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SOLID FUEL COVERED WITH A COMBUSTIBLE FIBROUS COMPOSITION

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ABSTRACT OF THE DISCLOSURE

A solid fuel composition which has at least a portion of its surface covered with a combustible fibrous composition. Upon ignition, the fibrous composition begins to emit heat and continues to do so until the solid fuel has been ignited and emits heat.

CROSS-REFERENCES TO RELATED APPLICATIONS

(1) Application Ser. No. 471,720, filed July 13, 1965 (parent application now abandoned).

(2) Application Ser. No. 401,665, filed Oct. 5, 1964 now abandoned.

This application is a continuation of my application Ser. No. 607,907, filed Jan. 9, 1967, now abandoned.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention is a continuation-in-part of my application Ser. No. 471,720, filed July 13, 1965, and relates to fuel compositions and, more particularly, to artificial carbonaceous fuel compositions having improved burning properties and to the method for their preparation. Still more particularly, the invention relates to artificial carbonaceous fuel compositions, in the form of briquettes having improved burning properties, and having particular utility when employed for purposes of orchard heating.

(2) Description of the prior art

Heretofore, a serious problem has been encountered in combating low-temperature and frost conditions, seasonally encountered in orchards and other outdoor vegetation and in crop areas, which cause destruction or heavy damage to fruit, branches, limbs and, in many instances, to vines and trees, themselves. To offset these injurious effects of periodic low-temperature climatic conditions, it is essential that there be provided a source of heat and means for carrying such heat to the vines, trees and other vegetation. For this purpose, heat has heretofore been supplied by various means, ranging from conventional gas and fuel-oil burning frost-pot and return-stack heaters to smudging and the burning of scrap rubber, and in which heat is carried to the vegetation by convection currents, or, in more sophisticated installations, by wind-machines designed to induce such currents. In this respect, however, the use of such devices has resulted in the accompanying dissipation of large quantities of smoke, causing the deposition of soot or smudges upon the fruit or vegetation. Furthermore, the presence of an open flame in close

proximity to the fruit, vines, trees or other vegetation may also result in their damage or even in their destruction. Also, prior to the present invention, the burning of artificial solid carbonaceous fuels in the form of small lumps or briquettes in specially designed heaters has been resorted to; however, in these instances, a smokeless type of fuel briquette is not available. Furthermore, apart from the undesirable deposition of soot resulting from the burning of the briquette, the presence of an open flame is still another factor which heretofore has rendered the use of carbonaceous briquettes, as a source of heat, unattractive for the aforementioned intended purpose.

The ability to employ a substantially smokeless fuel composition, for example, in the form of a briquette, which is capable of burning without the presence of any substantial flame, would, therefore, be highly desirable. The use of equipment such as the aforementioned frost-pots, return-stack heaters, wind-machines, etc. would be completely eliminated, with its attendant saving in cost. In addition, the ability of the fuel composition to burn without the presence of a flame would permit placing it in close proximity to the trees, vines or other forms of vegetation, and would thus avoid expensive waste of heat values, which is presently encountered when the heat source must be placed at a considerable distance from the desired point of application.

Prior to the present invention, charcoal briquettes or lumps for heating purposes have generally been fabricated from mixtures containing small amounts of charcoal and minor amounts of filler materials such as sawdust, wood shavings or excelsior, and various forms of binding agents. Such mixtures are usually compressed under relatively high pressure into the briquette or lump form, and are subsequently coated by immersion or spraying with a water-proofing agent, such as varnish, paraffin, or a resinous or plastic material. Various formulary modifications have also been suggested, including improvements relating to the filler, binder and water-proofing components. In all such formulations, it is found, however, that certain highly undesirable disadvantages are inevitably present. Of particular significance is the fact that the conventional briquette or lump-form composition cannot be burned without the release of smoke or the presence of an open flame, as hereinbefore described. Apart from these disadvantages, the ability of the briquette to release its heat at a controlled rate is highly desirable from both a practical and economic standpoint. In this respect, the conventional form of briquette is also deficient.

In application Ser. No. 401,665, filed Oct. 5, 1964, there were disclosed new and improved solid fuel compositions, preferably, for example, in the form of briquettes, which are manufactured, in general, by first forming a mixture comprising petroleum coke, wood-sawdust and charcoal components; forming another mixture comprising an aqueous solution of an oxidizing agent and a binder; combining these mixtures to form a slurry; and then subjecting this slurry to an extrusion operation to obtain a briquette of the desired configuration. Subsequently, the briquette thus produced is then passed into a heater or other device in which water is removed at elevated temperatures.

The aforementioned improved solid fuel compositions thus comprise, in general, a major proportion of a pri-

mary combustible solid having an ignition temperature in excess of about 2000° F., a minor proportion of a solid oxidizing agent capable of supporting combustion and a minor proportion of a secondary combustible solid having an ignition temperature below that of the primary combustible solid. These components are combined in such manner and amounts whereby, upon ignition, the oxidizing agent undergoes decomposition to liberate an oxidizing medium which, upon contact with the secondary combustible solid, produces an exothermic reaction providing, in turn, sufficient heat to effect combustion of the primary combustible solid. Thus, for example, these fuel compositions may comprise petroleum coke as the primary combustible solid, charcoal and/or wood-sawdust as the secondary combustible solid, and an oxidizing agent which may be selected from the group consisting of such materials as nitrates, perchlorates, peroxides and permanganates. Ignition of the solid fuel composition, for example, in the form of briquettes, results in combustion taking place, characterized by a relatively slow rate of burning and the ability to radiate heat without the presence of substantial smoke or flame. In employing such fuel compositions, adequate crop protection is provided, with sufficient heat being produced to extend for periods, for example, from about four to about five hours.

In this respect, it has been found, however, that periods of the order of about one-half hour of burning of the fuel composition must occur before any appreciable temperature rise in the area of vegetation, for example, in citrus or deciduous tree groves, can be detected. This characteristic of the aforementioned solid fuel composition makes it necessary for the grower to make a determination appreciably in advance of a deleterious temperature drop, to ignite the fuel for ultimate protection. During that time, weather conditions can improve to the extent that no additional protection, as a result of fuel combustion, is required. Furthermore, once the solid fuel composition has been ignited, it is found that there is no known way of extinguishing it for reuse at a subsequent time. It will therefore be apparent that modification of the aforementioned fuel composition to the extent that the release of instantaneous heat, rather than an ultimate build-up thereof, is highly desirable.

SUMMARY OF THE INVENTION

In accordance with the present invention, these and other improvements are attained by providing a substantially smokeless and flameless solid fuel which has at least a portion of its surface in contact with a combustible fibrous composition, which upon ignition begins to emit heat and continues to do so until the solid fuel, itself, has been ignited and emits heat. In this respect, it is found that the combustible fibrous composition or cap, when placed on one of the surfaces of the solid fuel (which may be employed in the form of a briquette) and ignited, results in the cap burning with a low flame, emitting instant convective heat. This fibrous cap is designed for the specific purpose of burning for a sufficient period of time to quickly ignite the bulk of the solid fuel, itself, and thereby permitting the latter to assume its primary heating role after the cap has been consumed. Thus, the ability to attain the full heat potential of the solid fuel composition within a relatively short period of time after ignition, avoids the necessity of making a possible erroneous anticipatory determination that additional heat will be required for protection of vegetation against frost or freezing conditions; and also avoids the problem of fuel waste in the event that weather conditions ameliorate during the intervening warm-up period of initial ignition and subsequent sustained combustion of the solid fuel composition, itself.

Of particular importance in the fuel compositions of the present invention is the primary combustible solid.

The material employed for this purpose is one which is capable of burning without the presence of substantial smoke or flame, and has an ignition temperature in excess of about 2000° F. These materials have a low volatility content of not more than about 12 percent. Various materials may be employed as the primary combustible solid in these fuel compositions. One such outstanding material is petroleum coke. This refractory carbonaceous material has not, heretofore, been considered as having any significant fuel value, from a practical commercial standpoint, because of its characteristic lack of being easily ignitable and its inability to readily support combustion. Thus, petroleum coke, which is generally commercially obtained in the form of either a delayed or fluid coke, possesses a low volatility content, usually not more than about 12 percent, and is ignitable only at temperatures as high as from about 2500° F. to about 2700° F. Delayed coke varying in physical properties from finely divided particles to relatively coarser and larger particles is more volatile and less carbonaceous than fluid coke and is ignitable at a somewhat lower temperature within the aforementioned range than fluid coke. In this respect, it is found that if the petroleum coke or other selected primary combustible solid (having the aforementioned characteristics) can be successfully ignited to a temperature where it can support combustion, it can burn in a state of glow, without emission of substantial smoke or the presence of an open flame, and at a controlled rate, thus making possible the realization of the previously discussed advantages. The primary combustible solid, as previously indicated, may, therefore, comprise any material which has an ignition temperature in excess of about 2000° F., and a volatile content of not more than about 12 percent, and may, therefore, include not only petroleum coke, either delayed or fluid coke, but also other materials such as coal, preferably of the anthracite type, and various forms of other materials which satisfy the above requirements as to minimum ignition temperature and volatility content.

In order to attain the aforementioned relatively high temperatures required for initially igniting the primary combustible solid and for subsequent self-burning sustained combustion thereof, the solid fuel compositions of the present invention, as previously indicated, are also comprised of a minor proportion of a secondary combustible solid having an ignition temperature below that of the primary combustible solid. In this respect, it is noted that ignition of the secondary combustible solid results in the combustion thereof at a sufficiently high temperature which is effective for the subsequent ignition and support of combustion of the primary combustible solid. This secondary combustible solid may, therefore, comprise such materials as charcoal, wood-sawdust, cotton hulls, or other naturally occurring fibrous materials, cellulosic derived materials, and similarly related combustible solids. In a preferred modification, the fuel compositions of the present invention may contain as the secondary combustible solid a mixture of charcoal and sawdust. In this embodiment, the presence of the wood-sawdust component makes possible a combustion mechanism in which the wood-sawdust, being the most easily combustible component present, is most readily ignitable, gives off sufficient heat upon being combusted to ignite the charcoal component, and the latter, upon being ignited and combusted, in turn gives off heat at a relatively increased temperature which is sufficient for the purpose of igniting and initiating sustained combustion of the petroleum coke or other selected primary combustible solid.

In order to easily initiate the combustion of the secondary combustible solid in the novel fuel compositions of the present invention, the aforementioned solid oxidizing agent, capable of supporting combustion, is incorporated in minor proportion in the solid fuel composition. The concentration of this oxidizing agent in the solid fuel

composition, above the minimum level required to support combustion of the primary combustible solid, can be varied to any desoired burning rate. In general, the function of the oxidizing agent in the novel fuel composition is such that upon ignition, the oxidizing agent undergoes decomposition to liberate an oxidizing medium which upon contact with the secondary combustible solid, as previously indicated, produces an exothermic reaction providing, in turn, sufficient heat to effect combustion of the primary combustible solid. Various types of oxidizing agents may be employed for this purpose, and particularly preferred are the nitrates, chlorates, perchlorates, peroxides, permanganates, chromates and dichromates. It will be apparent, of course, that in a given instance, each oxidizing agent can be employed in different amounts in order to obtain a desired burning rate for the fuel composition. In essence, therefore, this ability of being able to effect ultimate combustion of the primary combustible solid in a sustained manner and at a controllable burning rate makes possible the production of a solid fuel composition which can burn without the presence of substantial smoke or open flame and with all the obvious attendant advantages previously described.

It will be understood, of course, that various other materials may also be present in the novel fuel compositions of the present invention, if so desired, in addition to the basic primary and secondary combustible solids, oxidizing agent and combustible fibrous composition. Thus, the solid fuel compositions may also include various materials acting as consolidating agents or binders, such as resinous materials, plastics, paraffins, shellac and combustion-supporting adhesives. Particularly preferred are binders comprising a soluble starch. Furthermore, from a practical standpoint, in instances where the fuel composition is to be employed for outdoor heating purposes, the presence of minor amounts of a water-proofing agent may be desirable. For this purpose, various compatible combustible water-proofing agents may also be incorporated into the fuel composition. These may include such agents as water-soluble, but dispersible resins and polymers, such as polyethylene, and relatively non-volatile, viscous, combustible natural or synthetic oils. Particularly preferred are water-proofing agents comprising wax emulsions.

DESCRIPTION OF SPECIFIC EMBODIMENTS

On one embodiment of the novel fuel compositions of the present invention, these fuels may be comprised, by weight, of the primary combustible solid which is present in an amount from about 50 to about 90 percent; the secondary combustible solid which is present in an amount from about 3 to about 40 percent; and the oxidizing agent which is present in an amount from about 2 to about 15 percent. In a preferred form, the primary combustible solid is present, by weight, in an amount from about 65 to about 80 percent; the secondary combustible solid is present in an amount from about 5 to about 20 percent; and the oxidizing agent is present in an amount from about 5 to about 10 percent.

As a specific representative example, the novel fuel compositions of the present invention may comprise, by weight, from about 50 to about 90 percent, and preferably from about 65 to about 80 percent petroleum coke; from about 3 to about 20 percent, and preferably from about 5 to about 15 percent wood-sawdust; from about 4 to about 20 percent, and preferably from about 7 to about 20 percent charcoal; from about 2 to about 15 percent, and preferably from about 5 to about 10 percent oxidizing agent. In addition, such preferred fuel compositions may also contain from about 1 to about 10 percent, and preferably from about 3 to about 5 percent, by weight, of a binder. In instances where a water-proofing agent is to be employed, the latter may be present in an amount from about 0.5 to about 8 percent, and preferably from about 1 to about 2 percent, by weight. In order to facilitate extrusion of the solid fuel composition, itself, there may also be incorporated therein from about 1 to about 15, and preferably from about 2 to about 6 percent, by weight, of a non-hydratable clay for the purpose of preventing plugging at the extruder die-face.

The combustible fibrous composition, as previously described, is placed in contact with at least a portion of the surface of the solid fuel. This fibrous composition may comprise any fibrous material such as, for example, fiberboard, hardboard, paperboard, paperpulp, fibrous cellulosic materials, fibrous plastic materials and structurally related materials, which are covered or impregnated with an ignitable material whose heat of combustion is sufficient to ignite the above-described solid fuel composition, itself. These ignitable materials may therefore include paraffin waxes, polyterpenes, oils and other ignitable materials which will ignite before the solid fuel composition, itself, ignites. In a preferred modification, the fibrous combustible composition may be employed in the form of a cap comprising a piece of wax-impregnated fiberboard or paperboard positioned on the upper surface of a briquette comprised of the aforementioned solid fuel composition. When ignited, this cap will burn with a low, noticeable flame and emits instant convective heat. The burning time and the quantity of heat released are dependent upon the dimensions of this fiber cap and its density as well as the wax content. The fiber cap is designed specifically to burn sufficiently long, as previously indicated, to ignite the bulk of the solid fuel briquette, permitting it to assume its heating role after the cap has been consumed. Thus, this fibrous composition makes possible for the grower to have a relatively high degree of latitude for initiating frost or freeze protection in the shortest time. It should be noted that the aforementioned fibrous composition may simply be placed in contact with a portion of the surface of the solid fuel, itself, and then covered with an outer combustible material or wrapper, such as plastics, paper, and the like. It is also within the scope of the invention to merely cement or attach the fibrous composition to a surface of the solid fuel composition, if so desired, without the necessity for using any external wrapping material.

The following examples and corresponding data will serve to illustrate the novel fuel compositions of the present invention and the benefits derived by employing, in combination therewith, the aforementioned combustible fibrous composition as an essential component thereof.

A specimen of Celotex fiberboard measuring 7½" x 4¼" x $2^{9}/_{64}$", impregnated with 90 grams of paraffin wax and covering the top of two 2-lb. fuel briquettes (having the composition shown in Table I) was packaged and compared with two similar briquettes, but which were not covered with the aforementioned fibrous composition. In the latter case, in place of the fibrous composition, an ignition layer comprising a mixture of sawdust, charcoal and oxidizer was employed, corresponding to the ignition layer disclosed in the aforementioned application Ser. No. 471,-720.

It was found that ignition of both packages with a mixture of gasoline was rapid. After the packages were consumed, it was noted that the fiber cap burned with a low flame for about one-half hour, whereas the package containing briquettes having the aforementioned ignition layer merely glowed and spread very slowly. Temperature measurements made with a thermocouple indicated that after 5, 15, 30 and 60 minutes of combustion of the improved package, containing the aforementioned fibrous composition, there was realized a $+\Delta T°$ F. of 20, 40, 50 and 50 degrees over that of a similar package which was not covered with the aforementioned fiber cap, and which was burned under identical conditions. The following Table I illustrates the beneficial effect of the aforementioned fiber cap with respect to the burning rate of the solid fuel package.

TABLE I.—BURNING RATE[1], EFFECT OF WAXED FIBER CAP

	No cap	Fiber cap
Burning rate, percent:		
Example 1, 1 hr	31	42
Example 2, 2 hr	48	58
Example 3, 3 hr	61	70
Example 4, 4 hr	71	79
Example 5, 5 hr	78	
Avg.+ΔT° F.[2]	0.25–0.5	5

[1] 4 lb. package—composition (wt.)—68% petroleum coke, 12% $NaNO_3$, 9% wood-sawdust, 5% charcoal, 4% starch and 2% clay (75% silica, 25% alumina).

[2] Average +ΔT° F. in a peach tree (2 pkgs./tree), 5 ft. above ground, 15 minutes after ignition.

It was also found that where fiberboard is employed as the fibrous material, both density and size affected the wax loading capabilities of the fiber cap and, ultimately, its burning time and effective heat release. The following Table II summarizes the data obtained with respect to such investigations. It was noted that as the board density increases, the quantity of wax required to reach the saturation point diminishes. Thus, as the board density increases from a nominal 16 pounds per cubic foot to about 60 pounds per cubic foot, the free air space between the fibers diminishes rapidly, thus limiting the quantity of wax to be absorbed in the free space. In this regard, the fibrous material acts much like a wicking agent in assisting the wax to burn effectively with little or no smoke, in the manner of a conventional household candle. Thus, as the amount of wax contained in the cap is decreased, the burning time is diminished and less heat output is realized.

TABLE II

Interrelationship of Fiber Cap Density, Wax Loading and Burning Time

Example	Board type	Cap dimension in.	Density lb./ft.[3]	Wax impregnated, g.	Burning time, min.
1	Fiberboard	7½ x 4¼ x 29/64	16	40	14
2	do	7½ x 4¼ x 29/64	16	80	23
3	do	7½ x 4¼ x 29/64	16	90	25
4	do	7½ x 4¼ x 29/64	16	113	30
5	do	7½ x 4¼ x 20/64	22	80	17
6	do	7½ x 4¼ x 14/64	32	44	13
7	do	7½ x 4¼ x 9/64	50	21	10
8	Hardboard	7 x 4 x ⅛	60	10	18
9	Paperboard	7 x 4 x 1/12	16	21	6.5
		7 x 4 x ¼	16	42	8
		7 x 4 x ⅜	16	59	10
10	Paperpulp	6 x 4 x ¼	16	30	20
		6 x 4 x ¼	16	50	24

With the foregoing data in mind, it has been found that a minimum of about 30 minutes of burning time is required after the ignition of the aforementioned solid fuel briquette to provide effective heat. Optimum results are therefore obtainable when the burning time of the fibrous cap coincides with the aforementioned 30 minute burning time after ignition of the briquette for providing effective heat, in order to provide a quick release heat until the ignited briquette can assume its independent heating role. Furthermore, it was found that depending upon the type of fibrous material employed in the fiber cap, from about 50 to about 100 grams of wax are required to achieve the aforementioned objects. If less heat is required after ignition, the relatively smaller fiber cap containing a reduced amount of wax will also satisfactorily perform.

Quite unexpectedly, as a corollary to the above-described improved method of obtaining quick heat release, it was found that the burning fiber cap provided the improvement in reducing smoke output which may be realized with certain types of solid fuel briquettes. In this regard, it was noted that as long as the fiber cap is burning, the smoking tendencies of the solid fuel briquette are considerably reduced. It is theorized that the smoke consists mainly of organic volatile materials from the pyrolysis of wood, charcoal and petroleum coke. In this respect, therefore, while the solid fuel briquette without the fiber cap may emit a white smoke for a period of about one hour after ignition, the same briquette having the fiber cap is found to emit little or no smoke while the cap is burning, thus indicating that the volatile materials are being consumed by the flame. After the fiber cap has been consumed, it is found that the white smoke evolution now may last only for about one-half hour or less until the solid fuel briquette, itself, has reached its maximum heat output.

While preferred embodiments of the novel substantially smokeless and flameles solid fuel compositions of the present invention have been described for purposes of illustration, it will be understood that various modifications and adaptations thereof, which will be obvious to those skilled in the art, may be made without departing from the spirit of the invention.

I claim:

1. A substantially smokeless and flameless solid fuel package of at least three discrete solid bodies, two of which are constituted by long burning fuel bodies arranged to provide an interface therebetween, said long burning bodies having at least a position of their surfaces in contact with a fast burning body of combustible fibrous composition which upon ignition, begins to emit heat and continues to do so until the long burning fuel has been ignited and emits heat, said long burning fuel comprising from about 50 to 90 percent by weight of petroleum coke characterized upon combustion by a relatively slow rate of burning and the ability to radiate heat without the presence of a substantial flame, having an ignition temperature in excess of about 2000° F. from about 2 to about 15 percent, by weight, of a solid oxidizing agent capable of supporting combustion and from about 3 to about 40 percent, by weight, of a secondary combustible solid having an ignition temperature below that of said petroleum coke, the aforementioned components being combined in such manner and amounts whereby, upon ignition, said oxidizing agent undergoes decomposition to liberate an oxidizing medium which, upon contact with the secondary combustible solid, produces an exothermic reaction providing in turn, sufficient heat to effect combustion of said petroleum coke.

2. A fuel as defined in claim **1** which further comprises a soluble starch.

3. A fuel as defined in claim **1** in the shape of briquettes.

4. A fuel as defined in claim **1** wherein said petroleum coke has a volatility content less than about 12 percent.

5. A fuel as defined in claim **1** wherein said combustible fibrous composition comprises a fibrous material impregnated with a paraffin wax.

6. A fuel as defined in claim **1** wherein said combustible fibrous composition comprises fiberboard impregnated with a parafin wax.

7. A fuel as defined in claim **1** wherein said secondary combustible solid is at least one material selected from the group consisting of charcoal and wood-sawdust.

8. A fuel as defined in claim **1** wherein said oxidizing agent is selected from the group consisting of nitrates, perchlorates, peroxides and permanganates.

9. A fuel as defined in claim **1** wherein petroleum coke is present in an amount from about 65 to about 80 percent, by weight; said secondary combustible solid is present in an amount from about 5 to about 20 percent, by weight; and said oxidizing agent is present in an amount from about 5 to about 10 percent, by weight.

10. A fuel composition as defined in claim **1** wherein said fuel comprises from about 1 to about 15 percent, by weight of a non-hydratable clay.

11. A fuel as defined in claim **1** wherein petroleum coke is present in an amount from about 65 to about 80 percent, by weight; said secondary combustible solid is present in an amount from about 3 to about 40 percent,

by weight; and said oxidizing agent is present in an amount from about 2 to about 15 percent, by weight.

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