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TOBACCO COMPOSITION

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This invention relates to cigarettes and to the control of the temperature of the combustion of a cool burning cigarette, and particularly to the lowering of the peak temperature of the combustion zone without adversely interfering with the combustion of the cigarette at temperatures significantly below such peak temperature.

A marketable cigarette must meet certain standards relating to combustion behavior. The smoker must find it easy to light the cigarette. The smoldering of marketable cigarettes must continue under the variety of circumstances which are encountered during the smoking of cigarettes by various people in various places.

At the time when the smoker inhales, whereby a draft of air is drawn through the combustion zone of the cigarette, the glowing of the combustion zone must not cause the cigarette to burst into flame. The habits of smokers vary widely, and a cigarette must perform satisfactorily whether there are short or long intervals between the drafts of air through the combustion zone. The peak temperature during the glowing is dependent in part upon the rate of air flow, in part on the duration of the puff, in part upon the frequency of inhalations and in part upon other factors.

The normal smoldering temperature is lower than the peak temperature during the glowing. The lowest temperature at which the smoldering can just barely maintain itself is designated as the ember temperature. The ignition temperature necessary for initiating combustion is ordinarily between the ember temperature and the normal smoldering temperature. For any particular cigarette, there is a wide temperature range between the ember temperature and glowing temperature. Among different cigarettes, the range of each temperature (ember, ignition, smoldering and glowing) is affected by the range of moisture concentrations, humectant concentrations, tightness of packing of the tobacco, and the like, of the cigarettes.

Various smoking machines have been designed to simulate the puffs at spaced time intervals. Such smoking machines have been employed during attempts to measure the ember temperature, the smoldering temperature, and the glowing temperature of various cigarettes under various conditions. The data relating to such temperatures are very confusing, not only because of the differences in the operation of the smoking machines, but also because of the differences in the techniques for measuring the temperatures. It has been difficult to measure the fluctuation of temperature during the transitions from smoldering to glowing to smoldering combustion and there have been various theories about whether there was any such fluctuation of temperature. Some of the previous attempts at measuring such temperature fluctuations have employed instruments which responded only after a significant time lag. For example, thermocouples having a heat capacity relatively large in comparison to the heat capacity of the combustion zone of a cigarette have sometimes been employed. Such high heat capacity and time lag prevented an accurate measurement of the peak glowing temperature. Some thermocouples have been so cooled by exposure to the air that they did not respond accurately to the temperature in the cigarette combustion zone. During the development of the present invention, it was possible to obtain a better understanding of the effect of the composition of a cigarette upon the peak temperature because such peak temperatures were measured with improved reliability.

It has previously been observed that the smoldering temperature of a very dry cigarette was hotter than the smoldering temperature of a cigarette containing moisture. However, the lowering of the smoldering temperature has been only one of the less important reasons for the general practice of utilizing moisture and humectants in processed cigarette tobacco. Flavoring agents, such as chocolate and licorice have been employed in cigarette tobacco but their effect, if any, upon the combustion temperatures has not been important enough to treat such flavoring agents as temperature-controlling agents.

Heretofore, ceramic filter tips have been employed to provide a large surface area adsorbent for entraining particles of tar and the like. There have also been proposals for the preparation of cigarettes from a mixture of clay and tobacco, whereby the high surface area adsorbent would capture the tar-like components of the smoke before such could reach the tip of the cigarette.

In certain types of cigarettes, unusual flavoring agents, such as menthol have been employed. In order to retain such volatile flavoring agents within the cigarette until the combustion of the cigarette, it has been proposed in U.S. Patent 2,063,014 that the menthol be adsorbed on a silica hydrogel. It has also been proposed in U.S. Patent 2,114,281 (a continuation in part of 2,063,014) that tobacco mixtures for cigarettes should contain silica hydrogel previously impregnated with water. Under favorable conditions, such water-impregnated silica hydrogel may retain a significant amount, such as 20% by weight, of water. According to said Patent No. 2,114,281, water is evolved from such water-impregnated silica hydrogel at the temperature of cigarette combustion and such evolved water combines with the tobacco smoke to restore the flavor and aroma to the tobacco smoke as if it contained its optimum moisture content. About 5% silica hydrogel, providing moisture corresponding to 1% of the shredded tobacco is provided in the cigarette of the example of said Patent No. 2,114,281.

The presence of high surface area materials such as silica hydrogel, ferrous oxide hydrogel, or the like, is very disadvantageous by reason of the effect of such high surface area materials upon the smoldering characteristics of the cigarette. During the smoldering of the cigarette, steam is among the combustion gases. During a puff of a cigarette, such steam laden combustion gases are cooled while passing through the cigarette toward the tip, and significant amounts of water are sorbed on the high surface material in the tobacco mixture. As the combustion zone advances toward the tip, the thus sorbed water is driven from the high surface area material, thus cooling the combustion zone. Such cooling attributable to the presence of the high surface area material is influenced by the frequency and relative timing of inhalations of the smoker. Inasmuch as there are great differences in the smoking habits of various individuals, such cooling of the combustion temperature by high surface area materials cannot be relied upon. For example large amounts of a high surface area gel in the cigarette may reduce the temperature of the combustion zone below the ember temperature. The presence of high surface area materials in the tobacco composition within the shell of the cigarette tends either to have no effect on the temperature of the combustion zone or to reduce the temperature so much that the cigarette has the disadvantage of being self-extinguishing. Thus, a cigarette which is puffed only once every three minutes may be cooled sufficiently to extinguish itself, although it might not extinguish itself if the puffs were once every twenty seconds.

It is convenient to measure the duration of the smoldering when the puffs are every two minutes, inasmuch as this test correlates with a typical consumer's evaluation of the tendency of the cigarette to be self-extinguishing.

In accordance with the present invention, an improved cigarette consists essentially of a tubular shell filled with a mixture consisting predominantly of shredded prepared tobacco and as the only other significant ingredient a material having a surface area significantly less than 50 m.²/g. (i.e. less than fifty square meters per gram), said material undergoing a thermal decomposition, which absorbs at least 90 calories per gram, such thermal decomposition being less than 20% complete during 2 minutes at 500° F. and being more than 80% complete in 5 seconds at 1400° F., said material being present in a concentration between 7% and 40% of the mixture, and in such concentration as to require a predetermined number of calories within the range from 30 to 120 calories per gram of mixture to bring about the substantially complete decomposition of said material, whereby the peak temperature of the combustion zone of the cigarette is lowered by the absorption of such 30–120 calories per gram of mixture without adversely interfering with the combustion of the cigarette at temperatures significantly below the peak temperature. The material undergoing the decomposition must not be amorphous, but instead should have sufficient crystallinity to be identifiable as non-amorphous by X-ray examination. This thermally decomposable material must be inorganic as distinguished from organic.

The technical subject matter of the present invention is further clarified by a series of examples.

Example I

A bolometer was positioned to receive the radiation from a glowing cigarette, and the amplified variations were observed by the use of an oscillograph. Thus, it was possible to measure the temperature increase (proportional to the indicated voltage increase) during a short puff on a cigarette. The cigarette was burned in a smoking machine which permitted the cigarette to burn without draft during 57 seconds of each 1 minute cycle and to burn more rapidly during a controlled 3 second puff. Air was sucked through the combustion zone by sucking the smoke and combustion gases through the tip of the cigarette at a rate of 10 cc. per second during the 3 second simulated puff. The puff increased the combustion rate, increasing the cigarette temperature, influencing the bolometer, and affecting the voltage indicated on the screen of the oscillograph corresponding to the temperature increase in the glowing portion of the cigarette attributable to the controlled flow of air through the cigarette. It was thus feasible to obtain a reliable measurement of the peak temperatures, and to measure accurately the differences among cigarettes as regards such peak temperatures under the standard conditions of said puff per minute.

This apparatus was employed to measure the puff induced peak temperature in several types of cigarettes. In each case, several cigarettes were tested to provide an average value for each series of measurements. Although cigarettes of the same type possess individual differences, the data on the numerous similar samples provided a sound statistical basis for comparing the average values, and for establishing the reliability of the method. In each case, the cigarette was first conditioned by being stored for several hours in a chamber maintained at 70% relative humidity and 75° F.

Cigarette "A" was a commercially available cigarette concerning which published data indicated that its peak temperature was 1400° F.

Cigarette "B" was a cigarette prepared using a standard, hand-operated cigarette-making machine and using the shredded tobacco obtained by opening commercially available cigarettes of the type employed for "A" the purpose being to measure the effect, if any, of the use of a hand-operated (instead of factory power operated) cigarette making machine.

Cigarette "C" was tested in order to determine the effect, if any, of using shredded tobacco marketed for hand-made cigarettes instead of the shredded tobacco obtained from commercial cigarettes. Cigarette "C" was prepared in said hand-operated machine using a commercial grade of shredded tobacco retailed as suitable for "do it yourself" cigarettes.

Each of cigarettes "D," "E" and "F" employed the shredded tobacco and cigarette-making machine of cigarette "C" but differed therefrom only by reason of the presence of an inorganic modifier constituting 20% by weight of the mixture of shredded tobacco and modifier. These inorganic modifiers chemically decomposed somewhat below glowing temperatures, thereby making the peak temperature lower than the peak temperature for the standard cigarette. Such temperature lowering was noted.

Data relating to the temperature lowering attributable to the nature of the cigarettes are shown.

Code	Characterized by	° F. temperature lowering
A	Commercial cigarette	0
B	Hand-operated machine	0
C	Retailed shredded tobacco	0
D	Sorel cement modifier	75
E	$MgCO_3 \cdot 3H_2O$	81
F	$Al_2O_3 \cdot 3H_2O$	128

The Sorel cement modifier (supra) is a crushed powder from a hardened mixture of magnesium oxide, magnesium chloride, and relatively large proportions of water.

Example II

The cigarette smoking machine was modified to operate with a puff every two minutes instead of every minute. Cigarettes "A" through "F" burned satisfactorily until the length of the remaining cigarette was too short to be held by fingers. Cigarette "G" differed from "D" through "F" only as regards the composition of the modifier. The tobacco mixture in cigarette "G" contained 20% by weight silica gel having a surface area of about 300 m.²/g. Cigarette "G" extinguished itself after burning less than one-fourth of the cigarette and when more than three-fourths of the cigarette remained. Such self-extinction of cigarette "G" was attributed to the presence of high surface area material, which adsorbed steam from the combustion of the remote portion of the cigarette during initial puffing portions of the cycle and which subsequently released steam in sufficient quantities to cool the immediately contiguous combustion zone below ember temperature during the smoldering portions of the cycle. By a series of similar tests, it is established that the inorganic modifier must have a surface area less than 50 m.²/g. to serve satisfactorily in the cigarettes of the present invention.

Example III

The tobacco mixture in cigarette "H" contained 20% by weight potassium aluminum sulfate dodecahydrate, generally known as alum. The smoking machine was operated on the two minute cycle. Cigarette "H" extinguished itself after less than one-fourth of the cigarette had burned, leaving more than three-fourths of the cigarette standing. Such self-extinction was attributed to the low temperature of decomposition of the alum, whereby the combustion zone decomposed the alum for such a long distance from the combustion zone as to cool the combustion zone below the ember temperature. Alum decomposes to lose 9 of its 12 mols of hydrate water at about 149° F., and loses the other 3 mols of hydrate water at a relatively low temperature. Thus, alum is

about 75% decomposed at about 150° F. By a series of tests it was established that the inorganic modifier must not undergo more than a 20% decomposition at 500° F. if the inorganic modifier is to serve satisfactorily in the cigarettes of the present invention. Stated positively, the cigarettes of the present invention must contain an inorganic modifier which is at least 80% undecomposed at 500° F.

The tobacco process of the present invention comprises the lowering of the peak temperature of the combustion of tobacco in a smoking device by incorporating an inorganic modifier in the tobacco mixture. This process might have some usefulness in connection with cigars and smoking pipes, but it is particularly useful in connection with cigarettes.

Example IV

Data are obtained relating to the heat absorbed to bring about the complete decomposition of certain organic materials.

Material:	Heat absorbed during decomposition, cal./g.
Strontium carbonate	250
Calcium hydroxide	350
Magnesium hydroxide	327
Magnesium carbonate	333
Alumina trihydrate	385

By a series of tests, it is established that the modifier must absorb at least 90 calories per gram in order to be satisfactory for the cigarettes of the present invention.

There are many chemical reactions in which a solid can decompose to form a gas and another solid, for which the equilibrium constant at various temperatures can be calculated from measurements of the partial pressure of the gas at equilibrium conditions, and for which the reaction rate at various temperatures can be measured. For each such reaction there is a "decomposition temperature" at which the material undergoes fairly complete (e.g. more than 90%) decomposition within a reasonably short time (e.g., one hour) under optimum conditions of heat transfer, gas withdrawal, etc. If the decomposition temperature is excessively high (e.g. calcium sulfate evolves sulfur trioxide only at very high temperatures) then such material is not suitable for lowering the peak temperature in the cigarettes of the present invention. If the decomposition temperature is excessively low (e.g. silver carbonate evolves carbon dioxide at 424° F., or alum loses most of its hydrate water at 148° F.) then such material is not suitable for lowering the peak temperature in the cigarettes of the present invention.

A typical peak temperature for a commercial cigarette is 1400° F. It is desirable to lower this temperature about 75° F., or within the range from about 50–150° temperature lowering. In achieving such lowering in the cigarettes of the present invention, the modifier should desirably be an inorganic material having a decomposition temperature within the range from 450° F. to 1250° F. It has been noted that magnesium carbonate decomposes at a temperature higher than for magnesium hydroxide, and that ferric hydroxide, alumina trihydrate and calcium hydroxide have successively higher decomposition temperatures.

Some materials which begin to undergo a decomposition at a moderate temperature require a higher and higher temperature to achieve more complete decomposition. Moreover, decomposition rate at particular temperatures affects the usefulness of the modifiers of the present invention. By a series of tests, it is established that the modifier must within 5 seconds at 1400° F. undergo at least 80% of the decomposition possible at 1400° F. which decomposition must not be more than 20% complete within 2 minutes at 500° F. The present invention requires the use of modifiers which comply with such decomposition rate requirements, and with the minimum heat of decomposition of at least 90 calories per gram. These modifiers must be present in a concentration requiring 30 to 120 calories per gram of mixture for decomposition, and in a concentration of from 7% to 40% by weight of the mixture. Upon decomposition, these modifiers evolve no gases other than gases selected from the group consisting of carbon dioxide and steam.

Example V

A cigarette containing 60% alumina trihydrate and 40% tobacco is self-extinguishing. A cigarette containing 4% alumina trihydrate and 96% tobacco has a peak temperature only slightly lower than that of an unmodified cigarette. By a series of tests, it is established that there are critical ranges of concentration for the modifiers, and that the modifier must constitute at least 7% but not more than 40% of the mixture of prepared tobacco and modifier. Moreover, it is necessary for the quantity of modifier to be related to the endothermic nature of its decomposition so that the decomposition of the modifier requires at least 30, but not more than 120 calories per gram of mixture, as exemplified in cigarettes "D," "E" and "F."

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

What is claimed is:

1. A smoking mixture for cigarettes having the characteristic of a peak combustion temperature of about 125° F. lower than a cigarette containing only shredded, prepared tobacco, consisting essentially of about 20% crystalline alumina trihydrate and about 80% shredded prepared tobacco.

2. A smoking mixture for cigarettes having the characteristic of a peak combustion temperature of at least 75° lower than a cigarette containing only shredded, prepared tobacco consisting of about 7 to 40% by weight of crystalline alumina trihydrate and about 93 to 60% by weight of shredded, prepared tobacco.

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