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# THERMAL ANALYSIS OF VICTORIAN BROWN COAL

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## ABSTRACT

The proximate analysis of the five main lithotypes of Victorian brown coal has been obtained by thermogravimetry. The data are compared with proximate analysis data for a typical European lignite and North American anthracite.

## INTRODUCTION

Victorian brown coal is an abundant energy source. The major coal deposit is located in the La Trobe Valley within the State of Victoria and is estimated at 120,000 million tonnes. The coal seams range in thickness from 6-140 metres and are located beneath the surface at a depth ranging from 10-30 metres. Thus brown coal is easily and economically mined by the open-cut method and the present annual production is about 30 million tonnes.

Brown coal is a young, soft, low rank coal containing 50-70% water, which is considerably higher than for the higher rank coals; sub-bituminous coal, 25-30%; bituminous coal 5-10% and anthracite 2-5%. As coal rank increases, the carbon content of the coal increases, aromaticity increases and the proportion of volatile matter decreases. For brown coal, (dry basis), volatile matter amounts to 45-55% compared to bituminous coal, 20-40% and anthracite 5-7%. Brown coal also has a low specific energy (heat energy per g.), 25-30 kJ. $g^{-1}$ compared to bituminous coal, 30-35 and anthracite, 35-38 kJ. $g^{-1}$ respectively.

The composition of coal may be given in terms of its 'proximate analysis' which quantitatively defines water, volatile matter and ash contents and indirectly, the fixed carbon content. Proximate analysis data does not provide information on coal structure, but such data, in combination with specific energy data, may be directly correlated with the behaviour of coal in many industrial processes, in particular, those involved with energy production.

This Paper illustrates the application of thermogravimetry to the determination of the proximate analysis of Victorian brown coal. A special feature of this application is that proximate analysis data are generated from a single TG scan and the analysis is rapid and reproducible. The proximate analysis data for brown coal are discussed by comparison with similar data for some higher-rank coals.

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## EXPERIMENTAL

Five samples of Victorian brown coal, labelled as Medium-Light, Medium-Dark, Dark, Pale and Light and corresponding to the five major lithotypes, were analysed without any pre-treatment.

TG data were derived using a Stanton-Redcroft, STA 780 Simultaneous Thermal Analysis System[1], using nitrogen and oxygen in sequence as carrier gas (25 ml. $min^{-1}$ flow rate) over the temperature ranges: ambient - 750 and 750-900C respectively. Platinum crucibles, sample masses of 10 mg and a heating rate of 250C $min^{-1}$ were employed.

TG data were processed according to the general format: mass loss to 120C ≡ moisture content: mass loss 120-750C ≡ total volatiles content: mass loss 750-900C ≡ fixed carbon content and residue mass ≡ ash content.

## RESULTS AND DISCUSSION

Proximate analysis data in terms of % moisture, volatiles, carbon and ash for four samples of each of the five lithotypes studied are recorded in Table 1 and corresponding mean and standard deviation data are summarised in Table 2.

These data supplement much proximate analysis data available for a variety of coals but it is relevant to note that such data have only recently been obtained via thermogravimetry. The hitherto ASTM specified procedures[2] for coal assay involve heating the coal sample at a specified temperature and conditions until a constant weight is obtained, the moisture, volatiles, fixed carbon and ash contents are determined subsequently by difference procedures. These methods are more time consuming and less direct than the thermogravimetric method.

Various papers exist relating to the thermal analysis of coal and coal products[3-10] including the application of TMA to determine the Free Swelling Index of coals[11]. It is relevant to quote proximate analysis data, as obtained by TG, for typical European and American coals for comparison purposes with Australian brown coal. For German lignite, Barbiroli[12] reports water, volatiles and ash contents as 14.10, 43.95 and 8.53% respectively and for American anthracite, Hassel[11] quotes water, volatiles, fixed carbon and ash contents as 2.1, 5.7, 81.6 and 10.6% respectively. The relatively high water content of Australian brown coal intrinsically defines its low rank but the low ash content has significant industrial advantages.

TABLE 1. Proximate Analysis Data for the 5 main lithotypes of Victorian Brown Coal

| Lithotype | Mass Loss (Untreated Sample) % | | | | Mass Loss (Dry Sample) % | | |
|---|---|---|---|---|---|---|---|
| | Moisture | Volatiles (-moisture) | Carbon | Ash | Volatiles | Carbon | Ash |
| Medium Light | 60.6 | 19.5 | 19.2 | 0.7 | 49.5 | 48.7 | 1.8 |
| | 61.5 | 19.0 | 18.5 | 1.0 | 49.3 | 48.0 | 2.6 |
| | 59.6 | 20.3 | 19.3 | 0.8 | 50.2 | 47.8 | 2.0 |
| | 60.4 | 19.7 | 18.9 | 1.0 | 49.7 | 47.7 | 2.5 |
| Medium Dark | 62.0 | 18.5 | 18.9 | 0.6 | 48.7 | 49.7 | 1.6 |
| | 61.3 | 18.7 | 19.0 | 1.0 | 48.3 | 49.1 | 2.6 |
| | 60.7 | 18.6 | 19.3 | 1.4 | 47.3 | 49.1 | 3.6 |
| | 60.3 | 19.0 | 19.3 | 1.4 | 47.8 | 48.6 | 3.5 |
| Dark | 62.0 | 17.2 | 19.2 | 1.6 | 45.3 | 50.5 | 4.2 |
| | 61.9 | 16.9 | 19.2 | 2.0 | 44.4 | 50.4 | 5.2 |
| | 62.4 | 17.1 | 19.5 | 1.0 | 45.5 | 51.9 | 2.7 |
| | 61.4 | 17.9 | 20.0 | 0.7 | 46.4 | 51.8 | 1.8 |
| Pale | 51.2 | 27.5 | 19.0 | 2.3 | 56.3 | 38.9 | 4.7 |
| | 53.5 | 26.3 | 19.2 | 1.0 | 56.6 | 41.3 | 2.1 |
| | 52.6 | 27.0 | 19.4 | 1.0 | 57.0 | 40.9 | 2.1 |
| | 51.7 | 27.6 | 19.3 | 1.4 | 57.1 | 40.0 | 2.9 |
| Light | 59.5 | 20.5 | 18.9 | 1.1 | 50.6 | 46.7 | 2.7 |
| | 59.4 | 20.7 | 19.8 | 0.1 | 51.0 | 48.8 | 0.2 |
| | 57.6 | 22.0 | 20.4 | 0.0 | 51.9 | 48.1 | 0.0 |
| | 59.0 | 22.1 | 18.9 | 0.0 | 53.9 | 46.1 | 0.0 |

TABLE 2. Summary of Proximate Analysis Data for Victorian Brown Coal

| Lithotype | Mean Mass Loss (Untreated Sample) ($\bar{X}$ & $\sigma$) | | | | Mean Mass Loss (Dry Sample) ($\bar{X}$ & $\sigma$) % | | |
|---|---|---|---|---|---|---|---|
| | Moisture | Volatiles (-moisture) | Carbon | Ash | Volatiles | Carbon | Ash |
| Pale | 52.2 ±0.9 | 27.1 ±0.5 | 19.2 ±0.1 | 1.4 ±0.5 | 56.7 ±0.3 | 40.0 ±1.0 | 2.9 ±1.1 |
| Light | 58.9 ±0.8 | 21.3 ±0.7 | 19.5 ±0.6 | 0.3 ±0.5 | 51.8 ±1.3 | 47.4 ±1.1 | 0.7 ±1.1 |
| Medium Light | 60.5 ±0.7 | 19.6 ±0.5 | 19.0 ±0.3 | 0.9 ±0.1 | 49.7 ±0.3 | 48.0 ±0.4 | 2.2 ±0.3 |
| Medium Dark | 61.1 ±0.6 | 18.7 ±0.2 | 19.1 ±0.2 | 1.1 ±0.3 | 48.0 ±0.5 | 49.1 ±0.4 | 2.8 ±0.8 |
| Dark | 61.9 ±0.4 | 17.3 ±0.4 | 19.5 ±0.3 | 1.3 ±0.5 | 45.4 ±0.7 | 51.1 ±0.7 | 3.5 ±1.3 |

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