1. Combustion of Lignite samples

This report presents the results of the thermogravimetric tests that were performed for two groups of fuels, lignite and xylite. One sample from each group was used as reference case, representing the raw lignite and xylite samples, respectively. In order to identify the behaviour of the selected fuels, a thermogravimetric analyser (TA Q600) operated at ambient pressure was used for all the non-isothermal combustion experiments. Aiming to reduce the effects of mass and heat transfer limitations small sample weights, about 20mg, were placed in an open alumina sample pan. Air was used as heat transfer medium at the constant flow rate of 100ml/min. The combustion tests were investigated at the temperature range of 30°C to 1000°C at the constant heating rate of 20°C/min. The sample weight loss and the rate of weight loss were continuously recorded under dynamic conditions, as functions of time or temperature.

The main combustion characteristics of the fuels tested as initial combustion temperature (T_{in}), maximum combustion rate (R_{max}) and temperature at that rate (T_{max}), combustion time (t), total conversion (C_{total}) and conversion at particular temperature intervals are summarised in Tables 1 and 2.

Table 1: Combustion characteristics of lignite samples

Fuel	T_{in} [°C]	R_{max} [10^{-2}/min]	T_{max} [°C]	t [min]	C_{total} [%-ww]	Temperature Intervals [°C]	C [%-ww]
Lignite_R	185	7.12	411	31.70	83	150-250	4.7
						250-650	94
						650-850	1.3
Lignite_2	183	7.5	407	31.07	90	150-250	4.2
						250-650	94.8
						650-850	1
Lignite_4	177	7.2	384	32.25	80	150-250	5.2
						250-650	93.4
						650-850	1.4

According to Table 1 the combustion of the reference lignite sample starts at about 185°C. The total conversion of this sample approaches the percentage of 83%. It also reaches the maximum combustion rate which amounts to 7.12 x 10^{-2}/min in the temperature region of 250-650°C and especially in a temperature close to 411°C.The whole combustion process lasts for 31.7 min. The corresponding characteristics of the other two lignite samples are different. In particular, both samples start earlier the combustion. However, they differ in their temperature peaks and the time needed to complete the process. The first ranges from 384-407°C and the combustion time ranges from 31.07-32.25min. The low value of the given T_{max} corresponds to Lignite_4 sample, showing its higher reactivity. Even this sample presents higher combustion rate compared to the reference case of raw lignite. However, it yields a lower weight loss fraction (~80% of total) and needs more time for process completion. Contradictory results are observed for Lignite_2 sample, whose maximum combustion rate amounts to 7.5 x 10^{-2}/min and its total conversion approaches the percentage of 90%. All the above conclusions are illustrated in Fig.1. As clearly shown in this diagram, there is a shift to the left for the Lignite_4 curve, while the Lignite_2 curve presents a higher peak. This displacement is interpreted as a slight increase in their reactivity. According to literature [1], the following formula calculate the reactivity verifying these assertions

$$R=-W_o^{-1}(dw/dt)$$

Where R is the maximum reactivity expressed in mg/h or simply h^{-1}, W_o the initial weight of the char on dry-ash-free basis and dw/dt the maximum rate of fixed carbon loss. It is concluded that the pre-treatment via radiation affects the combustion behaviour and slightly increases their reactivity.

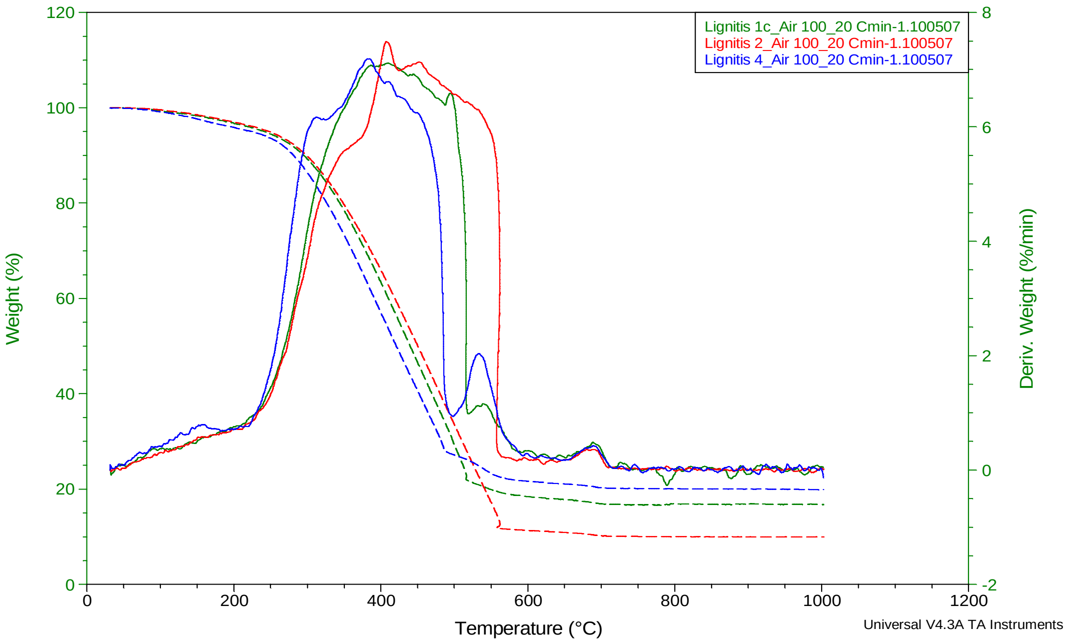

Figure 1: Comparison of TG / DTG curves of lignite samples.

2. Combustion of Xylite samples

As regards the Xylite samples, their combustion characteristics are shown in Table 2. In addition, a comparison between the attained TG/DTG curves for the combustion is presented in Fig.2. According to Table 2 the combustion of the reference xylite sample starts at about 190°C. A low fraction of non-combustible constituents is produced up to 10% on mass basis. This sample also reaches the maximum combustion rate which comes up to 8.3 x 10^{-2}/min in a temperature of 372°C. The whole combustion process lasts for only 29.87 min. Similarly to the lignite samples, the respective characteristics of the treated samples in the group of xylite show behaviour with declining relation to the reference case. In particular, all samples start later the combustion and differ in the initial, the temperature peaks and the combustion time. All the above values are higher than these of Xylite_1R. In contrast, lower values are calculated for the maximum combustion rate, which range in a narrow region of 7.1-7.7 x 10^{-2}/min. It is likely that the pre-treatment via radiation affects in an adverse way the combustion behaviour of the treated samples, reducing their reactivity. These statements can be verified by the previous equation [1] used for the lignite samples.

Table 2: Combustion characteristics of xylite samples

Fuel	T_{in} [°C]	R_{max} [10^{-2}/min]	T_{max} [°C]	t [min]	C_{total} [%-ww]	Temperature Intervals [°C]	C [%-ww]
Xylite_1R	190	8.3	372	29.81	89.8	150-250	4.1
						250-650	94.96
						650-850	0.94
Xylite_2	182	7.4	376	30.73	87.8	150-250	5.1
						250-650	94
						650-850	0.9
Xylite_3	191	7.1	429	29.87	85.25	150-250	3.6
						250-650	95.9
						650-850	0.5
Xylite_4	194	7.7	430	42.88	81.04	150-250	4
						250-650	95.4
						650-850	0.6

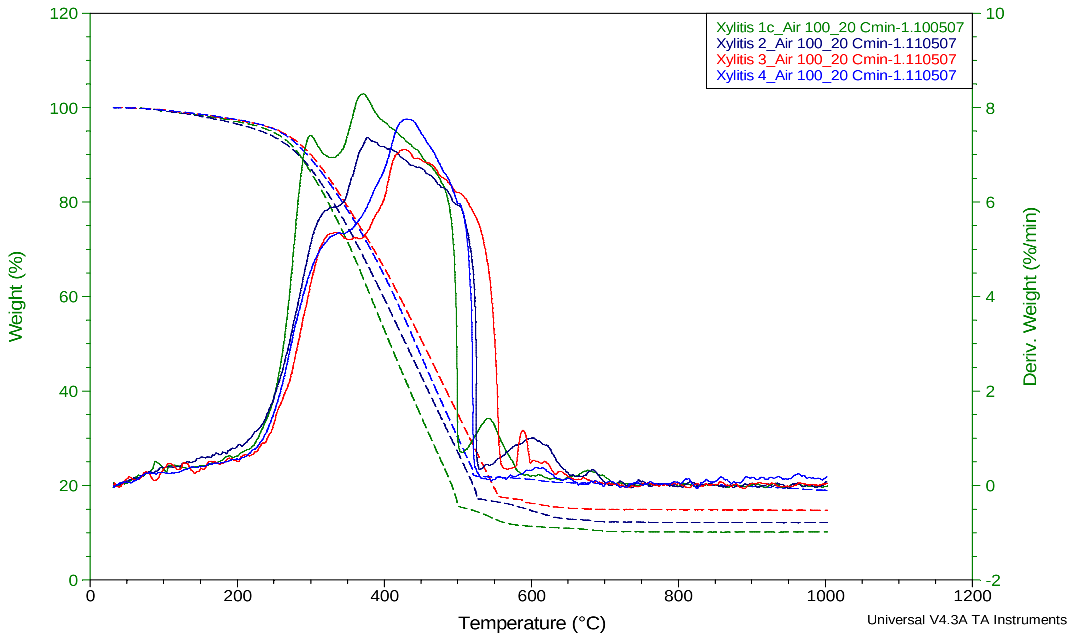

Figure 2: Comparison of TG/DTG curves of Xylite samples

References

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2. E. Kastanaki, D. Vamvuka, P. Grammelis, E. Kakaras: "Thermogravimetric studies for the reactivity of coal/biomass blends during devolatilisation", Fuel Processing Technology, 77-78, 2002, pp. 159-166.
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