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Study on correlations of coal chemical properties based on database of real-time data

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HIGHLIGHTS

- The correlations of coal chemical properties were quantitatively studied.
- Noteworthy variations were captured with some quantified expressions obtained.
- The majority of coals (~87%) lie within a range defined by fuel ratio of 1.0–10.0.
- The majority of low-fusion coals have high levels of volatile matter.

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ABSTRACT

The chemical properties of coal have conspicuous impacts on reactivity and thermal conversion of coal. Nevertheless, the quantitative investigation on correlations of coal chemical properties is still insufficient. The quantified correlations between fuel ratio and various indices of coal chemical property is yet lacking, and little research was conducted to quantitatively describe the proximate and ultimate analyses using ternary diagrams. Here, we investigated the correlations of coal chemical properties based on database of real-time (experimental or actual) data in China. Some noteworthy variations and quantified correlations among chemical properties of coal were firstly demonstrated. The majority of coals (~87%) lie within a range defined by the fuel ratio of 1.0–10.0. Ternary correlations of ultimate and proximate analyses show different distributions with coal rank. The index of coal explosibility is slightly lowered with the increasing carbon content, while the increase of oxygen content leads to certain rise of coal explosibility. In addition, the majority of low-fusion coals have high levels of volatile matter. The occurrence and content of minerals both present considerable influences on ash fusion behaviors. The present study can provide useful information for better understanding the correlations between chemical properties and reactivities of coal.

1. Introduction

Coal is the most important fossil fuel and plays an irreplaceable role in energy production and conversion worldwide [1–4]. Coal has been utilized on a large-scale in many countries, especially in China. It is the predominant energy source in current China and will still play a dominant role (occupying > 50% of the total energy consumption) in the coming decades [5,6]. However, the utilization of coal has given rise to severe environmental problems. The frequent fogy and hazy weather has distinctly affected human health and sustainable development of the society [7,8]. The utilization of coal, particularly in power plants, also causes the huge CO_2 emission and intensifies the greenhouse effect, which will result in irreversible influence on climate change [9–11]. Therefore, numerous researchers have conducted the studies on coal properties, thermal conversion process, pollutant emission control, CO_2 capture, and staged conversion during coal utilization with the purpose of realizing the efficient and clean utilization of coal.

The chemical properties of coal are important in the utilization of coal. The so called chemical properties can be represented by many parameters, the values of proximate analysis, elemental compositions of organic matter, the explosibility of pulverized coal, the calorific value of coal, and mineral compositions of coal ash are all among them. The chemical properties of coal have significant influences on formations of fine ash [12], nitrogen oxides [8,13,14], reactivity [15–17] and so on. Unfortunately, there are still many unresolved issues on coal due to its complicated structure and composition. Sometimes, the conclusions of research might be completely different even under the same experimental

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Nomenclature

A_{ar}	ash content of as-received basis, %
C_{ar}	carbon content of as-received basis, %
C_{daf}	carbon content of dry ash-free basis, %
DT	deformation temperature of ash, °C
FC_{ar}	fixed carbon content of as-received basis, %
FC_{ar}^{u}	the upper limit of FC_{ar}, %
FC_{ar}^{l}	the lower limit of FC_{ar}, %
FC_{daf}	fixed carbon content of dry ash-free basis, %
FT	fluid temperature of ash, °C
Fuel ratio	the ratio of fixed carbon content to volatile matter content
H_{ar}	hydrogen content of as-received basis, %
H_{daf}	hydrogen content of dry ash-free basis, %
HT	hemispherical temperature of ash, °C
K_T	index of coal explosibility
M_{ad}	moisture content of air dry basis, %
M_{ar}	moisture content of as-received basis, %
N_{ar}	nitrogen content of as-received basis, %
O_{ar}	oxygen content of as-received basis, %
O_{daf}	oxygen content of dry ash-free basis, %
$Q_{net,\ ar}$	the net calorific value of as-received basis, MJ·kg^{-1}
$Q_{net,\ daf}$	the net calorific value of dry ash-free basis, kJ·kg^{-1}
S_{ar}	sulphur content of as-received basis, %
ST	softening temperature of ash, °C
V_{ar}	volatile matter content of as-received basis, %
V_d	volatile matter content of dry basis, %
V_{daf}	volatile matter content of dry ash-free basis, %
V_{vol}	the lower limit of volatile matter required for combustion without regard to ash and fixed carbon, %
$V_{vol,que}$	the lower limit of volatile matter required for combustion, %

Subscripts

ar	as-received basis
ad	air dry basis
d	dry basis
daf	dry ash-free basis

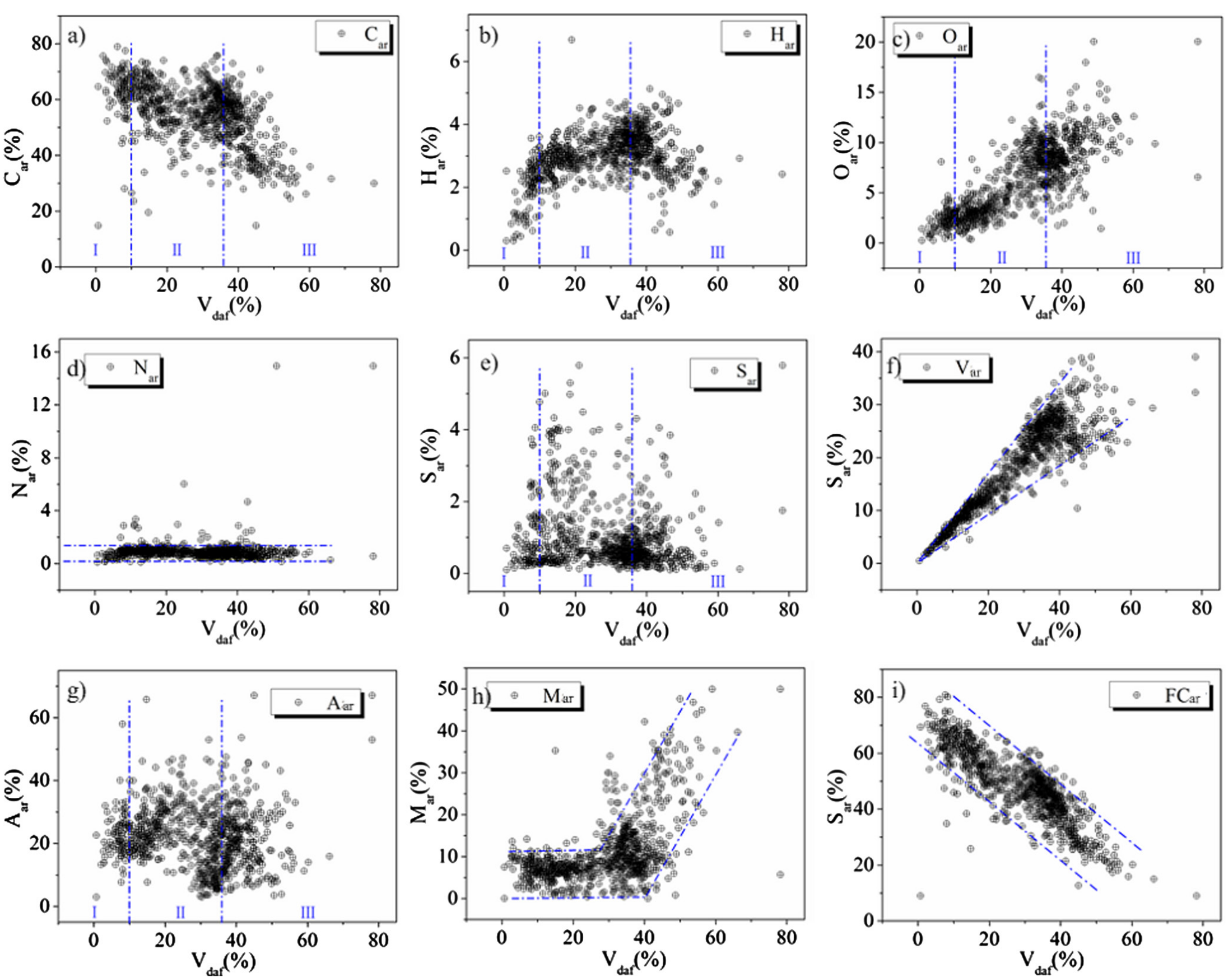

Fig. 1. Correlations between various indices of coal chemical property and volatile matter content of dry ash-free basis: (a) C_{ar} vs. V_{daf}; (b) H_{ar} vs. V_{daf}; (c) O_{ar} vs. V_{daf}; (d) N_{ar} vs. V_{daf}; (e) S_{ar} vs. V_{daf}; (f) V_{ar} vs. V_{daf}; (g) A_{ar} vs. V_{daf}; (h) M_{ar} vs. V_{daf}; (i) FC_{ar} vs. V_{daf}.

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