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Study on the influence of material thermal characteristics on dust explosion parameters of three long-chain monobasic alcohols

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ABSTRACT

Sensitivity and severity parameters are critical for risk assessment and safety management of dust explosions. In this paper, to reveal the effects of material thermal characteristics on dust explosions parameters during monobasic alcohols dust explosions, three long chain monobasic alcohols, being solid at room temperature and similar in physical–chemical properties, were chosen to carry out experiments in different functional test apparatus according to the internationally accepted ASTM standards. As a result, it was found that the material thermal characteristics strongly affected these basic explosive parameters. On the one hand, for the sensitivity parameters, Minimum Ignition Temperature, Minimum Ignition Energy and Electrical Resistivity were the highest in the Eicosanol dust cloud, while Minimum Explosible Concentration in this cloud was the lowest. On the other hand, for severity parameters, Maximum Explosion Pressure in Eicosanol dust cloud always maintained the highest values as varying the dust concentrations. In contrast, Deflagration Index showed a complex trend.

1. Introduction

A dust explosion is the fast combustion of dust particles suspended in the air in an enclosed location. If such an explosive combustion of a dust cloud takes place inside process equipment or work rooms, the pressure in the fully or partly enclosed explosion space may rise rapidly; the process equipment or building may burst; and life, property can be lost (Eckhoff, 2003). In spite of more than 150 years of extensive research and development to prevent and mitigate dust explosions in process industries, dust explosions are still a recognized threat to humans and property. Recently, safety management is a novel method to prevent such accidents by using risk evaluation. The risk assessment procedures are shown in Fig. 1. To assess the possibility of an explosion in a facility and to find the most appropriate approach for safety, explosion characteristics of the dust that is being handled in the facility should be determined. The explosion characteristics of dust normally fall within two groups, i.e. sensitivity and severity explosion parameters. The combination of sensitivity and severity parameters will define the explosion risk. According to the explosion risk level, appropriate safety measurements could be adopted to prevent such accidents (Dobashi, 2009).

Hence, in order to minimize the risk of dust explosions, basic sensitivity and severity explosion parameters which are governed by numerous factors must be known. Although much research was done on the measurement of Minimum Ignition Temperature, Minimum Ignition Energy, Minimum Explosible Concentration, Maximum Explosion Pressure, as well as rate of pressure rise, most of these research focused on the effect of initial pressure, chemical composition, particle size, shape and moisture content on these basic parameters in dust explosions (Cashdollar & Chatrathi, 1993; Dahoe, Zevenbergen, Lemkowitz, & Scartetl, 1996; Denkevitsa & Dorofeev, 2006; Going, Chatrathi, & Cashdollar, 2000; Hanai et al., 1999; Ju, Dobashi, & Hirano, 1998; Mittal, 1997; Mittal & Guha, 1997; Pilao, Ramalho, & Pinho, 2004; Proust, Accorsi, & Dupont, 2007). Unfortunately, so far no studies were conducted on the effect of material thermal characteristics on the basic sensitivity and severity parameters.

The aim of present study is to examine the influence of material thermal characteristics on basic sensitivity and severity parameters in monobasic alcohol dust explosions. Three long chain monobasic alcohols, being solid at room temperature and similar in physical–chemical properties, were chosen as the experimental materials. The three materials are widely used in the cosmetic industry as an opacifier in shampoos, or as an emollient, emulsifier or thickening

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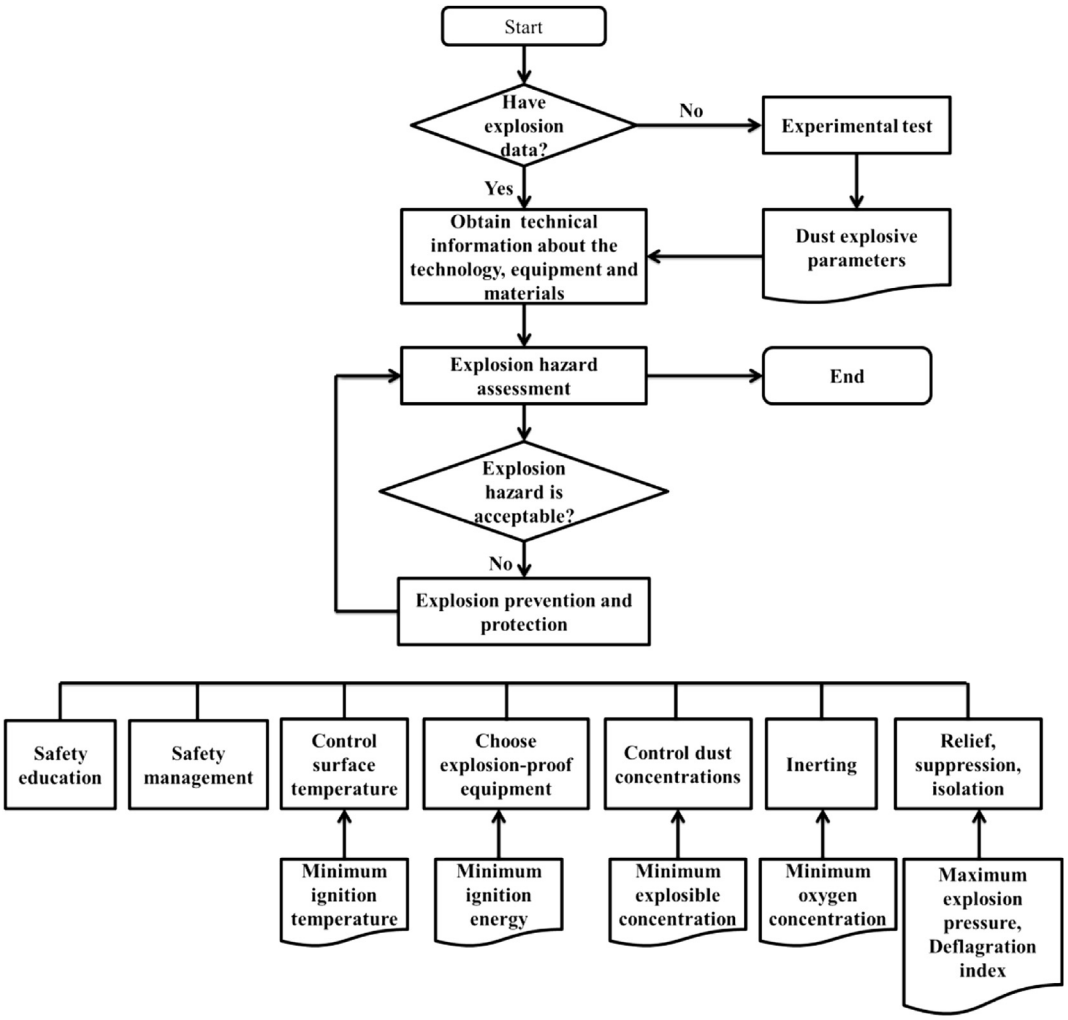

Fig. 1. Dust explosion assessment procedure.

agent in the manufacture of skin creams and lotions (Smolinske, 1992: pp. 75–76). Before the tests, the thermal characteristic data was obtained by experiments or literatures.

2. Experiment

2.1. Experimental apparatus and procedures

Different functional apparatus were used to measure the basic explosive parameters according to the internationally accepted ASTM standards. The detailed introductions of the apparatus and test procedures are as follows.

2.1.1. "Godbert-Greenwald" furnace test apparatus

Minimum Autoignition Temperature (MIT) of dust clouds was tested in the "Godbert-Greenwald" furnace, which is schematically shown in Fig. 2. The furnace includes a test chamber, two thermocouples, a dust sample container, an electromagnetic valve, a heater and a stopstock.

Test procedures which refer to the ASTM E1491 standard (ASTM E1491, 2006) are as follows.

(1) Inspect equipment to make sure it is thoroughly clean and predetermined value.
(2) Set the temperature of the furnace at the predetermined value.
(3) Place a weighed amount of dust in the dust sample vessel. In experiments, the experimental dust concentrations are from 100 to 1000 g/m^3.
(4) Disperse the dust and observe whether an ignition occurs. Ignition is defined as flame exiting from the chamber. During the experiment, it is useful to darken the room and utilize a mirror to make it easier to observe the flame.

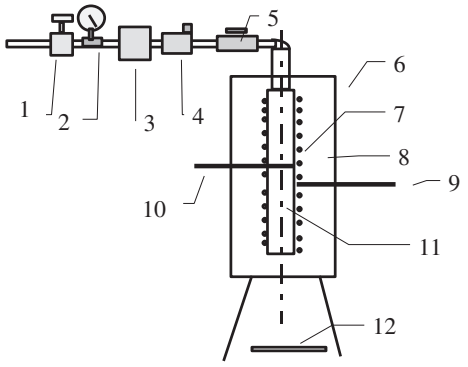

Fig. 2. Schematic diagram of the"Godbert-Greenwald" furnace. 1 Stopstock 2 Pressure gauge 3 Pressure vessel 4 Electromagnetic valve 5 Dust sample container 6 Furnace shell 7 Heating 8 Insulation materials 9 10 Thermocouples 11 Quartz furnace tube 12 Mirror.