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## AMYLACEOUS FIRE-RETARDANT COMPOSITION

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The present invention relates to a fire-retardant composition and more particularly to such a composition suitable for external application to wood.

It is an object of the invention to provide an improved fire-retardant composition.

The composition of our invention may be applied to wood, for example by brushing or spraying, either on the finished structure or on the lumber before construction, and when so applied, it will substantially reduce both the danger of ignition and the spreading of fire.

In time of war there is an urgent need for rapid building of fireproof structures and, at the same time, conventional fire-proof construction materials are difficult to obtain. By our invention lumber, which is readily available and admirably adapted to rapid construction operations, may be rendered sufficiently fire-resistant to be an acceptable substitute for conventional fire-resistant construction materials.

Our composition contains no chemicals which are injurious to the wood or which cause corrosion of nails or other metal adjuncts to the structure. It does not encourage, or even permit, the growth of fungi or bacteria which might cause decay. It does not contain any chemicals which are either poisonous or dangerous to workmen who apply the composition to the wood or erect structures with treated wood. The solvent or vehicle does not give rise to inflammable or explosive fumes.

Our composition, when applied to wooden structures, may, if desired, be covered with a waterproof and weatherproof paint (such as the common linseed oil paints) without significantly impairing the fire-retarding qualities of the composition. Many pigments are compatible with the composition, whereby any desired color may be imparted to it. It contains materials which are available in large quantities in time of war and which are not in such demand for other war purposes as to be difficult to obtain.

Numerous prior proposals have been made for the protection of wood against fire, but to the best of our knowledge, none of these proposals has sufficiently satisfied the numerous and exacting requirements for fireproofing on a commercial scale to be generally adopted and used. It is well known that certain chemicals, for example ammonium phosphate, borax, and others, have some fire-retarding action. Efforts have been made to enhance the effectiveness of these chemicals by vacuum and pressure tank impregnation into wood, or by the use of small amounts of

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adhesives such as glue, dextrin, or starch to increase the thickness of the surface coating on the wood. These proposals have fallen far short of achieving the desired objectives, as is demonstrated by the limited use of these procedures. It has also been proposed to employ thick coatings of non-combustible mineral matter such as silica, clay, gypsum, or sodium silicate. Such suggestions have not met the requirements necessary for commercial acceptance.

In accordance with our invention, fire-resistant and fire-retardant properties are imparted to wood or other combustible materials by applying to the same a layer of chemicals which is adherent, stable and potentially reactive and which, when subjected to heat, is converted into a layer of carbon which acts as an adsorbent, a heat insulator, and a means of excluding air. At the same time, the carbon layer thus formed is itself rendered substantially non-combustible by the presence therein of a fire-retarding chemical formed during the heat-induced chemical reaction. Thus the wood is protected from damage by destructive distillation or combustion to a sufficient degree to resist ignition and to prevent the spread of flame.

Our improved composition comprises essentially an activate and an activator therefor which, at elevated temperatures, will convert the activate, into a layer of so-called "activated" carbon on the surface which has been treated with the composition.

As the activate, we may use any solid carbonaceous substance which, at elevated temperatures such as the temperature of combustion of wood, or lower, will be converted into carbon rather than volatilize. Preferably, but not necessarily, the activate should be a substance which does not melt at these temperatures and which can be suspended, dispersed or dissolved in aqueous media. Carbohydrates generally are suitable materials for this purpose. Specific mention, by way of example, may be made of starch, dextrin, carbohydrate gums, sugar and like substances. It will be noted that these materials, by themselves, are combustible.

Since the viscosity of the final fluid composition is often an important consideration, the activate should be chosen so as to yield a viscosity suitable for the purpose in mind. The viscosity desired for various methods of applying the composition may vary considerably. Thus thick or thin boiling varieties of starch, or mixtures thereof, may be used.

As an activator we may use chemicals which,

t elevated temperatures such as those indicated bove, will convert the activate into a carbon ayer, that is, chemicals which, under the influnce of heat, are capable of forming so-called activated" carbon from the activate. Specific xamples of chemicals meeting these requireents include monoammonium phosphate, diammonium phosphate, phosphoric acid, sodium hosphates, zinc chloride, calcium chloride, tin hloride and other tin salts, aluminum sulfate, odium tungstate, boric acid and borates, amonium sulfamate, ammonium sulfate, and the ke.

Since the activate has a natural tendency to erment and since some activators (particularly hosphates) favor this fermentation and the rowth of wood-destroying fungi, we find it genrally desirable to include in our composition a ngicide and/or bactericide which will prevent ne growth of fungi and bacteria in the treated ood and in the composition itself. Suitable subances for this purpose include copper ammonia alts (the complex copper ammonia salts are preerred to simple copper salts since they do not recipitate with many anions such as the phoshate or tungstate ions), borax (if the alkalinity f the latter does not interfere with the actiator), zinc ammonia salts, fluorides, arsenates, rsenites, organic fungicides and the like.

A binder may also be used, if desired, for enancing the adhesion of our composition to the reated surface and also for increasing the mount of the composition adhering thereto. We ay use an aqueous emulsion of a resin of the lkyd type, urea formaldehyde resins and others hich possess binding properties. Obviously, the esin must be compatible with the other ingredints so that it will not precipitate from the composition. The activate itself may be so selected as o impart desirable binding properties to the composition. For example, certain thin boiling vaieties of starch of high fluidity can be used as oth activate and binder when they are boiled ith water prior to the addition of the activator.

An ingredient which will improve the water-resting quality of the dried composition on the ood, such as a wax, resin, gum, or the like, may e added if desired.

Pigments or other coloring materials may also e added.

The composition is dissolved or suspended in a quid medium, preferably water.

The activate should be present in our compotion in amount between approximately 20% and 0% of the weight of the activator present. We ave found that proportions outside these limits o not form an effective "activated" carbon layer.

The final liquid composition should contain at ast 25% by weight of the combined activate and ctivator. A preferred composition contains 50% y weight of these ingredients.

As one example of a suitable composition falling ithin the scope of our invention, the following ay be given, it being understood that this is illstrative only and is not to be construed in a miting sense:

675 grams of a thin boiling starch are stirred to 2835 cc. of cold water and the resulting susension is heated to about 80 to 85° C. with conant and thorough agitation. The temperature maintained in the neighborhood of 85° C. for pproximately five minutes and the solution is hen cooled, the agitation being continued.

An aqueous ammoniacal solution is made by issolving 225 cc. of ammonia (29.4% technical



grade) in 225 cc. of water. 210 grams of powdered copper sulfate ($CuSO_4.5H_2O$) is added to this ammoniacal solution and the mixture is stirred until the copper sulfate is entirely dissolved, thereby forming a complex copper ammonia sulfate. The ammonia functions to form a soluble complex copper ammonia salt, thus preventing subsequent formation of an insoluble copper phosphate which would precipitate from the solution. If the fungicide is one which does not form an insoluble compound with the activator, it will not be necessary to add ammonia to the composition.

The ammoniacal copper sulfate solution is added to the starch solution when the latter has been cooled to about 40° C. The copper sulfate solution should not be added to the hot starch solution because this is likely to result in loss of ammonia and decomposition of the complex copper salt. During the mixing of these two solutions, stirring should be continued for about five minutes.

To the resulting solution, add 2465 grams of diammonium phosphate in portions of about 300 to 400 grams each, with stirring. The smoothness of the final coated surface may be enhanced by using finely-divided diammonium phosphate, for example 100 mesh. When about half of the phosphate has been added, the composition thickens noticeably, but after the total amount has been added, the final composition will again become somewhat more fluid.

The density of the liquid composition prepared as in the foregoing example is approximately 1.3. This product is a slurry which, in addition to the starch and ammonium phosphate which are dissolved in the solution, contains suspended particles of starch and suspended undissolved crystals of ammonium phosphate. Although these suspended materials have a tendency to settle in time, the slurry may readily be restored to a suitable condition for use, by agitation.

It is not necessary to heat the starch as in the foregoing example. It may merely be suspended in cold water by agitation.

In some cases, it may be desirable to add to the composition a resin, as indicated above. This resin not only acts as a binder, but will also result in a harder surface, more resistant to abrasion and to moisture, after the composition has been applied to the material to be treated.

Comparative tests have shown that wood treated with our novel composition has fire-resistant and fire-retardant properties superior to those of wood treated only with the same amount of the activator. The activate, of course, being combustible, does not of itself impart any fire-resistant properties to the wood. The co-operation of the activator and activate in producing the fire-resistant properties of our composition is thus clearly demonstrated.

When wood which has been treated with a surface coating of our composition is subjected to the fire tube test developed by the Forest Products Laboratory of the United States Department of Agriculture [Proc. N. F. P. A. 100–102 (1938)], a layer of soft, porous carbon is formed on the surface of the wood. At a point a few inches above the contact of the wood with the flame, this carbon layer, after cooling, feels moist to the touch and the texture of the wood is retained beneath this layer.

While our invention is, of course, not limited to any particular theory of operation, it is our belief that this "activated" carbon layer, formed from the reaction of the activator upon the ac-

tivate in the presence of heat, functions as a fire-retardant in a number of ways. After the activated carbon layer has been formed, it may adsorb combustible gases and vapors such as methane, acetone, etc., which are formed by the destructive distillation of the wood in direct contact with the flame. It may also adsorb non-combustible gases such as carbon dioxide and nitrogen and thereby interfere with the ignition of the combustible gases. Moreover, owing to its finely-divided porous condition, the layer of activated carbon may act as an efficient heat insulator and also may help to prevent access of oxygen to the wood. Owing to the presence of the activator or of its decomposition products (e. g., phosphoric acid if ammonium phosphate is used as the activator), the activated carbon layer is itself resistant to combustion.

Our composition may be applied to wood or other combustible material in any convenient manner. While, as previously indicated, it is contemplated that the composition shall be capable of application by brushing or spraying, it may also be applied by various known impregnation processes if desired. One advantage of our composition, however, is that effective fire-retardation may be obtained by surface application.

Having thus described our invention, we claim:

1. A fire-retardant composition adapted for surface application to combustible materials, which composition is non-reactive with said material at ordinary temperatures and comprises an aqueous suspending medium having dispersed therein, as the principal ingredients, an activator selected from the group consisting of ammonium phosphate, ammonium borate, ammonium sulfate, and ammonium sulfamate, and also an amylaceous substance in amount at least 20% but not more than 70% of the weight of said activator, said amylaceous substance being intimately mixed with but not reacted with said activator, the sum of the weights of said activator and said amylaceous substance exceeding 25% of the total weight of the liquid composition.



2. A fire-retardant composition adapted for surface application to combustible materials, which composition is non-reactive with said materials at ordinary temperatures and comprises an aqueous suspending medium having dispersed therein, as the essential ingredients, ammonium phosphate and starch, the starch being present in amount of at least 20% but not more than 70% of the weight of the ammonium phosphate, the starch being intimately mixed with but not reacted with the ammonium phosphate, the sum of the weights of the phosphate and starch exceeding 25% of the total weight of the liquid composition.

3. A fire-retardant composition adapted for surface application to combustible materials as claimed in claim 1 wherein the sum of the weights of the activator and the amylaceous substance is about 50% of the total weight of the liquid composition.

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