普通高等教育“十二五”规划教材

化工专业英语（英汉双语版）

——化学工程与能源化学工程方向

Professional English for Chemical Engineering

(English-Chinese Bilingual Edition)

-Specialized in Chemical Engineering and Energy Chemical Engineering

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·北京·

本教材取材于化学工程及能源化学工程相关领域原汁原味的英文，所选文章涉及煤化工、石油化工、天然气化工、C_1 化学、甲醇化学、生物质转化技术、新能源、燃料电池、氢能等领域。全书共分四个部分、十二个单元，每一单元分为精讲和阅读两个部分，两者篇幅一致、难度相近、领域相同，可适用于不同学时的课堂教学。针对高年级本科生英语接受能力，教材对一些语法复杂、专业词汇偏多的段落进行了统一化处理，在保留专业英语原有语境基础上按通用英文语法进行重新编排。本教材除用于高等院校化工专业以及能源化学工程专业本科生及研究生专业英语教学，还可用于留学生专业汉语教学及同等水平人员自修参考学习。

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FOREWORD 前言

随着能源需求日益增加及环保规范日趋严格，清洁能源和新能源的生产逐步引起人们的普遍关注。近年来，我国涌现出很多清洁能源和新能源相关领域企业，新型能源化工企业不仅是传统化学工程与技术专业的延伸与升级，也是化学工程领域未来的希望。然而，由于缺乏相关专业人员，清洁能源及新能源企业发展受到很大限制。我国从2011年左右开始新增能源化工专业，目的是培养可在能源化工相关领域从事科学研究、技术开发、工程设计、生产管理方面的高级技术人才。高级技术人员需要高专业素养，专业教材则成为培养化学工程与工艺、能源化工相关专业学生基本素养和专业能力的关键要素。因此，编写高质量的相关专业教材成为许多专业院校的共同心愿。

随着外语教学在人才培养中被日趋重视，以及为满足了解专业国际现状的需求，相关专业英语教材需求日趋突出。本教材的编写，不仅可以进一步培养和提高学生的专业基本素养，而且很大程度上能使高校学生在英语水平和专业能力上得以补充和延伸。此外，随着我国对外交流的拓展和深入，国外留学生的汉语教学，尤其是专业汉语教学也越来越受到关注。编写这本能供中外学生共同学习化工专业知识的专业外语课的教材，旨在满足“化学工程与工艺”专业未来发展、“能源化工专业”的专业需求以及潜在的对外交流“专业化工专业汉语”的不同需求。

本教材参考了相关专业领域的权威英文原版书籍。针对本科生及研究生的专业英语接受能力，对一些语法句法复杂、生僻，专业词汇偏多的段落进行了简单化处理，使之在保留专业英语原有语境基础上按通用英文语法进行重新编排，让学生通过对专业英语的阅读，逐渐达到能够直接阅读专业英语书籍和外文文献的水平。

教材的编写分为英文和中文两大部分，中文与英文部分内容严格对照但又各自独立。在英文部分，所设计的专业词汇采用英文单词注解，让学生在英语思维模式下巩固专业英语水平和能力。中文部分对文中的汉语词汇进行了英文翻译。教材的附录部分包括全书的总词汇表、煤化工专业英语词汇表、基本元素词汇表。

全书共分四个部分、十二个单元。每一单元分为精讲和阅读两个部分，两者篇幅一致、难度相近、领域相同，可适用于不同学时的课堂教学。每篇课文后面包含专业词汇、专有名词词组和重点问题，便于学习、理解和记忆。本教材注重从化学工程与工艺、能源化学工程角度选择专业阅读材料，所选文章涉及煤化工、石油化工、天然气化工、C_1 化学、甲醇化学、生物质转化技术、新能源、燃料电池、氢能等领域。本教材可作为化工及能源化学工程类高年级本科生及研究生的专业英语教材，还可供能源化学工程与化学化工专业的科技人员及中等英语水平的其他人员自修参考。

在双语教材编写过程中，汉语部分基本保持和英文原文内容一致。同时，由于中英文版本针对的培养对象不同，每单元课后的专业词汇（Specialized English Words）、化工专业术语（Expressions and Technical Terms）和名词解释（Notes）并不完全相同，中文部分是为了更好配合英文部分解读。

本教材结构是在姚颂东教授（第一主编）和余江龙教授（第二主编）共同探讨下完成的。姚颂东教授在石油化工领域、天然气加工领域及能源化工领域都有着丰富的研究教学经验，曾在加拿大 NRC 燃料电池中心和加拿大 UNB 大学做访问学者和博士后。余江龙教授为辽宁省特聘教授，曾担任辽宁科技大学化工学院院长。其在澳大利亚工作留学多年并在中澳都拥有自己的课题小组，承担过十余项国家级自然基金项目。副主编陈星星教授拥有 10 余年欧洲留学及工作经验，现任 *Nature* 出版集团学术期刊 *Scientific Reports* 编委，国际电化学学会和国际生物电化学学会成员，主要负责本书的中英文的校对并执笔第十二单元燃料电池最后一稿的编写，其在句子结构、语法、格式等方面都倾注了大量心血。本教材编写还得到辽宁科技大学国际教育学院汤苏宁院长的帮助，使得教材可以同时兼顾中英文双语教学应用。参与教材编写的还有辽宁科技大学化工学院赖仕全教授和李犇副教授，他们参与了煤化工及能源化工部分的部分工作并在各自领域里提出宝贵意见。

由于时间仓促及编者水平所限，本教材中疏漏和不足之处在所难免，敬请同行和读者批评指正。

编者

2015 年 7 月

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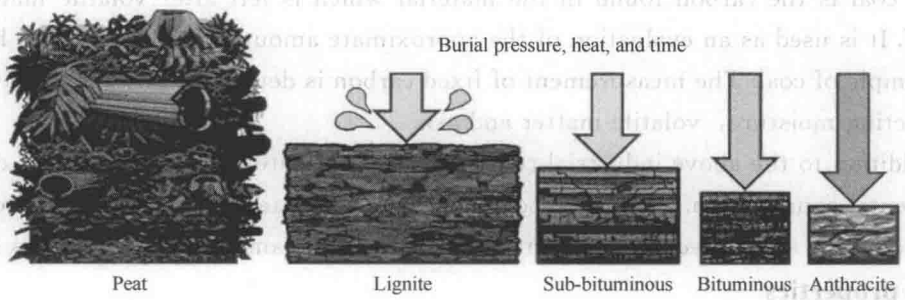
Part 1 Coal Chemistry

Unit 1 Properties of Coal

Introduction

Coal is a kind of brittle, combustible and carbonaceous organic sedimentary rock that is formed from the decomposition and alteration of plant (or vegetation) by compaction under high temperature and high pressure. The carbonaceous material of coal is normally more than 50% by weight and more than 70% by volume. Coal also contains different amounts of carbon, hydrogen, nitrogen, oxygen and sulfur as well as trace amounts of mineral matter. Coal is primarily used as a solid fuel to produce heat by burning. The process will produce carbon dioxide and sulfur dioxide which is supposed to be responsible for the formation of sulfate aerosol and acid rain.



Coal rank

The structure of the buried organic carbonaceous materials changed over time. Peat is considered to be the precursor of coal and can be used as a highly effective absorbent for fuel and oil spilling on land and water. Lignite, also called brown coal, is the lowest rank of coal and is exclusively used as fuel for electric power generation. Sub-bituminous coal, whose properties range from lignite to bituminous coal, is primarily used as fuel for steam-electric power generation and an important source of light aromatic hydrocarbons for chemical synthesis industry. Bituminous coal, a black or dark-brown dense sedimentary rock, can be used not only as fuel in steam-electric power generation, but also for heat and power applications in manufacturing coke. As the highest rank coal, anthracite is primarily used for residential and commercial space heating. It is hard, brittle and black lustrous, often referred to as hard coal.

Coal analysis

Typical coal analysis includes the measurement of moisture, volatile matter, ash and fixed carbon, which is commercially required to measure the physical and chemical properties of coals. There are four types of moisture existed in coals, including (1) surface

moisture, which is held on the surface of coal particles, (2) hydroscopic moisture, which is held by capillary action within the micro-fractures of the coal, (3) decomposition moisture, which is held within the coal's decomposed organic compounds and (4) mineral moisture, which is partially comprised in the crystal structure of hydrous silicates. The measurement of total moisture is determined by the relative weight loss after one of the following methods, they are (1) heating the coal with toluene, (2) drying in a minimum free-space oven at 150℃ within a nitrogen atmosphere and (3) drying in air at 100℃ to 105℃. Methods 1 and 2 are suitable for low-rank coals and method 3 is only suitable for high-rank coals. Air may promote the oxidation of low-rank coals during drying.

Volatile matter of coal is the mixture of hydrocarbons, aromatics and somewhat sulfur that are liberated at high temperature in the absence of air. The measurement of volatile matter is determined by additionally relative weight loss under rigidly controlled standards, normally heating the coal sample to (900±5)℃ for 7 min. Ash of coal is the non-combustible residue left after coal is burned. It represents the bulk mineral matter after carbon, oxygen, sulfur and water have been driven off during combustion. The measurement of ash is determined by the relative weight of remaining inorganic materials after coal is burned. The fixed carbon of coal is the carbon found in the material which is left after volatile materials are driven off. It is used as an evaluation of the approximate amount of coke that will be yielded from a sample of coal. The measurement of fixed carbon is determined by the relative weight by subtracting moisture, volatile matter and ash.

In addition to the above industrial coal analysis, ultimate analysis is used on describing coal elemental composition. For a dried coal, weight percentages of carbon, hydrogen, nitrogen and sulfur are measured. The remainder of the coal sample is designated as oxygen.

Physical properties

(a) Relative density

Relative density or specific gravity of the coal depends on the rank of the coal and degree of mineral impurity. There are some different density measurements for porous coals, including true density or particle density, apparent density, bulk density, and in-place density. In general, the measurement of true density or particle density is determined by helium displacement because helium can penetrate all the pores of a given coal sample without any chemical interaction. The measurement of apparent density is determined by weighting and immersing a coal sample into a liquid which was accurately measured before and after. The measurement of bulk density is to divide the total weight of coal particles that assembled in a fixed container by the volume of the container. For coal in the seam, the measurement of in-place density will be determined in term of tons per acre per foot of seam thickness and tons per square mile per food of seam thickness.

(b) Porosity

Porosity is a measure of the void spaces in coal particles, and is a fraction of the volume of voids over the total volume of coal particles. The calculation of porosity is derived from the determination of the true specific gravity and the relationship between them.

Thermal properties

(a) Calorific value

When coal is applied in electricity generation, heat generated from coal combustion can create steam to power the turbine generator. Heating value, or calorific value is then used to estimate the energy from the coal. Gross calorific value, also known as high heating value (HHV), is determined by measuring the heat of formation when coal is burned off in a constant-volume calorific-meter. On the other hand, net calorific value, also known as low heating value (LHV), is determined by subtracting the heat of vaporization of water from the HHV. For porous coal, especially for the low rank coal, water can be absorbed on coal's hydrophilic surface sites or stay in pores by capillary force. LHV was then used to estimate the combustion heat of the coal. In this case, water is only treated as vapor and the energy for vaporizing the water is not recognized as heat.

(b) Heat capacity

The heat capacity of coal can be measured by standard calorimetric methods. The value of heat capacity is equal to the ratio of the heat to the amount of substance, mass, or volume. The specific heat capacity of coal usually increases with content of volatile matter and moisture.

(c) Thermoplastic properties

The plastic behavior of coal is very important for semi-quantitative evaluation of metallurgical coal and coal blends used in the production of coke for steel industry. When bituminous coals are heated from 300℃ to 500℃ in the absence of air, volatile materials will be released and the solid coal particles will be soften. Bituminous coal become a plastic-like mass that swells and eventually re-solidifies.

(d) Ash fusibility

The fusibility of coal ash is determined by observing the temperature. During the test, coal is heated to a desired temperature at a specified rate under oxidizing atmosphere. An approximate ash fusion temperature can be observed when coal is sintered, melted and flowed.

Specialized English Words

Combustible Able to burn easily.

Sedimentary Made of the solid substances that settle at the bottom of the sea, rivers, lakes etc.; sedimentary rock.

Decomposition To decay or make something decay.

Aerosol A small metal container with liquid inside. Press a button on the container will drive the liquid come out in very small drops.

Bituminous A type of coal with a high percentage of volatile matter that burns with a smoky yellow flame. Also called soft coal.

Sub-bituminous A type of coal whose properties range from those of lignite to those of bituminous coal and are used primarily as fuel for steam-electric power generation.

Anthracite A dense, shiny coal that has a high carbon content and little volatile matter and burns with a clean flame. Also called hard coal.

Lustrous Having a high, radiant sheen or glow. Gleaming with or as if with brilliant light. Radiant.

Moisture Diffuse wetness that can be felt as vapor in the atmosphere or condensed liquid on the surfaces of objects, dampness.

Volatile A volatile liquid or solid substance will change easily into a gas.

Ultimate Most extreme or important because either the original or final, or the best or worst.

Micropore A pore in a catalytic material whose diameter is less than 2 nanometers.

Hydrophilic Having an affinity for water; readily absorbing or dissolving in water.

Capillary A tube that is very narrow inside. The chemist used a capillary tube to move the drop of liquid.

Metallurgical The science that deals with procedures used in extracting metals from their ores, purifying and alloying metals, and creating useful objects from metals.

Fusibility Capable of being fused or melted by heating.

Expressions and Technical Terms

Acid rain Acid precipitation falling as rain.

True density The true density is the ratio between the mass and the volume of a material.

Apparent density The weight per unit volume of solid particles, in contrast to the weight per unit volume of the individual particles.

Particle density The density of the particles that make up the powder.

Bulk density Defined as the mass of many particles of the material divided by the total volume they occupy. The total volume includes particle volume, inter-particle void volume, and internal pore volume.

In-place density The in-place density of coal is the means by which coal in the seam can be expressed as tons per acre per foot of seam thickness or tons per square mile per foot of seam thickness.

Notes

① **Organic sedimentary rock**: Like some limestone and coal, organic sedimentary rock is formed largely from the remains of once living organisms, such as marine organisms and vegetation. After these remains were piled up and covered by more and more deposits, they would gradually undergo compaction and petrifaction.

② **Coke rank**: The degree of alteration that occurs as a coal matures from peat to anthracite. Low-rank coals, such as lignite and sub-bituminous coals, have lower energy content because they have lower carbon content and higher moisture level. As time, heat and

burial pressure increase, the rank does as well. High-rank coals, including bituminous and anthracite coals, contain more carbon than lower-rank coals which results in a much higher energy content. They have a more vitreous (shiny) appearance and lower moisture content then lower-rank coals.

Reading Material 1 Situation of China's Coal

Resources and reserves

It is widely agreed that China possesses the third largest coal resources in the world, behind the United States and Russia. In 2010, China's coal reserve was reported as high as 114.5 billion tones based on raw coal. Shanxi province has the richest coal reserves in China, followed by Inner Mongolia and Shaanxi province. On a national level, 54% of China's coal reserves are classified as bituminous coal by volume, versus 29% sub-bituminous and 16% lignite. China is mainly focusing on extraction of bituminous coal and paid less attention on the production of anthracite and lignite. The production of bituminous coal reaches 76% of China's total coal production. The average depth of China's coal mines is 456 meters. Xinjiang province has more than half of coal reserves located at less than 1000 meters below the surface. Mines in eastern China are particularly deep, with an average depth of 600 meters.

North China contains the vast majority of domestic coal reserves and more than half the population. However, the regions have access to only 20% of national water resources. The distribution of coal and water resources leads to many challenges in meeting demand. The demand of coal is distributed in most parts of China, notably in coastal areas, but the supply of coal is concentrated in northern regions. Average per capital water in China is only 1/8 of the national average and 1/25 of the world average. As for China's mining industry, it has been estimated that the extraction of 1 tonne of coal requires 53～120 liters of water, depending on the location and depth of the coal. An additional 4 tonnes of water is needed for coal washing, which can reduce sulfur and particulate content while increasing energy content of raw coal.

Although China's coal resource is less than United States and Russia, it heavily depends on coal as a primary source of energy. Coal's share in China is as high as 67% while it is only 24% in United Stated and 16% in Russia. The unbalanced fossil resource distribution, self sufficiency and energy security lead to high levels of coal usage in China.

Coal usage

The long-term trend in China's coal usage is shift from direct coal utilization to transformation, primarily through thermal electricity generation. Between 2000 and 2006, total direct coal utilization dropped from 35% to 26% of annual coal consumption. Over the same period, power generation increased from 42% to 50% of the total. Industry use of coal increased on an absolute basis, but declined from 26% to 20% of total consumption. The shift from end use to transformation of coal is driven by inter-related processes of urbanization, heavy industry growth, and rising per-capital consumption.

The surge of coal consumption between 2000 and 2007 was largely driven by the rapid increase in electricity demand. Coal-fired power generation accounted for 56% of the marginal increase in coal use between 2000 and 2005. Over the same period, growth in coal used for power generation was still the largest growth drivers, followed was the growth in coal used for coke production (18%), for delivered heating (district heating) (6%), for chemicals production (3%) as well as the end-use of coal for production of building material (6%). The increase of coal is also related to China's electricity generation system. From 1980 to 2007, coal's share of electricity generation capacity has grown steadily from 69% to 78%. The absolute amount of coal-fired capacity grew at an average annual growth rate of more than 12% between 2000 and 2007, from 238GW to 554GW.

The average efficiency of thermal electricity generation is comparatively low in China due to the prevalence of small, outdated coal-fired power plants. Larger-scale plants are more capital intensive and require less coal per unit of output. However, only 45% of plants had a capacity of no less than 300 MW according to the China Electricity Council in 2006. Generally, four types of coal-thermal generation technologies are used in China. They are sub-critical, supercritical, ultra-supercritical and Integrated Gasification Combined Cycle (IGCC). The majority of China's thermal power generators use sub-critical combustion technology. Supercritical and ultra-supercritical technology can achieve higher fuel efficiency by operating at high temperatures and pressures where the boundary between water's liquid and vapor states disappears.

The utilization of coal brings environmental challenges. It may emit sulphur dioxide (SO_2), dust as well as NO_x significantly. China is one of the largest emitters of CO_2 although it's cumulative contribution to the atmospheric stock of CO_2 and per-capita emissions remain well below those of the world's industrialized nations. For now, China is making new contributions to protect the global climate. In 2007, China unveiled its national action plan on climate change, which includes goals to develop clean coal technologies, from more efficient coal mining equipment to CO_2 capture and storage (CCS).

Coal transportation

Moving coal around the country utilizes a large and growing share of domestic transport capacity. It was estimated that 80% of consumed coal was transported by rail, road or water. As we known, most of China's coal resources are located in the inland of northern provinces of Shanxi, and Inner Mongolia, which are away from coastal demand centers. In these

regions, coal transport attracts much attention. In 2007, the capacity of Daqin line (Datong to Qinhuangdao port) was increased from 250 Mt/a to 300 Mt/a. Qinhuangdao port, with a coal-handling capacity of 220 Mt/a (the worlds largest one), will guarantee eastern China's coal supply. Most of coal can be transported by rail lines, however, only half the volume of coal was produced in rail-connected mines. Coal supply capacity from the mid-west is limited by the number of barges that can traverse three gorges locks on Yangtze River. When rail and water transportation is impossible, coal is transported by road which is the most expensive mode of coal transportation in China.

Major current coal-related legislation and regulation

The laws and regulations in China's coal industry include resource administration (Rules for implementation of the mineral resources law, issued in March 1994), safety supervision (Work safety law, enacted in June 2002), environmental protection (The solid waste pollution prevention and control law, enacted in October 1995 and revised in December 2004), industry administration (Coal law, enacted in August 1996) and energy conservation (Energy conservation law, issued in November 1997 and revised in October 2007).

Specialized English Words

Emissions A substance discharged into the air, especially by an internal combustion engine. The act or an instance of emitting.

Cumulative Increasing or enlarging by successive addition.

Unveiled To remove a veil or covering from; to disclose; reveal.

Implementation The act of providing a practical means for accomplishing something; The act of accomplishing some aim or executing some order.

Supervision Authoritative control over the affairs of others.

Administration The act or process of administering, especially the management of a government or large institution.

Expressions and Technical Terms

Per capital Per unit of population; per person.

Outdated Old-fashioned and therefore not as good or as fashionable as something modern.

Coal-fired power generation In a coal-fired steam station, water is turned into steam, which in turn drives turbine generators to produce electricity.

Notes

① **Coal transportation**: The way that coal is transported to where it will be used depends on the distance to be covered. Coal transportation is generally carried out by conveyor or truck over short distance. Trains and barges are used for longer distance within

domestic markets.

② **National action plan on climate change**: Global warming was affecting China's ecological system and natural resources as well as life of the public. To cope with it, The Chinese government has announced its first national action plan to respond to climate change during a state council conference.

③ **Integrated Gasification Combined Cycle (IGCC)**: A key technology in a plan to promote empirical research projects that aim to realize "zero-emission coal-fired power generation". IGCC technology uses a gasifier to turn coal and carbon based fuels into synthesis gas (syngas). The technology then removes impurities from the syngas before it is combusted. Some of pollutants, such as sulfur, can be turned into reusable byproducts.

Exercise 1

1. Read the text and explain following concepts in English

Sedimentary rock	Coal rank	Coal analysis
Heat capacity	Heating value	Specific density
Volatile matter	Thermoplastic ability	Ash fusibility

2. Choose one right answer from four choices to complete the sentence

(1) ____ is the lowest rank of coal and is referred to as brown coal.

(a) Lignite (b) Bituminous (c) Sub-bituminous (d) Anthracite

(2) Moisture is measured by determining the weight loss after coal is dried at 104～110℃ while volatiles are measured by determining additional weight loss when coal is pyrolyzed at ____.

(a) 200～300℃ (b) 400～500℃ (c) 600～750℃ (d) 900℃

(3) For a dried coal, weight percentages of ____ can not be measured directly.

(a) carbon (b) hydrogen (c) oxygen (d) nitrogen and sulfur

(4) ____ is especially suitable for the estimation of the total energy from lignite.

(a) Net calorific value (b) High heating value

(c) Low heating value (d) Heat of vaporization of water

3. Filling the blank with no more than 3 words

(1) Coal's gross calorific value is also known as _____ _____ _____ (HHV).

(2) _____ _____ _____ can be determined by helium displacement because helium can penetrate all the pores of a coal sample without chemical interaction.

(3) Porosity is the fraction (or percentage) of the volume of coal that is occupied by pores and can be calculated from the _____ _____ _____.

4. Give a short answer to the following questions

(1) According to the coal rank, write down at least 3 kinds of coal in the order.

(2) Write down the typical analysis methods that are requested by coal industry.

(3) Describe how to measure the specific densities of coal.

(4) Compare the difference between HHV and LHV.

5. Put the following sentences into Chinese

(1) In general, true density of coal is determined by helium displacement because all the pores of a coal sample can be penetrated without any chemical interaction by helium.

(2) When metallurgical coal and coal blends is used in the production of coal for the steel industry, it is importance to evaluate the plastic behavior of coal.

(3) The in-place density (bank density) of coal can be expressed as tons per acre per foot of seam thickness and tons per square mile per food of seam thickness.

(4) Sub-bituminous coal can be used as fuel for steam-electric power generation and as a source of light aromatic hydrocarbons synthesis.