A vapor-phase reaction system (apparatus and method) for treating cellulosic textile materials and garments with vaporizable reagents is disclosed. The cellulosic material or garment to be treated is placed within a skeleton frame adjacent to a matrix which has an extensive surface area on which the reagent is dispersed, and the assembly is confined in an expandable container which has pleated walls to allow for expansion of the gases generated.
VAPOR-PHASE REACTION APPARATUS FOR TREATING CELLULOSIC TEXTILE MATERIALS AND GARMENTS

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This invention relates to a system for treating cellulosic textile materials or garments with vaporizable chemical reagents. More particularly, this invention relates to a method of reacting cellulosic textile materials and garments in a variable volume chamber by a most efficient manner of dispensing vaporous reagents. A garment or other cellulosic textile product can be placed in the reaction chamber of this invention in the preferred configuration, and, while being maintained in said configuration, reacted with a vaporizable reagent. The space required would be minimal and flexible in that the chamber walls can be proximal, distant, or adjustable in respect to each other in order to accommodate and/or control expansion of the reaction gases. The reagent is applied by vaporization from a matrix having a porous, extensive surface and which is positioned adjacent to the cellulosic garment or other textile material being treated.

DEFINITION

The word system is employed throughout this specification to include both the apparatus and method of the invention described herein.

The main object of this invention is to provide a system for conducting vapor-phase chemical reactions most efficiently, and where minimal quantities are applicable.

A second object of this invention is to provide a simple and economical means for conducting complex chemical reactions that currently would require specialized and elaborate equipment.

A third object of this invention is to provide a method and apparatus for the purpose of treating decorative (complex configuration) textile garments and products such as knits, ruffled and lacy dresses which ordinarily cannot be treated by liquid immersion methods.

A fourth object of this invention is to provide a vapor-phase reaction system wherein the volume of the reaction vessel can be easily and conveniently altered to achieve the preferred reaction conditions for a particular amount of material being treated.

THE PRIOR ART

Hitherto two generally accepted systems have been employed to conduct vapor-phase chemical reactions. The one has been a closed system wherein the material to be treated or reacted, and changed chemically and/or physically and the reagent are placed in the reaction chamber and sealed in order to bring about the reaction. As the vapors of the reagent are generated in this system, the pressure in the system rises to a level consistent with the final environment in the container. The fault with such a system lies in the fact that the reactor has been constructed of thick, rigid, impervious walls designed to withstand the maximum pressure involved in the reaction. Such type of construction makes the reactor expensive and of necessity must be reused many times.

The second type of system generally employed requires a special chamber operating at or slightly above atmospheric pressures wherein the vapors of the reagents are generated, or alternately, into which the vapors are blown after being generated in an external system or allowed to escape from containers in which they were stored under pressure. In this type of system the material to be reacted or treated is introduced, while the chamber is saturated with reagent vapors, through special devices designed to minimize leakage of vapors out of the reaction chamber as well as leakage of air into the chamber; said material remains for a specified period of time; and then exits through a device equivalent to that of the entrance. This type of system too, is also of a permanent nature and of necessity must be used many times.

Both of these types of vapor-phase reactors are discussed extensively in an article by W. J. Jutras et al., which appears in the Textile Chemist and Colorist, Vol. 1, No. 18, 1969, page 383.

Both of these systems are generally used for reactions conducted above ambient temperatures. Both are, in effect, constant volume systems. The first is a closed, sealed system in which the pressure must increase if any reagent vapor is introduced either by evaporation within the vessel or by insertion from an external container. The second is an open, constant pressure system because reagent vapors are constantly being supplied and simultaneously exhausted.

The limitations inherent in these conventional systems are overcome by the instant invention. One limitation of the constant volume, closed or sealed system is the increase in boiling point or vapor pressure required for boiling, due to the increase in pressure, which results from heating a closed vessel. This, of course, can be offset by evacuating the system before introducing the reagent but it increases the complexity and investment in equipment. On the other hand, in a constant volume, open chamber, even if the reagent is boiling, the vapors generated must of necessity, displace other vapors, since the system is constant volume and open to the atmosphere, and therefore excess reagent must be vaporized in order to prevent air from entering the chamber. The leakage of small quantities of air into the chamber is difficult to prevent, both at the entrance and at the exit devices, because of eddy currents and diffusion.

The instant invention avoids the limitations of these conventional systems by providing a sealed system with the capacity for extensive increase in volume to accommodate the vapors generated, and said increase is accomplished with only a very small increase in pressure. In this way all of the vapors generated are contained within the system so that they are available to react and the normal properties of said vapors prevail because there is no appreciable increase in pressure.

The single FIGURE of drawing is an exploded view, partially in section, of one specific embodiment of the invention.

The reaction system shown in the drawing consists of an outer impervious container 1 which serves as the reaction chamber and into which is inserted a rigid skeleton frame 2. This rigid skeleton frame provides support and rigidity to the assembly which includes; a matrix 3 which in this illustration is a glass fabric, but can be any other inert material having a porous exten-
sive surface; the material being treated, such as a garment 4; the reagent which can be either a liquid or a solid; and the garment hanger 5, which is supported on the frame 2 by rigid bar 8 secured to hanger wire 9. In this particular illustration, after the cotton garment 4 is placed in the skeleton frame 2 the inert material 3 is charged with the vaporizable reagent, and the assembly is immediately inserted into the impervious container 1 which is the reaction chamber. The vaporizable reagent can be a liquid or a solid, and is generally spread throughout the entire surface area of matrix 3 to provide a great area from which the reagent can evaporate.

The top of the container 1 is then closed either by conventional means or as illustrated by a screw clamp 6. Conventional means would, of course, include for example the use of a heat source to seal a polyethylene or other thermoplastic container. The encapsulated assembly is then subjected to heat. In the illustrated experiment the encapsulated assembly was heated by infrared radiation, but it has also been done in our development work by blowing hot air directly on the outer surface of the container. This is done to energize the system, that is, to vaporize the reagent and induce reaction between the cotton garment 4, for example, and the reagent vapors of the chemical formulation that we employed.

The wall or portions of the impervious container 1 must be relatively thin and pliable so that these areas can be folded as illustrated by folds 7 when the initial volume of the impervious container 1 needs to be reduced. The bellows-like arrangement would allow for expansion of the gases within the container. The wall area must, of course, be at least as great as the dimensions required to contain the inserted materials, and must unfold through the expansion of folds 7 to that size which would accommodate the increase in volume required after heating the system.

The final volume required and, therefore, the amount of excess wall area would be determined by conventional calculations based on the amount of all vaporizable materials that are sealed into the container. The expansion provided by the excess wall area permits a greater amount of reagent to evaporate at a given temperature; improves the rate of diffusion of the vapors; and prevents a pressure increase that could rupture the thin walls. The walls of the impervious container 1 are purposely made thin in order to increase the heat transfer and bring about the desired reaction much more rapidly. The said walls can be preferably constructed of sheet plastic, metal foil, or a combination thereof, but certain areas could be rigid while the folds or pleats 7 could be pliable.

The simplicity of construction of the illustrated container (reaction chamber) indicates the possibility of the container being fabricated of disposable materials for single reaction use.

With reference to skeleton frame 2, a minimum of rigid structural members that will circumscribe a volume equal to or greater than the volume of the garment 4 — such as a hexahedron, a cylinder, or a sphere — would be desirable. The frame 2 provides many useful functions in the combination of novel features. For example, it can provide support for the textile material being treated, it can provide a constant starting volume, but particularly it can provide the space required for the vapors to circulate at the start of the reaction before the container 1 begins to expand. Furthermore, the frame 2 can provide support for the inert material 3.

Inert material 3 adds novel features to the combination of elements that comprise the apparatus and method of the improved vapor phase reaction system of the present invention. For instance, the inert material 3 provides an extensive surface over which the reagents can spread thereby exposing a thin film that absorbs heat readily and evaporates rapidly, producing a voluminous amount of reactive groups. The inert material 3 can be of a granular nature, having many microporous configurations thereby providing extensive surfaces; however, a more practical inert material to use would be, as exemplified by FIG. 1, a glass fabric or an inert synthetic fabric. However if the material being treated is something other than cotton and cotton is inert to the reagent being used, then cotton fabric can be used to disperse the reagent. The many minute filaments that comprise the yarns and the many yarns that make up the fabric provide an extremely vast surface area in a relatively small volume. Matrix 3 can be secured to frame 2 by any suitable means (not shown) familiar to those skilled in the art.

Although the illustration in the drawing discloses one embodiment of the invention which is applicable to garments, it will be obvious that the system of this invention is applicable to most forms of cellulosic textiles. For instance, the cellulosic textiles that have been submitted to this vapor-phase reaction system are rawstock, yarn, knitted, woven, and nonwoven fabric.

The following examples serve to illustrate the application of the reaction system to woven fabric.

**EXAMPLE 1**

A piece of cotton printcloth (3.1 oz./sq.yd.) which had a length to width ratio of 4.5 to 1, was folded to form six layers so that the original length was reduced to one-sixth its size. The folded cloth was suspended by conventional means and inserted into a skeleton frame.

The frame circumscribed a parallelepiped whose smallest dimension was 10 times the total thickness of the six layers of cloth and the other two dimensions were slightly larger than the other two dimensions of the folded cloth. A piece of fiber glass fabric slightly larger in size than the folded dimensions of the cotton cloth was fastened to one of the two larger sides of the skeleton frame. The glass fabric was impregnated, by spraying, with an amount of liquid reagent equal to 20 percent of the weight of the cotton cloth. The reagent consisted of, 26 percent formaldehyde, 27 percent sulfur dioxide, 7 percent methyl alcohol and the remainder water. This reagent was used to crosslink the cellulose, thereby improving its resilience, and durable press properties.

The frame with the attached impregnated glass fabric and the folded cotton cloth was inserted into a thin walled, pliable polyethylene container and the opening in the container was sealed by melting with a hot wire. The container in this case was a flat bag which, when inflated with vapor, puffed up into a pillow-like shape. It was made of such a size that the inflated volume was large enough to contain all of the vapors generated by
evaporating all of the liquid reagent and the absorbed moisture on the cotton, as well as the air in the container when it was sealed. This volume was determined by conventional physical chemical calculations, based on the fact that one gram-molecular weight of a pure compound when vaporized will occupy 22.4 liters at standard conditions of temperature and pressure.

The sealed container was heated in a forced draft oven for 30 minutes at 205°F, after which the assembly was removed from the oven and the cotton cloth was removed from the container. Standard textile tests indicated that the wrinkle recovery of the cotton cloth was vastly improved and the creases where the cloth was folded remained sharp after many launderings, indicating that the durable press properties were excellent.

The improvement in the durable press properties using this reagent was found to be directly related to the percentage of bound formaldehyde on the cloth. This was only true, however, if the treatment was uniformly applied to all areas of the fabric. To test the uniformity of these treatments the cotton cloth was dyed with a direct cotton dye. The cellulose resists the dye if it is crosslinked but will absorb the dye readily if it is not crosslinked.

Chemical analysis of the cotton obtained in this example showed that the amount of bound formaldehyde was 0.64 percent and the dye test showed excellent uniformity throughout the cloth.

EXAMPLE 2

The apparatus and method of Example 1 was used to treat a piece of cotton printcloth the same size as the folded dimensions except that it was one-sixth the thickness or one layer. This made the smallest dimension of the skeleton frame about 60 times the thickness of the cloth. An amount of the same reagent equal to 90 percent of the weight of the cotton was dispersed on the glass fabric surface. After reacting for only 20 minutes, the amount of bound formaldehyde was 0.61 percent. The uniformity of the treatment was excellent.

When the same reaction was duplicated except that the reagent was placed in the container without being dispersed on the glass fabric, the dye test showed that the reaction was not uniform.

EXAMPLE 3

The apparatus, method and reaction of Example 1 was duplicated except that the amount of reagent was reduced to 10 percent of the weight of the cotton. The amount of bound formaldehyde was found to be 0.41 percent and the uniformity was excellent.

When this reaction was duplicated except that the skeleton frame was not used, the bound formaldehyde was found to be 0.29 percent and the reaction was not uniform.

Although specific reagents are mentioned by way of illustration it should be noted that the invention is not limited to these. Applicable reagents can be crosslinking agents, polymer forming monomers, flame retardants, etc. The significant criterion is that the reagents be vaporizable and that they react with the textile form present.

We claim:
1. A vapor-phase reaction apparatus for chemically treating cellulosic garments and other textile materials comprising:
   a. a gas-impervious reaction chamber having expandable side walls to permit expansion of volume when gas pressure is exerted from within;
   b. a rigid skeleton frame inside said reaction chamber encompassing a volume equal to or greater than the volume of a cellulosic garment or other textile material to be treated;
   c. means for suspending the cellulosic textile material within the confines of the rigid skeleton, said means supporting and maintaining the configuration of said cellulosic textile material, said suspending means being supported by the skeleton frame;
   d. a matrix having a porous extensive surface adjacent the skeleton frame, said matrix being adapted to receive chemical treating agents and subsequently permitting said agents to vaporize from the surface of said matrix; and
   e. means for sealing the reaction chamber to prevent escape of vaporized chemical treating agents from within said chamber.
2. The apparatus of claim 1 wherein the reaction chamber comprises a thin-walled pliable sheet material.
3. The apparatus of claim 2 wherein the sheet material is provided with a plurality of folds to produce a bellows-like configuration.