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PATENT SPECIFICATION

NO DRAWINGS

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COMPLETE SPECIFICATION

Improvements in or relating to the Coating of Reticulated Foam Structures

5 We, SCOTT PAPER COMPANY, a Corporation organized under the laws of the State of Pennsylvania, United States of America, of International Airport, Philadelphia 13, State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to a new reticulated foam structure, more particularly, this invention relates to a novel reticulated structure made from a membrane-free foam and inorganic particulate materials such as graphite, 15 metal powders, metal alloy powders, metal oxides of various kinds, as well as high melting organic polymers such as Teflons and nylon (the word "Teflon" is a registered Trade Mark).

20 The term "reticulated" is well known in the foam art and defines a net-like product consisting of nexae and strands joined together at spaced apart points to form a continuous structure. Generally, a prerequisite for foam reticulation is an open-celled structure (inter-communicating cells) for explosion and chemical reticulation or a structure 25 susceptible to partial chemical attack resulting in cell-wall removal. For the last process open-celled structure is also a desideratum. For explosion reticulation, open-celled foams are needed to allow the gas to be introduced into the interior thereof.

35 Prior art reticulated foam structures have commonly been made from polyurethanes such as polyether polyurethanes and polyester polyurethanes, and vinyl homopolymers and copolymers such as of vinyl chlorides and vinyl acetates and mixtures thereof. One of the prior art methods for preparing reticulated polyurethanes uses an explosive mixture of a

combustible gas and oxygen to dewindow the diaphanous membranes of the foam structures.

45 Other methods for dewindowing foam bodies are known but they are of less significance or they generally require more steps or involve use of chemicals which lend themselves poorly to desirable process control.

50 Previous attempts to produce reticulated structures having coated surfaces have been unsuccessful because conventional coating techniques have resulted in poor attachment of the inorganic materials. In using aluminium powder or leaf, especially troublesome problems have been encountered as the bond between the aluminium and the adhesive used has been very poor. Similarly, the limited numbers of adhesives which are compatible with the powder and the foam structure in attaching the particulate materials to the strands have resulted in a very limited application of the polyurethane structures coated with particulate mineral or metal powders. 65 Further, to achieve adhesion of non-fusible finely divided particles, it has been necessary to employ a binder of some type which generally changes the nature of the surface obtained. Still further, limited coating techniques have tended to give non-uniform distribution of the adhesive such as pooling and collecting of the solution at strand nexae because of surface tension. Thus, in the present process, the elimination of the surface tension problems has resulted in a more evenly-distributed material on the foam surface. 75

80 It has now been found that foam bodies reticulated or unreticulated (when open-celled) may be effectively made into novel articles of manufacture possessing properties heretofore unachieved by the present methods.

More particularly, it has now been found that to the strand of network of polymeric

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organic foams may be intimately and tenaciously attached inorganic particulate materials or successive deposits of inorganic particulate materials, either of the same inorganic nature or of diverse inorganic nature, resulting, in effect, in a structure having characteristics of both an organic polymer and the particulate material(s) attached. Moreover, no adhesive is needed to attach the particulate matter to the strand. Various materials such as polyolefines may be used to coat the foam substrate and then attach the particulate material; thus the present process is equally applicable to coated as well as uncoated foams.

The polymeric substrate foams capable of being reticulated or which are already reticulated are within the purview of the invention. Representative foams are polyurethanes, classified according to the resin system such as polyether, polyester, polycarbonate and castor oil (polyester polyurethane and polyether polyurethane foams are preferred): polyvinyl foams such as polyvinyl chloride, polyvinyl acetate, polyvinyl foams of mixed homopolymers; and polyethylene coated polyurethane foams. Foams with pore sizes of from 5 to 80 ppi (pores per linear inch) are useful; of from 5 to 45 ppi are preferred.

As the particulate material, except for those which readily decompose when exposed to the high temperature flame front, inorganic material such as all available powders are within the scope of this invention. Representative powders or particulate materials are obtained from materials such as iron, bronze, aluminium, copper, nickel, platinum, titanium and beryllium. Similarly, mixtures of these powders are within the scope of this invention, especially since many mixtures are useful in catalytic-contacting application. The novel structures includes those where the deposits are made from nickel and platinum mixtures, and titanium or vanadium complexes. Other particulate materials are graphite, titanium oxide, alumina, kieselguhr, asbestos, glass and various particulate mineral materials consisting of silicon oxides or siliceous base materials. Still other materials useful to produce the novel articles of manufacture are particulate or pulverized, organic polymers having melting points above the melting point of the foam material, e.g. nylon, Teflon, Kel-F (the word "Kel-F" is a Registered Trade Mark) and the polymers of 1-olefins such as 1-butenes.

In general pulverulent materials not susceptible to the decomposition of the flame front because of the high temperature of the flame front are useful in this process. However, it has been found that other methods such as fusion at elevated temperatures afford better means of attaching and dispersing those organic materials having lower melting points than the foam material. Consequently, the

thus produced structures may serve as substrates in the instant process.

Generally, particle size of the particulate material depends on the pore size of the foam material and the strand thickness. Particles having a size no greater than the average thickness of the strands of the foam material in its reticulated form may be used. Best results are obtained if particle size is below about half the thickness of the foam strands of the particular foam used. Particle sizes of from 1/4 to 1/100 of the strand thickness are generally used. Smaller particles may also be used and are often desired in catalyst applications. It has been found that very fine powders can equally well be used in the novel process.

The present invention provides a process for tenaciously depositing a solid particulate material on an organic, polymeric foam material which is, or is capable of being reticulated, the particulate material having a decomposition temperature or melting point equal to or greater than said organic foam material, which comprises intimately dispersing said particulate material throughout the organic foam material, the particulate material having a particle size no greater than the average thickness of the strands of the foam material in its reticulated form, subjecting all the organic material coated with said particulate material to an explosive flame front, and, if desired, repeating said steps.

Still further, the invention is accomplished by the process comprising the following steps: (a) coating the strands and nexae of an organic polymeric foam material with an inorganic particulate material; (b) permeating said reticulated foam material with an explodable fuel gas and a gas containing an explosion-sustaining amount of oxygen; (c) initiating an explosive flame propagation throughout the foam body, (d) subjecting again the foam to the treatment steps of (a) and (b) to deposit in a tenacious manner additional amounts of the said particulate material and (e) recovering the novel article of manufacture.

Still, further the invention is accomplished by coating primarily the strands and nexae of a reticulated polyurethane foam material with a metal powder, permeating the thus coated polyurethane foam material with an explodable fuel gas, or a liquid which vaporizes to form an explodable gas, and an explosion-sustaining amount of oxygen, initiating an explosive flame propagation throughout the foam body, repeating the above steps to deposit additional amount of said metal powder or other metal powders or mixtures thereof and recovering said novel article of manufacture.

One of the materials especially suitable for the primary attachment of the particles to the foam structure is water. If the foam is hydrophobic, volatile organic solvents such as ethyl alcohol and benzene are useful. However, care

should be used that excess solvent is removed. Merely moistening the surface of the polymeric foam material gives a sufficient temporary adhesion to subject it to the explosion-coating process. Additionally, the moisture of the slightly wet foam absorbs some of the excess energy occasionally encountered in the explosion-coating process. Other materials useful for the primary coating are those fluids possessing small contact angles with polyurethane materials and the particulate powder.

The products obtained from conductive particulate materials according to the above process are especially suitable for improved thermal emissivity and electrical conductivity.

If various layers of material are deposited, the properties of the foam can be considerably changed. For example, by employing various proportions of catalytically active materials such as platinum, nickel, alumina and kieselguhr treated with platinum, catalytically-active contacting pads are obtained possessing a spectrum of activities. By the same token, other materials such as alumina, silica and charcoal, may be employed to yield novel adsorbents especially suitable for removing impurities from fluid streams. It has also been found that by depositing a material having a desirable conductivity the foam material may be used as an electrostatic filter or as an absorber for high frequency electromagnetic energy.

The following examples are included to illustrate the various facets of the invention. These are to be construed with reference to the above discussion and claims and are not intended to limit the broader scope of this invention.

EXAMPLE 1

A block of adipate polyester polyurethane foam previously reticulated by a high temperature flame front and having about 12 pores per inch and an electrical resistance of 10^{12} to 10^{14} ohms/cc was dusted and thoroughly impregnated with graphite powder. The excess was removed by shaking. The block was then placed in a polyethylene bag, evacuated and filled with a gas mixture composed of 16.7% propane and 83.3% oxygen (by volume). The gas mixture was then detonated by a suitable igniter with an attendant sharp explosion. Examination then showed that each strand was uniformly coated with a tenaciously-adhering layer of graphite which resisted washing. Weight gain of the block amounted to 76% compared to the parent reticulated foam. The product exhibited a resistance of about 20×10^8 ohms/cc.

EXAMPLE 2

In the same manner as illustrated above, a polyether polyurethane foam previously reticulated by a high-temperature flame front is immersed in water and the excess water re-

moved by thorough shaking and squeezing. The polyurethane block is then dusted and impregnated with a nickel powder and excess is removed by shaking. The experiment is then carried out as in Example 1. Examination of the block shows a uniformly coated tenaciously-adhering layer of nickel powder on polyurethane which resists washing.

In the same manner as illustrated above, particulate materials such as titanium dioxide, iron, kieselguhr, alumina, aluminium powder and leaf, and various metal oxides producing especially suitable properties were produced. These products have a tenaciously attaching bond between the particulate material and substrate with the material coating each strand and nexus.

WHAT WE CLAIM IS:—

1. A process for tenaciously depositing a solid particulate material on an organic, polymeric foam material which is or is capable of being reticulated, the particulate material having a decomposition temperature or melting point equal to or greater than said organic foam material, which comprises intimately dispersing said particulate material throughout the organic foam material, the particulate material having a particle size no greater than the average thickness of the strands of the foam material in its reticulated form, subjecting all the organic material coated with said particulate material to an explosive flame front, and, if desired, repeating said steps.

2. A process according to claim 1, wherein said explosive flame front is created by permeating said reticulated foam material with an explodable fuel gas containing an explosion-sustaining amount of oxygen and igniting the gas.

3. A process according to claim 1 or 2, wherein said explosive flame front is created by permeating said reticulated foam material with a liquid which vaporizes to form an explodable gas, and an explosion-sustaining amount of oxygen, evaporating the liquid and distributing the vapor of said liquid within the foam material, and thereafter igniting said vapor.

4. A process according to any one of claims 1 to 3, in which the solid particulate material is inorganic material.

5. A process according to any one of the preceding claims, wherein the solid particulate material is at least one metal powder.

6. A process according to any one of the preceding claims, wherein the solid particulate material is a mixture of nickel and iron powder.

7. A process according to any one of claims 1 to 4, wherein the said particulate materials is graphite.

8. A process according to any one of claims 1 to 4, wherein the particulate material is titanium dioxide.

should be used that excess solvent is removed. Merely moistening the surface of the polymeric foam material gives a sufficient temporary adhesion to subject it to the explosion-coating process. Additionally, the moisture of the slightly wet foam absorbs some of the excess energy occasionally encountered in the explosion-coating process. Other materials useful for the primary coating are those fluids possessing small contact angles with polyurethane materials and the particulate powder.

The products obtained from conductive particulate materials according to the above process are especially suitable for improved thermal emissivity and electrical conductivity.

If various layers of material are deposited, the properties of the foam can be considerably changed. For example, by employing various proportions of catalytically active materials such as platinum, nickel, alumina and kieselguhr treated with platinum, catalytically-active contacting pads are obtained possessing a spectrum of activities. By the same token, other materials such as alumina, silica and charcoal, may be employed to yield novel adsorbents especially suitable for removing impurities from fluid streams. It has also been found that by depositing a material having a desirable conductivity the foam material may be used as an electrostatic filter or as an absorber for high frequency electromagnetic energy.

The following examples are included to illustrate the various facets of the invention. These are to be construed with reference to the above discussion and claims and are not intended to limit the broader scope of this invention.

EXAMPLE 1

A block of adipate polyester polyurethane foam previously reticulated by a high temperature flame front and having about 12 pores per inch and an electrical resistance of 10^{12} to 10^{14} ohms/cc was dusted and thoroughly impregnated with graphite powder. The excess was removed by shaking. The block was then placed in a polyethylene bag, evacuated and filled with a gas mixture composed of 16.7% propane and 83.3% oxygen (by volume). The gas mixture was then detonated by a suitable igniter with an attendant sharp explosion. Examination then showed that each strand was uniformly coated with a tenaciously-adhering layer of graphite which resisted washing. Weight gain of the block amounted to 76% compared to the parent reticulated foam. The product exhibited a resistance of about 20×10^6 ohms/cc.

EXAMPLE 2

In the same manner as illustrated above, a polyether polyurethane foam previously reticulated by a high-temperature flame front is immersed in water and the excess water re-

moved by thorough shaking and squeezing. The polyurethane block is then dusted and impregnated with a nickel powder and excess is removed by shaking. The experiment is then carried out as in Example 1. Examination of the block shows a uniformly coated tenaciously-adhering layer of nickel powder on polyurethane which resists washing.

In the same manner as illustrated above, particulate materials such as titanium dioxide, iron, kieselguhr, alumina, aluminium powder and leaf, and various metal oxides producing especially suitable properties were produced. These products have a tenaciously attaching bond between the particulate material and substrate with the material coating each strand and nexus.

WHAT WE CLAIM IS:—

1. A process for tenaciously depositing a solid particulate material on an organic, polymeric foam material which is or is capable of being reticulated, the particulate material having a decomposition temperature or melting point equal to or greater than said organic foam material, which comprises intimately dispersing said particulate material throughout the organic foam material, the particulate material having a particle size no greater than the average thickness of the strands of the foam material in its reticulated form, subjecting all the organic material coated with said particulate material to an explosive flame front, and, if desired, repeating said steps.

2. A process according to claim 1, wherein said explosive flame front is created by permeating said reticulated foam material with an explodable fuel gas containing an explosion-sustaining amount of oxygen and igniting the gas.

3. A process according to claim 1 or 2, wherein said explosive flame front is created by permeating said reticulated foam material with a liquid which vaporizes to form an explodable gas, and an explosion-sustaining amount of oxygen, evaporating the liquid and distributing the vapor of said liquid within the foam material, and thereafter igniting said vapor.

4. A process according to any one of claims 1 to 3, in which the solid particulate material is inorganic material.

5. A process according to any one of the preceding claims, wherein the solid particulate material is at least one metal powder.

6. A process according to any one of the preceding claims, wherein the solid particulate material is a mixture of nickel and iron powder.

7. A process according to any one of claims 1 to 4, wherein the said particulate materials is graphite.

8. A process according to any one of claims 1 to 4, wherein the particulate material is titanium dioxide.



9. A process according to any one of the preceding claims, wherein the particle size of the solid particulate material is less than 1/4 of the thickness of the average organic material strand.

10. A process according to any one of the preceding claims, wherein the foam material is polyurethane.

11. A process according to any one of the claims 1 to 9, wherein the foam material is polyvinyl chloride.

12. A process according to any one of the claims 1 to 9, wherein the foam material is polyethylene covered polyurethane.

13. A process according to any one of the preceding claims, wherein the foam material has a pore size from 5 to 80 ppi, preferably from 5 to 45 ppi.

14. A process according to any one of the claims 1 to 4, wherein the primary deposition of the particulate material is effected by means of first wetting the foam material with water and then dispersing the particulate material throughout the moistened foam material.

15. A reticulated adipate polyester poly-

urethane foam having 12 ppi and an electrical resistance of 10^{12} to 10^{14} ohms/cc having a tenacious coating of solid graphite and exhibiting a resistance of about 20×10^8 ohms/cc.

16. A reticulated foam according to claim 15, having a tenacious coating of graphite amounting to 76% by weight compared to the reticulated foam.

17. A process for tenaciously depositing a solid particulate material on a reticulated organic, polymeric foam material substantially as hereinbefore described.

18. A reticulated organic, polymeric foam material having on its surface a coating of solid particulate material whenever produced by the process of any of claims 1 to 14 and 17.

19. A reticulated adipate polyester polyurethane foam coated by a process substantially as hereinbefore described.

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