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(72) Inventeurs/Inventors:
HAMAGUCHI, MAKI, JP;
OKUYAMA, NORIYUKI, JP;
KOMATSU, NOBUYUKI, JP;
SHISHIDO, TAKAHIRO, JP;
SAKAI, KOJI, JP

(73) Propriétaire/Owner:
KABUSHIKI KAISHA KOBE SEIKO SHO (KOBE STEEL,
LTD.), JP

(74) Agent: RICHES, MCKENZIE & HERBERT LLP

(54) Titre : PROCEDE DE FABRICATION DE MATIERES CARBONEES

(54) Title: METHOD FOR PRODUCING CARBON MATERIALS

(57) **Abrégé/Abstract:**

The present invention provides a method for producing a carbon material, by which a high purity carbon material which is dense and has an extremely low ash concentration can be economically obtained. In the present invention, it is a method for producing a carbon material which can be used as a nonferrous metal reducing agent, a structural carbon material, a carbon material for an electric material or a raw material thereof, the method comprising: an ashless coal production step of producing an ashless coal as a modified coal by modifying a coal with a solvent; an ashless coal heating step of subjecting the ashless coal produced in the ashless coal production step to a heating treatment; and a carbonization step of obtaining a carbon material by carbonizing the ashless coal which has been subjected to the heating treatment in the ashless coal heating step. The atomic ratio (H/C) of hydrogen to carbon in the ashless coal which has been subjected to the heating treatment in the ashless coal heating step is from 0.6 to 0.67.



ABSTRACT

The present invention provides a method for producing a carbon material, by which a high purity carbon material which is dense and has an extremely low ash concentration can be economically obtained. In the present invention, it is a method for producing a carbon material which can be used as a nonferrous metal reducing agent, a structural carbon material, a carbon material for an electric material or a raw material thereof, the method comprising: an ashless coal production step of producing an ashless coal as a modified coal by modifying a coal with a solvent; an ashless coal heating step of subjecting the ashless coal produced in the ashless coal production step to a heating treatment; and a carbonization step of obtaining a carbon material by carbonizing the ashless coal which has been subjected to the heating treatment in the ashless coal heating step. The atomic ratio (H/C) of hydrogen to carbon in the ashless coal which has been subjected to the heating treatment in the ashless coal heating step is from 0.6 to 0.67.

DESCRIPTION

METHOD FOR PRODUCING CARBON MATERIALS

5 Technical Field

[0001]

The present invention relates to a method for producing a carbon material which is included in a nonferrous metal reducing agent, a structural carbon material or a carbon material for an electric material, and the present invention particularly relates to
10 a method for producing a carbon material which is used as an aggregate of an anode for aluminum smelting.

Background Art

[0002]

15 As a main raw material of an anode for aluminum smelting, there is generally used petroleum coke produced from residues of petroleum refinery processes. However, the petroleum coke is produced together with transportation fuels such as gasoline, so that there is a problem that the supply quantity thereof is limited or a problem that impurities such as sulfur contained in crude oil exerts an adverse effect on
20 aluminum purity.

[0003]

On the other hand, coal-derived coke used in blast furnace iron-making has properties close to those of the petroleum coke, and is distributed in more than enough quantities in the market as the main raw material of the anode for aluminum smelting.
25 However, the coal-derived coke has a problem in quality, because it contains coal-

derived ash in an amount of about 10 mass %. Accordingly, it has not been used for this purpose.

[0004]

So, in terms of a raw material of a low-ash carbon material, so-called ashless coal (hyper-coal) is cited (for example, see Patent Document 1), and recently, the development thereof has been actively advanced. Here, the ashless coal is produced by extracting coal with a solvent, separating only components soluble in this solvent, and thereafter removing the solvent. From the structural point of view, the molecular weight of this ashless coal widely distributes from a relatively low-molecular-weight component having 2 or 3 condensed aromatic rings to a high-molecular-weight component having about 5 or 6 condensed aromatic rings. Further, ash is insoluble in the solvent, so that the ashless coal substantially contains no ash and shows high fluidity under heating. This is excellent in thermal fluidity. Of coals, some such as caking coal show thermoplastic properties at around 400°C, but the ashless coal generally melts at 200 to 300°C (has thermoplasticity), regardless of the grade of a raw material coal. So, taking advantage of this property, the application development as binders for coke production has been advanced. Further, in recent years, it has been tried to produce a carbon material by using this ashless coal as a raw material of the carbon material.

20 Prior-Art Documents

Patent Documents

[0005]

Patent Document 1: JP-A-2001-26791

25 Summary of the Invention

Problem that the Invention is to Solve

[0006]

However, the conventional methods for producing a carbon material have a problem as shown below.

As described above, the ashless coal is characterized in that it contains no ash
5 and has thermoplasticity. It is therefore known that the ashless coal is effective as a
caking additive for metallurgical coke making. Further, to contain no ash is a
preferred property for an aggregate (main raw material) of an anode for aluminum
smelting. However, when conversion to carbon (carbonization) in which the ashless
coal is subjected to a heating treatment to form a carbon material, the ashless coal
10 foams. This is an another general property of the ashless coal. This poses a problem
in the production of the main raw material coke of the anode for aluminum smelting
(hereinafter appropriately referred to as the anode coke). That is to say, when the as-
produced ashless coal is carbonized, pores caused by low-molecular-weight compound
gases (water vapor, CO, CO₂, hydrocarbons and the like) formed when carbonization
15 remain as such. Accordingly, there is a problem of not forming dense coke which is
proper as the anode coke. Also, when the ashless coal is used in a nonferrous metal
reducing agent, a structural carbon material, a carbon material for an electric material
other than the anode coke, or the like, the same problem is encountered.

[0007]

20 The invention has been made in view of the above-mentioned problem, and an
object thereof is to provide a method for producing a carbon material, by which a high
purity carbon material which is dense and has an extremely low ash concentration can
be economically obtained.

25 Means for Solving the Problems

[0008]

The present inventors have studied, and then found that atomic ratio of hydrogen to carbon (hereinafter appropriately referred to as the H/C atomic ratio) in ashless coal is preferably adjusted in a predetermined range for using as a raw material of an anode coke, a nonferrous metal reducing agent, a structural carbon material or a carbon material for an electric material other than the anode coke.

[0009]

In order to adjust the H/C atomic ratio in the ashless coal in the predetermined range, specifically, the ashless coal is subjected to a heating treatment. Such chemical and physical changes so as to decrease the hydrogen content, such as decomposition of an alkyl group, an aromatization reaction, decomposition of an oxygen-containing functional group and removal of a low-molecular-weight component, proceed by the heating treatment to gradually decrease the H/C atomic ratio. The present inventors have found that expansibility of the ashless coal can be suppressed thereby to result in being able to suppress foaming when carbonization, thus achieving the invention.

[0010]

That is to say, a method for producing a carbon material which can be used as a nonferrous metal reducing agent, a structural carbon material, a carbon material for an electric material or a raw material thereof, according to the invention, is characterized by comprising: an ashless coal production step of producing an ashless coal as a modified coal by modifying a coal with a solvent; an ashless coal heating step of subjecting the above-mentioned ashless coal produced in the above-mentioned ashless coal production step to a heating treatment; and a carbonization step of obtaining a carbon material by carbonizing the above-mentioned ashless coal which has been subjected to the heating treatment in the above-mentioned ashless coal heating step, wherein an atomic ratio (H/C) of hydrogen to carbon in the above-mentioned ashless

coal which has been subjected to the heating treatment in the above-mentioned ashless coal heating step is from 0.6 to 0.67.

[0011]

According to such a production method, the coal is modified in the ashless coal production step, thereby producing the ashless coal as the modified coal having an extremely low ash concentration. Next, in the ashless coal heating step, this ashless coal is subjected to the heating treatment, thereby specifying the H/C atomic ratio in the ashless coal to the range of 0.6 to 0.67. Subsequently, in the carbonization step, this ashless coal is carbonized, thereby obtaining the carbon material. Then, the H/C atomic ratio in the ashless coal after the heating treatment is 0.6 or more, resulting in sufficient sintering properties of the ashless coal, and the H/C atomic ratio is 0.67 or less, which suppresses expansibility of the ashless coal to suppress foaming of the ashless coal when the carbonization treatment, thereby forming the carbon material which is dense and has an extremely low ash concentration.

15 [0012]

Further, in the method for producing a carbon material according to the invention, it is preferred that the above-mentioned heating treatment of the ashless coal in the above-mentioned ashless coal heating step is performed under the presence of the same solvent as used for the modification of the above-mentioned coal in the above-mentioned ashless coal production step.

[0013]

According to such a production method, use of the solvent increases the efficiency of heat transfer to make heating of the ashless coal uniform. Further, the same solvent as used for the modification of the coal is used, so that economic efficiency is improved.

Advantages of the Invention

[0014]

According to the method for producing a carbon material of the invention, the carbon material which is dense and has an extremely low ash concentration can be
 5 obtained. Further, such a carbon material can be economically obtained.

Brief Description of Drawing

[0015]

[Fig. 1] Fig. 1 is a graph indicating the relationship between the strength and
 10 the H/C atom number ratio in Examples and Comparative Examples of the invention.

Embodiment for Carrying Out the Invention

[0016]

The method for producing a carbon material according to the invention will be
 15 described below.

The method for producing a carbon material according to the invention comprises an ashless coal production step, an ashless coal heating step and a carbonization step. The respective steps will be described below.

[0017]

20 <Ashless Coal Production Step>

The ashless coal production step is a step of producing an ashless a coal as a modified coal by modifying a coal with a solvent.

The ashless coal said in the invention is so-called hyper-coal, and is produced by subjecting the coal to solvent extraction to remove ash and insoluble coal
 25 components. This ashless coal has an extremely small ash content (ash concentration: 1.0 mass % or less) and a water content of about 0.5 mass % or less.

[0018]

As a method for obtaining the ashless coal, a known method is utilizable, and the kind of solvent and production conditions are appropriately selected in view of properties of the coal and design of the carbon material as a raw material. As a typical
5 method, there is a method of heating a mixture of a solvent having high solubilization ability to the coal, which is an aromatic solvent (hydrogen-donating or non-hydrogen-donating solvent) in many cases, and the coal to extract organic components in the coal. However, in order to obtain the ashless coal more efficiently and inexpensively, it is preferred to produce the ashless coal, for example, by the following method. In that
10 method, first, a mixture (slurry) of the coal and the non-hydrogen-donating solvent is heated, thereby extracting coal components soluble in the non-hydrogen-donating solvent. Next, the slurry after extraction is separated into a liquid part and a non-liquid part, and the above-mentioned non-hydrogen-donating solvent is separated from the above-mentioned liquid part, thereby producing the ashless coal.

15 [0019]

As the coal of the raw material of the ashless coal (hereinafter also referred to as the raw material coal), it is preferred to use low rank coal. Use of inexpensive low rank coal makes it possible to produce the ashless coal more inexpensively, so that economic efficiency can be further improved. However, the coal used is not limited to
20 the low rank coal, and bituminous coal may be used as needed.

[0020]

Here, as the low rank coal, there is coal such as non-slightly-caking coal, steam coal or low-rank coal (brown coal, subbituminous coal or the like). As the low-rank coal, there is, for example, brown coal, lignite, subbituminous coal or the like.
25 Further, for example, as the brown coal, there is Victorian coal, North Dakota coal, Berga coal or the like, and as the subbituminous coal, there is West Banco coal,

Binungan coal, Samarangau coal or the like. The low-rank coal is not limited to ones exemplified above. Any coal which contains a large amount of water and is required to be dehydrated is included in the low-rank coal called in the present invention. It is preferred to previously pulverize the coal into fine grains as small as possible, and the grain size is preferably 1 mm or less.

[0021]

The non-hydrogen-donating solvent is a coal derivative as a solvent which is mainly purified from distillation products of coal and mainly composed of bicyclic aromatic compounds. This non-hydrogen-donating solvent is stable even in a heated state, and excellent in affinity with the coal. For this reason, when the non-hydrogen-donating solvent is used, the rate of soluble components (coal components herein) extracted in the solvent (hereinafter also referred to as the extraction rate) is increased, and the solvent can be easily recovered by a method such as distillation. Typical components of the non-hydrogen-donating solvent include naphthalene, methylnaphthalene, dimethylnaphthalene, trimethylnaphthalene and the like as the bicyclic aromatic compounds. In addition, naphthalenes, anthracenes and fluorenes, which have aliphatic side chains, and alkylbenzenes in which biphenyls or long-chain aliphatic side chains are added thereto are contained in components of the non-hydrogen-donating solvent.

[0022]

The extraction rate of the coal achieved by the high temperature extraction using the non-hydrogen-donating solvent is generally high. Further, the non-hydrogen-donating solvent is easy to be cyclically used, because it is easily recoverable, different from a polar solvent. Further, it is unnecessary to use expensive hydrogen, catalyst and the like, so that the ashless coal is obtained by solubilizing the coal at a low cost, thereby being able to improve economic efficiency.

[0023]

The coal concentration based on the solvent is preferably in a range of 10 to 50 mass %, and more preferably in a range of 20 to 35 mass %, on a dry coal basis, although it depends on the kind of raw material coal. When the coal concentration
5 based on the solvent is less than 10 mass %, the ratio of the coal components extracted in the solvent to the amount of the solvent decreases. This is therefore not economical. On the other hand, the higher coal concentration is better. However, when the coal concentration exceeds 50 mass %, the viscosity of the slurry prepared is increased. Accordingly, it is liable to become difficult to handle the slurry or to separate a liquid
10 part from a non-liquid part (described later).

[0024]

The extraction temperature of the slurry is preferably within a range of 300 to 450°C. When the extraction temperature is within this range, bonds between molecules which constitute the coal are loosened to cause mild pyrolysis, resulting in
15 the highest extraction rate. When the extraction temperature is less than 300°C, it is liable to become insufficient for weakening the bonds between the molecules which constitute the coal, and it is difficult to improve the extraction rate. On the other hand, when the extraction temperature exceeds 450°C, the pyrolytic reaction of the coal becomes very active to cause recombination of pyrolytic radicals formed.
20 Accordingly, it is difficult to improve the extraction rate, and modification of the coal becomes difficult to occur. The heating temperature is preferably from 300 to 400°C.

[0025]

A criterion of the heating time (extraction time) is a time until reaching dissolution equilibrium, but realization thereof is economically disadvantageous.
25 Accordingly, the heating time is usually from about 10 to 60 minutes, although it cannot be said without reservation because it varies depending on conditions such as the grain

size of the coal and the kind of solvent. When the heating time is less than 10 minutes, the extraction of the coal components is liable to become insufficient. On the other hand, even when the heating time exceeds 60 minutes, the extraction proceeds no further. This is therefore not economical.

5 [0026]

The extraction of the coal components soluble in the non-hydrogen-donating solvent is preferably performed under the presence of an inert gas. The reasons for this are that contact with oxygen is dangerous because there is a possibility of catching fire, and that use of hydrogen causes an increase in cost.

10 The inert gas used is preferably inexpensive nitrogen, but is not particularly limited thereto. Further, the pressure is preferably from 1.0 to 2.0 MPa, although it depends on the temperature in the extraction or the vapor pressure of the solvent used. When the pressure is lower than the vapor pressure of the solvent, the solvent is volatilized and not kept in a liquid phase, resulting in impossibility of the extraction.

15 In order to keep the solvent in the liquid phase, a pressure higher than the vapor pressure of the solvent is required. On the other hand, when the pressure is too high, an instrument cost and an operation cost are increased. This is therefore not economical.

[0027]

20 After the coal components have been extracted as described above, the slurry is separated into the liquid part and the non-liquid part. Here, the liquid part is a solution containing the coal components extracted in the solvent, and the non-liquid part is a solute containing coal components (ash-containing coal, namely ash coal) insoluble in the solvent.

25 [0028]

As methods for separating the slurry into the liquid part and the non-liquid part, various filtration methods and centrifugation methods are generally known. However, in the methods by filtration, frequent replacement of filters is necessary. Further, in the methods by centrifugation, blocking caused by undissolved coal components is liable to occur. It is therefore difficult to industrially perform these methods. Accordingly, it is preferred to use a gravity settling method which can continuously operate a fluid and is also suitable for bulk handling at a low cost. The liquid part (hereinafter also referred to as the supernatant liquid) as a solution containing the coal components extracted in the solvent is obtained thereby from an upper part of a gravity settling tank. Further, from a lower part of the gravity settling tank, the non-liquid part (hereinafter also referred to as the solid concentrated liquid) as a solvent containing the coal components insoluble in the solvent is obtained.

[0029]

Then, the ashless coal is obtained by separating the non-hydrogen-donating solvent from this liquid part.

As methods for separating the solvent from the supernatant liquid (liquid part), there can be used common distillation methods, evaporation methods (such as spray dry methods) and the like. From the supernatant liquid, the ashless coal containing substantially no ash is obtained. This ashless coal has an ash content of 1.0 mass % or less, and scarcely contains ash. Further, this ashless coal has a water content of approximately 0.5 mass % or less, and shows a calorific value higher than that of the raw material coal. Accordingly, the high purity carbon material having an extremely low ash concentration can be obtained by carbonizing this ashless coal.

[0030]

<Ashless Coal Heating Step>

The ashless coal heating step is a step of subjecting the ashless coal produced in the above-mentioned ashless coal production step to a heating treatment.

The as-produced ashless coal shows extremely high volumetric expansion. Accordingly, in order to suppress expansion, the heating treatment is performed. It is
5 necessary to perform the heating treatment so that the atomic ratio (H/C) of hydrogen to carbon in the ashless coal after the heating treatment is adjusted to a range of 0.6 to 0.67.

[0031]

Here, the H/C atomic ratio of the as-produced ashless coal which is subjected
10 to no treatment is in a range of approximately 0.7 to 1.0, although it varies depending on the kind of raw material coal or production conditions of the ashless coal. However, when the heating treatment is performed to this ashless coal, chemical and physical changes so as to decrease the hydrogen content, such as decomposition of an alkyl group, an aromatization reaction, decomposition of an oxygen-containing functional
15 group and removal of a low-molecular-weight component, proceed to gradually decrease the H/C atomic ratio. Then, the H/C atomic ratio is adjusted to a range of 0.6 to 0.67 by the heating treatment.

[0032]

That the H/C atomic ratio is smaller than 0.6 means that the heating treatment
20 is excessive. When the heating treatment is excessive, sintering properties become insufficient to obtain only a powdery carbon material, even though this ashless coal is carbonized. For this reason, when the H/C atomic ratio is less than 0.6, the carbon material used as the raw material of the anode coke cannot be obtained. On the other hand, that the H/C atomic ratio is larger than 0.67 shows that the heating treatment is
25 insufficient, and a relatively large amount of hydrogen is contained in the ashless coal. For this reason, when the H/C atomic ratio exceeds 0.67, the ashless coal foams during

the carbonization in the carbonization step. Thus, foaming of the ashless coal during the carbonization can be suppressed while leaving proper sintering properties by adjusting the H/C atomic ratio to a range of 0.6 to 0.67 by the heating treatment of the ashless coal.

5 [0033]

A method of the heating treatment of the ashless coal is not particularly limited, and it can be performed by a known method. For example, the ashless coal is heated at 350 to 500°C, preferably at 380 to 460°C, in vacuum, under high pressure or in an inert atmosphere. The treating time required is roughly from 10 minutes to 5
10 hours, although it varies depending on properties of the ashless coal or the treating temperature. Thus, the H/C atomic ratio is regulated to a range of 0.6 to 0.67 by taking into consideration the properties of the ashless coal, and appropriately adjusting the treating temperature and the treating time.

[0034]

15 Further, the heating treatment of the ashless coal is preferably performed under the presence of the same solvent as used for the modification of the coal in the ashless coal production step.

That is to say, the ashless coal is mixed with the solvent so as to form a slurry form, and thereafter subjected to the heating treatment. The amount of the solvent
20 based on the ashless coal is not particularly limited. However, from the viewpoint of obtaining the slurry having a proper viscosity, the ashless coal concentration based on the solvent is, for example, in a range of 10 to 50 mol %, and preferably in a range of 20 to 35 mol %, on a dry coal basis. Further, the heating treatment of the ashless coal as said herein may be performed without separating the solvent, by heating the liquid part
25 as the coal components extracted in the above-mentioned solvent, as it is. As methods for separating the solvent from the ashless coal after the heating treatment, there can be

used common distillation methods, evaporation methods (such as spray dry methods) and the like.

[0035]

By using the solvent, the efficiency of heat transfer is increased more than the case of heating the ashless coal as it is, and uniform heating becomes possible.

Further, use of the same solvent as used for the modification of the coal can reduce a production cost. The solvents used for the heating treatment of the ashless coal include alkyl naphthalenes, anthracene oil and the like as suitable ones.

[0036]

10 <Carbonization Step>

The carbonization step is a step of obtaining a carbon material by carbonizing the ashless coal which has been subjected to the heating treatment in the above-mentioned ashless coal heating step. The ashless coal is carbonized by this carbonization step to obtain the carbon material.

15 [0037]

A method and conditions of the carbonization treatment are not particularly limited, and a known technique can be used. Typically, the ashless coal is baked in an inert gas atmosphere such as nitrogen or argon at about 1,000°C to be subjected to the heating treatment, thereby converting the ashless coal to carbon. Further, of the rising temperature rate may be about 0.1 to 5°C/min. This carbonization treatment may be performed under pressure using a hot isostatic pressing apparatus or the like. Furthermore, a binder component such as asphalt pitch or tar may be added as needed. In addition, after the ashless coal which has been subjected to the heating treatment is appropriately formed, the carbonization step may be performed. There is no particular limitation also on the form of a carbonization furnace, and a known one can be used. Examples thereof include a pot furnace, a lead hammer furnace, a kiln, a rotary kiln, a

shaft furnace, a chamber furnace and the like. However, the carbonization furnace is not limited thereto, and another one may be used.

[0038]

Then, the carbon material obtained by the production method of the invention
5 can be suitably used as the main raw material coke of the anode for aluminum smelting. Further, in addition to this, the carbon material obtained by the production method of the invention can also be used as the nonferrous metal reducing agent, the structural carbon material or the carbon material for an electric material other than the anode for aluminum smelting, or can also be used as a raw material of the nonferrous metal
10 reducing agent, the structural carbon material or the carbon material for an electric material. Here, the nonferrous metal reducing agent is a reducing agent used for reduction of a nonferrous metal such as silicon or titanium. Further, the structural carbon material is, for example, a carbon material used as a raw material of a structural material made of carbon such as a carbon heat insulator or a crucible. Furthermore,
15 the carbon material for an electric material is a carbon material used as a raw material of an electric material made of carbon such as a carbon electrode, as well as the anode for aluminum smelting. The description of being used as a raw material thereof is described, for example, because it is necessary to perform a secondary treatment such as heat treatment to the carbon material in some cases.

20 [0039]

As described above, the method for producing a carbon material of the invention comprises the ashless coal production step, the ashless coal heating step and the carbonization step. However, in carrying out the invention, another step such as a coal pulverization step for pulverizing the raw material coal, a removal step for
25 removing unwanted matter such as refuse or a ashless coal drying step for drying the ashless coal may be contained between or before or after the above-mentioned

respective steps, within a range not exerting an adverse effect on the above-mentioned respective steps.

Examples

5 [0040]

The method for producing a carbon material according to the invention will be specifically described below with respect to examples and comparative examples.

[Production of Ashless Coal]

First, ashless coal was produced by the following method.

10 A raw material coal is a raw material coal for coke production (coal A) as bituminous coal or a steam coal for thermal power generation (coal B) as bituminous coal. A solvent (1-methylnaphthalene (manufactured by Nippon Steel Chemical Co., Ltd.)) is mixed in an amount (20 kg) four times larger than that (5 kg) of this raw material coal, thereby preparing a slurry. This slurry was pressurized with nitrogen of
15 1.2 MPa, followed by extracting in an autoclave with an internal volume of 30 L under conditions of 370°C and 1 hour. This slurry was separated into a supernatant liquid and a solid concentrated liquid in a gravity settling tank maintained at the same temperature and pressure, and the solvent was separated and recovered from the supernatant liquid by a distillation method to obtain the ashless coal.

20 [0041]

[Heating Treatment]

Then, the ashless coal is subjected to a heating treatment by the following method.

The heating treatment of the ashless coal is performed under conditions of
25 using 1-methylnaphthalene (manufactured by Nippon Steel Chemical Co., Ltd.) as a solvent in an amount three times (three times by mass) that of the ashless coal, or under

conditions of using no solvent at all. The heating treatment was performed by rising the temperature to a predetermined temperature shown in Table 1 at 10°C/min while stirring the ashless coal in an airtight autoclave having an initial nitrogen pressure of 0.1 MPa, and keeping it for a predetermined period of time shown in Table 1. After the treatment, the gas in the autoclave was discharged, and heating was performed under a pressure of 0.001 MPa at 150°C for 1 hour, thereby removing by distillation the solvent and oil components which were possibly generated. Thereafter, the ashless coal which had been subjected to the heating treatment was recovered. Then, the H/C atomic ratio is determined by elemental analysis thereof.

10 [0042]

[Carbonization Treatment]

Next, the ashless coal is subjected to a carbonization treatment by the following method.

5 g of the ashless coal which had been subjected to the heating treatment and pulverized to 1 mm or less was filled in a quartz test tube having an internal diameter of 20 mm so as to obtain a bulk density of 0.8 g/cc. Thereafter, in the nitrogen atmosphere, the temperature was raised to 1,000°C at 3°C/min and kept at this temperature for 30 minutes to perform carbonization, thereby obtaining a carbon material.

20 [0043]

The carbon material was cut to a length of 10 mm, a crushing test was performed to measure the strength. The crushing test is performed by placing a sample on a lower pressure plate, compressing the sample with an upper pressure element, and measuring the strength (crushing strength) at the time when the sample breaks. Then, the sample having a strength of 5.0 MPa or more is judged as a dense carbon material. However, the strength also varies depending on the conditions of the carbonization

treatment (the bulk density of the raw material, whether formed or not formed, or the heat treatment temperature), so that this value is just a relatively comparative value. The carbon material having a higher strength is denser, and suitable as the raw material of the anode coke.

5 [0044]

Table 1 shows the results of this test. In Table 1, the values not satisfying the range of the invention are indicated as underlined. Further, 1-methylnaphthalene is denoted as MN in the table. Further, Fig. 1 shows a graph indicating the relationship between the strength and the H/C atomic ratio. The strength "0.00" indicates that the
10 strength could not be measured because of lack of a measurable strength.

[0045]

[Table 1]

No.	Raw Material Coal	Solvent	Treating Temperature (°C)	Treating Time (min)	H/C Atomic ratio	Strength (MPa)
1	A	MN	440	60	0.61	8.30
2	A	MN	440	90	0.62	6.40
3	A	MN	460	30	0.64	12.20
4	A	MN	440	120	<u>0.58</u>	4.80
5	A	MN	480	30	<u>0.57</u>	1.70
6	A	MN	480	120	<u>0.50</u>	0.00
7	A	MN	480	0	<u>0.73</u>	0.00
8	A	Not used	460	90	<u>0.68</u>	0.00
9	A	Not used	420	60	<u>0.74</u>	0.00
10	A	Not used	440	60	<u>0.72</u>	0.00
11	A	Not used	460	60	<u>0.70</u>	0.00
12	A	Not used	420	90	<u>0.75</u>	0.00
13	A	Not used	440	90	<u>0.71</u>	0.00
14	B	MN	440	30	0.62	5.90
15	B	MN	430	60	0.64	7.40
16	B	MN	440	45	0.65	8.80
17	B	MN	440	60	0.64	8.00
18	B	MN	450	30	0.64	11.90
19	B	MN	460	15	0.65	9.10
20	B	MN	460	30	0.63	11.40
21	B	MN	440	60	<u>0.58</u>	1.30
22	B	MN	460	30	<u>0.57</u>	0.50
23	B	MN	430	30	<u>0.73</u>	0.00
24	B	MN	420	60	<u>0.72</u>	0.00
25	B	MN	460	10	<u>0.70</u>	0.00

[0046]

As shown in Table 1 and Fig. 1, Nos. 1 to 3 and 14 to 20 satisfy the range of
5 the invention. These were therefore carbonized without forming in the carbonization
step to form the dense carbon materials, and the strength thereof was high.

[0047]

On the other hand, Nos. 4 to 6, 21 and 22 have a H/C atomic ratio of less than the lower limit value. The carbon materials therefore became powdery to fail to form the dense carbon materials, and the strength thereof was low. The strength in No. 6 could not be measured.

5 Further, Nos. 7 to 13 and 23 to 25 have a H/C atomic ratio exceeding the upper limit value. The ashless coal was therefore foamed in the carbonization step, and thus, the dense carbon materials could not be obtained, and the strength thereof could not be measured.

[0048]

10 The method for producing a carbon material according to the invention has been described above in detail showing the embodiments and examples. However, the gist of the invention is not limited to the contents described above, and the scope of right thereof should be broadly interpreted based on the description of the claims. It goes without saying that the contents of the invention can be widely modified, changed,
15 etc. based on the description described above.

We claim:

1. A method for producing a carbon material for use as a nonferrous metal reducing agent, a structural carbon material, a carbon material for an electric material or a raw material thereof, the method comprising:
 - an ashless coal production step of producing an ashless coal as a modified coal by modifying a coal with a solvent;
 - an ashless coal heating step of subjecting the ashless coal produced in the ashless coal production step to a heating treatment; and
 - a carbonization step of obtaining a carbon material by carbonizing the ashless coal which has been subjected to the heating treatment in the ashless coal heating step, wherein an atomic ratio (H/C) of hydrogen to carbon in the ashless coal which has been subjected to the heating treatment in the ashless coal heating step is from 0.6 to 0.67.
2. The method for producing a carbon material according to claim 1, wherein the heating treatment of the ashless coal in the ashless coal heating step is performed under the presence of the same solvent as used for the modification of the coal in the ashless coal production step.

1/1

FIG. 1