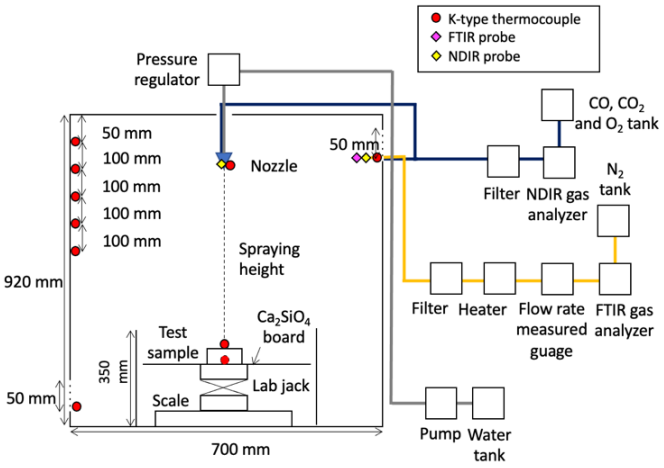

Fig. 1 Schematic of chamber with test apparatus

which were the nozzle model of “7KB” (Nozzle A) and “J” (Nozzle B). The size and distribution of discharged water mist droplets were characterized by using oil coated on a plate at 20 cm from nozzle A and 25 cm from nozzle B. The specified water flux density discharged from nozzle was regulated with the experiment conducted by Tokyo Fire Department. [*Results*] The averaged water mist droplets diameter spraying on horizontally projected area with nozzles A and B were 0.42 and 0.61 mm, respectively. The results of gas concentration at smoke ventilation and temperature at 150 mm from the ceiling were used for representative in this study (Fig. 2). Two regions were distinguished with water sprays activation time: free burning region and water mists discharged region. In free burning region, CO concentration increased and reached to the peak during incipient stage due to the combustion of flammable gel. The combustion rate of polymers after gel completely evaporated depended on heats of combustion of polymers. In water mist discharged region, temperature in water application of nozzle B was abruptly declined. In wood, CO concentration with water discharge by nozzle B on wood burning abruptly decreased, but gradually reduced by nozzle A. For the reason that water gases were generated when the hot surface charring obtained water sprays. The extinguishment process by nozzle A gradually completed in 191 s was observed. Remarkably, fires were quickly extinguished in only 18 s with water mist sprays from nozzle B. Thermoplastic polymer that not containing with nitrogen such as PP, the concentrations of HCN, NO and NO_2 were unexpectedly measured in free burning region. It can be deduced that formed NO concentration affected to HCN concentration due to thermal NO_x reaction occurred in PP burning with high temperature that can cause HCN formation as an intermediate product. Temperature of PP burning with water sprays from nozzle B rapidly increased due to boil-over fire. It can be assumed that incomplete combustion occurred resulting in a large amount of CO concentration. However, CO concentration peak after water mists suppression from nozzle A that discharged smaller droplets size was little as temperature was insignificantly changed. *[Conclusions]* In the study, fire combustion toxicity products were analyzed with the influences of water mist droplets size on polymers burning. Water mist sprays significantly influenced on extinguishing time and the emission of toxic gas concentration. Futhermore, CO concentration was associated with water mist activation on the combustion of polymeric materials.

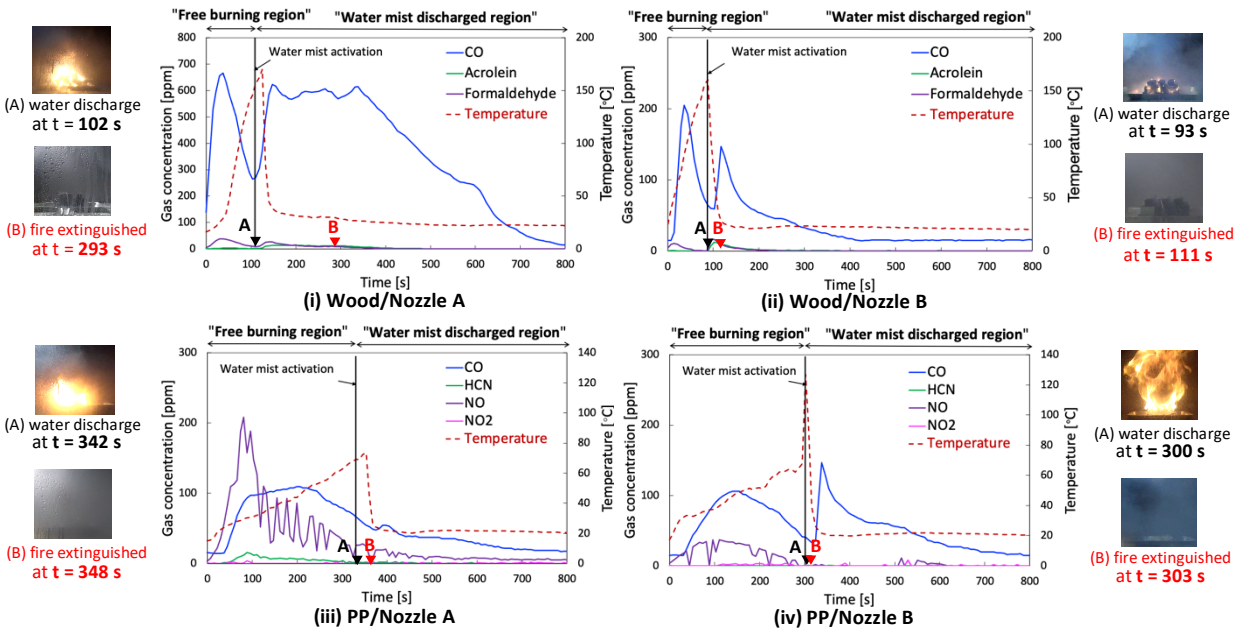

Fig. 2 Gas concentrations and temperatures measured in the representative cases

KEYWORDS: water mist, toxic gases, polymers, fire suppression, bench scale-testing.