# Semiannual Patents Review July — December 2003

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**KEYWORDS**

Chemical, Contaminant, Deinking, Enzyme, Patent, Reclaimed fiber, Reclaimed paper, Recycling, Review, Stickies.

## INTRODUCTION

This review summarizes patents related to paper recycling that first appeared in patent databases during the last 6 months of 2003. Two on-line databases, Claims/U.S. Patents Abstracts and Derwent World Patents Index, were searched for this review. This semiannual feature is intended to inform readers about recent developments in equipment design, chemicals and process technologies for recycling paper, and alternative products derived from postconsumer paper. Only brief summaries of individual inventions are included in the review. Because many of the patents are not readily available in English, much information was extracted from abstracts that were translated to English. For more complete information, readers will need to access the full text of a specific patent. Three excellent on-line sources for further review are www.uspto.gov, http://ep.espacenet.com, and www.mayallj.freeserve.co.uk.

As an indication of the amount of patent activity in the papermaking field, the 59 patents reviewed here were selected from 146 patent abstracts obtained in an initial search. Patents were selected on the basis of their specific applicability to the paper recycling industry as opposed to papermaking in general.

## EQUIPMENT AND PROCESSES

Many recent patents disclose alternative equipment designs or process modifications to raise the quality and production of recycled paper. The first of these is a patented process by Danger et al. [1] for coarse screening of contaminants from fiberized wastepaper. The method uses a primary flat screen, following a pulper, to separate contaminants (such as plastic, foil, and wires) from the acceptable fiber. The rejects from the primary screen are subsequently processed in a secondary screen where the material is further separated into rejects and accepts. The accepts from the second screen are combined with the accepts from the primary screen. The rejected material from the primary screen is fed to the secondary screen at least 80% of the time, keeping the reject concentration from building up to inefficient levels in the primary screen. When the rejects are not fed to the secondary screen, appropriate valving is used so that the rejects of the secondary screen can be flushed to a tertiary screen for separation of contaminants from the process water that is returned to the pulping system. With this process arrangement, the primary screen is functional 100% of the time while the secondary screen is in operation at least 80% of the time. This provides a uniform fiber accept flow.

Another process related to screening described in a German patent granted to Rienecker and Schweiss [2]. The process separates wastepaper into coarse and fine fractions while simultaneously removing contaminants. The system uses two pressure screens in succession. The fine accepts of the first screen supply the feed to the second screen. The contaminants are removed with the rejects from the first screen, while the rejects from the second screen are blended back with the stock entering the first screen to minimize fiber loss. One innovative aspect of this patent is the combination of two pressure screens stacked one above the other in one main casing. Internal plumbing directs the flows such that external plumbing is not required. A second embodiment of the patent describes this process as conducted by cleaners rather than screens.

Using a turbo-separator, impurities can be removed from wastepaper, as described in a recent Russian patent granted to Zajtsev et al. [3]. The turbo-separator has a sieve opening to keep coarse fibrous material in the separator until it is properly broken up. A stock velocity of 8 m/sec along with

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a high velocity gradient going into the turbo-separator is claimed to provide additional fiber deflocculation. The system is claimed to provide increased selectivity for removing light contaminants.

Two recent patents are concerned with removing impurities through flotation. The first, by Cho et al. [4], describes a flotation cell that uses swirl-type air injector. The injector enhances the mixing of fiber and dispersion of ink, which facilitates the production of a uniformly cleaned pulp. The second, a French patent granted to Trichet [5], describes an improved deinking process that utilizes ozone treatment. The pulp is first screened and then treated with ozone prior to flotation. The process is claimed to use less chemicals and to produce a cleaner pulp.

Methods for maximizing the efficiency of defiberization in a drum pulper are described in a patent granted to Kankaanpaeae [6]. The drum pulper is driven by a variable speed motor so that the power input can be controlled. Parameters such as electric power, wastepaper feed rate, water addition, and chemical injection are monitored with appropriate sensors. These collected parameter values are input to a control unit that regulates the speed of the drum rotation to give either maximum power input or a specific energy consumption per fiber mass. The authors suggest that these controls enable uniform and efficient pulping. Goto et al. [7] were granted a patent for a small-scale pulper designed to replace shredders. The pulper destroys sensitive printed materials more thoroughly than does a shredder. The system includes a dewatering screw and a water recycling system. Deinking chemicals can be used to enhance the removal of printed material.

Recovery of useable fiber from the whitewater of tissue-making operations can be enhanced through the use of a new screening method developed by McDonald [8]. The fine, flexible screen is mounted in a frame such that the screen is allowed flex. The whitewater is directed at the screen, allowing the undesirable ash and fines to pass through the screen for subsequent collection and treatment, while the longer fibers are retained for reuse. The screen can be shaped as a cone or an inclined trough with an outlet at the end for the long fibers. Motion, either rotary or vibratory depending on the screen configuration, is applied to the screen to flex and undulate it, causing the retained fibers to move down the screen surface for collection and reuse. The flexing of the screen also serves a self-cleaning function, preventing plugging by fines and ash.

An improved method for the recovery and reuse of filler and coating materials from recycled papers is disclosed in a re-issued patent granted to Vikio [9]. The newer patent contains an additional 10 claims relating to further possible equipment configurations for achieving the necessary size reduction of rejected fillers for re-introduction into the pulp stream. The overall scheme of the technology is to pass the rejects from the standard cleaners through an additional cleaner that concentrates and thickens the rejects. The thickened rejects are then processed in a mixing or dispersion unit to shear the filler and coating particles into the 1-micron size range, which is suitable for use in papermaking. The material processed in the dispersion unit is processed in a cleaner or screen one or more times to ensure that only small particles are re-introduced into the pulp stream.

To reduce the chemical oxygen demand (COD) of wastewater from a wastepaper deinking system, Takahashi and Yamakawa [10] have developed a paper recycling process that operates at neutral pH. The process includes pulping with deinking agents at neutral pH followed by flotation. The pulp is thickened, dispersed or kneaded, and then reductively bleached. A small amount of caustic is applied with formamidine sulfinic acid (FAS) such that the pH at the end of the bleaching sequence is 6 to 8. The pulp quality is claimed to be equal to conventional methods using higher pH and hydrogen peroxide bleaching while having lower COD.

Bruening and Frost [11] received a patent for a sizing process claimed to be beneficial when recycled fibers are part of the paper stock. In this method, the sizing is added at a stage with high stock consistency, rather than at the typical low-consistency point. The authors claim better sizing distribution and attachment as well as less interference from ash and other wet-end chemicals. The sizing dose can be reduced to one-third that of normal application levels.

Hansen et al. [12] received a patent for a multiply paperboard composed of at least 80% recycled fiber with mechanical properties equal to those of paperboard produced from virgin fiber. The paperboard has a minimum of three inner plies. In the preferred method, each inner ply is formed on an individual Fourdrinier with a means to induce stock activity, such as velocity-induced drainage, an activity lip, step foils, or a lead-in dewatering element. In addition, the inner ply stock velocity is 1% to 10% greater than the forming fabric velocity. The outer plies are composed of at least 80% recycled fiber and can be formed on almost any type of machine. The exact ratios of softwood to hardwood and chemical to mechanical pulp used for each ply are fully described in the patent. The patent also contains many examples of paperboard produced by the disclosed process compared to conventional paperboard.

The replacement of the normal wear parts of pulpers. pressure screens, and cleaners can be simplified through the use of bolts with modified heads according to a recent U.S. patent application by Brettschneider [13]. The modified bolt heads have a minimum of two drilled holes into or through the head, parallel to the bolt axis. A spanner-type wrench, with protruding pins, is used to loosen and tighten the bolt.

The author claims that good engagement is maintained between the spanner-type wrench and bolt head even if significant wear occurs to the bolt head. This is in comparison to conventional hex head bolts where wrenches will no longer make adequate contact if the bolt head flats have significant wear from the processed material.

## DEINKING

Novozymes A/S [14] holds a comprehensive world patent for enzymatic bleaching, deinking, and pitch removal in the papermaking industry. This patent application claims that fatty acid oxidizing enzymes (oxygenases) and an appropriate substrate used in combination with proteases, lipases, xylanases, mannanases, cellulases, endoglucanases, amylases, or other enzymes or surfactants can effectively replace conventional chemicals for deinking, bleaching, and pitch removal. These enzymes can be used on either chemical or mechanical pulps made from hardwood or softwood, either virgin or recycled,. Enzymatic treatment can be included at various stages of processing at conventional consistency and temperature ranges, with ranges from pH 6 to 9 or pH 4 to 9.5.

A U.S. patent application by Emalfarb et al. [15] deals with a method of forming cellulase from *Chrysosporium* with high activity in neutral or slightly alkaline pH. Mutant enzymes from *Chrysosporium* display a neutral or alkaline cellulase activity. A computer-based method and apparatus are described that identify numerous mutations of the cellulases for industrial application. One application could be for deinking recycled paper at neutral pH.

The BASF Corporation has submitted a patent application for a triglyceride emulsion used in deinking [16]. This emulsion is used with FLOATSAN 209 (an alkoxylated fatty alcohol made by BASF) for flotation deinking. The invention claims a higher brightness pulp and lower reject rate with the triglyceride compared to that obtained with other fatty acid soap formulations. The triglyceride emulsion controls foaming, thereby minimizing rejects.

Inventors Klass and Joyce have submitted patent applications for a high performance purified natural zeolite pigment composition and its application in coating paper for ink jet or digital printing [ 17,181. This material is a readily retained filler that improves optical properties and coeffcient of friction of paper and is also an economical extender for titanium dioxide. Novel aspects of this pigment include its ability to serve as a micro-particulate retention aid during papermaking, as an additive to improve the performance of deinking, and as a coating agent for ultra-lightweight coated publication papers.

A novel approach to biological deinking is offered by a recent U.S. patent application by Raghukumar et al. [19]. Rather than a direct application of enzyme preparations for deinking, this patent targets an extended incubation with bacteria for the decolorization of photocopied and ink-jet printed papers. The coccoid bacterium, which is isolated from marine sediment and cultured in a nutrient-enriched agar, is capable of producing lipase and amylase. The cultured bacteria is inoculated onto fiberized office paper suspended in dilute seawater and incubated for at least 4 days at room temperature to decolorize the pulp. Released ink, contaminants, and bacterial cells are removed by flotation.

A Japanese patent assigned to Nippon Shokubai Co., Ltd. [20] targets removal of ink from recycled paper, newsprint. and magazines with polyamine polyalkoxylate compound without ink reattachment to the secondary fiber. The invention offers an efficient deinking agent to produce high quality white printing and writing paper from deinked pulp.

A novel approach to regenerate printing paper by using a hybrid ink is offered by Toyo Ink Manufacture Co., Ltd. [21]. The patent claims that the hybrid ink used for printing has favorable ink-removal properties and that the paper can be regenerated without polluting the environment. The ink consists of a pigment that is an oxidation-curing binder and vegetable oil and has minimal volatile content.

## STICKIES CONTROL

A new invention for stickies control assigned to Luzenac America, Inc. [22] offers a modified talc additive that controls stickies formation and removes anionic contaminants from various recycled furnishes, including old corrugated containers (OCC), old newspaper (ONP), deinked pulp, old magazine (OMG), coated broke, and thermomechanical pulp. The talc is treated with a cationic polymer such as a tertiary or quaternary amine, which results in cationic sites for attracting anionic contaminants in pulp furnishes as well as hydrophobic/oleophobic surfaces for attracting stickies such as pressure-sensitive adhesives, hot melts, and waxes. The inventors claim that stickies bind to the modified talc and can be removed from the process.

CIBA Specialty Chemicals [23] has invented a chemical method to control the accumulation of white pitch or stickies in papermaking systems that utilize pulp derived from at least 10% recycled or broke paper. The chemical control system is two-fold, consisting of a cationic polyelectrolyte coagulant (a polyammonium salt) and an anionic microparticle material such as bentonite or other swellable clay from the smectite family. The order of the addition of the chemicals is important, First, the coagulant is added to the pulper or thick stock chest. Then, the microparticulate is added at the exit of the pulper or stock chest prior to

stock dilution. The inventors claim that white pitch/stickies become partially cationic and can then be adsorbed by the anionic microparticles, reducing their amount in the papermakingeffluent.

Another invention by CIBA Specialty Chemicals Corp. [24] targets removal of synthetic hydrophobic resinous particles from recycled pulp suspensions. This method uses a cationic polymer with a hydrophobic moiety formed from two water-soluble cationic monomers. When this polymer is added to mill process water after the washing and thickening stages of recycling, colloidal resinous particles remaining in the water are coagulated and subsequently separated frap the water.

An invention by Huntsman Petrochemical Corp. [25] offers a chemical means to inhibit the tackiness of sticky materials in aqueous pulp and paper processes, including white pitch/ stickies (hot melt, SBR, acrylic adhesives). The chemical means employs an anionic alkoxylated sulfosuccinamate surfactant and a multivalent metal cation containing calcium, magnesium, strontium, barium, nickel, copper, tin, cobalt, iron, zinc, or mixtures thereof. The advantage claimed by the inventors is that this chemical means prevents the formation of gummy residues on tanks and processing equipment. The chemistry may be added at various points in the process where accumulation of sticky material is a problem and can be injected in-line or sprayed.

## DEPOSIT INHIBITORS AND FOAM CONTROL

A Japanese patent by Kurita Water Industries, Ltd. [26] presents a scale-inhibiting chemistry that prevents calcium carbonate build-up in water systems containing inorganic suspended solids. Applications include pulp digestion, bleaching, and deinking processes. The scale-inhibiting chemistry involves a phosphonic acid and/or a phosphonate and a low molecular weight water-soluble polymer that, when incorporated into a water system, suppresses scale build-up on equipment, piping, and tank surfaces.

A Japanese patent by Hakuto Co., Ltd. [27] presents a chemical method for inhibiting growth and sterilization of microorganisms in water systems. The inventors claim industrial uses in process water, cooling water, and wash water and note applicability to water reuse in pulp and paper manufacturing.

A U.S. patent by Air Products and Chemical, Inc. [28] offers a foam control agent with wide application to water-based industrial processes, including pulp and paper processing. Although not all alkyl glycidyl ether-capped polyamines are capable of reducing or eliminating foam, this patent provides the correct combination of polyamine and alkyl glycidal ether group and an optimum degree of addition for reducing or eliminating foam. The inventors claim that this alkyl glycidal ether-capped polyamine generates an initial foam height that is at least 30% less than a 0.1 weight percent aqueous solution of dioctyl sodium sulfosuccinate (DOSS) when added at 0.1 weight percent to the aqueous DOSS solution, measured according to ASTM D 1 173-53 at ambienttemperature.

## BLEACHING

In a process presented by Call [29], recycled office paper or newsprint can be upgraded by deinking and/or by bleaching deinked pulp suspensions with an oxido-reductase such as laccase or peroxidase in the presence of a co-substrate. A co-substrate, such as oxygen, hydrogen peroxide, organic peroxide, or a peracid, generates an active oxygen species, such as dioxidrane, dioxetane, or peroxy, which efficiently transforms secondary fiber into quality papermakingpulp.

BASF [30] offers a patented process for producing papermaking pulps from recycled paper by multi-stage bleaching and deinking that uses N-alkyl ammonium acetonitrile salt as a bleaching activator together with a surfactant. The brightness obtained is comparable to that of high quality pulp bleached with chlorine. The bleaching activator is readily soluble in the pulp and is active at relatively low temperatures and over a wide pH range.

A U.S. patent application by Novozymes A/S [31] focuses on the ability ofmannanase to modify cellulosic fibers. This enzyme, applied solely or together with lipases, cellulases, laccases, or xylanases, can also be used in the paper industry to delignify and brighten recycled fibers or mechanical pulps.

Two U.S. patent applications [32,33] deal with adding carbon dioxide to lower the pH of cellulose fiber suspensions to the pH required for optimum bleaching with chlorine dioxide. While these patents relate most directly to virgin fiber, they could also be used for bleaching recycled fiber, especially semi-bleached kraft or mechanical fibers, to high brightness. Pulp suspensions containing recycled fibers can be bleached using a patented process that introduces carbon dioxide prior to or simultaneously with a bleaching agent that requires acidic conditions. Chlorine dioxide, peracetic acid, or ozone bleaching is performed at pH 4 to 6 (consistency preferably 3% to 15%) to suppress secondary reactions that degrade the carbohydrate chain and to obtain optimum brightness with the minimal amount ofbleaching agent and COD in the bleach effluent. Carbon dioxide has the advantage of being more environmentally friendly compared to acids that are typically used to lower pH as a result of the salt byproducts formed.

## RECYCLABLE SIZING AND WAX

Several patent applications are aimed at agents that provide water resistance to paper and remain benign when the paper is ultimately recycled. The first of these patents, by Hassan et al. [34], describes a wax for paper coating derived from a variety of hydrogenated plant oils rather than from petroleum products. The wax can be produced from soybean, corn, cottonseed, rape, canola, sunflower, palm, palm kernel, coconut, cranbe, linseed, and peanut oils. The resulting wax is dispersible in warm water with melting point in the 120°F to 165°F (49°C to 74°C) range. Examples show good water and vapor resistance as well as ease in recycling when the coating is applied to paper and linerboard.

An invention by Kobayashi and Kaneko [35] is also related to recyclable wax-type paper coatings. The coatings are mixtures of latex and emulsified waxes produced by specific techniques, which are disclosed in the patent. The latexes are combinations of copolymers with different glass transition temperatures and silane coupling agents. Examples of different versions of the coating applied to paper show good vapor resistance and crease durability as well as recyclability.

A third invention offers a method to produce a recyclable water-resistant paper product by adding polyester sizing [36]. This water-soluble polyester resin can be added at the wet end of the papermaking process and used alone or with other internal or external sizing to improve wet and dry paper strength, stiffness, water repellence, and sizing properties. The polyester size can be made from either virgin or recycled polyethylene terephthalate or from fresh glycol and a polyacid. Paper sized with traditional wet-strength resins, such as Kymene, is not easily repulped or recycled; however, when combined with this water-dispersible polyester, the sized paper is more readily repulped and recycled.

Finally, Novozymes A/S has been assigned a patent for methods of using enzymes to improve paper wet strength [37]. The patent discloses a novel result of using laccase and a mediator on unbleached or semi-bleached virgin or recycled fiber. Usually considered an effective bleaching agent, this laccase/mediator combination has been found to enhance wet strength. When applied to a pulp slurry, dewatered on a paper machine, and finally heat-dried above 300°F (1 50°C) at atmospheric pressure, the resulting paper displays increased wet strength suitable for producing corrugated linerboard or containers. Enzymatic treatment of the pulp and whitewater suspension polymerizes aromatic materials present in the whitewater (lignins, resin acids, fines, etc.), thereby retaining them in the paper sheet, which results in increased yield, decreased COD load, and decreased toxicity of the effluent. Polymerization may also contribute to the strength of the product. Unlike conventional papers, laccase-treated papers can be more readily recycled.

## WASTEWATER

Three recent Japanese patents describe processes to treat wastewater. The first, granted to Fujita and Suetsugu [38], discloses an integrated flocculation settling tank and polishing filter. The tubular tank has three perforated cones that are centered in the tank, one above the other. An open channel is maintained around the periphery of the cones for the flocculated material to settle to the bottom of the tank. The wastewater and flocculants are injected through the perforated cones. The majority of the material flocculates and slides down the cones to the bottom of the tank. The water and a small quantity of contaminants travel upward through a screen. A coarse filter on top of the screen polishes the wastewater. The cleaned water rises to the top of the tank and is discharged. Most of the accumulated material on the filter material settles to the bottom of the tank. The system is compact and is claimed to operate at high throughputs and long durations between backflushing of the filter media,

In the second invention, by Kimura and Okamoto [39], air micro-bubbles are used to speed the activated sludge treatment of wastewater. With the use of a tangential flow mixer, compressed air is injected and mixed under pressure into the recycled activated sludge, creating micro-bubbles. This mixture is then blended with the wastewater and depressurized in a pretreatment chamber. This sudden, turbulent depressurization is claimed to greatly increase the dissolved oxygen in the water. With increased oxygen levels, the speed of treatment is increased while nitrogen, phosphorous, and sludge levels are significantly reduced. The inventors suggest that the rapid depressurization promotes stripping of ethane, methane, and propane from the wastewater.

The third Japanese patent, assigned to Chuo Insatsu KK/ Toyo Ink Manufacturing Co., Ltd. [40], offers a new flocculant composition for treating wastewater from industrial processes, including the pulp and paper industry [40]. The new flocculant contains a tangleweed extract, potash alum, and sodium bicarbonate. The inventors claim that their new method ofwastewater treatment generates a lower volume of sludge and that the treated sludge is safe for humans and the environment,

## USES FOR SLUDGE

Several inventions have been patented to address residuals from paper recycling. One of these inventions is disclosed in a Japanese patent granted to Ishigaki et al. [41]. It offers an innovative use for pulp and paper sludge, including that generated from flotation deinking processes, by converting the sludge into a usable solid fuel. The fuel, which incorporates the combustible waste sludge, is manufactured by a process in several stages: grinding to 15 mm

particle size, mixing, shaping in an extruder to 30 mm diameter, producing 30- to 60-mm lengths, and drying to 35% moisture content or less.

Sludge can also be used to produce a soil conditioning compost using a process developed by Niwada [42]. The process ferments a portion of the sludge and incinerates other portions. The incineration ash is mixed back into the fermenting portion to produce low-odor compost.

Finally, two recently patented processes provide details for producing high quality animal litter. The first patent, by Wiedenhaft and Yoder [43], discloses methods for treating fibers and/or fiber-containing sludges with guar gum to produce clumping animal litter. Similarly, Bloomer [44] has invented a process to produce a clumping cat litter from bentonite clay and paper mill sludge.

## WASTEPAPER SORTING

Three recent inventions address the sorting of wastepaper from the recycling stream. The first is a published U.S. patent application by Liddle and Tassielli [45] that describes a comprehensive system for separating a mixed waste stream into plastics, metals, and various paper grades. In regard to paper sorting, OCC, cardboard, and newspaper are initially separated from smaller sheet papers in a rotating drum with 6- to 12-inch (152- to 305-mm) holes in the periphery. The large pieces traverse the drum while the smaller paper sheets are ejected through the holes. The large materials are collected on a conveyor after exiting the drum. Newspaper is then separated from OCC in a gap between two conveyors; the stiffer OCC bridges the gap while the flexible newspaper falls into the gap. Meanwhile, the smaller sheets of paper, which were initially removed from the drum periphery, are shredded and passed through two water baths. The first bath has a fast current such that high density materials (such as glass, metals, and some plastics) sink while lower density materials are transported to the second bath. In the second bath, the current is much slower so that highly wettable papers, i.e., uncoated papers, sink while coated papers and plastics remain floating. The OCC, newspaper, and uncoated papers are individually compacted before delivery to the customer.

The second patent, granted to Rosenboom [46], also uses density differences to separate a wastepaper stream into an OCC and paperboard fraction, a lightweight paper fraction, and a heavy paper fraction. In this process, the material is passed over a sieve where flexible paper falls through the openings while the stiff OCC is transported across the sieve openings and collected. The separated paper is moved on an inclined conveyor, where a vacuum lifts the paper while heavy waste falls off the conveyor end. The collected paper is next fed into the top of a zig-zag sifter, a vertical baffled chute with an upflowing air current. The upflowing air blows the lightweight paper out the top of the sifter for collection. The heavier material falls to the bottom of the chute and is transferred to a second sifter. Any remaining lightweight paper is separated in the second sifter and fed back to the first sifter for further classification. The heavy material from the second sifter is collected as mixed paper. The process is claimed to be simple and cost effective.

The third sorting patent, granted to Rehrmann et al. [47], utilizes spectral analysis to distinguish between various paper and printing types in a mixed wastepaper stream. The expert system receives inputs from a CMYK (cyan, magenta, yellow, and carbon black) sensor, a near-infrared (NIR) sensor, and a color CCD (charge coupled device) camera, which are directed at a conveyor carrying the mixed wastepaper. The system identification of the paper type is subsequently used to direct air jets to separate the papers. The NIR detector is used to differentiate between paper and non-paper substrates such as plastic sheets. The CMYK sensor detects whether the sheet is printed with black or colored ink and whether the sheet itself is white or colored. The camera provides additional information such as sheet size, surface reflectivity, and color richness as well as many other physical parameters. Algorithms combine each sensor's input to distinguish between the type of wastepaper (newspaper, magazines, OCC, paperboard, office paper) and the type of printing used.

## ALTERNATIVE PRODUCTS

Several recent patents or applications address the use of reclaimed fiber in non-paper products. The descriptions of these inventions are presented to indicate the wide range of ideas for utilizing the reclaimed fiber resource.

Four of these patents are in the area of plastic and paper composites. The first, from Lee [48], demonstrates a process for producing lightweight structural panels from wastepaper and waste polypropylene bags. Likewise, Shin [49] describes methods for compressing and heating mixtures of reclaimed fiber and plastics to produce structural panels, which could replace wood panels. An invention by Lagace and Medoff [50] deals with manufacturing composites from cellulosic materials and resins. Last, Crews et al. [51] disclose procedures for producing fiber pellets to be used in the manufacture of fiber- reinforced polymer materials and products.

The use of reclaimed fiber in structural materials is demonstrated in other recent patents as well. An invention by Stuendel and Eckert [52] shows improved methods of pressure molding reclaimed fiber into lightweight building and insulation panels. In an invention by Kim [53], drywall-type panels can be produced from waste gypsum and 10% to

20% reclaimed fiber. Last, a patent granted to Ambrose [54] describes a lightweight concrete admixture of water, clay, and reclaimed fiber that can be used for landscaping blocks and as a replacement for sand and gravel in poured slabs.

The adsorbency of reclaimed fiber can be used in pollution control according to two recently granted patents. The first, by Hori [55], utilizes ground reclaimed fiber in a floating boom to collect waste oil. The collected material can be incinerated. Likewise, a patent granted to Choi and Ro [56] describes the use of pulverized reclaimed fiber to collect highly contaminated wastewater, which can be subsequently incinerated.

A recent patent granted to Dussaud and Bouvier [57] describes the use of biodegradable papers as mulching for vegetables in place of plastic sheeting. The papers are a mixture of unbleached kraft and deinked pulps, treated with a water-resistant resin. Once the vegetables are harvested, the paper is sprayed with an enzyme to hasten degradation. In a related invention by Choi [58], a mixture of reclaimed fiber and hay is used to produce a mulching cover that is easily degradable after application.

Finally, Wingerson [59] has recently received a patent for processing biomass, including reclaimed fiber, into pure cellulose for use as a feedstock for plastic or ethanol production. The delignification process is claimed to be benign since only steam, water, oxygen, and a small amount of caustic are used. The two-stage process claims lignin levels less than 1% in a 10-minute treatment.

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