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⑤④ **Improved dunnage material.**

⑤⑦ Expanded, resilient, thermoplastic dunnage particles are rendered more effective by coating the outer surface of the particles with an additive which increases the coefficient of friction of that outer surface. The additive also promotes at least a minimum amount of adhesion between the dunnage particles.

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0162306

IMPROVED DUNNAGE MATERIAL

This invention relates generally to an improved dunnage material, preparation of such dunnage material and use of such dunnage material.

Dunnage materials such as foamed plastic
5 particles or strands are known to be highly desirable
for use in packaging articles. The foamed particles or
strands protect articles in shipping by absorbing shock
and by isolation of the articles from shipping container
walls. Typical particles or strands are set forth in
10 U.S. Patents 3,188,264 and 3,723,240.

Dunnage materials are usually placed beneath,
around the sides of, and atop articles being packaged
in order to isolate the articles from container walls.
Packaging relatively light articles in this manner is
15 generally effective. Packaging delicate but relatively
heavy articles, such as electronic or optical equipment,
in this manner is less effective.

It has been found that relatively heavy articles tend to settle and migrate, or move through, the dunnage materials due to vibration or handling. For example, in shipments in a truck, van, or rail car, migration of these heavy articles frequently continues until contact is made with a shipping container wall and breakage or other damage occurs. Breakage from this and other causes may be as much as fifteen percent, or even higher, especially where prolonged shipment or handling is involved.

A number of attempts have been made to reduce migration through dunnage materials.

Landen, in U.S. Patent 3,292,859 discloses the use of very small, expanded dunnage particles having a surface coating of an adhesive or sticky material.

Holden, in U.S. Patent 3,188,264, discloses particles having a number of concave surface indentations to promote interlocking between particles.

Skochdopole et al., in U.S. Patent 3,723,240, discloses asymmetrically foamable strands which curl upon foaming to form a generally helical structure. The helical structures interlock to a degree when placed under pressure.

Humbert et al., in U.S. Patent 3,251,728, disclose a dunnage material consisting essentially of a tangled interlocking mass of non-linear, elongated pieces of foamed polymer.

0162306

Graham, in U.S. Patent 3,047,136, discloses a dunnage material which consists of a plurality of strings of hollow crushable cylinders, each of the strings being partially cut through at spaced intervals.

- 5 A resilient or rubbery outer coating may be applied to the strings to reduce sliding of the strings relative to each other as well as to supplement interlocking between the strings.

- 10 In one aspect the present invention is an improved packing material comprising a plurality of expanded, resilient, thermoplastic, synthetic resinous dunnage particles, which particles comprise a friction enhancing amount of a friction enhancing additive deposited on at least a major portion of an outer
- 15 surface area of a majority of said dunnage particles which additive results in the packing material having improved cushioning properties and reduces the tendency of articles to migrate through the dunnage particles, wherein the improvement comprises the use of particles
- 20 which have an average maximum cross-sectional dimension of at least 1.27 centimeters (0.5 inch).

- In a related aspect, the present invention is an improved method for preparing packing material in the form of foamed dunnage particles, the method
- 25 comprising: providing a plurality of foamed particles and applying a friction enhancing amount of a friction enhancing additive to at least a portion of an outer surface area of a majority of said foamed particles wherein the improvement comprises providing particles
- 30 which have an average maximum cross-sectional dimension of at least 1.27 centimeters.

0162306

In another related aspect, the present invention is the use of the improved packing material of Claim 1 in a method for packaging an article comprising:

- 5 (a) providing a packaging container, the container having at least one wall, a top and a bottom, the container also being of sufficient size to contain (1) at least one article to be packaged and (2) an amount of packing material particles sufficient to space the article from the wall, the top and the bottom
10 of the container;
- (b) adding a quantity of improved packing material particles to the packaging container, the quantity being sufficient to provide a layer of adequate thickness to space the article to be packaged from the
15 bottom of the container;
- (c) placing the article to be packaged on the layer of packing material particles;
- (d) adding a further quantity of improved packing material particles to the packaging container,
20 the further quantity being placed about the sides, within and on top of the article to space it from the walls and the top of container and from other articles, the further quantity being sufficient to provide a slight overfill of the packaging container;
- 25 (e) closing the packaging container to slightly compact the particles by pushing down on the overfill.

One modification is to add a step where a first deformable sheet of material is placed over the
30 layer of dunnage particles added to the container, and a second deformable sheet of material is placed over the article to be packaged. When placed under a compressive force, the first and second deformable sheets will generally deform so that portions of the second deformable

0162306

sheet come in contact with portions of the first deformable sheet thereby creating an envelope around the article.

A second modification is to wrap at least one deformable sheet of material around the article before it is placed on the layer of dunnage particles.

5 The improved packing material can also be used advantageously when the article to be packaged is placed in contact with a wall, top or bottom of the container. Dunnage particles suitable for use in the present invention are readily prepared from a wide variety of synthetic, resinous, thermoplastic polymers.

10 One group of suitable thermoplastic polymers includes polymers which comprise, in chemically combined form, at least seventy (70) percent by weight of at least one alkenyl aromatic compound. Such compounds have the general formula



wherein Ar represents an aromatic hydrocarbon or a ring-substituted halohydrocarbon radical of the benzene series, and R is hydrogen or a methyl radical. Examples
20 of such alkenyl aromatic polymers are homopolymers of styrene, alpha-methylstyrene, ortho-, meta-, and para-methylstyrene, Ar-ethylstyrene, tertiary-butylstyrene and Ar-chlorostyrene; the copolymers of two or more of such alkenyl aromatic compounds with one another;
25 and copolymers of one or more of such alkenyl aromatic compounds with minor amounts of other readily polymerizable olefinic compounds such as divinylbenzene, methylmethacrylate, or acrylonitrile.

0162306

A second group of suitable thermoplastic polymers which are suitable for preparing expanded dunnage particles includes aliphatic olefin polymers which are normally solid polymers obtained by polymerizing
5 at least one alpha-mono-olefinic aliphatic hydrocarbon containing from 2 to 8 carbon atoms per molecule. Illustrative hydrocarbons include ethylene, propylene, butene-1, pentene-1, 3-methylbutene-1, 4-methylpentene-1, 4-methylhexene-1, and 5-methylhexene-1. The hydrocarbons
10 may be polymerized alone, with one another, or with various other polymerizable compounds. The polymers of ethylene or propylene alone are desirable because they produce tough, resilient, fine-celled, chemically inert products.

15 Examples of suitable polymerizable organic compounds which can be polymerized with ethylene or propylene are vinyl acetate; C_1-C_4 alkyl acrylates, such as ethyl acrylate; styrene; lower alkyl esters of methacrylic acid, such as methylmethacrylate; tetra-
20 fluoroethylene; and acrylonitrile.

Copolymers containing, in chemically combined form, 75 percent by weight or more of ethylene or propylene with not more than 25 percent of one or more of such other polymerizable organic compounds also
25 produce suitable results.

The aliphatic olefin polymers can be modified by blending with polymeric materials. Illustrative polymeric materials include polyisobutylene, acrylonitrile/butadiene rubbers, poly(2-chlorobutadiene-1,3),
30 polyisoprene, ethylene/acrylic acid copolymers and ethylene/vinylacetate copolymers.

A third group of suitable thermoplastic polymers suitable for preparation of expanded dunnage particles includes halogenated aliphatic olefin polymers, as well as polymers of a wide variety of ethylenically unsaturated monomers which produce foamable thermoplastic compositions. Illustrative polymers include those prepared by polymerizing isopropenyl toluene; vinyl naphthalene; esters of alpha-methylene aliphatic monocarboxylic acids, such as methyl acrylate, ethyl acrylate, n-butyl acrylate, isobutyl acrylate, dodecyl acrylate, 2-chloroethyl acrylate, 2-chloropropoyl acrylate, 2,2'-dichloroisopropyl acrylate, phenyl acrylate, cyclohexyl acrylate, methyl alpha-chloroacrylate, methacrylate, ethylmethacrylate and methyl-ethacrylate; nitriles such as acrylonitrile and methacrylonitrile; vinyl esters such as vinyl acetate, vinyl chloroacetate, vinyl propionate, vinyl butyrate, vinyl laurate and vinyl stearate; vinyl ethers such as vinyl methyl ethers, vinyl isobutyl ethers and vinyl 2-chloroethyl ether; vinyl ketone; methyl isopropenyl ketone; isobutylene; vinylidene halides, such as vinylidene chloride and vinylidene chlorofluoride; N-vinyl compounds such as N-vinyl pyrrole, N-vinyl carbazole, N-vinyl indole, N-vinyl succinimide, acrolein, methacryolein, acrylamide, methacrylamide and N-methylol acrylamide; and allyl compounds such as allyl alcohol, methallyl alcohol, allyl acetate, allyl methacrylate, allyl lactate, allyl alpha-hydroxyisobutyrate, allyl trichlorosilane, allyl acrylate and methallyl phosphate.

Foamable compositions of polymers are readily prepared by incorporating therein a gas, a volatile liquid, a solid gas-releasing blowing agent or a combination of two or more of these which cause expansion of the polymeric material on heating.

0162306

In order to obtain improved cushioning according to the present invention, it is desirable to use expanded dunnage particles which have an average maximum cross-sectional dimension of at least 1.27 centimeters (0.5 inch).
5 Preferably, the particles have an average minimum cross-sectional dimension of at least 1.27 centimeters.

In one method for preparing the improved packing material, a heat plastified mass of synthetic resinous material is provided in a first step. The
10 heat plastified mass contains an expanding agent. The mass is capable of expansion to form a plurality of closed, gas-filled cells. In a second step, the heat plastified mass is put and maintained under pressure. In a third step, the heat plastified mass is cooled to
15 a temperature which is less than a temperature at which the heat plastified mass would foam under a reduced pressure. In this step, a cooled heat plastified mass is obtained. In a fourth step, the cooled heat plastified mass is extruded, without significant foaming, from a
20 shaping configuration to form elongate strands. In a fifth step, the elongate strands are severed to form a plurality of foamable elements of relatively high bulk density. As an alternative, a die face cutter or similar apparatus could be used to pelletize the cooled
25 heat plastified mass as it is extruded. In a sixth step, the foamable elements, or pellets, are heated to an elevated temperature. The elevated temperature is sufficient to cause the elements to expand and thereby form foamed particles having a plurality of gas-filled
30 cells therein. In a seventh step, a friction enhancing amount of an additive is applied to at least a portion of the outer surface area of a majority of the foamed particles.

0162306

The friction-enhancing additive is suitably any material which meets three criteria. First, it must be capable of being deposited on the outer surface area of the dunnage particles. Second, it must remain
5 on the outer surface area of the dunnage particles for a useful length of time. The useful length of time is that which is sufficient to allow one or more articles to be (a) packaged with the dunnage particles, (b) shipped or transported to a desired destination,
10 with or without intermediate periods of storage, and (c) unpackaged, again with or without intermediate periods of storage. Third, the additive must impart to the outer surface area of the dunnage particles an increased coefficient of friction. Preferably, the
15 additive promotes at least a minimum amount of adhesion between the dunnage particles.

In order to determine whether an additive meets the aforementioned criteria, a modified peel test was developed. The results of the peel test were
20 compared with results of a vibrational settling test to establish a correlation between the tests. The tests are set forth in hereinafter.

Materials which meet the aforementioned criteria include synthetic polymer latexes, pressure
25 sensitive adhesives and glues, low molecular weight polymers, waxes, contact cements, starch-derived adhesives, urethane adhesives and protein-derived adhesives.

Low molecular weight polymers, as used herein,
30 are those polymers which have a ring and ball softening point of greater than about 30° Centigrade, preferably

0162306

greater than about 50° Centigrade. Ring and ball softening points are determined in accordance with American Society for Testing and Materials Test E-28.

5 Starch-derived adhesives include pastes, such as wheat paste, dextrans, borated dextrans, jelly gums and the like. Suitable starches are those represented by the formula $(C_6H_{10}O_5)_n$ where $n = 1$ to about 1,000,000.

Protein derived adhesives include animal glue, casein and the like.

10 Useful synthetic polymer latexes are those which meet the aforementioned criteria and which are aqueous colloidal suspensions of particles of a polymer obtained by emulsion polymerization. The colloidal
15 suspensions are generally stabilized by addition of one or more suitable surface active agents.

Suitable latexes include those based on, for example, styrene-butadiene copolymers, acrylic copolymers, butadiene acrylonitrile polymers, vinylidene chloride copolymers, vinyl chloride copolymers and copolymers of
20 vinyl alkanoates, such as vinyl acetate.

Beneficial results are obtained when the polymer latex contains a carboxyl functionality. A suitable level of carboxyl functionality is from 0.01 to 25 percent by weight of polymer. The carboxyl
25 functionality is obtained by including one or more alpha,beta-olefinically unsaturated carboxylic acid monomers with other polymerizable monomers to be used in preparing the aforementioned latexes.

0162306

Suitable carboxylic acid monomers contain from three to twelve carbon atoms per molecule. Such acid monomers include acrylic acid, methacrylic acid, ethacrylic acid, alpha-chloroacrylic acid, alpha-
5 -cyanoacrylic acid, crotonic acid, beta-acryloxypropionic acid, hydrosorbic acid, sorbic acid, alpha-chlorosorbic acid, cinnamic acid, beta-styrylacrylic acid, itaconic acid, citraconic acid, maleic acid, fumaric acid, mesaconic acid and aconitic acid. Beneficial results
10 are obtained with carboxylic acid monomers containing from three to six carbon atoms per molecule such as acrylic acid and methacrylic acid.

Satisfactory results are obtained when the additive is a latex of a styrene-butadiene copolymer
15 which has a carboxyl functionality. Such copolymers typically have polymerized therein (a) styrene in an amount of from 40 to 70 percent by weight of copolymer, (b) butadiene in an amount of from 15 to 40 percent by weight of copolymer, and (c) carboxylic acid monomer(s)
20 in an amount of from 0.1 to 20 percent by weight of copolymer.

Acrylic copolymers typically have polymerized therein (a) one or more alkyl acrylates which contain from one to eighteen carbon atoms per alkyl moiety and
25 (b) one or more monomers which are copolymerizable therewith. The alkyl acrylates beneficially have from four to ten carbon atoms per alkyl moiety. Illustrative alkyl acrylates include butyl acrylate, amyl acrylate, hexyl acrylate, heptyl acrylate, octyl acrylate, nonyl
30 acrylate, decyl acrylate and various isomers of these acrylates such as isooctyl acrylate and 2-ethylhexyl acrylate.

Satisfactory results are obtained when the additive is an acrylic copolymer or interpolymer which has polymerized therein (a) from 40 to 80 percent by weight of polymer of at least one alkyl acrylate and
5 (b) from 20 to 60 percent by weight of polymer of at least one ethylenically unsaturated monomer which is copolymerizable therewith.

Illustrative copolymerizable ethylenically unsaturated monomers include alpha-olefins containing
10 from 2 to 10 carbon atoms; vinyl esters of alkanolic acids containing 3 to 10 carbon atoms, such as vinyl acetate and vinyl octoate; ethyl and methyl esters of methacrylic acid; styrene; and vinyl chloride.

Vinyl chloride latexes which contain either
15 vinyl chloride homopolymer or interpolymers of vinyl chloride also provide satisfactory results. Vinyl chloride interpolymers typically have polymerized therein from 50 to 97 percent by weight of polymer of vinyl chloride and from 3 to 50 percent by weight of
20 polymer of at least one ethylenically unsaturated monomer which is copolymerizable therewith. Illustrative copolymerizable monomers include the alkyl acrylates hereinabove specified, the vinyl esters of alkanolic acids hereinabove specified, alkyl esters of methacrylic
25 acid containing from one to four carbon atoms per alkyl moiety, and vinylidene chloride.

Latexes are generally prepared by emulsion polymerization using anionic or nonionic surfactants or mixtures thereof. Suitable anionic surfactants include
30 sodium dioctyl sulfosuccinate, sodium diamyl sulfosuccinate, sodium dihexyl sulfosuccinate, sodium lauryl

0162306

sulfate, and sodium dodecyl benzene sulfonate. The nonionic surfactants which may be considered exemplary include nonyl or octyl phenoxy polyethoxyethanol condensates wherein the ethylene oxide content may vary from 5 to 50 moles. Conventionally, two or more of these nonionic surfactants may be employed. Latex preparation is achieved using conventional polymerization methods.

Polymer latexes containing up to about 60 percent by weight total polymer solids may be conveniently sprayed. For optimum results, solids concentrations of 35 to 55 percent are preferred.

Any spraying method capable of atomizing the additive may be employed. Accordingly, the particular method of spraying is not critical to production of the improved dunnage particles of the present invention. Thus, air, airless or aerosol systems may be employed. Low fluid delivery rates and low atomization pressures are advisable since these will minimize overspray and misting of the adhesive into the surrounding atmosphere. The fluid delivery system most suitable is an airless sprayer with a pneumatic pump. Other suitable spraying equipment includes a pressurized vessel in combination with conventional air spray equipment and peristaltic action pumps.

The additive to be sprayed is generally delivered into the spray equipment at a rate of 50 to 500 wet grams per minute, preferably 100 to 400 wet grams/minute. The amount of atomization pressure required will be proportionate to the adhesive delivery rate and will typically range from 35 to 550, preferably 70 to 550 kilopascals (kPa).

Application of additive to foamed dunnage particles is not limited to spray equipment and methods using such spray equipment. Accordingly, additives may be applied by brush, by roller or by any other means so long as a sufficient quantity of additive is applied to the dunnage particles.

The improved dunnage particles, if prepared and dried in advance of packaging, may be readied for use simply by applying a light water mist or steam spray to the surface thereof. The mist or spray may be applied to the improved dunnage particles prior to, simultaneously with, or subsequent to addition to a packaging container. If the improved dunnage particles have clumped together, as is the case where the improved dunnage particles are being re-used, the mist or spray beneficially wets the additive sufficiently to allow the improved dunnage particles to separate into individual particles or small, but useable, clumps.

The additive is acceptable if it provides, under the modified peel test hereinafter described, a peel strength of at least 1.5 grams per centimeter. The additive beneficially provides a peel strength of greater than 9 grams per centimeter. The additive desirably provides a peel strength of greater than 40 grams per centimeter. The additive preferably provides a peel strength of 150 grams per centimeter. Greater peel strength is acceptable but is not necessary.

Another way of determining whether or not an additive is acceptable is to determine an overall settling value under the modified vibrational settling test hereinafter described. The overall settling

0162306

value is suitably less than 65, beneficially less than 45, desirably less than 30 and preferably less than 25.

The peel strengths and overall settling values specified hereinabove are readily obtained with an amount of additive of from 1400 to 6000 grams of wet additive per cubic meter of foamed dunnage material. Beneficial results are obtained with an amount of additive of from 1600 to 3400 grams of wet additive per cubic meter of foamed dunnage material.

Amounts of additive in excess of 6000 grams of wet additive per cubic meter of dunnage material will satisfactorily modify the coefficient of friction of the foamed dunnage material. In other words, amounts of wet additive of up to 10,000 and more grams of wet additive per cubic meter of dunnage can be used according to the present invention. Such amounts are, however, excessive and may be undesirable for several reasons - such as cost effectiveness, uneconomical drying rates and damage to the article(s) being packaged.

Amounts of additive of less than 1400 grams of wet additive per cubic meter of foamed dunnage material are generally unsatisfactory because they do not provide sufficient coverage of the foamed dunnage material.

One advantage of the improved dunnage particles of the present invention is that they provide lower vibrational settling values than conventional dunnage particles. In other words, migration of articles through the improved dunnage particles is less likely than with conventional dunnage particles.

A second advantage is that the improved dunnage particles, when used in packaging, provide reproducible cushioning properties. Conventional dunnage particles provide erratic
5 cushioning properties. Reproducibility is highly desirable in the area of package design.

A third advantage is that the improved dunnage particles of the present invention tend to stick together until pulled apart, particularly when the additive is
10 an adhesive, a glue, a contact cement and the like. Conventional dunnage particles have no tendency to stick together and are known to spill over the edge of the package and to scatter over the surface upon which the package is resting. Picking up the scattered
15 dunnage particles is time consuming and bothersome. The improved dunnage particles will, depending upon the amount of additive, be removed from the package either as several small clumps of particles or as a few large masses of particles.

A fourth advantage is that by varying the
20 amount of additive applied to the improved dunnage particles, a broad spectrum of package properties can be attained. In other words, it is possible to tailor the improved dunnage particles to meet a specific need.
25 With conventional dunnage particles, there is a very narrow spectrum of package properties.

These advantages are attained with relatively low levels of additive. Application of the additive to the dunnage particles is neither complicated nor expensive.
30 At low levels of additive, drying time is short thereby providing minimal interference with normal package handling procedures.

0162306

Modified Peel Test

General purpose polystyrene film having one side surface sulfonated was used for the peel test. The film had a thickness of 6.35 micrometers and was commercially available from The Dow Chemical Company under the trade designation Trycite® 1101. Samples having a size of 2.54 centimeters in width and 33 centimeters in length were cut from the film so that the latter dimension was in the machine direction.

10 The samples were prepared for peel testing in the following manner. Using a #10 Meyer rod, one end of the sulfonated side of the film sample was coated for a distance of about ten centimeters with the additive to be tested. The film sample was then folded over so
15 that an equal distance of sulfonated surface from the other end of the sample was in intimate contact with the coated portion. The film samples were then placed in a dessicator and aged for a period of 72 hours. The dessicator had a relative humidity of from 17 to 20
20 percent and a set temperature of from 21° to 24° Centigrade.

After aging, the samples were removed from the dessicator. The samples had a bonded end and a loop end. The loop end was then cut to yield two free
25 ends of approximately equal length. The free ends had no additive coated thereon.

An Instron Universal Testing Machine, Model Number 1123 was used to determine peel strength. The Instron testing machine had two sets of jaws which were
30 spaced apart and opposite each other. One set of jaws was stationary and affixed to the machine. The other

0162306

set of jaws was attached to a load cell which in turn was attached to the mobile crosshead of the machine.

The free ends of the samples were placed into the two sets of jaws. One free end was clamped by the stationary set of jaws. A second free end was clamped by the set of jaws attached to the load cell. The crosshead of the machine was actuated so as to move the set of jaws attached to the load cell away from the stationary set of jaws at a speed of either 200 or 254 millimeters per minute. The crosshead speed had no effect upon peel strength. The samples were pulled apart until they separated along their entire length. The load cell registered the peel strength for the sample.

15 Vibrational Settling Test

The purpose of this test was to determine whether an article packaged in dunnage material moved due to vibration and, if so, how much. The test was a modified version of the vibrational settling test described in United States Federal Specification PPP-C-1683, Section 4.9 for expanded polystyrene loose-fill cushioning material.

About 57,000 cubic centimeters of dunnage material were placed in an open-topped box. The box measured 100 centimeters in length by 60 centimeters in width by 60 centimeters in height. A 0.635 centimeter mesh screen was placed over the opening in the box.

A Craftsman Model 919.1561410 spray gun, having a capability for either internal or external fluid to air mixing and being commercially available

0162306

from Sears, Roebuck and Co., was used to spray an admixture of a dye and the additive to be tested for friction enhancement down through the screen onto the dunnage material. The dye was used to provide a visual
5 indicator of coverage of the additive onto the dunnage material. The spray gun had a reservoir portion into which the admixture was placed for application thereof onto the dunnage material. The reservoir portion was
10 pressurized to a pressure of 275 kilopascals gauge in order to provide a consistent flow rate of about 0.11 liters of admixture per minute. The flow rate provided a force of spray sufficient to cause a mixing of the dunnage material with the box.

Spraying was continued until a visual inspection
15 tion of the dunnage material showed that a generally uniform coating of the admixture was deposited on the dunnage material.

The rate of spray, in terms of wet grams of additive per minute, varied with the additive being
20 applied. In other words, as density of the additive changed, the rate of spray also changed. By way of example only, an additive having a specific gravity of about 1.0 at a temperature of 24° Centigrade had, when applied using the aforementioned spray gun at a pressure
25 of 275 kilopascals gauge, a flow rate of from about 100 to about 140 wet grams of additive per minute for a nominal flow rate of 125 wet grams of additive per minute.

A cardboard test box having interior dimensions
30 30 centimeters by 30 centimeters by 30 centimeters was filled about halfway with the coated dunnage material.

0162306

A load box having exterior dimensions of 15 centimeters by 15 centimeters by 15 centimeters and weighing either 2.4 or 7.3 kilograms was placed into the test box in such a manner as to yield a 7.6 centimeter (± 2.54 centimeter) gap between the top of the load box and the top of the test box. The 2.4 kilogram load box was used to supply 1035 Newtons per square meter loading. The 7.3 kilograms load box was used to supply a 3105 Newtons per square meter loading.

10 An additional amount of coated dunnage material was added to the test box to fill it even with the top of the test box. Consistent with recommended packaging guidelines for expanded, thermoplastic loose-fill dunnage materials, the test box was then overfilled with a pyramid or crown of the coated dunnage material. The crown had a depth of about 2.54 centimeter, the depth being measured from the top of the test box to the top of the crown. The lid of the box was then closed and taped shut with fiberglass reinforced tape.

20 After being closed, the test boxes and their contents were allowed to dry at a temperature of $21^{\circ} \pm 9^{\circ}$ Centigrade for a period of about sixteen hours. No specific control of humidity or of temperature was attempted during drying.

25 A small hole, measuring 0.356 centimeters in diameter, was made in the center of the top of the test box.

30 A stiff piece of stainless steel wire also 0.356 centimeters in diameter, was inserted into the hole and thereafter pushed through the dunnage material

0162306

until it contacted the top of the load box. The length of wire between the top of the test box and the top of the load box was measured and recorded as "initial displacement".

5 The test box and its contents were placed on
a table capable of vibrating at a frequency of 4.5
Hertz with a vertical displacement of 2.54 centimeters.
The table was designated as an MTS Series 840 Servo-
hydraulic Vibration Test System and was commercially
10 available from MTS Systems Corporation.

The table had a square sample receiving surface which measured 90 centimeters on a side. An internally screw threaded aperture having a diameter of 0.953 centimeter had been machined into the sample
15 receiving surface at each corner thereof. An externally screw threaded rod was threadably engaged with each of the threaded apertures. Four rubber strips measuring 66 centimeters long by 1.91 centimeters wide by 0.64 centimeter thick and having hooks attached to each end thereof
20 were connected between adjacent screw threaded rods so as to form a peripheral boundary around the table. The four rubber strips, also known as boundary strips, were spaced above the table surface a distance of about 13 centimeters. Two additional rubber strips, identical
25 to the other rubber strips were connected between opposing boundary strips so as to divide the sample receiving surface into four equal square sample holding areas.

Four test boxes, prepared as hereinbefore described and of approximately equal weight, were
30 placed on the sample receiving surface. One of the test boxes was placed within each of the sample holding

0162306

areas. The test boxes were not secured to the table in keeping with the guidance set forth in United States Federal Specification PPP-C-1683, Section 4.9. The test boxes had to be approximately equal in weight in order to maintain a balanced load on the table.

After the four test boxes were placed on their respective sample holding areas, the table was actuated. After a period of thirty minutes, the table was stopped. The same stiff piece of wire was inserted through the hole once again until it touched the top of the load box. The length of wire between the top of the test box and the top of the load box was measured and recorded as "final displacement".

Any increase in length from initial displacement to final displacement was converted to a percentage and recorded as "percent settling".

It was found that percent settling values at the 3105 Newtons per square meter loading (7.3 kilograms load box) were much larger than those at the 1035 Newtons per square meter loading (2.4 kilogram load box). In order to develop a meaningful pass-fail evaluation, a total settling value was calculated. The total settling value was determined by multiplying the settling value at the 1035 Newtons per square meter loading by a factor of 6.71 to obtain a product and then adding the product to the settling value at the 3105 Newtons per square meter loading.

The following experiment is for purposes of illustration only and is not to be construed as limiting the scope of the present invention.

A number of additives were evaluated for suitability using the "Peel Test" and the "Vibrational Settling Test" set forth hereinabove. Table I contains a description of the additives together with an
5 abbreviated code for such additives. Table II contains peel test data and vibrational settling test data for each of the additives and for a control to which no additive had been applied. The dunnage material used in the vibrational settling tests was an expanded
10 polystyrene particulate material commercially available under the trade designation Pelaspan-PacTM from The Dow Chemical Company, the particles having an average minimum cross-sectional dimension of about 1.27 centimeters (0.5 inch) and an average maximum cross-
15 -sectional dimension of about 2.86 centimeters (1.125 inch).

0162306

TABLE I

Additive Identification

	<u>Code</u>	<u>Description of Additive Tested</u>
	A1*	Fumed silica
5	A2*	Ground pepper
10	A3	A carboxylated styrene butadiene copolymer latex, the copolymer having polymerized therein styrene in an amount of 48 percent by weight of polymer, and butadiene in an amount of 50 percent by weight of copolymer, and fumaric acid in an amount of 2 percent by weight of polymer. The latex had a nominal particle size range of from about 0.16 to about 0.2 μ m, a specific gravity of 1.02 and a solids content of from about 47 to about 49 percent. The latex was available from The Dow Chemical Company under the trade designation XD-30586.20.

25 * Experimentally determined not to be a friction-enhancing additive for the purposes of the present invention.

0162306

TABLE I Continued

	<u>Code</u>	<u>Description of Additive Tested</u>
	A4	A vinylidene chloride polymer latex, the polymer having
5		polymerized therein
		(a) vinylidene chloride in an
		amount of 82 percent by weight
		of polymer, (b) methyl acrylate
10		in an amount of 18 percent by
		weight of polymer, (c) acrylic
		acid in an amount of 4 parts
		per 100 parts of (a) and (b),
		and (d) 0.5 parts of sodium
15		sulfoethyl methacrylate per
		100 parts of (a) and (b).
		The latex had a particle size
		of from about 0.1 to about
		0.14 μm , a viscosity, measured
		at 25° Centigrade using a
20		Brookfield viscometer with a
		number one spindle and a rotor
		speed of 60 revolutions per
		minute, of less than about
		1.5 pascal second (Pa·s) a
25		solids content of from about
		48 to about 50 percent, and a
		surface tension of from 0.045
		to about 0.055 newtons per
		meter (N/m). The latex was
30		available from The Dow Chemical
		Company under the trade designa-
		tion XD-30452.22.

0162306

TABLE I Continued

	<u>Code</u>	<u>Description of Additive Tested</u>
5	A5	A self cross-linking polyvinyl acetate homopolymer latex having a nominal particle size of 0.7 μm , a pH of 3.0, a specific gravity of 1.08, a viscosity, measured at 25° Centigrade using a Brookfield viscometer with a number one spindle and a rotor speed of 60 revolutions per minute, of 0.06 Pa·s, and a surface tension of about 0.041 N/m.
10		
15		The latex was commercially available from Borden Chemical under the trade designation POLYCO® 2136.
20	A6*	A vinyl chloride homopolymer latex having a nominal particle size of 0.16 μm , a pH of 9.5, a specific gravity of 1.18, a viscosity, measured at 25° Centigrade using a Brookfield viscometer with a number one spindle and a rotor speed of 60 revolutions per minute, of 0.03 Pa·s, and a surface
25		

30 * Experimentally determined not to be a friction-enhancing additive for the purposes of the present invention.

0162306

TABLE I Continued

<u>Code</u>	<u>Description of Additive Tested</u>
5	tension of 0.04 N/m. The latex was commercially available from Borden Chemical under the trade designation POLYCO® 2622.
A7	A small particle size paint pigment latex containing a styrene copolymer and having a nominal particle size of 0.13 μm a nominal weight average molecular weight of 100,000 grams per mole, a solids content of 45 to 50 percent, and a specific gravity of 1.05 (at a temperature of 25° Centigrade). The copolymer had polymerized therein about 99.2 parts of styrene and about 0.8 parts of itaconic acid. The latex was commercially available from The Dow Chemical Company under the trade designation DPP 788.
10	
15	
20	
25	
A8	A large particle size paint pigment latex containing a styrene copolymer and having a nominal particle size of 0.35 μm , a nominal weight average molecular weight of
30	

0162306

TABLE I Continued

<u>Code</u>	<u>Description of Additive Tested</u>
5	350,000 grams per mole, a solids content of 45 to 50 percent, and a specific gravity of 1.05. The copolymer had polymerized therein about 97 parts of styrene and about 3 parts of acrylic acid. The
10	latex was commercially available from The Dow Chemical Company under the trade designation DPP 722.
15	A9 A vinylidene chloride polymer latex, the polymer having polymerized therein
20	(a) vinylidene chloride in an amount of about 90 percent by weight of polymer, (b) acrylonitrile in an amount of about 5 percent by weight of polymer, (c) butyl acrylate in an
25	amount of about 5 percent by weight of polymer, and (d) 1.4 parts of sodium sulfoethyl methacrylate per 100 parts of
30	(a) plus (b) plus (c). The latex had a particle size of from about 0.1 μm to about 0.13 μm , a viscosity, measured at 25° Centigrade using a Brookfield viscometer with a

0162306

TABLE I Continued

	<u>Code</u>	<u>Description of Additive Tested</u>
5		number one spindle and a rotor speed of 60 revolutions per minute, of less than 0.05 Pa·s, a solids content of from about 53 to 55 percent, and a surface tension of from about 0.06 to about 0.073 N/m. The
10		latex was commercially available from The Dow Chemical Company under the trade designation SL143.
15	A10	A styrene copolymer latex having a nominal particle size of 0.03 μ m, a nominal weight average molecular weight of 500,000 grams per mole, a
20		solids content of 35 to 40 percent and a specific gravity of 1.05. The copolymer had
25		polymerized therein styrene in an amount of 96 parts by weight and acrylic acid in an amount of 4 parts by weight, both amounts being based upon
30		copolymer weight. The latex was available from The Dow Chemical Company under the trade designation XD 8510.

0162306

TABLE I Continued

<u>Code</u>	<u>Description of Additive Tested</u>
A11	A wallpaper wheat paste prepared by dispersing wheat flour in water, the paste containing 18 percent by weight of wheat flour. The wheat flour, which was prepared by grinding hard winter wheat, contained a non-toxic vermicide. The wallpaper paste was commercially available under the trade designation wallpaper wheat paste item #61102 from Bondex International, Inc.
A12	A urethane laminating adhesive which contained (a) about 55 weight percent of an isocyanate terminated prepolymer, (b) about 32 weight percent methylene chloride, (c) about 5 weight percent of toluene, (d) about 5 percent ethyl acetate, and (e) about 2.5 weight percent free diphenylmethane diisocyanate, all percentages being based upon weight of adhesive. The adhesive had a solids content of 58± 1 percent and a specific gravity of 1.13. The adhesive was commercially available

0162306

TABLE I Continued

	<u>Code</u>	<u>Description of Additive Tested</u>
5		under the trade designation Mor-Ad 337 from Morton Chemical Company.
10	A13	A carboxylated styrene butadiene copolymer latex, the copolymer having polymerized therein styrene in an amount of 42 percent by weight of copolymer, butadiene in an amount of 55 percent by weight of copolymer and itaconic acid in an amount of 3 percent by weight of co- polymer. The latex had a nominal particle size of from about 0.14 to about 0.18 μ m, a specific gravity of 1.01 and a solids content of from about 44 to about 47 percent. The latex was commercially available from The Dow Chemical Company under the trade designation DL-219A.

0162306

TABLE II

Test Data

5	Ex. No.	Additive	Peel Strength grams/ centimeter	Vibrational Settling Test		Overall Settling Value
				Percent 1035 New- tons per square meter	Settling 3105 New- tons per square meter	
10	1*	-	0	8	41	95
	2*	A1	0	40	70	338
	3*	A2	0	36	59	301
	4	A3	252	0	25	25
	5	A4	47	0	29	29
15	6	A5	1.57	3	37	57
	7*	A6	0.08	4	58	85
	8	A7	9.5	0	13	13
	9	A8	10	3	22	42
	10	A9	35	0	18	18
20	11	A10	4.7	3	43	63
	12	A11	35	0	17	17
	13	A12	175	0	17	17
	14	A13	190	0	24	24

* Comparative Experiment not representative of the
25 present invention.

From the data presented in Table II, it is
clear that a disparity exists among various additives.
Some, such as additives A3, A4, A7 through A9, A11, A12
and A13 markedly improve the overall settling value of
30 dunnage material. Others, such as additives A1 and A2,

0162306

actually promote settling as indicated by an increased overall settling value.

5 A reduction in the overall settling value is desirable because it indicates that the dunnage material will then be more effective in cushioning articles which are packaged therewith.

0162306

1. An improved packing material comprising a plurality of expanded, resilient, thermoplastic, synthetic resinous dunnage particles, which particles comprise a friction-enhancing amount of a friction-enhancing
5 additive deposited on at least a major portion of an outer surface area of a majority of said dunnage particles which additive results in the packing material having improved cushioning properties and reduces the tendency of articles to migrate through the dunnage particles,
10 wherein the improvement comprises the use of particles which have an average maximum cross-sectional dimension of at least 1.27 centimeters (0.5 inch).

2. The packing material of Claim 1 wherein the dunnage particles are formed from a synthetic resinous material, the resinous material being selected from the group consisting of (a) polymers which comprise,
5 in chemically combined form, at least about seventy percent by weight of at least one alkenyl aromatic compound; (b) aliphatic olefin polymers which are normally solid polymers obtained by polymerizing at least one alpha-mono-olefinic aliphatic hydrocarbon
10 containing from 2 to 8 carbon atoms per molecule; and (c) halogenated aliphatic olefin polymers.

01-62306

3. The packing material of Claim 1 wherein the friction-enhancing additive is selected from the group consisting of synthetic polymer latexes, pressure sensitive adhesives, glues, low molecular weight polymers, waxes, contact cements, urethane adhesives, starch derived adhesives and protein derived adhesives.

4. The packing material of Claim 3 wherein the additive is a synthetic polymer latex, the latex containing a polymer selected from the group consisting of styrene-butadiene copolymers, acrylic copolymers, butadiene-acrylonitrile copolymers, vinylidene chloride copolymers, vinyl chloride copolymers and vinyl alkanoate copolymers.

5. The packing material of Claim 3 wherein the polymer has polymerized therein styrene in an amount of from 40 to 70 percent by weight of polymer, butadiene in an amount of from 15 to 40 percent by weight of polymer and acrylic acid in an amount of from 0.1 to 20 percent by weight of polymer.

6. The packing material of Claim 1 wherein the amount of additive is from 1400 to 6000 grams of wet additive per cubic meter of expanded dunnage particles.

7. The packing material of Claim 3 wherein the additive provides a peel strength of greater than 1.5 grams per centimeter and an overall settling value of less than 65.

0162306

8. An improved method for preparing packing material in the form of foamed dunnage particles, the method comprising: providing a plurality of foamed particles and applying a friction-enhancing amount of a friction-enhancing additive to at least a portion of an outer surface area of a majority of said foamed particles wherein the improvement comprises providing particles which have an average maximum cross-sectional dimension of at least 1.27 centimeters.

9. The use of the improved packing material of Claim 1 in a method for packaging an article comprising:

(a) providing a packaging container, the container having at least one wall, a top and a bottom, the container also being of sufficient size to contain (1) at least one article to be packaged and (2) an amount of packing material particles sufficient to space the article from the wall, the top and the bottom of the container;

(b) adding a quantity of improved packing material particles to the packaging container, the quantity being sufficient to provide a layer of adequate thickness to space the article to be packaged from the bottom of the container;

(c) placing the article to be packaged on the layer of packing material particles;

(d) adding a further quantity of improved packing material particles to the packaging container, the further quantity being placed about the sides, within and on top of the article to space it from the walls and the top of container and from other articles, the further quantity being sufficient to provide a slight overfill of the packaging container;

0162306

25 (e) closing the packaging container to slightly compact the particles by pushing down on the overfill.

10. The method of Claim 9 comprising in step (c) placing a first deformable sheet of material over the quantity of dunnage particles; then placing the article to be packaged atop the first sheet of material;
5 and placing a second deformable sheet of material over the article to be packaged.