Irradiated ignition over solid materials in reduce pressure environment: Fire safety issue in man-made enclosure system

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Effects of ambient pressure and oxygen yield on irradiated ignition characteristics over solid combustibles have been studied experimentally. Aim of the present study is to elucidate the flammability and chance of fire in depressurized enclosure system and give ideas for the fire safety and fire fighting strategies in such environment. Thin cellulosic paper is considered as the solid combustible since cellulose is one of major organic compounds and flammables in the nature. Applied atmosphere consists of inert gas (either CO2 or N2) and oxygen, and various mixture ratios are of concerned. Total ambient pressure level is varied from 0.1MPa (standard atmospheric pressure) to 0.02MPa. Ignition is initiated by external thermal flux exposed into the solid surface as a model of unexpected thermal input to initiate the localized fire. Thermal degradation of the solid induces combustible gaseous products (e.g. CO, H2, or other low class of HCs) and the gas mixes with ambient oxygen to form the combustible mixture over the solid. Heat transfer from the hot irradiated surface into the mixture accelerates the local exothermic reaction in the gas phase and finally thermal runaway (ignition) is achieved. Ignition event is recorded by high-speed digital video camera to analyze the ignition characteristics. Flammable map in partial pressure of oxygen (Pox) and total ambient pressure (Pt) plane is made to reveal the fire hazard in depressurized environment. Results show that wider flammable range is obtained depending on the imposed ambient pressure. In middle pressure range (0.1MPa-0.04MPa), required partial pressure of oxygen for ignition is *decreased* almost linearly as the total pressure is decreased, indicating that higher fire risk is expected. In lower pressure range ($<$0.04MPa), required partial pressure of oxygen is increased dramatically, suggesting that the fire safety might be ensured in this range. Although it has been reported that higher oxygen concentration is preferable for plant growth in depressurized field, such condition may increase the chance of fire appearance. Present results imply that there must be optimum pressure condition to achieve less fire chance with acceptable plant growth. An increase of the flammable range in middle pressure level might be derived by following two reasons: one is physical effect such as a weak convective thermal removal from ignitable domain (near the hot surface) to the ambient, and the other is chemical effect which causes so call “explosion peninsula” by chain-branching reactions.