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Thermal behaviour of organic solid recovered fuels (SRF)

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ABSTRACT

The determination of the safety conditions in the storage and handling of solid recovered fuels (SRFs) was evaluated in order to avoid the presence of explosive atmospheres. Ten SRF samples were selected from different solid waste streams and collected in different seasons and different locations in Spain.

Four different testing methodologies for characterizing the SRF dusts were carried out in order to determine thermal susceptibility and flammability. By means of thermogravimetric techniques, differential scanning calorimetry, minimum ignition energy and minimum ignition temperature on a cloud tests it has been possible to analyse the thermal susceptibility and ignition sensibility of SRFs. A prediction of the self-ignition risk level has been also obtained by a graphical method thanks to the data obtained.

Introduction

One of the main environmental problems in all developed countries is the enormous increase in the amount of waste materials disposal arising from quick industrialization, increasing population and economic development [1].

SRFs from municipal and industrial wastes are defined as a product of high interest due to their possible use as a fuel. Energy industries are looking for implementing these recovered fuels for sustainable development which can successfully cover economic and environmental aspects [2].

The order of priorities for solid waste management [3] was established in order to reduce waste generation, to minimize waste transport distance, to promote material or energy recovery and to ban the landfilling of untreated waste or waste that cannot be treated any further (see Fig. 1).

In this framework, one of the alternative waste-to-energy concepts is the production and thermal utilization of SRFs, derived from nonhazardous mixed waste streams. The use of SRFs as a source of energy is an integral part of waste management and it is regulated by EU regulations [4].

Nevertheless, biomass materials, including SRFs, present several hazards that have to be studied before their treatments, as the potential to cause dust explosions and fires [4]; an increasing number of accidents related to the explosion and fire of SRF is documented in research literature and their number indicated a relevant increasing tendency [5,6].

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Fig. 1 – Waste management hierarchy.

One of the main causes of fires in solid fuels facilities is the self-ignition of these materials, which is why information about this tendency is essential for the facilities that handle, store and process powdery substances. As an example, handling these materials may generate dust that gets into atmosphere [7–9], and if there were an ignition source it could end up in an explosion.

In addition to the flame or explosion caused by the ignition source, SRF could also lead to a self-ignition when the sample acts as its own heat source. In this case, the heat generated by a slow oxidation in the sample surpasses the heat that can be dissipated into the atmosphere, so the temperature of the sample rises until smoldering and flame nests appear [10]. Added to this, these nests created by the self-heating of the bulk material can ignite explosive clouds.

Critical conditions for self-heating in stored bulk materials can be determined by employing suitable laboratory-scale test methods [11], such as thermogravimetric analysis and differential thermal analysis [12,13]. Thermogravimetric analysis is one of the most commonly used [14], and can be performed under atmospheric, hyperbaric or pulse ignition conditions [15,16]. This methodology has been demonstrated as a good tool for describing the combustion and pyrolysis of solid materials [17].

In the present work, ten different SRFs samples were characterized to define their thermal susceptibility and the ignition sensibility of their clouds, in order to provide an overview of the hazards associated with this kind of materials.

Materials and methods

Ten SRF samples have been studied. These samples are defined as the thermally treated organic fraction of urban waste, whose main compositional ratios are detailed in Table 1.

Four different tests have been done to the studied samples in order to determine their thermal behaviours and the ignitability of their clouds of dust: thermogravimetry, differential scanning calorimetry, minimum ignition energy and minimum ignition temperature on a cloud. The samples were milled before the tests in order to obtain the needed grain size for them.

Table 1 – Compositional ratios of the studied samples.

Sample	H/C	O/C	Volatiles/Ashes
L1	1.59	0.56	1.43
L2	1.30	0.59	1.52
L3	1.55	0.64	1.38
L4	1.61	0.52	1.29
L5	1.34	0.35	0.63
L6	1.47	0.85	2.17
L7	1.47	0.73	1.31
L8	1.54	0.50	1.93
L9	1.40	0.90	0.79
L10	1.62	0.67	2.00

Thermogravimetric techniques were used to analyse the thermal susceptibility of solid materials, i.e. their thermal behaviour, exothermic reactions and self-ignition tendency.

Thermogravimetric test (TG) consisted on recording the sample weight changes (weight loss) against temperature or time when the sample was heated with a programmed heating rate. In this test, temperature ranges started at 30 °C and finished at 800 °C with a heating rate of 5 K/min and an isothermal period of 10 min applied when reaching 800 °C.

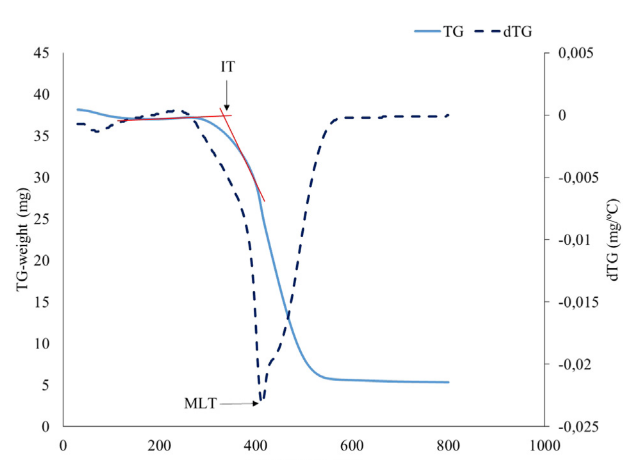

Fig. 2 – Example of thermogravimetric diagram.

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