MANUFACTURE OF ACTIVE CARBON FROM ANTHRACITE COAL

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No Drawing. Application April 30, 1957
Serial No. 655,964
16 Claims. (Cl. 252—445)

This invention relates to the manufacture of active carbon from anthracite coal, and particularly to the securing from anthracite coal of active carbon having a wide range of utility which embraces those uses to which powdered active carbon as derived from pulp mill waste, wood, peat, and lignite are commonly put.

Many different processes for preparing active carbon are known in the prior art. Various objectives have led to the development of these processes. Some are specific to particular raw materials. Others seek to develop specific adsorptive properties. In general the activation procedure leaves a characteristic imprint on the carbon which is revealed in its adsorptive behavior.

The varied behavior of different brands of active carbon indicates that different qualities of adsorptiveness can be developed, depending upon the total activation process employed. No one carbon is universally best, and consequently selection of a suitable preparation method depends both upon the source material and upon the purpose for which the carbon is to be used.

A leading source of powdered active carbon has been the concentrated, used cooking liquors of paper mills. This material, however, is so valuable as fuel for the mill furnaces, and is so conveniently available for that purpose, that there is a tendency to withdraw it from use as a starting material in the preparation of active carbon. This points to the desirability of finding a suitable replacement material, and of devising an economically feasible procedure of deriving from such replacement material a powdered active carbon having the required properties. Anthracite coal has heretofore been proposed for the preparation of hard granular carbons suitable for use in gas masks and in the reconditioning of solvent vapors, but has not been found to be suitable for the preparation of filter bed or color adsorbent carbon. Anthracite coal of suitable particle size is available in large quantities, in central geographical locations, and at low cost, in the culm banks of various mining companies. This indicates the desirability of devising an economical, efficient, and commercially practical process for producing high grade active carbon from this material. The devising of such a process presents problems which are not encountered when peat and bituminous coal are used as raw materials.

In accordance with the present invention, a practical and advantageous method has been contrived for economically producing from anthracite coal multiple purpose powdered active carbon which is in all respects substantially equal to the best powdered active carbon heretofore derived from the used cooking liquor of pulp mills.

The carbon which is secured from anthracite coal in accordance with the invention is adapted for many uses, including, among others, the adsorption, desorption of many antibiotics, purification of corn sugar and of cane sugar; maintenance of insecticide concentrations, prevention of color migration in plastic solids, and many others.

In carrying out the novel procedure of the present invention, pulverulent anthracite coal as recovered by flotation from culm banks of coal and steel companies is used as the starting or raw material. A typical analysis of the anthracite coal referred to is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile matter</td>
<td>6.34</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>81.69</td>
</tr>
<tr>
<td>Ash</td>
<td>13.77</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.88</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.014</td>
</tr>
<tr>
<td>Fusion</td>
<td>B.t.u.</td>
</tr>
<tr>
<td>Initial deformation</td>
<td>13,160</td>
</tr>
<tr>
<td>Softening point</td>
<td>2800</td>
</tr>
<tr>
<td>Fluid point</td>
<td>2900</td>
</tr>
</tbody>
</table>

A variable part of the ash content of anthracite coal consists of silica.

A screen analysis of the commercial coal shows the following size range:

<table>
<thead>
<tr>
<th>Size Range</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>+8 mesh</td>
<td>0.1</td>
</tr>
<tr>
<td>+8 mesh —10 mesh</td>
<td>0.4</td>
</tr>
<tr>
<td>—10 mesh +14 mesh</td>
<td>1.8</td>
</tr>
<tr>
<td>—14 mesh +20 mesh</td>
<td>5.6</td>
</tr>
<tr>
<td>—20 mesh +28 mesh</td>
<td>11.7</td>
</tr>
<tr>
<td>—28 mesh +35 mesh</td>
<td>18.1</td>
</tr>
<tr>
<td>—35 mesh +48 mesh</td>
<td>19.4</td>
</tr>
<tr>
<td>—48 mesh +65 mesh</td>
<td>14.3</td>
</tr>
<tr>
<td>—65 mesh +100 mesh</td>
<td>8.7</td>
</tr>
<tr>
<td>—100 mesh +150 mesh</td>
<td>2.7</td>
</tr>
<tr>
<td>—150 mesh +200 mesh</td>
<td>6.0</td>
</tr>
<tr>
<td>—200 mesh</td>
<td></td>
</tr>
</tbody>
</table>

Studies with different coal particle sizes indicate that a +20 mesh coal does not lend itself readily to activation and that losses are greater when small particle sizes such as those of a —40 mesh coal are used. The utility of the present process is not confined to the particle size range of 20 to 40, but that range is preferred as affording the optimum combination of yield and activation.

Fundamentally the procedure involved in the preparation of a decolorizing carbon from anthracite coal includes, first steam activating a batch of coal to increase the porosity and to raise the iodine value to approximately 80 percent. A measured quantity of the coal is then slurried with a water solution of a chemical (sodium hydroxide or a salt of sodium such as sodium carbonate or sodium sulfate), the solution including enough water to ensure intimate and uniform mixing. The mixture is taken to dryness, and the solid mixture of coal and chemical is roasted at a temperature high enough to cause the chemical to fuse, and for a period of time long enough to cause the coal to be properly conditioned for subsequent activation, consistent with a good yield of the final product. The chemical must then be washed from the coal with water, desirably followed by an acid treatment, so that the major part of the chemical is removed. The roasted material is finally activated by heating it, preferably at a lower temperature than the roasting temperature in an atmosphere of superheated steam until it reaches the desired molasses value, or until a predetermined yield has been obtained.

The final activation procedure is conducted at a temperature of about 750° C. and definitely no more than 800° C. for about ninety minutes, the quantity of steam utilized being, by water equivalent, about five to seven mls. per minute per 120 to 150 g. coal of the quantity of steam activated coal chosen for treatment.

The preparation of the carbon which precedes the final step of activation controls the final characteristics of the product.
A more detailed outline of the preferred procedure, together with reasons therefor, is set forth below:

A quantity of coal, desirably limited to the particle size range of -20 mesh to +40 mesh, is first subjected to a preliminary steam activation at about 800° C. to 900° C. for about three hours, to increase the porosity and the iodine value, and a measured quantity of coal so treated is chosen for further treatment. For illustrative purposes, it will be assumed that the quantity thus measured is 160 gm. The chemical used in treating the coal is dissolved in about 150-250 ml. of water, the quantity being equivalent roughly to 1 ml. of water per gram of coal. The amount of water must be sufficient, at least, to effect the complete solution of the chemical chosen. Sodium compounds are utilized, such as sodium hydroxide, sodium sulfate, or sodium carbonate, because an important purpose of the chemical treatment is to eliminate silica, and the silicate of sodium is water-soluble. The corresponding potassium compounds are regarded as the equivalents of the sodium compounds referred to.

Besides helping to remove the silica, the comparatively small quantity of chemical which remains with the coal acts as a catalyst to enable a final activation treatment to be accomplished at a surprisingly low temperature. The coal is strolled in the chemical solution.

The slurry can be immediately taken to dryness with good results, but it has been found more advantageous, and is the preferred procedure, to allow the coal to soak overnight so as to secure a thorough and adequate penetration of the chemical, and then to take the mixture to dryness.

The dried material is next roasted. This may be a closed roast of one and one-half hours' duration. The closed roast was formerly preferred because it was expected that it would produce a higher yield. Open roasting for 20-30 minutes, at 850° C. to 910° C. is now preferred, however, because extensive experiments have shown that this procedure yields as good, if not superior, activation results, with the added advantages of cutting the roasting time in half, and of using equipment which is more suitable to industrial operations. From the standpoint of yield, the shortened time of roasting compensates largely for the fact that the open roast tends to cause the material to be oxidized more rapidly.

The open roasting is accomplished by placing the dried material in a five-inch activation dish and heating it in an electric muffle furnace, while stirring the material at three-minute intervals. After roasting, the sample is cooled to a temperature not higher than 160° F., in the absence of air. The removal of the chemical while holding the consumption of water within practical limits has presented a problem of considerable difficulty, the solution of which constitutes an important feature of the invention.

In the early stage of the experimental work which has led to the development of the invention, the make of active carbon of defined characteristics from coal was the prime objective without regard to the economics of the process, the roasted and cooled material was washed to the phenolphthalein end point, i.e. to a pH of 8.3-10, with a continuous stream of water. Frequently this washing was carried on overnight, and great quantities of water were consumed. In an effort to put the process on a more practical basis, samples were also washed on a filter cloth in a Büchner funnel, and the amount of water necessary to wash to the phenolphthalein end point was measured. It was found to vary between fifteen and thirty liters of water for a sample which would yield about thirty grams of active carbon. Converted to an industrial scale, the consumption of that amount of water would be prohibitive; but the use of a small quantity of water for washing left the material in such a condition that it could not be activated.

It was discovered, however, through numerous analyses of the washing, that the major part of the chemical used on a 160 gm. starting batch of coal was removed in the first 750 ml. of water. It was believed that the chemicals remaining after the bulk of it had been removed was trapped in the small surfaced particles. It was reasoned that, since the removal of the chemical was dependent upon a diffusion process, and could therefore be accomplished only very slowly, the continuous stream of water in excess of 750 ml. was actually wasted. In order to cut the diffusion process, several devices were resorted to. The material, after it had been initially washed with 750 ml. of water, was given a second open roast of shorter duration (5-15 minutes). This roast was followed by a second 750 ml. wash. Although the ratio of chemical recovery to water consumption was improved, the activation process which followed was only sporadically successful. These unsuccessful devices were, therefore, abandoned, and in their place a new procedure was devised which has proved to be practical and advantageous.

The material is first washed on a filter cloth with 750 ml. of water. The washed material is then mixed with a comparatively small quantity (250 ml.) of water and is allowed to soak overnight, or for a period of about eighteen hours, while being subjected to agitation. This solves the problem of removing most of the soluble debris with a comparatively small quantity of water, but it does not solve the entire problem. It has been noticed that during the soaking period a flock forms (mainly silica), which, upon subsequent filtration, settles on top of the carbon and does not pass through the filter cloth. As a consequence of filtration, this foreign material has been caused to be retained in the carbon sample.

In order to eliminate this flocculent material from the soaked coal, the slurry or mixture, after agitation for sixteen hours, is allowed to stand a short period of time, sufficient to allow the coal to settle to the bottom of the container, but not long enough for the flocculent material to settle. The spent wash water, which contains the flocculent material, is then decanted.

The remaining material is then additionally washed on a filter cloth with 500 ml. of water at 160° F. The material is then slurried in 250 ml. of water, to which 5 ml. of concentrated sulfuric acid (66 Bé) has been added, and is allowed to soak overnight (for about eighteen hours) while being subjected to agitation. The solid material then permitted to settle out of the liquid and the liquid is decanted. The material is next washed on a filter cloth with 750 ml. of water at 160° F. and is then dried in an oven at 140° C.

The material is finally steam-activated for approximately 90 minutes, at 750° C.-800° C., in a tube which measures 26 inches in length and 2 inches in diameter.

One end of the tube is capped and tapped to receive a one-quarter inch diameter piece of pipe used as an inlet for steam. Inside the cap is a piece of fine mesh screen and a clay block containing holes, the arrangement being such that the steam may escape but that loss of the carbon particles is avoided. During the activation, sufficient steam is introduced to obtain a turbulent agitation of the coal in the tube.

The effect of using varying amounts of sodium hydroxide and sodium carbonate, and mixtures thereof, has been extensively studied, the amount of the chemicals employed being varied from ten percent to fifty percent by weight of the quantity of coal treated. Optimum activation results were obtained substantially with twenty percent sodium hydroxide or forty percent sodium carbonate. In general, consistently good activation results have been obtained with the use of sodium hydroxide and sodium carbonate. When using the optimum percentages of chemicals indicated above, greater resulting yields are obtained with the use of sodium carbonate (about 80
percent), but the yields obtained with sodium hydroxide are almost as good.

In testing the end products for activation results, the carbon is ground and the pH adjusted, dry, to approximately neutral for the following tests:

<table>
<thead>
<tr>
<th>Molasses value</th>
<th>Iodine value</th>
<th>Corn sugar</th>
<th>Methylene blue</th>
<th>Aniline blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alizarin red</td>
<td>Malachite green</td>
<td>Ponceau R</td>
<td>Chrysoidine R</td>
<td>Rhodamine B</td>
</tr>
</tbody>
</table>

In these tests, comparisons have been made with the corresponding properties of the activated carbon which is sold commercially as Nuchar. The carbon obtained with the use of sodium hydroxide or sodium carbonate is found to be fully equal to Nuchar. Without the preliminary steam activation step, and with the use of sodium hydroxide or sodium carbonate, in the chemical treatment of the coal prior to roasting, activation (with correspondingly lower yields) must be carried to the point giving relatively higher molasses values (twice as much) for the end product required to approximate the corn sugar and various dye relative efficiencies of Nuchar.

When (without prior chemical preparation) the preliminary tube activation of the coal with steam to an iodine value of approximately 80 percent is performed, followed by the use of either sodium hydroxide or sodium carbonate in the process described, the product has been found to have corn sugar and various dye relative efficiencies that approximate those of Nuchar of equal molasses value. When using a total of 1500 ml of wash water, 9.4 parts of wash water to one part coal, chemical recoveries have been approximately 70 percent for sodium hydroxide and 80 percent for sodium carbonate.

The final activation of the coal can be conducted in a carbon dioxide atmosphere instead of a steam atmosphere, if desired, since either treatment produces a controlled erosion of surfaces of the carbon particles, but with carbon dioxide the efficiency of the process is greatly decreased. This step cannot be satisfactorily conducted in air, because the erosion of the sample cannot be satisfactorily controlled. A steam activation temperature in the range of 750° to 800° C. has been found to produce better activation results than temperatures above or below this range. At activation temperatures above 800° C. the carbon tends to burn up too rapidly, while at temperatures below 750° C. the activation progresses at a slow rate, and the prolonged heat treatment tends to produce relatively good activation. The fact that the upper limit of the optimum range is 800° C. is a surprising and advantageous point, since a somewhat higher temperature was expected to be necessary. The explanation is believed to reside in the fact that a small quantity of the alkali chemical is left in the carbon and that this catalyzes the reaction, enabling it to proceed at a lower temperature.

The preferred process involved in the preparation of a decolorizing carbon is illustrated by the following examples.

**Example I**

1. A 200 gm. batch of raw coal was preliminarily steam-activated in a 2-inch tube to increase the porosity of the coal, and to increase the iodine value to substantially 80 percent;
2. A chemical consisting of 32 gm. of sodium hydroxide (20 percent by weight of the steam-activated coal to be treated) was dissolved in 200 ml. of water, and the solution was added to 160 gm. of the steam-activated coal.
3. The coal was caused to soak overnight in the chemical solution;
4. The mixture was taken to dryness;
5. The dried material was open-roasted for 30–35 minutes at 850° C. to 900° C.;
6. The roasted material was cooled in the absence of air;
7. The material was washed on a filter with 750 ml. of water, at 160° F.;
8. The material was allowed to soak overnight in 250 ml. of water while being subjected to agitation;
9. The mixture was allowed to stand a short time, sufficient to settle the coal but not long enough for the flocculent material to settle. The liquid, with the flocculent material contained in it, was then decanted.
10. The material was again washed on a filter, this time with 500 ml. of water at 160° F.;
11. The material was soaked overnight, while subjected to agitation, in a dilute solution of sulfuric acid consisting of 250 ml. of water and 15 ml. of concentrated sulfuric acid, after which it was allowed to settle, and the liquid was decanted;
12. The material was washed on a filter with 750 ml. of water at 160° F.;
13. The material was dried;
14. The material was activated in a 2-inch tube with steam at 750° C. to 800° C.

**Example II**

The procedure was the same as for Example I, save that at step (2) 64 gm. of sodium carbonate (40% by weight of the steam-activated coal to be treated or 3.8 moles per kilogram of coal) was employed in place of the sodium hydroxide specified in Example I.

**Example III**

The procedure was the same as for Example I, save that at step (2) 80 gm. of sodium sulfate (50% by weight of the steam-activated coal to be treated or 3.5 moles per kilogram of coal) was employed in place of the sodium hydroxide specified in Example I.

While certain preferred embodiments of the invention have been illustrated and described in detail, it is to be understood that changes may be made therein and the invention practiced in other forms. It is not, therefore, the intention to limit the patent to the specific details illustratively described, but to cover the invention broadly in whatever form its principles may be utilized.

We claim:

1. The method of producing multiple purpose active carbon from anthracite coal which comprises, in the order stated, initially steam activating a batch of raw anthracite coal in pulverulent form at 800° to 900° C. for a sufficient time to increase the porosity and to increase the iodine value of the coal to about 80%, soaking the coal until adequate penetration is had, in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate, in a ratio of about 3.5 to 5 moles of chemical per kilogram of coal, evaporating the solution with the contained coal to dryness, roasting the coal at a sufficient temperature and for a sufficient time to convert a substantial portion of any silica contained in the coal into soluble sodium silicate and the remainder to an insoluble form which admits of ready physical separation, removing from the roasted coal the major portion of the chemical, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

2. The method of producing multiple purpose active carbon from anthracite coal which comprises, in the order stated, initially steam activating a batch of raw anthracite coal in pulverulent form at 800° to 900° C. for a period of about three hours to increase the porosity, soaking the coal in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate, in a ratio of about 3.5 to 5 moles of activating carbon, by John Hassler, Chemical Publishing Co., Inc., 1961.
2,894,914

chemical per kilogram of coal, until adequate penetration is had, evaporating the solution with the contained coal to dryness, open roasting the soaked and dried coal for a period of about twenty to thirty-five minutes at a temperature of 850° C. to 910° C., removing from the roasted coal all but a trace of the chemical, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

3. The method of producing multiple purpose active carbon from anthracite coal, which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of the raw anthracite coal particles in the size range limited to 

-20 mesh and +40 mesh to increase the porosity of the coal, soaking the coal in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate in a ratio of about 3.5 to 5 moles of chemical per kilogram of coal, evaporating the solution with the contained coal to dryness, open roasting the soaked and dried coal for a period of the order of twenty minutes at a temperature of 850° C. to 910° C., removing from the roasted coal the major portion of the chemical, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

4. The method of producing multiple purpose active carbon from anthracite coal which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of the raw anthracite coal particles in the size range limited to 

-20 mesh and +40 mesh to increase the porosity of the coal, soaking the coal in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate in a ratio of about 3.5 to 5 moles of chemical per kilogram of coal, evaporating the solution with the contained coal to dryness, open roasting the soaked and dried coal for a period of the order of twenty minutes at a temperature of 850° C. to 910° C., removing from the roasted coal the major portion of the chemical, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

5. The method of producing multiple purpose active carbon from anthracite coal as set forth in claim 4 in which the quantity of the solvent water is at least equal to that of the coal but is not otherwise substantially in excess of the amount required to dissolve the chemical.

6. The method of producing multiple purpose active carbon from anthracite coal as set forth in claim 4 in which the coal is cooled in the absence of air, and in which the major part of the chemical is removed from the roasted and cooled coal by first washing the coal with a limited amount of water on a filter, then soaking it overnight with agitation in a small quantity of water, allowing the mixture to stand for a short time, sufficient to settle the coal, decanting the liquid, again washing the coal on a filter with a limited quantity of water, allowing the coal overnight with agitation in a small quantity of dilute sulfuric acid, settling the mixture and decanting the liquid, and again washing the coal on a filter with a limited amount of water.

7. The method of producing multiple purpose active carbon from anthracite coal as set forth in claim 6 in which the several wash waters and the dilute acid solution are maintained at temperatures of about 160° F.

8. The method of producing multiple purpose activated carbon from anthracite coal which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of raw anthracite coal particles in the size range limited to 

-20 mesh and +40 mesh to increase the porosity there of, soaking the coal overnight in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate in a ratio of about 3.5 to 5 moles of chemical per kilogram of coal, evaporating the solution and the contained coal to dryness, open roasting the treated coal for a period of about twenty minutes at a temperature of 850° C. to 910° C., removing from the roasted coal the major portion of the chemical by a procedure which includes a first washing of the roasted coal with a limited amount of water sufficient to remove most of the chemical, soaking the washed coal in water overnight while subjecting the coal and water to agitation, allowing the mixture of coal and water to stand for a time just sufficient to settle the coal, and decanting the liquid, then drying the roasted treated coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

9. The method of producing multiple purpose activated carbon from anthracite coal which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of raw anthracite coal particles in the size range limited to 

-20 mesh and +40 mesh to increase the porosity thereof, soaking the coal thoroughly in a water solution of sodium hydroxide in which the weight of sodium hydroxide is substantially twenty percent that of the coal, evaporating the solution and the contained coal to dryness, open roasting the treated coal for a period of about twenty minutes at a temperature of 850° C. to 910° C., removing from the roasted coal the major portion of the chemical, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

10. The method of producing multiple purpose activated carbon from anthracite coal which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of raw anthracite coal particles in the size range limited to 

-20 mesh and +40 mesh to increase the porosity thereof, soaking the coal in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate in a ratio of about 3.5 to 5 moles of chemical per kilogram of coal, evaporating the solution with the contained coal to dryness, open roasting the soaked and dried coal for a period of the order of twenty minutes at a temperature of 850° C. to 910° C., removing from the roasted coal the major portion of the chemical, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

11. The method of producing multiple purpose activated carbon from anthracite coal which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of raw anthracite coal particles in the size range limited to 

-20 mesh and +40 mesh to increase the porosity thereof, soaking the coal overnight in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate in a ratio of about 3.5 to 5 moles of chemical per kilogram of coal, evaporating the solution with the contained coal to dryness, open roasting the soaked and dried coal for a period of the order of thirty minutes at a temperature of 850° C. to 910° C., washing the roasted and dried coal on a filter with a limited quantity of water sufficient to remove the major part of the chemical, soaking the coal overnight with agitation in a small quantity of water, allowing the
mixture to stand for a period just sufficient to settle the coal, and decanting the liquid.

13. The method as set forth in claim 12 in which the chemical contained in the solution consists of sodium hydroxide weighing substantially twenty percent as much as the coal undergoing treatment.

14. The method as set forth in claim 12 in which the chemical contained in the solution consists of sodium carbonate weighing substantially forty percent as much as the coal undergoing treatment.

15. The method as set forth in claim 12 in which the chemical contained in the solution consists of sodium sulfate weighing substantially fifty percent as much as the coal undergoing treatment.

16. The method of producing multiple purpose active carbon from anthracite coal which comprises, in the order stated, initially steam activating, at 800° to 900° C. for a period of about three hours, a batch of raw anthracite coal in pulverulent form to increase the porosity and the iodine value of the coal, soaking the coal until adequate penetration is had, in a solution of chemical chosen from the group consisting of sodium hydroxide, sodium carbonate and sodium sulfate, evaporating the solution with the contained coal to dryness, roasting the coal at a sufficient temperature and for a sufficient time to convert a substantial portion of any silica contained in the coal into soluble sodium silicate and the remainder through hydrolysis to an insoluble, flocculent form of silica, dissolving the silicate by soaking in water for a protracted period while agitating the mixture, then allowing the mixture to stand long enough to settle the coal but not long enough to settle the flocculent silicate, decanting the liquid in which the silicate is dissolved and the silica is suspended to remove these products, further treating the coal with acid to assure that the major part of the chemical is removed, drying the coal, and steam activating the dried coal in the temperature range of 750° C. to 800° C. for a period of about ninety minutes.

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