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Maceral Contents Of Tertiary Indian Coals And Their Relationship With Calorific Values

Arpita Sharma
Coal Chemistry Division
CSIR-North East Institute of Science & Technology, Jorhat, India
Binoy K Saikia
Coal Chemistry Division
CSIR-North East Institute of Science & Technology, Jorhat, India
Bimala P Baruah
Coal Chemistry Division
CSIR-North East Institute of Science & Technology, Jorhat, India

Abstract

The petrographic composition of some high sulphur tertiary Indian coal samples is determined and their reactivity is predicted. The relationship between maceral contents and Gross Calorific Value (GCV) of these coal samples have been investigated by multi-variable regression analysis. The maceral analysis indicates that the North-East Indian (NE) coal samples have high vitrinite content (80.07% average), a moderate to low liptinite (10.23% average) and a low inertinite (9.3% average). The liptinite and inertinite contents were found to have a strong linear relationship (R^2=0.9283 and R^2= 0.9223). From this study, reasonable GCVs can be interpreted. These regression curves show a good fingerprint for energy calculations.

Key words: *Macerals; Indian Coal; Petrography; Gross calorific value*

Introduction

Coal is a chemically and physically heterogeneous and combustible substance that consists of both organic and inorganic compounds. Coal rank, organic petrology and inorganic petrology are three independent aspects that show coal quality. Coal is currently a major energy source worldwide, especially among many developing countries, and will continue to be so for many years [1].The chemical analysis of coal includes proximate and ultimate analyses. The proximate analysis gives the relative amounts of moisture, volatile matter, and ash, as well as the fixed carbon content of the coal. The ultimate or elemental analysis gives the amounts of carbon, hydrogen, nitrogen, sulfur, and oxygen in the coal.

Heating value is the basis for purchase of coal which indicates the useful energy content of coal, and thereby its value as a fuel. Heating value is defined as the amount of heat evolved when a unit weight of the fuel is burnt completely and the combustion products cooled to a standard temperature [2] and called it gross calorific value (GCV). GCV as a rank parameter depends on the maceral and mineral composition of coal [3-4]. Many equations have been developed for the estimation of gross calorific value (GCV) based on proximate analysis and/or ultimate analysis [5-10].

Coal petrography can be described broadly as the microscopic determination of the organic and inorganic constituents of coal and the degree of metamorphosis, or rank, which the coal has obtained. Petrographic constituents can be directly correlated to important properties affecting the combustion behavior of coal. The term 'maceral' is used to represent the different plant tissue from which the coal was originally formed. Vitrinite, liptinite and inertinite are the main maceral categories. Vitrinite, for instance, is derived from cell walls, cell contents of precipitated gels preserved under water and is relatively oxygen rich. Algae, spores and waxy leaves for example formed liptinite, the hydrogen-rich maceral type. Inertinite originated from plant tissue that had oxidized, altered, degraded or burnt in the peat stage of coal formation, and is carbon rich. The term microlithotype describes the association of the macerals and mineral matter. The degree of "mixing" of the macerals and the nature of the minerals bound within the coal will influence its mechanical and technological properties. A coal with higher inertinite content will burn with a longer flame at higher temperatures while a vitrinite rich coal will burn more quickly and produce a shorter flame [11]. Yakorskii et al (1968) reported that combustibles in ash were largely the result of incompletely burnt inertinite particles [12].

North east Indian Tertiary coals usually have a high vitrinite content (80 % average), with the non-vitrinite fraction being predominantly inertinite. The liptinite content is usually < 20 %. Gondwana coals on the other hand have a low vitrinite content (< 60 %), low liptinite contents and high inertinite content (> 40 %). Vitrinite and liptinite are both reactive. They enhance the rate of combustion. Inertinite has a low reactivity, which retards combustion. Gondwana coals are inherently less reactive and also frequently have higher ash contents than NE Tertiary coals.

Experimental Sections

The coal samples for the present study have been collected from different Tertiary NE Indian coalfields (Assam, Nagaland, Meghalaya and Arunachal Pradesh) by adapting standard sampling methods. For chemical analysis coal samples were ground to 72 BS and polished blocks of coal samples were prepared for petrographic study. Proximate analysis and Sulphur analysis have been done by using Proximate Analyzer (TGA 701, Leco, USA) and 144 DR Sulphur Determinator and the percentage of oxygen was calculated by difference. The Calorific Values of coal samples have been determined by using Automatic Bomb Calorimeter (LECO AC-350) .The chemical analysis of coal samples are given in Table 1.

Samples	**Proximate analysis**					**CV**
	M	**Ash**	**VM**	**FC**	**TS**	**(Kcal/kg)**
Coal-1	3.13	4.41	42.0	50.4	3.77	7130
Coal-2	2.88	1.11	41.3	54.7	2.07	6845
Coal-3	2.90	8.43	39.6	49.1	2.37	7125
Coal-4	2.07	6.36	40.4	51.2	2.75	5730
Coal-5	4.87	31.7	32.7	30.7	3.27	5780
Coal-6	2.35	21.5	36.9	38.8	2.35	5820
Coal-7	10.8	2.71	38.9	47.6	2.62	5860
Coal-8	9.52	5.86	39.7	44.9	3.84	5890
Coal-9	4.33	6.19	32.8	56.7	3.55	6285
Coal-10	3.77	10.8	40.6	44.8	7.01	6810

Coal-11	2.75	9.80	39.6	47.85	2.81	7195

Table1: Physico-chemical characteristics of coal (as received basis, wt %)

All analysis of the samples were carried out in quadruplicate and mean values have been reported.

Petrographic analysis and the identification of maceral types were done according to standard procedures (Stach et. al., 1975). For this purpose coal samples were crushed to obtain ±18 mesh (<1 mm) size fraction to prepare polished mounts or pallets. A mixture of hardener and Canada wax or coal mounting resin in the ratio 1:5 is used for embedding the coal samples for pellet preparation, followed by their grinding and polishing. Microscopic observation has been made on Leica DMLP microscope under both white incident light as well as fluorescence mode. The microscope is provided with 10x ocular and 10x dry lens objective. Recommendations of Stach et al. (1982) and ICCP (1963, 1971, 1975, 1998) have been followed for data collection and interpretation and the volume percent of various macerals are calculated using a swift point counter. The maceral analysis of coal samples are given in Table 2.

Samples	**Maceral %**		
	vitrinite	**liptinite**	**inertinite**
Coal-1	82.3	12.4	5.3
Coal-2	85.7	11.2	3.1
Coal-3	83.4	12.3	4.3
Coal-4	75.3	9.2	15.5
Coal-5	78.9	7.3	13.8
Coal-6	78.4	8.4	13.2
Coal-7	78.9	9.1	12.0
Coal-8	78.3	8.3	13.4
Coal-9	79.3	10.1	10.6
Coal-10	80.4	11.5	8.1
Coal-11	84.3	12.8	2.9

Table2: Petrographic analysis of coal (mineral matter free basis, v %)

Results And Discussion

Regression analysis

Regression analysis is a statistical tool that is used to investigate the relationships between variables. The investigator assembles data on the underlying variables of interest and employs regression analysis to estimate the quantitative effect of the causal variables upon the variable that they influence. The investigator also typically assesses the statistical significance of the estimated relationships, that is, the degree of confidence that the true relationship is close to the estimated relationship [13].

Maceral constituents and GCV

The organic constituents (macerals) singly, and particularly in combination, have a fundamental influence on coal properties. In NER coals usually have a high vitrinite content (> 80 %), with the non-vitrinite fraction being predominantly liptinite. The inertinite content is usually < 6 % but in Meghalaya coal inertinite content is slightly higher (>12%). Vitrinite and liptinite are both reactive; they enhance the rate of combustion. Inertinite has a low reactivity, which retards combustion. The GCV of the coal samples is found to be 5730-7195 Kcal/kg.

Relationships between GCV with Macerals

The Tertiary coals of different coalfields of North Eastern region are characterized by dominance of vitrinite maceral groups (average 80.47%) followed by the macerals of liptinite (average 10.23%) and inertinite (average 9.30%). Inertinites are present in low proportions. The inter-relationship of the important parameter GCV of coals was plotted against the maceral constituents. The relationship between vitrinite contents and GCV is important as it appears to provide a good measure of coal rank or maturity. The vitrinite content of NER coals shows a linear trend as indicated by its linear correlation with the Calorific value (R^2=0.7520) indicating its increasing nature with the rise of vitrinite content [Fig 1(a)]. The relationship of liptinite with GCV is more significant as it is H rich with higher H/C ratio and has the highest individual calorific value followed by vitrinite and inertinite. Thus, in this investigation vitrinite and liptinite shows strong linear correlation with GCV (R^2=0.7520 & R^2=0.9283) and inertinite on the other hand shows the reverse correlation with GCV (R^2=0.9223) respectively [Fig 1(a), (b) & (c)].

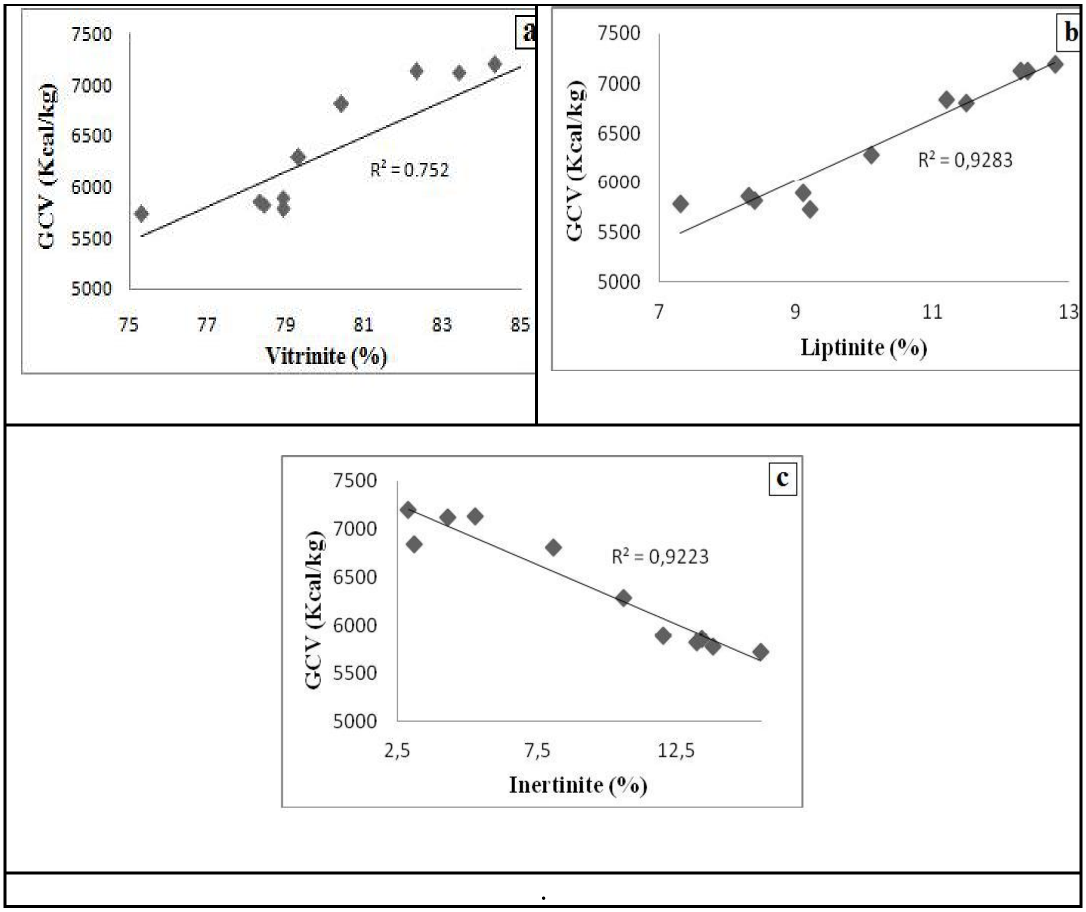

Figure 1: Relationship between macerals (%) with GCV

Conclusion

In this investigation, the intercorrelations between maceral analysis and GCV of coal shows that with the increase of inertinite contents in coal can decrease GCV and the higher vitrinite and liptinite contained in coal can result in higher GCV. Using graphical analysis, the correlation coefficient (R^2) between the experimental datas of macerals and GCV are 0.7520, 0.9283 and 0.9223 respectively for the linear regression. The results were shown that coal petrographic analysis (macerals) can be used as predictors of GCV successfully.

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