A cellulose mixture including a protein based adhesive binder and colorant. The mixture can be compression molded or extruded and upon curing in the presence of microwave or radio frequency energy or in a thermally controlled appliance, produces board or shape formed stock. The produced stock exhibits colorations and a grain pattern comparable to natural stone. Unlike stone, the material exhibits a light weight, low density, structural rigidity and ready machinability. A preferred method includes admixing separate, colorized batches of feedstock, each feedstock includes shredded waste newsprint, soybean flour, water and a colorant; reducing the moisture content of each feedstock or a proportioned admixture of several feedstocks, such as by air drying or compressing or performing the admixture in the presence of heat; compacting the admixture to final shape; and curing the shaped material. Final forming and finishing apparatus complete the process.
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BOARD STOCK AND METHOD OF MANUFACTURE FROM RECYCLED PAPER
BACKGROUND OF THE INVENTION

The present invention relates to byproducts of recycled paper and, in particular, to a molded stock formed from one or more relatively dry, colorized batches of admixture ingredient. Each batch ingredient includes a soybean derived adhesive binder, a separate colorant and other additives. Predetermined concentrations of the batch ingredients are combined and cured under pressure in the presence of microwave, radio frequency or thermal energy.

With growing concerns and pressures to find alternative uses for waste matter, various efforts have been directed to developing conversion processes for deriving usable products from recycled newsprint and other paper stocks. The majority of these efforts have been directed to producing building insulation materials in shredded form and in molded sheet form. Such sheet goods can comprise recycled paper or relatively more dense or thicker materials such as construction grade panel board or liana board. These processes may include the addition of various adhesives and additives, molding and curing steps.

Processes directed to the production of insulation materials can be found upon directing attention to U.S. Patent Nos. 4,184,311 and 4,300,322. The former patent discloses a molded insulation product laminated to an
outer covering. The latter discloses a dry shredded mixture which is injected into a batting envelope and which envelope can be mounted in conventional fashion. Sprayed processes also exist in which shredded newsprint particulate is mixed with water and sprayed into structural spaces, where the material hardens, after skimming away excess material. Australian application Serial No. 36603/84 entitled Improved Insulation Product also discloses a molded newsprint insulation. The material is principally air cured, although reference is made to microwave curing.

U.S. Patent No. 4,148,952 discloses a process for partially shredding and consolidating waste paper to facilitate transport. U.S. Patent Nos. 4,111,730 and 5,011,741, otherwise, disclose processes wherein a binder derived from a cooked starch and urea formaldehyde resin are added to slurries which are molded under pressure and cured to form uncolored board stocks. The former may also be used as a structural building member.

U.S. Patent Nos. 4,994,148 and 5,064,504 also disclose methods for creating molded structural blocks from a newsprint slurry which is formed in a screen wall molding chamber. A plaster or cement binder is also disclosed. Curing of the blocks is effected through air drying.

Various adhesive preparations, including soybean derived adhesives, for a broad range of laminate gluing
applications are also disclosed in the Handbook of Adhesives, Van Nostrand Rheinhold (1962).

Finished materials produced by the prior art, unless separately laminated with a decorative finish laminate, have uniformly demonstrated undesirable dull grey or matte grey colors without any distinctive or aesthetically appealing pattern.

Unknown in the prior art is a process utilizing unprocessed waste papers to form decorative, structurally stable building stocks having a natural stone appearance and which stocks can be molded or extruded as sheet goods or in a variety of shaped forms. Natural stone appearing stock requiring specific bulk color patterns and/or esthetically pleasing surface textures are especially unknown for use as finished surface treatments, such as for floors, walls, ceilings and furniture.

The lack of such a construction stocks is believed due to a variety of factors, including: (1) shredding and re-pulping of waste paper reduces the length of the cellulose fibers and thereby compromises the tear and shear strength of the finished material; (2) the prior lack of means for repeatedly producing an aesthetically pleasing texture and coloration of the finished material; (3) costly de-inking and bleaching of the pulp stock which reduces the competitiveness of the material; and (4) the potential presence of unknown and undesired contaminates in the raw waste paper stock that can
deleteriously effect surface finish and structural integrity of the produced stock.

Otherwise, it has been found that irregularly patterned, multi-colored materials such as the mineral aggregates and, for example, granite, are not easily duplicated or replicated in modern composites or laminates. These difficulties have been resolved through an appreciation of the process of forming natural stone and the relationship of human perceptions of natural stone.

That is, natural stone is formed from densely packed random crystals of variously colored minerals which, over time, in response to specific physical laws combine toward a minimum energy system. Such a process parallels recent understandings of the theories of ordered chaotic systems pioneered by F. Mandelbrot. Human eye-brain perceptions in contrast are learned and thus any recognition and appreciation that a material is "natural" or "artificial" is formed upon a mental comparison in relation to learned perceptions made by each observer. Because the artificially produced materials of the invention closely approximate the natural random ordering of stone, particularly granite, the resultant material is perceived to be granite.

SUMMARY OF THE INVENTION

In appreciation of the above and to overcome the shortcomings of the known art, the present invention
seeks to provide a structurally rigid material that exhibits colorized patterns and a bulk texture resembling granite and other natural stones. The invention also discloses the processes necessary to repeatedly fabricate board stock laminates and shape formed products which exhibit a variety of colored and textured patterns that simulate virtually any available building stone.

In one of the processes, the material is molded to form sheet stocks or is extruded to various shapes, which may be further laminated, embossed in cameo or intaglio or inlaid with other materials. The end products are producible from a base process that includes the mixing of one or more colorized ingredient batches containing a cellulosic pulp and a protein rich adhesive binder, most notably a processed soybean derivative, and the curing of a prepared mixture in the presence of radio frequency, microwave energy or thermal energy.

It is accordingly a primary object of the invention to provide a variety of products derived from mixtures containing shredded or pulverized paper, preferably newsprint, an adhesive binder, and desired colorants and cured under conditions of heat and pressure.

It is still a further object of the invention to obtain natural stone appearing and structurally stable materials which can be repeatedly produced.

It is a further object of the invention to provide mixtures including a binder comprising derivatives of
agricultural grains and pulse crops, particularly, soybeans with or without natural oils.

It is a further object of the invention to provide mixtures having controlled pH characteristics and including additives such as sodium hydroxide, polyvinyl acetate, and aluminum sulfate, which permit the coagulation into a comparatively dry mixture, and which upon compaction in the presence of radio frequency, microwave or thermal energy enables desired properties in the derived stock.

It is a further object of the invention to provide a fabrication methodology including the pre-drying of each colorized, ingredient batch or the admixture to a preferred moisture content, for example, by applying one or more heating or curing steps, interspersed with multiple compression steps, whereby a preferred moisture content is obtained.

It is a still further object of the invention to heat and/or cure the ingredient mixtures in the presence of radio frequency, microwave energy or thermal energy and wherein the forming molds can comprise the oven electrodes.

Various of the foregoing objects, advantages and distinctions are obtained in a preferred method of manufacture which for a single colorant feedstock includes the preparation of an alkaline pH adhesive binder from a soybean derivative and water; adding a
colorant to the binder; mixing the binder with suitably shredded or pulverized newsprint and drying the mixture a "semidry" mass of a preferred moisture in the range of 12 to 20 percent; compressing the mixture to form; and heating the formed mixture until cured. In one preferred method, controlled curing is obtained in the presence of radio frequency or microwave energy, which may be applied via plates which are machined to the shape of a molded end product. Alternatively, the mixture can be extruded and or cured in the presence of microwave, RF or thermal energy or combinations thereof. The cured stock may also be kiln dried and stored in a controlled humidity environment to enhance dimensional stability.

One preferred end product is a structural laminate having a natural stone appearance. The apparent granularity or pattern of the material is determined from the consistency of separately colored ingredient feedstocks which are admixed.

The stone-like granularity is believed to result from coagulation or "curdling" that occurs during the blending of the adhesive binder with shredded paper particulates, which have been made acidic, and a color additive. The resultant mixture demonstrates a non-bleeding color stability and a grainy or "dry" feel. Each colored feedstock can be blended with other colored feedstock of the same or differing granularity. When the separately
prepared feedstock mixtures are admixed, subjected to pressure and cured, with or without the addition of heat, the resultant solid mass forms a chaotic or disordered color pattern which the eye discerns as a natural stone-like solid.

During one preferred process for preparing a board stock of a single color and except for the collection of raw materials, four separate and distinct process stages are followed. Stage 1 involves the preparation of a relatively dry, soybean-based adhesive binder having the consistency of bread dough or children's PLAYDOUGH and an alkaline pH of the order of 11 to 13. An alkaline adhesive is desired in order to "uncoil" the high molecular weight protein fragments of the ground soybean, which may or may not be defatted, but which typically is screened to a meal or flour consistency and de-hulled.

During stage 2, various additives are blended with the adhesive binder to improve moisture resistance and impart desired mechanical hardness, strength and the like to the end product. Colorants, usually in the form of metal oxides, are added to the adhesive binder. The colorized adhesive binder typically exhibits a pH in the range of 10-12.

A shredded pulp stock is separately prepared by adding an acidic agent, for example, by spray, to a cellulosic "fluff" or pulp stock, which fluff is prepared by chopping and flailing waste paper, such as newspaper
or uncoated printing papers. Alternatively, various commercially available insulations can be used and which may include a fire-retardent, such as boric acid. The granularity of the fluff can be varied as desired, for example by mixing shredded particulates of different sizes. The pH of the resulting pulp stock is typically in the range of 9-11. The colorized adhesive binder and pulp stock are next mixed at stage 3 to form one or more feedstock mixtures. The pH of each feedstock mixture which is molded or extruded to shape is preferably in the range of 7-10. The relative moisture content of each feedstock is established in the range of 12 to 20 percent, which can be obtained by partially drying the feedstock in the presence of heated air.

During stage 4, two or more single color feedstock mixtures can be further mixed in preferred proportions of colors selected to resemble mixtures of colored particles, such as quartz, that appear in natural "granite" or other decorative stone. During stage 5, a single feedstock or feedstock admixture may be progressively compacted under controlled pressures in the range of 2 to 50 tons per ft$^2$ and controlled temperatures in the range of 45 to 95 degrees Celsius to further extract undesired a portion of the water. The compacted material is final heated at slightly higher pressures to over time drive-off as vapor any remaining water, while "curing" the compacted feedstock to final form. The
cured stock or resulting material may be further kiln
dried and held at a controlled humidity to control
dimensional stability.

Based upon an unaided visual appearance of the
resulting cured stock, and even under a magnification of
the order of 10X, it is believed that the natural laws
governing the densification and aggregation of the
mixture under heat and pressure are of similar nature to
those governing the "ordered chaos" seen in a naturally
formed decorative stone, such as granite. Consequently,
a similar stone-like appearance of comparable consistency
and uniformity is presented by the produced stock.

The density and machinability characteristics of the
cured stock are comparable or better than wood or wood-
like materials, such as flake or particle board. For
example, the stock can be sawed, routed, planed, sanded,
and finished like cabinet-grade wood. The material
accepts nails and screws in a similar fashion, without
fracture or splitting. The material may also be used as
part of large or complex assemblies or structures
constructed of a number of individual panels or pieces
joined together with conventional cabinetry techniques.
Provided the panels are fabricated from the same colorant
batch mixture, once bonded, sanded and finished, the
seams are essentially invisible.

In contrast to polished stone, the material exhibits
less than half the density, is machinable like wood and
does not exhibit brittle fracture, as do natural stone materials like granite. The limited porosity of the produced material also renders it suitable for vacuum impregnation with acrylcs, varnishes or other surface treatments to increase the suitability of the material for building, decorative or structural purposes.

Depending on the additives and the applied pressure and heating schedule, the surface hardness, bending modulus and tensile and compressive strength of the cured stock can also be varied from values comparable to a representative low-density fiberboard to values exceeding those of oak. A stiffness and strength exceeding that required of structural grade particle board and other building panels may also be obtained. The density may also be tailored to a range on the order of 45 to over 75 pounds/ft$^3$.

Still other objects, advantages and distinctions of the present invention will become more apparent from the following detailed description and the appended drawings and tables. Although various presently preferred constructions and methodologies are described, the description should not be construed in limitation thereto, but rather should be interpreted within the scope of the following appended claims. Considered modifications and improvements to the invention are described as appropriate. Various tested attributes are also defined. To the extent certain properties may have
been observed, although may not be completely understood, considered explanations are proposed.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of a preferred method of manufacture.

Figure 2 is a block diagram of an alternative method of manufacture.

Figure 3 is a drawing of a microwave or RF curing station wherein RF or microwave coupling plates compress and form the end product.

Figure 4 is a photograph of the stone-like, granular structure exhibited by board or extruded stock formed from the invention.

Figure 5 is a drawing of a continuous extruder station.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, a generalized block diagram is shown of the presently preferred process used to fabricate board stock from untreated (i.e. unbleached), pulped paper stocks, such as newspaper. The preferred process is in broad terms carried out in five distinct stages to produce a raw board or shaped stock. The raw stock is then finished with appropriate sizing, shaping and surface finishing steps to produce a final finished product. If used as a laminate or molding accent, a finished board stock would typically undergo further preparation for attachment to furniture or possibly ceiling or wall panels.
During the first or initial stage, the required raw materials are selected, graded, sorted and stored in appropriate bins in a form ready for pre-processing in stage 2. These materials typically comprise a cellulosic pulp stock of appropriately sized shredded paper particulates; a processed soybean derivative, colorants, water and miscellaneous additives. Each of the materials is described in more detail below.

During stage 2, a pulp stock is prepared by dry shredding waste paper, such as newsprint or other uncoated printing papers, to desired particulate sizes and relative size concentrations. The shredded paper is commingled as necessary with other dry materials to impart certain desired properties to the finished product (e.g. fire retardance via the addition of boric acid or an acidic additive to facilitate bonding).

An adhesive binder is separately prepared by mixing the processed soybean derivative, which may comprise a meal or flour, with water and other additives according to finished product requirements. When using a soybean meal or flour, the meal or flour is typically prepared by grinding hulled and husked, whole beans in a conventional cold grinding process to a granularity in the range of 150 to 325 mesh. The meal or flour can be de-fatted or include natural oils. If the oils are removed, this can be achieved using conventional mechanical or chemical extraction techniques. The prepared meal or flour is not
otherwise washed or treated.

Monochromatic colorants are selected according to the desired color pattern prescribed for the finished product.

Suitable colorants are ground metal oxides such as used to color cement or grout. Each colorant is separately stored, since the eventual coloration of the produced stock is obtained upon mixing proportions of the mixtures derived at stage 3.

During stage 3, one or more monochromatic batches of preprocess components (i.e. shredded paper, adhesive binder and colorant) are mixed to defined proportions. The fibers of each batch of pulp stock is colorized with a colorant that becomes chemically bound to the fibers during mixing. A three color batch is depicted and wherein the different style lead lines indicate the mixing of the three separate colorized batches. Each feedstock may also be partially dried to a moisture content in the range of 12 to 20 percent. Drying can be achieved by passing heated air through each colorized batch as the batch is fluffed or passed along a mesh conveyor.

The separate colorized batches, in turn, are combined or admixed at stage 4 in various prescribed proportions to provide a desired feedstock yielding a reproducible "chaotic" color pattern in the finished product. The feedstock mixture exhibits the form of a
loosely aggregated, multicolored, semidry flocculent material having a coleslaw consistency, which upon forming and curing yields a desired stone-like appearance.

At stage 5 the cured raw product is produced in one method by compressing and curing the feedstock under controlled heat and pressure in a hot press. Alternatively, the feedstocks can be roll pressed, reference Figure 2, or extruded in a screw extruder, reference Figure 5. Preferably, the material is progressively compacted and heated over time as any retained moisture is driven off and the compressed material is cured.

At the finish stage, the raw shaped product is surface finished, sized and final shaped according to various market requirements by sanding, planing, sawing, shaping or other appropriate machining. The surface may also be coated or impregnated with preferred sealants, lacquers, varnishes or the like.

By bonding individual board stock components together, seamless appearing complex shapes and assemblies can be formed. Composites with other materials can also be obtained, such as by inlay. Seamed assemblies preferably are formed from stock prepared from common color batches to minimize any color differentiation.

A more detailed description of the process stages 2
through 5 of Figure 1 follows. Various alternative mixtures or process variations are also described as regards a number of desirable finished product characteristics.

5 The principal concern during the preparation of the adhesive binder is to prepare a low cost binder which is capable of evenly wetting, coating and bonding the fibers and colorant of the cellulosic pulp stock. Most adhesives are rather costly, even if purchased in large quantity, and thus are not suitable for use in the preferred embodiments. Accordingly, many resin glues have been passed over.

In addition to cost, the adhesive binder must preferably retain its stability in the presence of microwave, radio frequency or thermal energy. Additional desirable attributes are that the adhesive not be susceptible to foaming, have a relatively low moisture content, have an alkaline pH in the range of 8 to 12, and demonstrate a moisture resistance, once set or cured.

15 Non-petroleum based adhesives and, in particular, starch and protein based adhesives have been used to advantage. Suitable protein based adhesives can be derived from various agricultural grains and pulse crops, most notable are soy beans.

20 A presently preferred adhesive binder is derived from processed soybeans. The soybeans are hulled, husked and ground to a meal or flour-like consistency, which in
flour form is on the order of 150 to 325 mesh. As desired, the beans may be pre-washed and may be stripped of natural oils via known mechanical and chemical treatments. Oils may also be added to reduce later foaming. Added to the soybean derivative in suitable quantity and as desired or necessary are various additives such as sodium or potassium hydroxide, sodium silicate, polyvinyl acetate and latex. The latter additives impart various desirable properties to the finished product and/or facilitate the removal of water and other liquids in later stage processing. Moisture resistance, fire retardance, mold resistance, elasticity and surface hardness represent some of the aforementioned desirable properties.

A variety of industrial batch mixers are available, which satisfy the requirements for mixing the adhesive binder and the colorants and pulp stock with the binder, and which accommodate various batch sizes. A continuous feed mixer, such as a ribbon blender, may also be used to advantage to continuously blend each separately colored batch of feedstock. Appropriate proportioning controls are required to assure the proper compositions of the feedstock ingredients. More of the details of such equipment are described with reference to Figure 2.

The principal cellulose filler material of the preferred mixtures is a shredded or pulverized newsprint. Depending upon various appearance and mechanical
attributes desired for the finished end product, the particulate size of the newsprint can be varied. That is, the particulate size may range from finely ground newsprint, which is ground to the consistency of fibrous materials such as flax or cotton, to a chopped material having nominal particulate dimensions of approximately 1/4 by 1/2 inches. Combinations of differently sized particulates may also be used.

A desirable attribute of newsprint is that the derived cellulose fibers are essentially lignin-free, which facilitates the surface absorption and wetting of the fibers of the cellulose with the adhesive binder. Newsprint, and most uncoated printing papers are essentially lignin free, since the lignin is typically removed during the processing of the wood fibers. The protein chains of the present soybean based adhesive binders when mixed in an alkaline to neutral solution with the cellulose material are believed to bond to the cellulose fibers by inducing a motioned, uncoiling and re-coiling of the fibers upon wetting. The re-coiling traps the added colorants and adjacent fibers to form a very strong molecular, inter-particle bond.

In preferred mixtures, the newsprint is shredded to a particulate size in the range of 1/10 to 1/4 by 1/10 to 1/2 inches. Other sized particles and shapes may also be used. Such particulates, when mixed with suitable colorants, in the following described fashion, provide
board stocks which exhibit a "stone-like" appearance. That is, a granular appearance is exhibited which in one instance closely resembles granite. Other appearances are attainable upon varying the concentrations of the sized particulates and colorants. Figure 4 depicts a photograph of the granular structure and stone-like appearance of a section of board stock prepared with the invention.

Although shredded newsprint can be used by itself, other fibrous materials may be included to provide certain desirable attributes. For example, chopped fiberglass, spun plastics or other fibrous additives of appropriate fiber length can be incorporated into the feedstock. Depending upon the fibrous material, the fibers can be randomly dispersed or mixed in various fashion to predetermined alignments. Where a directional fiber layering is used, a board stock can be developed from multiple laminations having specific axial alignments of the added fiber. The derived board stock can thereby exhibit preferential bending, shaping, shear or tear characteristics. Alternatively, laminations of random fiber alignment can be laid down one upon another. In all cases, however, a stone-like appearing board stock is obtained with improved structural integrity.

The colorants used in the preferred embodiment consist of various, generally inorganic, metal based coloring materials. In the presently preferred mixtures,
ground metal oxide colorants are incorporated without further preprocessing. Such colorants are commonly used to color cement and grouts. It is believed that many other types of coloring agents could be used to comparable advantage.

The required attributes of any colorant are color fastness under heat and pressure. Most importantly each colorant, once mixed with the pulp stock particulates or fibers of one color batch, must not bleed or transfer color to adjacent fibers. Color fastness must exist in each colorized batch prepared in stage 3, the admixed feedstock derived at stage 4 and in the final formed board or shaped stock. All of these requirements are met by commercially available colorants when processed according to the teachings of the current invention.

As discussed at stage 3 of the molding process of Figure 1, three batches of the pre-processed feedstocks are prepared. Each batch includes a single monochromatic colorant. More or less batches of the same or different volumes may be mixed as necessary to obtain the proportions required to achieve a desired type and color of board stock. Table I, below, summarizes a preferred process sequence for the preparation of a single monochromatic batch of feedstock through stages 2 and 3.
TABLE I
SINGLE COLORANT FEEDSTOCK PREPARATION

<table>
<thead>
<tr>
<th>Stage 2: (units)</th>
<th>Ingredient</th>
<th>Amount (wg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1:</td>
<td>Add Water (60-70 degrees F)</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>Ground Soybean</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Pine Oil</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mix 3 minutes or until smooth</td>
<td></td>
</tr>
<tr>
<td>Step 2:</td>
<td>Add Water (60-70 degrees F)</td>
<td>169</td>
</tr>
<tr>
<td></td>
<td>Mix 2 minutes or until smooth</td>
<td></td>
</tr>
<tr>
<td>Step 3:</td>
<td>Add 25% Sodium Hydroxide Solution</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Mix 1 minute</td>
<td></td>
</tr>
<tr>
<td>Step 4:</td>
<td>Add 'N' Brand Sodium Silicate</td>
<td>25</td>
</tr>
<tr>
<td>Step 5:</td>
<td>Add Soy Glue #5-27-92/1 Polyvinyl Acetate</td>
<td>117.25</td>
</tr>
<tr>
<td></td>
<td>Mix 1 minute</td>
<td></td>
</tr>
<tr>
<td>Step 6:</td>
<td>Add H.B. Fuller WB-2523</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Mix 1 minute</td>
<td></td>
</tr>
<tr>
<td>Step 7:</td>
<td>Add H.B. Fuller RM-0255</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Mix 1 minute</td>
<td></td>
</tr>
<tr>
<td>Stage 3:</td>
<td>Add Desired metal oxide colorant</td>
<td>8</td>
</tr>
<tr>
<td>Step 8:</td>
<td>Mix 1-2 minutes</td>
<td></td>
</tr>
<tr>
<td>Step 9:</td>
<td>Add Mixture from Step 8 Cellulose pulpstock (treated)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Mix until mixture takes on a semi-dry coleslaw consistency</td>
<td></td>
</tr>
</tbody>
</table>
22

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount (wght)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 10:</strong> Add</td>
<td></td>
</tr>
<tr>
<td>40% Aluminum Sulfate solution</td>
<td>1</td>
</tr>
<tr>
<td>Resultant from Step 9</td>
<td>50.2</td>
</tr>
</tbody>
</table>

*Note: 40% Alum Solution is sprayed onto the resultant mixture from Step 9 to decrease the pH of the mixture to approximately 6-7.*

Modest variations of the formulation of Table I has been shown to produce final formed board or shaped stock with more stable or optimized mechanical properties.

Tables II and III, below, have each been shown to produce stock with improved properties of hardness and moisture sensitivity.

**TABLE II**

FEEDSTOCK FORMULATION—BASELINE

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>(% by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>55.9</td>
</tr>
<tr>
<td>Cellulose (paper)</td>
<td>16.9</td>
</tr>
<tr>
<td>Soy flour</td>
<td>15.8</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>4.1 (50% in water)</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>2.3 (50% in water)</td>
</tr>
<tr>
<td>Lime</td>
<td>1.9</td>
</tr>
<tr>
<td>Styrene-butadiene latex</td>
<td>1.6</td>
</tr>
<tr>
<td>Tint</td>
<td>0.7</td>
</tr>
<tr>
<td>Pine Oil</td>
<td>0.5</td>
</tr>
<tr>
<td>H.B. Fuller WB-2523</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

**TABLE III**

FEEDSTOCK FORMULATION—WATER RESISTANT

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>(% by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>54.8</td>
</tr>
<tr>
<td>Cellulose (paper)</td>
<td>17.7</td>
</tr>
<tr>
<td>Soy flour</td>
<td>15.4</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>4.0 (50% in water)</td>
</tr>
<tr>
<td>Potassium hydroxide</td>
<td>3.1 (45% in water)</td>
</tr>
<tr>
<td>Lime</td>
<td>1.9</td>
</tr>
<tr>
<td>Ingredient</td>
<td>Quantity</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>SBR latex</td>
<td>23</td>
</tr>
<tr>
<td>Tint</td>
<td>1.6</td>
</tr>
<tr>
<td>Pine Oil</td>
<td>0.7</td>
</tr>
<tr>
<td>H.B. Fuller WB-2523</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

A similar process is followed to prepare each separate batch of differently colored feedstock. Once prepared, each of the separate feedstock batches is stored until combined at stage 4 as shown in Figure 1.

At stage 4, desired proportions of the pre-processed feedstock batches are combined in a main or primary mixing step to provide the final feedstock used in the stage 5 processing. The color pattern ensuing in the derived board stock is entirely determined by the relative proportions of each of the batch feedstocks in the admixture. For example, to provide a board stock product that virtually duplicates the appearance of natural "red" granite, separate red, black and white feedstock batches are prepared. The individual white, red and black batch stocks are then mixed in weight percentage ratios of 25:37.5:37.5 to form the stage 5 feedstock.

Upon blending the colored feedstock batches at stage 4, a relatively dry mixture is obtained. The consistency of the mixture is similar to coleslaw. This consistency is significantly different from the aqueous slurries that are prepared in the earlier referenced recycled newsprint processes.

In spite of the relatively low water content of the
stage 4 feedstock mixture, at stage 5 the admixture is preferably subjected to a pre-drying, which for the compression molding process of Figure 1, may include one or more pre-forming or partial compression steps to further remove a portion of the alkaline liquid and to consolidate the mixture. Final water removal occurs at the "hot press" step or stage 5 of Figure 1 or the second roller compression step of stage 5 in the continuous extrusion process of Figure 2. While a small quantity of moisture enhances the reaction of the adhesive binder with the fibrous cellulose and additives and promotes preferential bonding, extraneous water hampers later curing and can increase production costs.

During the pre-dry step of Figure 1, a quantity of water in the range of 50 to 65 percent by weight of the water initially present in the admixed feedstock is removed. For example, for a feedstock batch initially weighing 13 pounds, a volume of water weighing approximately 4 pounds is removed prior to subjecting the material to one or more final heating and curing steps.

The water is removed by partially compressing the feedstock over one or more compression cycles or through a progressive compression over time. The feedstock may simultaneously be subjected to microwave or radio frequency energies or a thermally controlled environment for a sufficient duration to uniformly heat the mixture to an average cross-sectional temperature on the order of
45-95 degrees Celsius. Such heating facilitates moisture release. Because microwave or radio frequency heating provides a relatively uniform energy distribution throughout the volume of the material, such a heating method is preferred. Alternatively, infrared and other convection or contact heating methods can be employed.

The admixed feedstock of stage 4 may also be pre-dried with air before being pre-formed at stage 5. This can be accomplished, for example, by passing dry heated air through a layer of the feedstock supported by an open metal mesh belt. An air temperature of 140 to 180 degrees Fahrenheit and exposure time up to 30 minutes may be used to decrease moisture content to 12 to 20 percent prior to hot pressing. The extraction of water from the admixed feedstock permits a more rapid heating in the molding press, without creating significant quantities of steam or liquid. For example, a cured one inch thick board can be formed during the hot press step of Figure 1 upon applying 300 to 550 psi to the pre-dried feedstock with press platens held at 280 to 320 degrees Fahrenheit over a period 5 to 30 minutes. Without air drying the feedstock, several additional minutes would be required with consequent greater energy usage. Regardless of the curing process, pre-drying the feedstock with air provides advantages to the overall process.

Without pre-drying or air drying the feedstock, conventional thermal heating processes have demonstrated
certain disadvantages. That is, unless the material is subjected to relatively long heating times, a "skin effect" can occur which tends to harden the outer surfaces of the board stock and prevent the release of internal moisture. Interior temperatures can also artificially rise to the point where chemical bonding between the adhesive and fibers is damaged. Edges may also char or become brittle to the point where additional mechanical processing is required to remove the unusable edges. Pre-drying the admixed feedstock with air is therefore desired for a production process which incorporates conventional radiant heating or thermal curing equipment.

Final curing during the hot press step of Figure 1 may be achieved in a microwave or radio frequency heated environment. Although such heating appliances are tolerant to moisture, energy requirements are reduced if unnecessary moisture is first removed, such as by pre-drying the feedstock admixture. Pressures in the range of 200 to 300 psi are typically, progressively applied during the pre-forming step and increased to 300 to 500 psi during the final curing step. Once compressed to final form, the feedstock is re-exposed during a final exposure to the microwave or radio frequency heating energy and cured to final shape. It is to be appreciated the compacted feedstock can either be alternately heated and compressed or simultaneously heated and compressed.
The duration of the final cure exposure and applied thermal energy are selected in relation to the thickness and desired density of the board stock being prepared. For a nominal board stock of 1 inch thickness, an exposure time in the range of 3 to 5 minutes and 2 to 5 kilowatts per square foot at microwave frequencies up to 2.5 GHz has produced suitable board stock. Although higher frequency microwaves may provide certain advantages, most commercial grade ovens operate at lower RF frequencies of 13.6, 27, 44 and 100 MHz. The lower RF frequencies are equally effective to obtain final curing.

Depending upon the stock being prepared, a suitable oven or heated press is selected which is capable of compacting the feedstock to desired size and providing a preferred stock throughput rate and energy consumption. The particular heated, pour batch molding press or "hot press" used in the process of Figure 1 is shown at Figure 3 in cross-section view. This heated molding press is suitable for hot pressing a single piece of board stock.

The body of the press mold is constructed of suitable heavy metal side and bottom walls. The walls must be capable of withstanding the maximum molding pressure and may or may not be lined with a porous member to facilitate removal of extracted liquid, such as a screen. A movable top wall or compression plate is provided along the top of the mold and is coupled to hydraulic means (not shown for convenience and clarity,
but similar to the piston 20 described below) for
directing the plate 3 to compress any feedstock material
contained in the mold cavity 4.

The compression plate 3 includes an RF or microwave
5 plate electrode 5 which is fed by a suitable coaxial
cable or waveguide 6 through a connector 7 from an RF or
microwave generator 10. The center conductor 8 of the
cable 6 passes through an electrical and thermal
insulator plate 9 which separates the compression plate 3
10 from the electrode 5. Any substitute plate 5 should be
capable of providing adequate heating to the feedstock.

Once the feedstock is compressed and heated to a
final stock form as shown at 11, the stock is extracted
from the mold cavity 4 via the piston 20. The piston 20
is secured to a plate 12 along the bottom wall 1 of the
mold. An additional porous member 13 may be placed below
the member 2 and between the formed board stock 11 and
the plate 12 to facilitate removal of released moisture.
Either or both the bottom and top plates 12, 5 also
20 contain an array of holes or channels 14 to permit the
extraction of released moisture via insulating tubing 15
and a vacuum or other suitable suction pump 16.

With attention next directed to the extrusion
process of Figure 2, a generalized block diagram is shown
of a continuous production process, rather than a batch
process. Such a process and related production equipment
can be constructed to provide board stock thicknesses
varying from 1/8 to 2 inch thickness and would typically include an extrusion molder that includes a continuous feed oven or heating assembly. The configuration of a screw type extrusion apparatus 30 which could be used in the extrusion process is shown at Figure 5.

With the exception of the final stage 5, each of the process stages of Figures 1 and 2 are the same, use comparable equipment and generally follow the steps and use feedstocks of Tables I, II and III. That is and as in Figure 1, a mixer is provided at stage 2 to receive appropriate solids and liquids from the raw material storage hoppers or liquid supply lines of stage 1. Motorized paddles or augers mix the separate pulp stock and adhesive binder ingredients to a preferred consistency before transferring the ingredient mixtures to a mixing station at stage 3 for preparing each of the colorized feedstock batches.

In lieu of separate mixing stations at stages 2 and 3, a single mixer may be provided that includes a hopper. The hopper can contain a suitable supply of shredded, pre-processed pulp stock. The hopper may also include a shredder mechanism for final shredding the pulp stock to an appropriate particulate size or shredding an additive pulp stock mixed with the base pulp stock. Once appropriate quantities of the adhesive binder and pulp stock are admitted to the mixer, the materials are blended with the colorant and any additional additives,
such as strengthening fibers, etc., are admixed.

The batches of monochromatic colorant mixtures are next admixed at stage 4 at either a different mixer station or combined using the mixer of stage 3. The produced feedstock is next fed through a screw drive extruder 30, such as shown at Figure 5. The feedstock is particularly received at a material intake 32 and lowerlying screw 34, which is driven by a drive system 35, the feedstock is progressively compressed, extraneous liquids are removed and the feedstock is shaped by forcing the feedstock through an appropriately configured extrusion die 36. The shape of the die orifice 38 can be varied as desired. For a board stock, a wide, shallow height rectangular orifice 38 is used. The temperature of the feedstock along the path of the screw 34 can be varied with provided heaters which surround the screw 34 and control signals applied at temperature control lines 40.

Upon exiting the extrusion die 36, the extruded material is typically admitted to a sequential arrangement of shaping rollers, such as roll formers or pinch rollers, which may include or be separated by intervening RF, microwave or thermal heating appliances. The feedstock is progressively compressed as the feedstock is further heated. Final compression and forming occurs at the outboard section of shaping rollers. Residual moisture and vapor is bled off at each
roller section prior to the shaped feedstock being final cured. Final curing can occur in a larger oven appliance which may surround the rollers or at a separate oven appliance which cures the formed feedstock to proper composition and dryness.

A post-curing or kiln drying process, as shown in dashed line, may be incorporated into either of the processes of Figures 1 and 2. Whether the raw stock is formed by compression at Figures 1 and 3 or extrusion at Figures 2 and 5, it typically will retain 9 to 12 percent moisture. Preferably, this can be reduced to below 4 percent, or even well below 2 percent, in a heated kiln. Kiln drying is typically performed over 6 to 24 hours at an oven temperature of 250 to 320 degrees Fahrenheit.

Once dried, the raw stock is preferrably stored in a controlled humidity environment to return to 6 to 8 percent moisture in order to enhance long-term dimensional stability.

Once cured and following either the batch process of Figure 1 or the continuous extrusion process of Figure 2, the raw stock is sequentially admitted to appropriate surface preparation, sizing, and shaping stations where appropriate sanding and surface forming assemblies prepare the stock to proper dimension. Subsequently, the material is admitted to a finish coating station where appropriate surface coatings are applied to the material. Board stock of thicknesses ranging from 1/8 to 1 inch is
readily obtained from the present invention, either in
the primary molding process or upon subsequent surface
finishing. Other thicknesses may also be obtained with
process adjustments.

Table IV, below, discloses a listing of certain
measured mechanical properties which confirm the
integrity of obtained board stocks derived from the
feedstock mixtures of Tables I, II and III. Such
measurements were taken using generally accepted testing
techniques and equipment.

| TABLE IV |

| Properties of Processed Board Stock of Table I |
|-----------------|-----------------|
| Product Density: | Low | High |
| Press psi        | 200 | 600  |
| Final Density    | 25  | 80   |
| lb/ft³           |     |     |
| Specific Gravity | 0.40 | 1.28 |
| Young's Modulus, psi | 500,000 | 1,200,000 |
| Modulus of Rupture, psi | 2,000 | 4,500 |
| Ball Hardness, lb | 1,900 | 3,800 |
| Immersion Moisture Absorption, % | 19 | 12.5 |
| Linear Expansion at 90% relative humidity, % | 1.4 | 0.2 |

Table V demonstrates comparable measured values of
wood based products to raw board stock samples A-D of a
one inch thickness, which were produced in accord with
the above.
TABLE V

COMPARATIVE PROPERTIES

<table>
<thead>
<tr>
<th></th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IMMERSION Property</td>
</tr>
<tr>
<td>10</td>
<td>ABS. Measured %</td>
</tr>
<tr>
<td></td>
<td>MOR (KPSI)</td>
</tr>
</tbody>
</table>

**Representative Wood-Based Products**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Type 1 Part. spec ANSI A208.1 15-40</td>
<td>3.40</td>
<td>400</td>
<td>140</td>
</tr>
<tr>
<td>20</td>
<td>1-H-3</td>
<td>3.40</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>25</td>
<td>Type 2 Part. spec ANSI A208.1 2-H-2</td>
<td>2.4-</td>
<td>350-</td>
<td>125-</td>
</tr>
<tr>
<td>Mat-formed Wood; Part. High Dens.</td>
<td>7.5</td>
<td>1000</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Waferboard</td>
<td>2.0-</td>
<td>450-</td>
<td>50-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5</td>
<td>650</td>
<td>100</td>
</tr>
<tr>
<td>35</td>
<td>Oak</td>
<td>12.20</td>
<td>2500</td>
<td>1138.00</td>
</tr>
<tr>
<td></td>
<td>Pine</td>
<td>11.60</td>
<td>1600</td>
<td>378</td>
</tr>
</tbody>
</table>

**Sample Boards**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Sample A</td>
<td>2.0-4.6</td>
<td>550-1200</td>
</tr>
<tr>
<td></td>
<td>Sample B</td>
<td>2.5</td>
<td>570</td>
</tr>
<tr>
<td>45</td>
<td>Sample C</td>
<td>2.85</td>
<td>&gt;250</td>
</tr>
<tr>
<td></td>
<td>Sample D</td>
<td>4.90</td>
<td>1300</td>
</tr>
</tbody>
</table>

A desirable attribute of the board stock produced by either of the processes of Figures 1 or 2 is that the material is relatively dense and thus can be finished to a relatively smooth surface. Correspondingly, the edges
accommodate conventional finger, or butt jointing and other jointing techniques to enable the production of larger, complex pieces from multiple smaller pieces. Because, too, of the unique homogeneous color patterns exhibited throughout an entire volume of the produced stock, essentially seamless joints are obtained. Complex shapes, such as corner molding, contours and orthogonal jointed corners can also be formed with invisible seams at the juncture of two pieces of the same material.

A further attribute of derived board stocks is that compositional or inlaid board stock can be fabricated, using the batch processing method. In such instances and for the process of Figure 1, separately prepared inlay members, such as commemorative plates, name tags or the like, and which can comprise almost any organic material (e.g. wood or plastics), or inorganic material (e.g. metal) can be inserted into the press mold prior to stage 5. Once the feedstock is added and compressed during the molding process, it forms around and in intimate contact with the inlay material. Upon final curing, a strong contact is made between the inlay and board and the inlay, becomes an integral part of the resulting board stock.

Still another attribute of the invention and using the process and equipment of Figures 1 and 3 is the ability to machine the upper and/or lower plates either in cameo or intaglio with a desired figure or shape.
When the feedstock is pressed in the mold, the board stock will retain an image of the pattern provided in the mode plate either intaglio or cameo, depending upon whether the mold plate pattern is raised or inset. Upon curing the raw product or board stock, the pattern is retained in fine detail.

Although the invention has been described with respect to various presently preferred mixtures and production equipment, it is to be appreciated that still other methods and mixtures may be suggested to those skilled in the art. Accordingly, it is contemplated that the foregoing description should be interpreted to include all those equivalent embodiments within the spirit and scope thereof.

What is claimed is:
36
CLAIMS

1. A method for making a product from recycled paper comprising:
   (a) shredding a paper stock to a predetermined particulate dimension to form a pulp stock;
   (b) blending the pulp stock with an adhesive binder, wherein said adhesive binder consists essentially of a pulse crop derivative, a colorant and water to form an alkaline pH feedstock;
   (c) compressing the alkaline feedstock to a predetermined shape under predetermined conditions of pressure and temperature; and
   (d) final curing the shaped feedstock to a dimensionally stable material.

2. A method as set forth in claim 1 including the step of blending an acidic material with the feedstock to provide a feedstock having a pH in the range of 6 to 7.

3. A method as set forth in claim 1 wherein said compressing step is achieved with apparatus comprising means for progressively compressing the feedstock at controlled pressures and including means for applying electromagnetic energy to heat the feedstock.

4. A method as set forth in claim 1 wherein said feedstock is formed in the presence of electromagnetic energy selected from a class consisting of microwave and radio frequency energy.

5. A method as set forth in claim 4 wherein at least one of said compressing and final curing steps are
performed in means for producing electromagnetic energy
and having transmission plates configured in the shape of
a predetermined end object.

6. A method as set forth in claim 5 wherein said
5 electromagnetic means includes means for removing
moisture derived from the feedstock in the form of liquid
and vapor during curing.

7. A method as set forth in claim 1 including the
step of adding a fire retardant to said pulp stock.

8. A method as set forth in claim 7 wherein said
fire retardant comprises a quantity of boric acid in the
range of 3 to 4% by weight of said adhesive binder.

9. A method as set forth in claim 1 wherein said
adhesive binder comprises 5 parts of a soybean meal
prepared to a 150 to 200 mesh size to 1 part of a
formaldehyde resin.

10. A method as set forth in claim 1 including the
step of blending a powdered iron oxide colorant with the
pulp stock.

11. A method as set forth in claim 10 including the
step of blending a quantity of polyvinyl acetate with the
adhesive binder in the range of 15 to 20% by weight.

12. A method as set forth in claim 1 wherein said
paper stock comprises newsprint shredded to a particulate
size in the range of 0.1 by 0.1 inches to 0.25 by 1.25
inches.

13. A method as set forth in claim 1 including
apparatus for vacuum removing moisture derived from the feedstock.

14. A method as set forth in claim 1 including the step of blending a plurality of monochromatic feedstocks, wherein each feedstock contains an adhesive binder prepared from a soybean derivative and the further step of blending each of said plurality of monochromatic feedstocks to derive an alkaline feedstock exhibiting a ph in the range of 8 to 12.

15. A method for making a product from recycled paper comprising:

(a) shredding an uncoated, lignin-free paper stock to a predetermined particulate dimension to form a pulp stock;

(b) blending a plurality of colorized mixtures, each colorized mixture prepared by blending a quantity of the pulp stock with an adhesive binder, wherein said adhesive binder consists essentially of a cold processed soybean derivative, a monochromatic iron oxide colorant and water to form an alkaline ph feedstock;

(c) blending the plurality of colorized mixtures to predetermined proportions to form an alkaline feedstock having a ph in the range of 8 to 12;

(d) progressively compressing the feedstock to a predetermined shape under predetermined conditions of pressure and temperature in the presence of
electromagnetic energy derived from a class consisting of
microwave and radio frequency energy; and
(e) final curing the shaped feedstock to a
dimensionally stable material.

16. A method as set forth in claim 15 including the
step of blending an acidic material with said alkaline
feedstock to decrease the feedstock to a pH in the range
of 6 to 7.

17. A method as set forth in claim 15 including the
step of impregnating a finished surface of the
dimensionally stable material with a moisture resistant
sealant.

18. A method as set forth in claim 15 including the
blending of fibrous materials selected from a class
consisting of fiberglass and spun plastics to said pulp
stock.

19. A method as set forth in claim 15 wherein said
compressing step is achieved with apparatus comprising
extrusion means for progressively compressing the
feedstock at controlled pressures, including means for
roll forming the feedstock, and further including means
for applying electromagnetic energy to heat the
feedstock.

20. Apparatus for forming end products from
recycled paper comprising:
(a) means for mixing an adhesive binder
including a soybean derivative;
(b) means for shredding a paper stock to a predetermined particulate size;

(c) means for blending said adhesive binder and paper particulate to form a feedstock;

(d) means for partially compressing the feedstock and including means for heating said feedstock;

(e) means for extruding said partially heated feedstock through a die mold;

(f) means for roll forming the extruded feedstock;

(g) means for curing the formed feedstock in the presence of microwave energy;

(h) means for finishing the cured material to a final shape; and

(i) means for finish coating the cured material.

21. A method for making a wood substitute product from recycled paper comprising the steps of:

(a) shredding a paper stock to form a pulp stock;

(b) preparing an adhesive binder comprising a finely ground soybean derivative and water;

(c) blending the pulp stock with the adhesive binder to form a feedstock having a pH in the range of 7 to 10;

(d) reducing the moisture content of the feedstock to a state of flocculence;
(e) forming the flocculent feedstock to a predetermined shape in the presence of pressure and heat; and

(f) curing the shaped feedstock to form in the presence of thermal energy.

22. A method as set forth in claim 21 wherein said forming step comprises extruding said feedstock through a forming die.

23. A method as set forth in claim 21 wherein said forming step comprises compressing said feedstock between forming dies.

24. A method for making a product comprising the steps of:

(a) preparing a pulp stock from cellulosic waste materials;

(b) preparing an adhesive binder comprising a finely ground legume derivative and water;

(c) blending the pulp stock with the adhesive binder to form a feedstock;

(d) reducing the moisture content of the feedstock to a state of flocculence;

(e) forming the feedstock to a predetermined shape in the presence of pressure and temperature; and

(f) curing the shaped feedstock in the presence of thermal energy.

25. A method for making a product from recycled materials comprising the steps of:
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(a) preparing a pulp stock from a cellulosic material;

(b) preparing an adhesive comprising a finely ground soybean derivative and water;

(c) blending the pulp stock with the adhesive to form a feedstock having a pH in the range of 7 to 10;

(d) reducing the moisture content of the feedstock to a state of flocculence;

(e) forming the flocculent feedstock to a predetermined shape in the presence of pressure and temperature; and

(f) curing the shaped feedstock to form in the presence of thermal energy.

26. Apparatus for forming a product from recycled paper comprising:

(a) means for mixing an adhesive binder comprised of a finely ground pulse crop derivative and water;

(b) means for shredding a waste cellulosic material to form a pulp stock;

(c) means for blending said adhesive binder and pulp stock to form a feedstock;

(d) means for reducing the moisture content of the feedstock to a state of flocculence;

(e) means for extruding the flocculent feedstock through a forming die; and

(f) means for thermally curing the formed
feedstock.

27. A product comprising a shredded cellulosic waste material mixed with an adhesive binder, which adhesive binder consists essentially of a flocculent mixture of a finely ground soybean derivative and water and having a pH in the range of 7 to 10, shaped in the presence of pressure and temperature, and thermally cured to a predetermined form.

28. A product comprising a shredded cellulosic waste material mixed with an adhesive binder, which binder consists essentially of a flocculent mixture of a finely ground legume derivative and water and having a pH in the range of 7 to 10, shaped in the presence of pressure and temperature and thermally cured to exhibit a stone-like granular structure as depicted at Figure 4.
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

<table>
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<th>IPC(5)</th>
<th>US CL</th>
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<td>B22B 31/00; D21F 13/00; D21J 3/00; B30B 15/30</td>
<td>Please See Extra Sheet.</td>
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According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

| U.S. | 100/73, 100/74, 162/118 |

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

- Handbook of Adhesives, 1962, I. Skeist editor

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>*</td>
<td>See Attached Sheet.</td>
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</table>

*Further documents are listed in the continuation of Box C.*

See patent family annex.

* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be part of particular relevance
  - "E" earlier document published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority data claimed
  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "&" document member of the same patent family

Date of the actual completion of the international search: 06 OCTOBER 1993

Date of mailing of the international search report: 12 NOV 1993

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231

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Authorized officer: [Signature]

Authorized officer: [Signature]

Telephone No. (703) 308-1977

Form PCT/ISA/210 (second sheet)(July 1992)
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<td>Y</td>
<td>US.A, 4,111,730 (Balatinecz) 5 Sept 1978 See col. 3, lines 3-21.</td>
<td>1, 7, 9, 12, 20, 26-28</td>
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<td>US.A, 4,994,148 (Shetka) 19 Feb 1991 See col. 3, lines 14-46.</td>
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<td>Y</td>
<td>US.A, 5,075,057 (Hoedl) 24 Dec 1991 See col. 5, lines 1-7.</td>
<td>3-5, 15-17, 19, 20-25</td>
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<td>Y</td>
<td>US.A, 4,708,623 (Aoki et al.) 24 Nov 1987 See col. 9, lines 37-51.</td>
<td>6, 13, 26</td>
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<td>Y</td>
<td>US.A, 4,184,311 (Rood) 22 Jan 1980 See col. 2, lines 62-64.</td>
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<td>Y</td>
<td>US.A, 4,812,492 (Eckes et al.) 14 Mar 1989 See col. 8, lines 9-12.</td>
<td>10, 15-17, 19, 21-25</td>
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<td>US.A, 5,011,741 (Hoffman) 30 Apr 1991 See col. 5, lines 26-38.</td>
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<td>Y</td>
<td>US.A, 4,963,603 (Felegi Jr. et al.) 16 Oct 1990 See col. 1, lines 18-26.</td>
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<tr>
<td>Y</td>
<td>US.A, 4,769,109 (Tellvik et al.) 6 Sep 1988 See col. 3, lines 12-63.</td>
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A. CLASSIFICATION OF SUBJECT MATTER:
US CL :
162/4, 162/5, 162/8, 162/147, 162/159, 162/218, 162/226, 162/227, 162/377, 162/380, 100/72, 100/914; 156/272.2,
273.7, 275.7, 379.6