EMISSIONS FROM THE PYROLYSIS AND COMBUSTION OF DIFFERENT WASTES

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Abstract

A comparison between different emission rates of various pollutants obtained from various wastes is presented. The studied wastes were the following: polyethylene, tyres, sewage sludge, polyvinyl chloride, cotton textiles, polyester textiles, meat and bone meals, varnish wastes, olive oil solid waste (pomace), waste lube oils, paper waste, tomato plant, pine needles and cones, mobile phones and automotive shredder residue.
The decomposition of these wastes was studied in a horizontal laboratory scale reactor at 850 ºC in an inert and an oxidizing atmosphere, and the analysis of the pollutants evolved comprised several compounds such as light hydrocarbons, PAHs and PCDD/Fs.

Keywords: *wastes, pyrolysis, combustion, PCDD/Fs, PAHs.*

1. Introduction

Pyrolysis and combustion have always been considered as attractive alternatives for waste disposal, since these techniques provide a reduction in volume of waste and also involve profitable energetic and/or chemical products.

Thermal decomposition of waste can take place both in controlled conditions (incinerators, cement kilns…) and non-controlled conditions (fires, open-air burning…). The substances emitted during non-controlled plastic thermal degradation may create a serious hazard for human health and for the environment [1] .

2. Materials and Methods

Since 1984, the Department of Chemical Engineering at the University of Alicante has been working on different research projects involving the pyrolysis of organic wastes such as polyethylene (PE), tyres, sewage sludge, polyvinyl chloride (PVC), paper waste, cotton textiles, polyester textiles, meat and bone meal (MBM), polyurethane-based varnish, olive pomace, waste lube oils, tomato plant, pine needles and cones, mobile phones and automotive shredder residue. These wastes were first of all studied from a kinetic point of view by using a thermobalance, which is not the aim of the present work. The pollutants emitted in different experimental conditions have also been studied [2-19]. In this latter case, the appliance used was a quartz tube placed inside a horizontal furnace. The atmospheres used were both N_2 and synthetic air in order to simulate pyrolysis and combustion conditions, respectively, and the temperatures were in the range 500 - 1100 ºC.

In this work, a comparison between different compounds obtained from pyrolysis and combustion of different wastes at 850 ºC is presented. The aim of the present work is to compare the pollutants evolved in the decomposition of different wastes, in order to detect similar behaviors between different pollutants, especially polyaromatic hydrocarbons (PAHs) and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs).

3. Results and Discussion

From the studied wastes, a general behaviour was deduced regarding the evolution of semivolatile compounds with the increase of temperature, both in pyrolysis and combustion.

- The results showed that the emissions of some compounds decreased with increasing oxygen ratio. Compounds with this behaviour were mainly volatile hydrocarbons (methane, ethane, benzene), semivolatile aliphatic compounds (1-dodecene, n-pentadecane), monoaromatic hydrocarbons (o-xylene, 1-propenyl benzene) and polyaromatic hydrocarbons (biphenyl, anthracene), which were formed in pyrolytic conditions, but consumed in the presence of oxygen.

- Partially oxidized compounds presented a maximum with oxygen ratio, such as alcohols, organic acids, furans and some amides. Some compounds without oxygen in their structure present also this behaviour, but they are most likely formed by decomposition of oxygenated compounds such as aldehydes or ketones.

- Intermediate compounds with very high resistance to the oxygen under the working conditions increased continuously in concentration when the oxygen ratio increased, such as carbon oxides, volatile hydrocarbons at moderate temperatures (propylene) and some oxygenated compounds (11-docecenal, tridecanal).

Regarding its behavior with respect to temperature, the following trends were observed:

- There were compounds whose yields decreased with increasing temperature, such as volatile hydrocarbons (n-butane) and semivolatile compounds (1-heneicosene, n-hexadecane…).

- Some pollutants are promoted at intermediate temperatures, e.g. light hydrocarbons (ethane, isobutene), semivolatile compounds (1-dodecene, 1,16-heptadecadiene), many monoaromatic compounds (phenylethyne, m-methylstyrene) and many polyaromatic hydrocarbons (naphthalene, phenanthrene, benzo(a)fluorene, 1- and 2-chloronaphthalene).

In a pyrolysis process (850 ºC) it was shown that high emission factors or yields of PAHs can be obtained, especially naphthalene, so their formation, retention or presence in the condensate phases must be studied or taken into account.

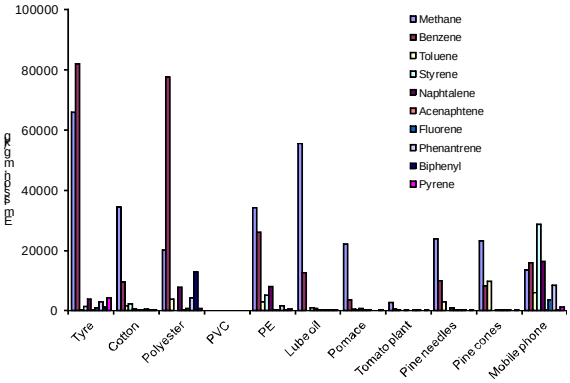

Figure 1. Main semivolatiles in combustion at 850 ºC.

In a combustion process (850 ºC), the evolution of methane, benzene and PAHs, especially naphthalene, are important in order to analyze the operating conditions (oxygen, temperature, residence time and turbulence of the incineration). In this way, the presence of these compounds indicates the formation of puffs with poor oxygen concentration (see Figure 1).

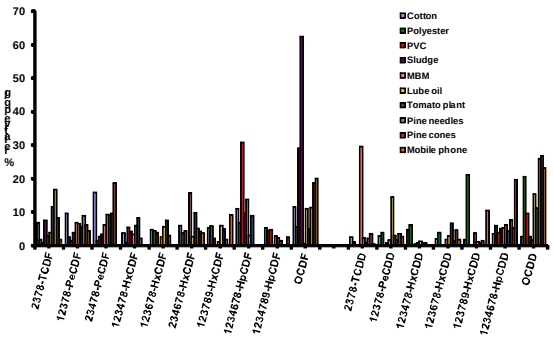

Figure 2. PCDD/Fs in combustion at 850 ºC.

The formation of PCDD/Fs is important in both combustion and pyrolysis processes (see Figure 2). In pyrolysis, there can be a significant increase of congeners and/or an increase of the total toxicity due to the redistribution of the chlorine atoms to the most toxic congeners. The fingerprint or congener distribution in pyrolysis and combustion at 850 ºC was different for each waste, without a clear trend.

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Acknowledgements

Ministry of Education and Science (Spain) (CTQ2008-05520 project) and Valencian Community Government (Spain) (PROMETEO/2009/043/FEDER project).