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Volatile release profiles of some Turkish lignites

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Abstract

Volatile matter determination is one of the most important criteria in coal analysis, because it is used for evaluating coals for utilisation.

In this study, using TG curves of twenty-five lignite samples from various coal reserves in Turkey, the volatile release profiles were prepared. In the light of these profiles, the devolatilisation behaviour of the lignite samples was discussed.

During the TG studies, 100 mg sample was used and nitrogen was allowed to flow through the system. The temperature was raised with a heating rate of about 40 K min^{-1} to 1223 K and the volatile matter release of the sample was determined as a function of time and temperature.

INTRODUCTION

The volatile matter released during the pyrolysis of coal consists mainly of combustible gases such as hydrogen, carbon monoxide, methane, and other hydrocarbons, tar vapours and some incombustible gases, such as carbon dioxide and water vapour [1]. The amount and composition of the volatile matter in coal vary greatly with the rank. The proportion of incombustible gases in the volatile matter of a coal increases as the rank of the coal decreases.

The volatile matter release profile test covers the determination of the weight loss rate of coal versus temperature in an inert atmosphere. The resulting curve arises from loss of volatile matter as the various organic constituents of coal break down. The volatile matter release profile test is a sensitive "fingerprint" for identifying coals and could find useful application in gasification and carbonisation experiments.

The purpose of this study is to investigate the volatile matter release behaviour of 25 Turkish lignites.

EXPERIMENTAL

Thermogravimetric analysis was carried out using a Shimadzu TG 41 thermal analyser. During the studies, the flow rate of the nitrogen was fixed at 40 cm^3 min^{-1}. The chart speed was selected as 2.5 mm min^{-1}. 100 mg

lignite samples, after grinding to pass a 0.25 mm sieve, were spread uniformly on the bottom of the crucible made of alumina.

Before heating, the system was flushed with dry nitrogen for 30 min to remove all traces of oxygen. The furnace was then turned on. The temperature was raised with a heating rate of 40 K min^{-1} to 1223 K and held at this temperature after the weight was constant.

The proximate analyses and the calorific value measurements of the lignite samples were performed according to ASTM standards [2].

The carbon content of the samples was determined by a Heraus elementary analyser.

RESULTS AND DISCUSSION

The DTG curves of coal determined in an inert atmosphere are called "volatile release profile" [3]. The volatile release profile is much less sensitive to changes in sample mass than the burning profile because there

TABLE 1

The analyses of the lignite samples

Sample no.	Moisture (wt.%)	Ash (wt.%)	Volatile matter (wt.%)	Fixed carbon (wt.%)	Carbon (wt.%)	Net. cal. value (MJ kg^{-1})
L1	10.5	32.2	32.2	25.1	36.4	10.7
L2	4.4	40.6	22.2	32.8	42.2	14.5
L3	15.7	31.8	36.1	16.4	30.2	11.8
L4	9.6	11.0	39.2	40.2	55.3	22.0
L5	10.5	12.1	36.8	40.6	53.0	21.0
L6	19.9	14.0	30.3	35.8	49.7	17.4
L7	27.6	9.8	39.8	22.8	45.5	17.6
L8	24.2	6.2	38.4	31.2	45.3	17.8
L9	2.0	14.4	32.0	51.6	64.7	27.1
L10	14.0	26.6	36.1	23.3	36.6	14.6
L11	7.2	7.3	46.4	39.1	56.7	26.2
L12	25.3	29.3	28.7	16.7	33.3	12.2
L13	16.2	32.6	40.9	10.3	27.7	12.5
L14	15.9	6.7	41.0	36.4	51.8	20.4
L15	35.4	9.0	32.2	23.4	39.9	14.3
L16	12.5	22.9	32.3	32.3	40.3	19.5
L17	17.9	18.7	37.3	26.1	43.9	16.6
L18	27.0	20.6	34.4	18.0	33.5	15.3
L19	14.1	12.7	33.4	39.8	49.8	20.0
L20	13.9	39.2	24.6	22.3	35.1	12.5
L21	40.4	15.2	32.1	12.3	38.3	13.8
L22	6.4	27.6	28.6	37.4	49.5	19.1
L23	5.9	8.9	31.8	53.4	65.5	27.8
L24	27.5	14.1	34.4	24.0	37.6	12.9
L25	48.0	12.0	28.2	11.8	26.1	10.8

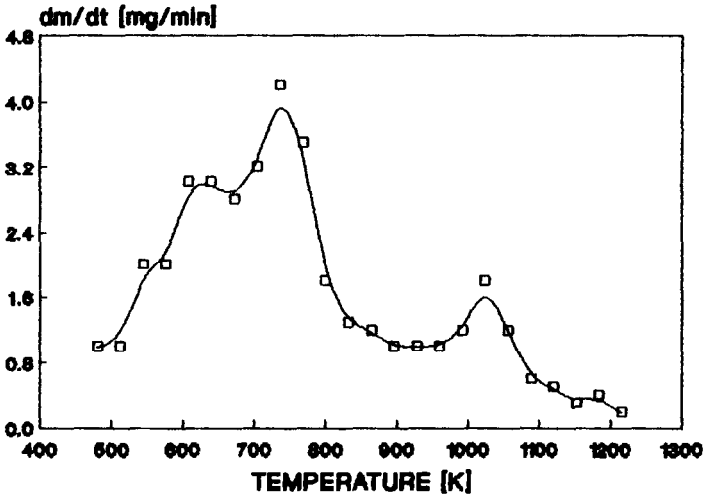

Fig. 1. The DTG curve of the lignite sample L1.

is no reaction between the sample surface and the furnace atmosphere; therefore the volatile loss takes place throughout the bulk of the sample and is not critically dependent on the particle–gas interface [4]. This test is valuable for carbonisation and gasification processes.

The proximate analysis, the net calorific value and the carbon content of the lignite samples are given in Table 1. The moisture content of the lignite samples varies between 4.4 and 48.0%, the ash content between 6.2 and 40.6%, the volatile matter content between 22.2 and 46.4%, the fixed

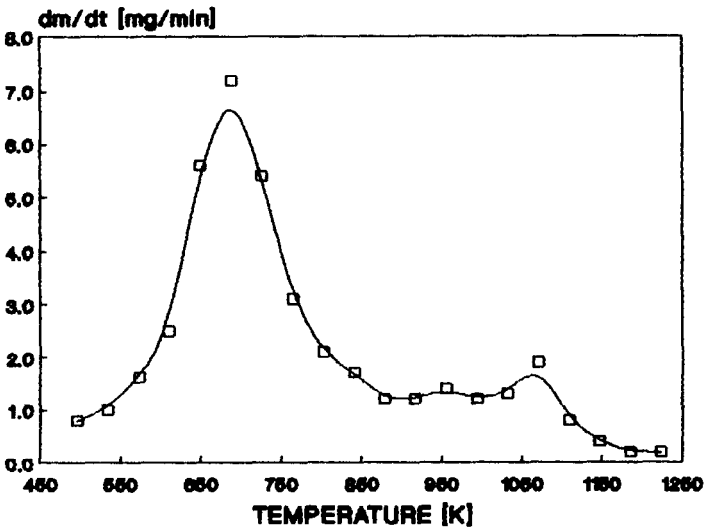

Fig. 2. The DTG curve of the lignite sample L8.

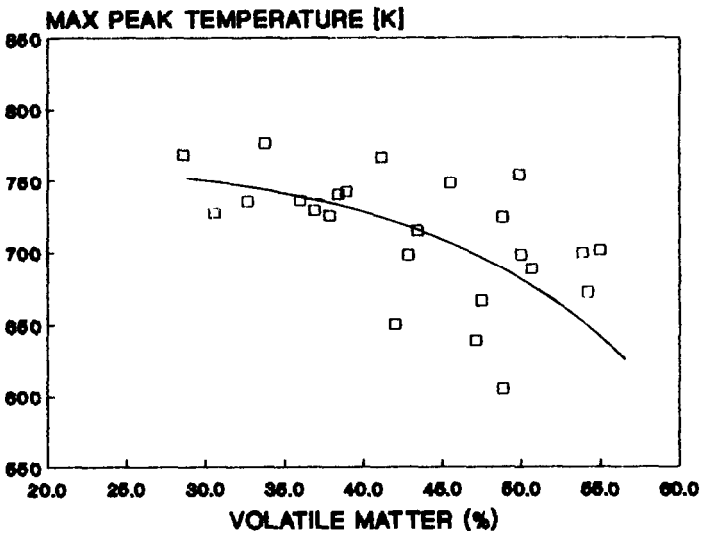

Fig. 3. The relation between volatile matter content of the lignite samples and the maximum peak temperature (dry basis).

carbon content between 10.3 and 53.4%, the carbon content between 26.1 and 65.5% and the calorific value between 10.7 and 27.8 MJ kg^{-1}.

The devolatilisation curves of the lignite samples generally exhibit two peaks: the first in the temperature range 623–773 K and the second in the range 973–1123 K. The initial low temperature peak is correlated with the primary devolatilisation, in which compounds containing carbon, hydrogen and oxygen are released; the second peak is caused by the secondary degasification, in which mainly methane and hydrogen are removed [5].

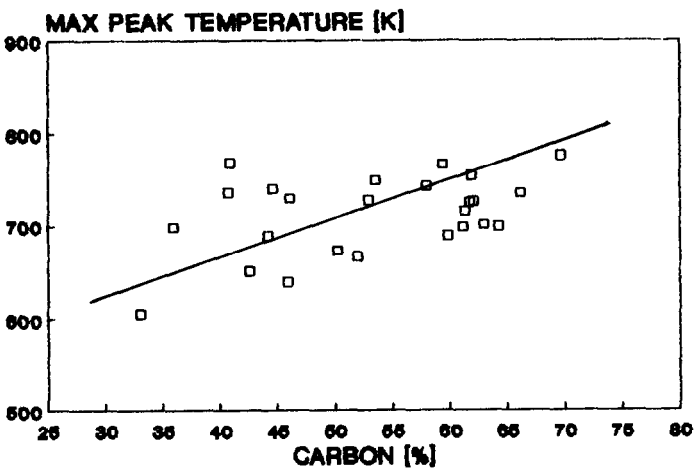

Fig. 4. The relation between carbon content of the lignite samples and the maximum peak temperature (dry basis).

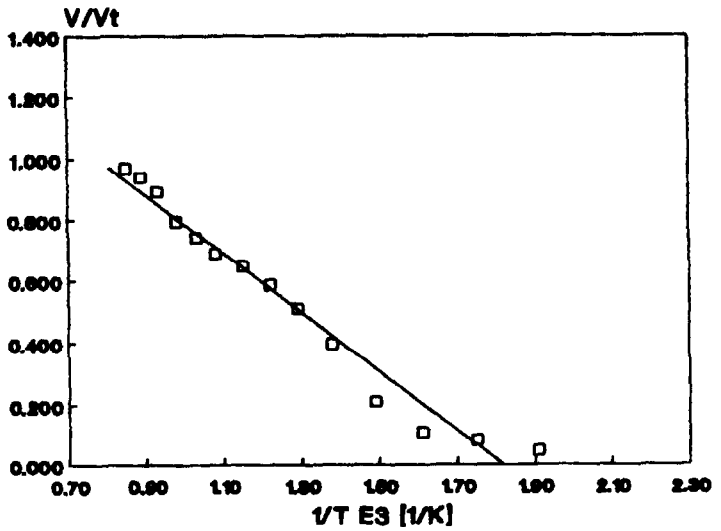

Fig. 5. The relation between temperature and the released fraction of the volatile matter for the lignite sample L20 (V_t = total volatile matter content; V = volatile matter content released up to temperature T).

The secondary degasification peaks are much shorter than the primary peaks.

The volatile release profiles (DTG curves) derived from TG curves of the lignite samples exhibit significant differences in volatile release rate versus temperature. In Figs. 1 and 2, two examples of the volatile release profiles (DTG curves) prepared for the lignite samples can be seen.

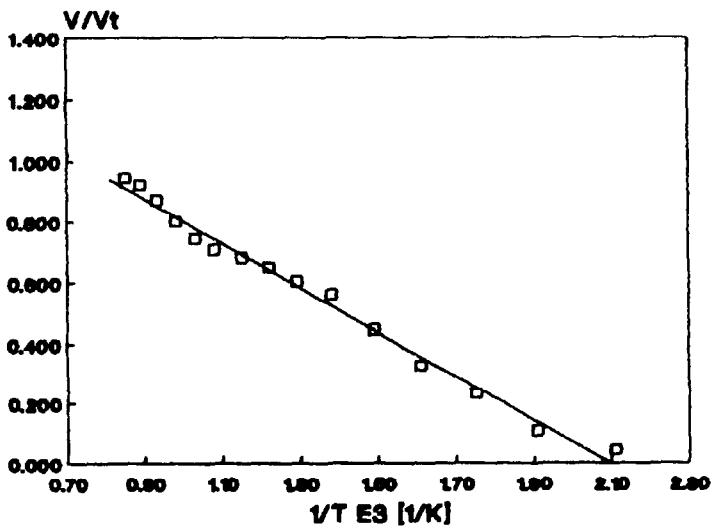

Fig. 6. The relation between temperature and the released fraction of the volatile matter for the lignite sample L21.

The devolatilisation rate depends on the coal rank and with an increase in rank, the maximum peak temperatures increase.

The maximum peak temperatures determined from the DTG curves of the lignite samples exhibit significant differences. An increase in the volatile matter content of the lignite sample causes a decrease in the maximum peak temperature of the DTG curve (Fig. 3). As shown in Fig. 4, increasing the carbon content (dry basis) of the lignite sample appears to cause an increase in the maximum peak temperature.

The volatile matter release fractions versus temperature were obtained from the TG curves of the lignite samples. Two examples are shown in Figs. 5 and 6. There is a linear relationship between temperature and the released fraction of the volatile matter. The correlation was examined by means of regression analysis. The regression coefficient calculated for 25 lignite samples is generally about 0.9.

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