SOOTS FROM COAL FLUIDIZED BED COMBUSTION

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Introduction

Carbon is the main component of fossil fuels. Incomplete combustion results in unburnt hydrocarbon with adverse effects on human health. These hazardous hydrocarbons are contained in the soot emitted from coal combustion and are also key precursors to photochemical oxidants in the atmosphere. A review on the mechanism of formation was given by Finlayson-Pitts [1].

It seems that PAH are the main contributors to soot formation early in the flame [2] and radicals from pyrolysis are involved as growth species [2] and also responsible of the interconversions or associations between themselves [3]. In this way, the PAH can exist in the gas emitted or can be supported on particulate matter, or even give rise to particulate matter, soots, depending on the size of their association. In this work, the influence of incomplete coal combustion and the incidence of the pyrolytic process previous to combustion are studied in order to know how PAH are involved in the route of soot particles formation.

Experimental

A low rank coal (%C 80.17, %H 6.69, %N 1.01, %S 5.68) from North East of Spain has been burnt in a FBC. The coal combustion was carried out with different air excess percentages at 850 °C in a laboratory fluidized sand bed combustor with a continuous feed (up to 200 g/h). The combustion efficiencies, calculated by the formula (where IOM means Initial Organic Matter and FOM means Final Organic Matter):

$$\%\,Efficiency = \frac{(IOM)_{coal} - (FOM)_{ashes}}{(IOM)_{coal}} * 100$$

are shown in Table 1.

The sampling was carried out with a 20 µm nylon filter as limiting: that from the outlet gas trapped in cyclones (>20 µm), that deposited on the filter (<20 µm) and that escaping from the filter (gas phase), see Table 2. The PAH content in the three trapped particulate matter was analyzed by fluorescence spectroscopy (FS) at the synchronous mode, see Table 3.

Results and Discussion

Results obtained show that incomplete combustion is far away to be the main cause of both soot particles emission and PAH deposition on particulate matter. Table 1 shows that combustion efficiencies were in all the runs higher than 99 % but, in spite of that, emissions in the range of published works have been detected.

Table 1. Combustion efficiencies as a function of air excess at 850 °C

Air excess (%)	5	10	20	40
Efficiency (%)	99.4	99.4	99.1	99.4

According to this, interactions between radicals from the pyrolysis previous to combustion are determinant in soots/PAH formation and emissions [4]. Moreover, Table 2 shows that the air excess presence in the radicals formation region is the most important variable in soot particles formation and in the PAH content of these particles.

The PAH listed as priority pollutants have been analyzed by FS and their distribution as a function of their ring number is shown in Table 3. It can be observed that the higher the oxygen excess the lower the PAH independently of their rings number.

Conclusions

Radical association from the pyrolytic step previous to coal combustion is the main via to soot particles formation and PAH emissions .

Air excess presence in the combustor area of radical formation is a determinant variable in soot particles formation and PAH emissions.

Table 2. Characterization of soot from a low rank coal fluidized bed combustion at 850 °C

	Air excess (%)			
	5	10	20	40
Particulate matter (%)*				
>20 μm	3.63	3.55	5.29	4.19
<20 μm	$5.7\cdot10^{-3}$	$2.8\cdot10^{-3}$	$5.6\cdot10^{-5}$	$8.9\cdot10^{-4}$
PAH content (μg/kg)**				
>20 μm	11.32	14.18	0.28	0.34
<20 μm	3.44	8.44	1.20	2.22

* particulate matter vs. coal feed

** PAH content of the soot vs. coal feed

Table 3. PAH (μg/kg) distribution in soot emitted from coal fluidized bed combustion by aromatic rings number.

	Air excess (%)			
	5	10	20	40
2-3 rings				
particulate matter >20 μm	3.60	2.68	0.20	0.16
particulate matter <20 μm	0.09	2.09	0.22	1.68
gas phase	1.70	0.82	0.30	3.34
4 rings				
particulate matter >20 μm	5.02	2.80	0.00	0.04
particulate matter <20 μm	0.46	1.90	0.26	0.11
gas phase	0.54	0.23	0.16	0.11
5 rings				
particulate matter >20 μm	6.48	3.25	0.02	0.03
particulate matter <20 μm	0.33	0.74	0.26	0.06
gas phase	0.14	0.22	0.07	0.28
6-7 rings				
particulate matter >20 μm	9.17	9.17	0.01	0.10
particulate matter <20 μm	2.56	3.72	0.00	0.38
gas phase	1.90	0.25	0.50	0.47

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References

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