

signal_name	signal_description	mindmap_maincategory	mindmap_subcategory	degree_of_emergence
3D Printing	3D printing is transforming how wood is used by making it possible to create new wood-based materials and products that are more functional and sustainable. By dissolving and regenerating cellulose fibers, wood-derived substances like microcrystalline cellulose can be included in 3D-printed materials that conduct electricity, which are useful in electronics and energy storage. Mixing wood flour with polymers such as polylactic acid allows for the production of sound-absorbing materials and strong wood-plastic composites, which have better mechanical properties and are better for the environment. Advanced techniques like coextrusion and additive manufacturing make it possible to layer wood-polymer composites precisely, leading to the creation of complex architectural shapes and lightweight building parts. These developments help reduce the use of fossil fuels, support recycling and reuse, and broaden the ways wood can be used in areas like furniture, construction, and bioengineering.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.107913669
Absorbent Material	In wood composites, absorbent materials such as cellulose fibers and superabsorbent polymers are added to improve how well the material holds and distributes liquids. This makes wood composites useful for advanced applications like hygienic products and energy-efficient panels. For example, cellulose-based absorbent layers in wood products increase capillary action and allow for quick moisture absorption, which is important for items like diapers and sanitary pads. Absorbent materials also help wood function better in energy systems by managing moisture and making combustion more efficient during thermochemical conversion processes. Innovations include using absorbent wood-derived layers in solar panels to control heat, demonstrating wood's flexibility in renewable energy. These developments help reduce dependence on fossil fuels and support circular economy practices, making wood a sustainable choice for many industries. By using absorbent materials, wood is able to move beyond its traditional roles and contribute to new environmental and technological solutions.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.478417266
Activated Carbon	Activated carbon, when used in wood-based composite materials, helps purify air and control odors by absorbing harmful substances like formaldehyde and other volatile organic compounds. This makes wood panels and flooring systems safer for indoor environments. In water treatment, activated carbon made from wood effectively removes heavy metals and organic pollutants, proving useful for cleaning water and supporting environmental protection efforts. The production of activated carbon also supports the circular economy by using wood waste, such as sawdust and lignin, which reduces dependence on fossil fuels and cuts down on waste. In industry, wood-derived activated carbon is used in biorefining systems to purify products and treat emissions, highlighting its adaptability and environmental advantages. Overall, these uses show how activated carbon can transform wood into a valuable resource for sustainable practices and broaden its applications in various fields.	Chemical and Bioremediation	Bioremediation wood treatment	0.307553957
Adhesive and Gluing	Automated devices ensure even glue distribution, which strengthens the bond between layers and improves the structural integrity of products like multi-layer solid wood floors. These devices use features such as automated spraying, pressing, drying assemblies, and air purification systems. This not only increases production efficiency and reduces waste but also creates a healthier work environment by limiting harmful gas emissions. Advancements in adhesive formulations, including protein-based adhesives and modified phenolic resins, improve moisture resistance, flame retardancy, and environmental compatibility. These improvements support eco-friendly manufacturing and help create durable composites by bonding different materials such as bamboo, aluminum, and thermoplastics. This expands the use of wood composites in construction, furniture, and packaging. New adhesive technologies, like UV-curable adhesives and those enhanced with nanoparticles, further increase bonding strength and reduce dependence on fossil-based materials. These innovations promote resource efficiency, extend the lifespan of wood products, and support circular economy principles. Overall, the use of advanced adhesive layers transforms wood into high-performance, sustainable materials, helping the wood industry meet ecological goals and broaden its range of applications.	Chemical and Bioremediation	Liquefaction of mixed wood waste and green adhesives based on polyols	0.598920863
Aluminum Alloy	Composite systems that combine aluminum alloy and wood offer several advantages. Aluminum alloy frames in products like windows provide durability, weather resistance, and better sealing, while wood adds visual appeal and insulation. When aluminum alloy is integrated into wood-based products such as beams and doors, it increases strength and reduces the risk of deformation. Aluminum's lightweight and strong properties make it easy to work with and compatible with wood, allowing for modular designs and efficient assembly. Adding aluminum alloy layers to wood-plastic composites improves thermal and sound insulation, reduces the amount of wood needed, and extends the product's lifespan. This combination supports environmental sustainability by optimizing material use and reducing waste, which aligns with circular economy principles.	Cascade refinement technologies for wood waste upcyclinq	Validation of new composite products through prototyping	0.725719424
Anti Cracking Floor	The use of aluminum honeycomb cores with wood-based materials further enhances composite panels. These panels become stronger, more rigid, and more resistant to moisture, fire, and pests. The honeycomb structure also reduces material use while maintaining durability and lightness. In wood panels, honeycomb cores improve acoustic and thermal insulation, and their hexagonal shape provides stability and resistance to pressure. Aluminum honeycomb bonds well with wood layers, allowing for seamless integration and improved appearance and function. Overall, these innovations address challenges in construction and furniture by combining the strengths of aluminum and wood. They promote eco-friendly, high-performance solutions, reduce reliance on solid wood, and encourage the use of recyclable materials, supporting environmental protection and efficient resource use. Anti-cracking floors improve the use of wood by making it more durable, functional, and sustainable. These floors use new designs, such as composite layers, special coatings, and engineered grooves, to prevent cracks caused by changes in moisture, temperature, or physical stress. For instance, grooves filled with epoxy resin help reduce cracking while keeping the floor strong. Using layers of hardwood and softwood in staggered patterns also increases strength and stability, helping the floor last longer under tough conditions. Other features include layers that absorb moisture, coatings that resist wear, and strong adhesives to keep the wood from drying out and cracking. Flooring systems may also use interlocking grooves and reinforcing rods to make connections more stable, making installation easier and extending the floor's lifespan. These improvements help reduce waste and use resources more efficiently, supporting environmentally friendly practices. By preventing cracks and deformation, anti-cracking floors make wood a better choice for construction, furniture, and interior design, encouraging sustainable use and reducing the need for non-renewable materials.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.241007194

Anti Deformation	Composite wooden doors use multi-layer splicing with high-density and polymer plates to prevent warping and increase lifespan. Aluminum-wood composite boards feature V-shaped grooves and high-pressure bonding, making them resistant to twisting and more stable. Solid wood core boards now include cross-cut designs and grooves that reduce stress, helping to prevent swelling and warping. These improvements allow for larger panels and less material waste. Overall, these innovations make wood products more durable and sustainable by reducing the need for fossil fuels and supporting recycling. Enhanced resistance to deformation means wood materials last longer and can be used in more ways, from furniture to construction, leading to more efficient and eco-friendly use of natural resources.	Cascade refinement technologies for wood waste upcycling	Composite production	0.559352518
Anti Skid Layer	Integrating anti-skid features—such as convex grooves, embossed textures, or special coatings—into wood-based materials improves traction and reduces the risk of slipping. This makes these materials well-suited for flooring and structural uses. For example, anti-skid layers in wood-plastic composites and solid wood floors help prevent accidents and also increase wear resistance and water repellency, which extends the material's lifespan. Other innovations, like anti-skid pads and textured surfaces in wood veneers, enhance both the look and function of wood by improving moisture absorption and grip. These developments promote safer, more sustainable construction and highlight wood's versatility in modern design and manufacturing.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.381294964
Assembly Methods	The assembly method offers new possibilities in construction and manufacturing by combining wood with materials like plastic or steel using precise techniques such as mortise-and-tenon joints and modular designs. This approach improves structural stability and flexibility. Examples include embedding wood panels in composite frameworks and using wood-plastic composites for structures that are easy to assemble. These methods make efficient use of materials and help lower environmental impact. They also enable the creation of lightweight yet strong products, such as prefabricated walls and modular furniture, which simplify both production and installation. Additionally, assembly methods support sustainability by using recycled or engineered wood, encouraging a circular economy. Overall, these techniques make wood more adaptable and functional, reduce dependence on traditional materials that require a lot of fossil fuels, and promote innovation in environmentally friendly construction and design.	Cascade refinement technologies for wood waste upcycling	Composite production	0.570143885
Bending Strength	Bending strength is crucial for composite wood boards, as it ensures they are durable and resistant to bending or deformation. This makes them suitable for demanding uses, such as in construction and furniture. New techniques like acetylation improve bending strength and help the boards stay stable even in harsh conditions, such as repeated wetting and drying, which increases their lifespan. In engineered wood products, strong bending strength allows for the creation of advanced multi-layered materials, like bamboo-wood laminates and steel-wood beams, which are both flexible and able to support heavy loads. These innovations help reduce waste and make better use of resources. Additionally, improved bending strength supports the use of recycled and bio-based materials, such as composites reinforced with starch, which have better mechanical properties. Overall, these developments encourage more sustainable practices, support a circular economy, reduce dependence on fossil fuels, and broaden the ways wood can be used in modern engineering and design.	Chemical and Bioremediation	Upcycled wood validation	0.14028777
Biodegradable Materials	Materials like polylactic acid (PLA), polyhydroxyalkanoates (PHA), and cellulose derivatives are combined with wood fibers to make composite materials. These composites keep the natural look of wood while improving durability, biodegradability, and environmental impact. Manufacturing methods such as compression molding and extrusion are used to create wood-plastic composites, which mix wood particles with biodegradable polymers. The result is products that are strong and resistant to moisture, aging, and pests. New developments include transparent wood composites, where biodegradable polymers replace lignin, making the material suitable for energy-efficient buildings. Additionally, biodegradable adhesives and coatings from natural sources improve wood's use in packaging and construction. These innovations help reduce dependence on non-renewable resources, support a circular economy, and allow wood-based products to meet modern sustainability standards.	Cascade refinement technologies for wood waste upcycling	Composite production	0.366906475
Biomass	Technologies like hydrothermal carbonization and pyrolysis convert biomass into valuable products such as biochar, activated carbon, and bio-oil. These products can be added to wood-based materials or used on their own. For example, activated carbon made from biomass can improve the strength and environmental performance of wood composites. Other processes, such as co-gasification and thermochemical conversion, turn biomass into renewable fuels, helping to reduce reliance on fossil fuels. Biomass is also used to create environmentally friendly wood treatments, like carbonized coatings, which make wood more durable and resistant. These innovations support a circular economy by reusing agricultural and forestry waste, cutting down on waste, and lowering carbon emissions. Overall, using biomass in these ways expands the uses of wood and supports sustainable development goals.	Energy, Gas and Ashes Voliarisation	Hydrothermal carbonisation through microwaves	0.508992806
Bonding Strength	In flame-retardant wood-plastic composites, strong bonding between the surface and core layers is essential for maintaining structural integrity and providing fire resistance. New adhesives, such as those made from sesame protein, offer high bonding strength while being water-resistant and free from formaldehyde, making wood processing more environmentally friendly. Other advanced adhesives, including those based on starch or polyurethane, also improve bonding and are used in products like composite wood floors and structural panels. These adhesives often contain cross-linking agents or fiber reinforcements, which help them withstand moisture and heat. Strong bonding also allows for the combination of materials like aluminum or bamboo with wood composites, increasing mechanical stability and broadening their use in construction and decoration. By improving bonding strength, these innovations help make wood products more sustainable, reduce waste, and support a circular economy, making wood a more versatile and eco-friendly material for modern industries.	Chemical and Bioremediation	Upcycled wood validation	0.264388489
Carbon Fiber	Carbon fiber layers added to composite wooden panels improve their bending strength, impact resistance, and durability, addressing weaknesses found in traditional materials like plastic and polyurethane foam. Techniques such as carbon fiber impregnation and cold-press curing help maintain stability during manufacturing, preventing issues like delamination and bulging. In bamboo-wood composites, carbon fiber reinforcement increases the material's ability to bear loads, resist moisture, and withstand earthquakes, making it suitable for use in structural elements such as beams and columns. When used in wood-based products like flooring and furniture, carbon fiber boosts strength, wear resistance, and thermal performance, while also lowering environmental impact. These advancements allow for lightweight, strong designs and expand the use of wood in sustainable construction and manufacturing. Overall, integrating carbon fiber into wood products supports energy conservation, reduces dependence on fossil-based materials, and fits with circular economy goals, making wood a more versatile and environmentally friendly choice for modern industries.	Cascade refinement technologies for wood waste upcycling	Composite production	0.478417266

Cellulose Fiber	Cellulose fibers, derived from wood, are transformed through processes like delignification and fibrillation, and by combining them with polymers, into advanced materials such as composites, films, and foams. These fibers can be densified to produce strong construction materials or integrated into thermoplastics to create lightweight, moldable products used in automotive and architectural fields. Innovations include flame-retardant textiles and transparent wood composites, demonstrating the versatility of cellulose fibers in safety and energy-efficient applications. Using cellulose fibers also supports sustainability by making use of wood waste and agricultural leftovers, which helps reduce dependence on fossil fuels. These developments support the circular economy by encouraging renewable material use and lowering environmental impact. As a result, wood-based industries are able to expand into areas like energy storage, packaging, and advanced manufacturing, making wood an important resource for eco-friendly innovation. Clamping grooves in composite wood products allow for secure and easy assembly and disassembly of items like flooring and panels. This design strengthens connections, makes maintenance simpler, and lowers the risk of parts warping or deforming during installation or use. In wood-metal composites, clamping grooves help keep materials tightly aligned, which increases durability and resistance to weather. They also make it possible to create hybrid products that are both sustainable and high-performing.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.598920863
Clamping Groove	In addition to structural improvements, clamping grooves make it easier to add advanced features such as fireproof coatings and soundproofing layers. This enhances the product's functionality without making assembly more complicated. These innovations help reduce material waste, extend the life of products, and encourage more sustainable practices in the wood industry. Overall, clamping grooves allow for precise engineering and a wide range of uses, representing a significant advancement in modern wood processing. They support goals like using resources efficiently and promoting a circular economy.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.791366906
Coating Composition	Acrylic coatings enhance laminated wood by increasing its resistance to wear and chemicals, protecting it from environmental damage and extending its lifespan. New developments, such as multilayer coatings with optical or thermal features, allow wood to be used in energy-efficient buildings and advanced manufacturing. Methods like plasma spraying and UV curing improve how coatings stick to wood and strengthen its surface, making it more durable under stress and exposure. Some coatings use nanomaterials or bio-based ingredients, reducing the need for fossil fuels and supporting environmentally friendly practices. These innovations make wood stronger, more attractive, and suitable for a wider range of uses, from construction to interior design. Overall, these coating technologies help make wood a high-performance, sustainable material for modern engineering and environmental protection. The text describes recent advancements in wood-based composite materials, highlighting how integrating various layers—such as solid wood, adhesives, polymers, metals, and specialized coatings—improves the stability, durability, and performance of wood products. Innovations include the use of formaldehyde-free adhesives and activated carbon layers to reduce harmful emissions and absorb odors, contributing to healthier indoor environments. Other developments, like honeycomb aluminum cores, bamboo charcoal, and graphene oxide, enhance strength, sound insulation, fire resistance, and thermal stability, making these composites suitable for construction, furniture, flooring, and more. Manufacturing processes such as hot pressing, advanced bonding, and extrusion molding ensure uniform stress distribution, prevent deformation, and extend product lifespan. These methods also enable the efficient use of fast-growing wood species and recycled materials, reducing reliance on traditional hardwoods and supporting resource conservation. The integration of renewable and recycled components aligns with circular economy principles by minimizing waste and enabling recyclability.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.683453237
Composite Elements and structures	Composite materials, such as ABS composites and thermochemically modified wood, offer superior mechanical properties and expand wood's applications to areas like 3D printing, automotive interiors, and precision manufacturing. Composite formwork and beams, which combine wood with steel, fiberglass, or concrete, improve structural integrity, adaptability, and seismic resistance while reducing material consumption and environmental impact. In flooring and panels, multilayer designs and the use of additives like magnesium oxide and melamine resin provide improved moisture resistance, abrasion resistance, and fireproofing. Techniques like embossing and lamination create decorative and functional surfaces, while edge locking systems enhance assembly. Overall, these innovations transform wood into a versatile, high-performance, and eco-friendly material. By bridging traditional wood uses with modern material science, composite wood products support sustainable practices, extend product lifespans, and meet the evolving needs of construction, manufacturing, and design industries.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.449040767
Conductive Material	By adding conductive layers, particles, or wires to wood-based materials, wood can become an active part of technologies like touch-sensitive displays, sensors, and energy storage systems. Methods such as impregnation with conductive compounds, laser transfer printing, and multilayer deposition make wood electrically conductive while keeping its natural look and strength. These improvements allow wood to be used in smart packaging, interactive labels, and bioenergy systems, and also support sustainable energy production through processes like thermochemical conversion and co-gasification. Conductive wood can also be used in electronic devices, communication systems, and environmental monitoring, helping to connect renewable materials with advanced technology. Using conductive materials in wood reduces dependence on fossil-fuel-based products and supports circular economy practices, making wood a flexible and environmentally friendly option for modern technology.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.523381295
Connecting Mechanisms	Connecting mechanisms in composite materials offer several advantages across different applications. In steel-wood composite shear walls, these mechanisms remove the need for welding, making installation easier while still providing strong connections between steel and wood parts. In wood-plastic composite boards, they help join load-bearing and supplementary layers smoothly, which enhances water resistance and appearance. For bamboo-wood shear walls, connecting mechanisms create secure links between walls and bamboo columns, improving the transfer of forces and making large-scale production more practical. Overall, these innovations help reduce material waste, increase durability, and encourage sustainable practices. They support goals such as lowering dependence on fossil fuels and advancing circular economies in wood-based industries. By allowing for precise and flexible connections, these mechanisms make wood a more adaptable material for modern construction and manufacturing.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.456834532

	The use of composite wood templates in scaffolding simplifies processing, reduces cracking, and lowers maintenance costs. Prefabricated systems, such as steel-wood composites and modular wood molds, make assembly faster, reduce labor needs, and enhance stability.			
Construction Methods	Innovations like steel-wood composite floors and fireproof wood walls combine wood's natural properties with advanced materials, resulting in durable and environmentally friendly structures. These methods reduce the need for traditional, resource-intensive construction techniques, speeding up projects and minimizing resource use. Composite wooden box structures and multifunctional wooden templates further improve stability, mobility, and resource efficiency by incorporating recycled wood. Wood-steel composite systems use the strengths of both materials to create durable frameworks for large projects, while modular systems allow for adaptable designs and easier assembly. Embedding polymer rods in wooden beams increases their load-bearing capacity. These techniques optimize wood's mechanical properties, reduce reliance on fossil-fuel-based materials, and support circular economy principles. Construction waste is also transformed into valuable materials through sorting, grading, and recycling. For example, hydraulic composites made from waste wood fibers improve structural integrity and reduce the need for new resources. Wood bits from waste are used in lightweight architectural elements, and advanced sorting technologies ensure precise separation for reuse. Integrating wood fibers into refractory materials or panels further supports sustainability and reduces environmental impact. Overall, these innovations position wood as a key material in eco-friendly construction, promoting resource efficiency and sustainable building practices.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.507793765
Container Bottom Plate	The composite bottom plate is made using methods like hot pressing and multi-layer assembly, which give it high strength, durability, and environmental benefits. Staggered layers of bamboo and wood veneers improve its mechanical properties, while glass fiber reinforcement increases its strength and resistance to aging. Using bamboo fibers and recycled materials helps reduce the amount of wood needed, supporting sustainability efforts. Advanced manufacturing techniques, such as defibering and recombination, make the plate more uniform and prevent cracking, leading to greater reliability. As a result, this composite plate performs better than traditional wood-based plates in terms of abrasion resistance, load-bearing ability, and protection against moisture. By making better use of materials and following circular economy principles, the plate helps lower fossil fuel use and encourages environmentally friendly practices in the wood industry.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.552158273
Container Design	Containers made with wood fibers or wood-based composites are used in products like bamboo-wood floors, laminated plywood, and moisture-resistant plastic-wood panels. These designs take advantage of wood's natural qualities—such as strength, durability, and sustainability—while combining them with modern materials like polyethylene or aluminum to improve performance. Manufacturing methods like extrusion and injection molding are used to create layered wood composite structures. These techniques help improve insulation against heat and sound, as well as resistance to moisture. For example, bamboo-wood boards provide better sound and temperature insulation, and special damp-proof layers help prevent decay, making wood-based products last longer. Using wood fibers in containers also makes them more biodegradable and supports environmental goals by reducing the use of non-renewable materials. Overall, adding wood to container designs helps industries create sustainable products that offer both environmental and practical benefits, encouraging innovation in materials and responsible use of resources.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.510791367
Control Units	Control units play a key role in modern wood processing systems. In intelligent multi-blade saws, they manage blade positions and cutting actions using real-time width measurements, which leads to efficient and precise wood cutting. In wood-plastic composite extrusion machines, control units automatically adjust pressure and diameter to ensure consistent quality. They also improve safety and accuracy in wood sawing correction devices by detecting errors and sending signals to correct cutting paths. By working with sensors and actuators, control units help save energy, reduce waste, and speed up production. These improvements support sustainable practices by making better use of resources and lowering environmental impact. Overall, control units are making wood processing more automated, efficient, and environmentally friendly.	Digital tools for improving circular flows	Development of Interfaces and Protocols	0.444244604
Conveying Mechanisms	In the production of multi-layer wood composite flooring, various conveying mechanisms—such as composite conveyors, transverse conveyors, and telescopic assemblies—are used to move materials efficiently, reduce manual labor, and improve production speed. Rotating shafts and belt systems help align and sort wood panels accurately, ensuring consistent quality. In automatic sorting devices for square timber, chain-driven systems and lifting devices transfer and align timber layers smoothly, which helps with stable stacking. Intelligent sorting systems use multi-layer conveyors and vertical sorting mechanisms to automatically classify and store wood panels based on size, thickness, or specific order needs. These technologies reduce the need for manual handling, increase production rates, and make better use of space, supporting sustainable and efficient manufacturing. In fiber recovery, conveying systems move biomass slurry through electric channels, allowing for precise separation and recovery of fibers. For composite wood board production, conveyor belts assist with processes like overturning and spraying, enabling double-sided treatment without manual repositioning. Automated systems also use conveyors for sorting, cutting, and stacking panels, which ensures uniformity and further reduces manual work. In wood-plastic extrusion, conveyor belts provide steady material transport, which is essential for consistent heating and cooling, resulting in high-quality products. Overall, these conveying systems streamline operations, reduce waste, and support sustainable practices by minimizing reliance on fossil fuels and encouraging circular economy principles in the wood industry.	Separation and sorting of CDW	Separation of wood and metallic components by human-robot collaborator	0.748201439
Core Layer Variations	Composite wood products use a core layer made from materials like wood fibers, bamboo, or engineered composites to provide strength and durability. In flooring systems, this core layer is important for resisting deformation, improving sound insulation, and increasing moisture resistance, which helps the flooring last longer and perform well in different conditions. New designs, such as zigzag-shaped wooden elements or corrugated structures, help distribute stress more evenly and use less material without sacrificing strength. Using recycled wood flakes or plant-based fillers in the core layer also supports environmental goals by reducing waste and making better use of resources. These improvements in core layer design not only make wood products technically better but also support sustainability and adaptability in modern construction and manufacturing.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.737410072

Corrosion Resistance	Integrating corrosion-resistant layers, coatings, and treatments helps protect wood-based materials from moisture, microbial decay, and chemical damage, which extends their lifespan and maintains their strength. New developments, such as anti-corrosion composite boards, flame-retardant coatings, and modified bamboo-wood composites, improve wood's performance in challenging settings like construction, transportation, and industry. Additional processes, including thermochemical treatments and the use of graphene oxide, make wood even more durable, allowing it to be used in hybrid systems and under high stress. These improvements lower maintenance needs, reduce waste, and encourage environmentally friendly practices by lessening dependence on fossil-based materials. Overall, making wood corrosion-resistant turns it into a more versatile and sustainable material, supports circular economy goals, and encourages innovation in engineering and design while helping to protect the environment.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.535971223
Cutting Devices	Advanced cutting mechanisms, such as laser cutting and hydraulic systems, help produce composite wood products, veneers, and solid wood structures with greater accuracy and less waste. These technologies make processes more efficient by enabling automated defect removal in crosscut saws and optimized cutting in intelligent multi-blade saws. This ensures high-quality products that meet specific size and pattern requirements. Innovations like dust collection systems and fire prevention features also improve workplace safety and environmental sustainability by addressing issues such as wood chip buildup and overheating during cutting. Automated controls and real-time adjustments further reduce material waste and boost production efficiency. Overall, these advancements support sustainable practices in wood manufacturing by optimizing resources and promoting eco-friendly production.	Cascade refinement technologies for wood waste upcycling	Composite production	0.537769784
Damp Proof Layer	For solid wood composite doors, the damp-proof layer reduces cracking and warping caused by changes in humidity, which extends the door's lifespan and keeps it looking good. In wood-plastic composite wallboards, the damp-proof layer works with other waterproof features to protect the core material from moisture and decay. For flooring, such as solid wood composite and bamboo-wood container floors, the damp-proof layer prevents expansion and mildew caused by dampness, making these floors more reliable in humid settings. These improvements also help reduce the use of fossil-based materials and promote sustainability by making wood products last longer, which supports the principles of a circular economy. Overall, adding damp-proof layers to wood products increases their durability, makes them more resistant to environmental challenges, and expands their use in construction and design.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.674460432
Decoration and Design	Recent innovations in wood composite technology have greatly enhanced both the appearance and functionality of materials like MDF and HDF. Techniques such as intaglio and digital printing allow for detailed, layered designs that imitate natural patterns, while also improving resource efficiency by integrating paper layers and transparent coverings for added durability. New materials, including graphene composites, enable quick installation and easy dismantling, supporting reusability and sustainable building practices. Eco-friendly options, such as formaldehyde-free straw composites and sound-absorbing laminates, show how decoration processes can incorporate recycled materials and multifunctional features like noise reduction and fire resistance. These advancements help reduce dependence on fossil fuels and support circular economies by repurposing waste and extending the lifespan of wood products. Decorative layers play a key role in processes like hot-melt lamination and embossing, creating durable films for flooring, wall panels, and furniture. These layers, often combined with resin and abrasion-resistant particles, improve wear resistance and longevity. In specialized applications, such as fireproof boards and soundproof flooring, decorative layers add both structural strength and visual appeal. Further innovations include composite layers made from bamboo-wood fiber, aluminum-wood combinations, and fireproof coatings, all of which enhance durability and resistance to environmental factors. For example, bamboo-wood fiber plates use natural antibacterial properties and carbon fiber for strength, while aluminum-wood plates use honeycomb structures to prevent deformation. Additional features like UV coatings, embedded soundproofing, activated carbon, and nanotechnology provide benefits such as fireproofing, waterproofing, noise reduction, and improved indoor air quality. Overall, these advancements transform wood composites into versatile, durable, and environmentally friendly materials, making them well-suited for modern architecture and interior design.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.660071942
Detection Devices	Detection devices are playing a transformative role in the wood industry by improving product quality, safety, and efficiency. For example, moisture content detection devices for solid wood composite floors use motors and clamping mechanisms to ensure even drying and heating, followed by precise moisture measurement. This process enhances the durability and quality of wood products. Fire resistance detection devices for aluminum-wood composites use sensors to measure temperature and smoke concentration, helping to meet safety standards. Automatic inspection devices for wood-based veneers use sensors and micro-displacement technology to achieve high detection accuracy, making it easier to integrate these checks into manufacturing. Additionally, systems that control wood drying parameters use sensors to monitor temperature, humidity, and moisture content in real time, which improves drying efficiency and reduces energy use. These technological advancements support sustainable practices, better product performance, and integration into circular economies, highlighting the significant impact of detection devices in the wood industry.	Separation and sorting of CDW	An advanced multilayer sorting system	0.474820144
Dielectric Layer	Dielectric materials in wood-based composites enhance energy storage, thermal insulation, and the transmission of electromagnetic waves, making it easier to integrate electronics and sensors into wood products. For instance, applying dielectric coatings can improve how wood reflects and absorbs light, leading to more energy-efficient building solutions. Dielectric substrates also allow for the creation of multilayered structures used in electrical devices such as antennas and filters. Furthermore, dielectric surfaces can control electromagnetic waves to make processes like pyrolysis and co-gasification more efficient, which helps save energy during wood processing. These innovations support sustainable energy systems and encourage the use of renewable resources, reducing dependence on fossil fuels and promoting a circular economy. By combining natural wood with advanced dielectric technologies, wood becomes a multifunctional material suitable for modern construction, renewable energy, and advanced manufacturing. This combination highlights the importance of dielectric layers in making wood a versatile and environmentally friendly option for technological advancements.	Cascade refinement technologies for wood waste upcycling	Composite production	0.566546763

Driving Motor	In composite batten machining, motors control threaded rods to adjust clamping plates, allowing for precise changes in batten width and smooth transfer to shaping devices. In wood-plastic composite production, motors operate extrusion and mixing equipment, ensuring even blending of materials and efficient production of strong wood-plastic products. For cutting wooden doors and composite boards, motors rotate cutting tools, which increases efficiency and accuracy while reducing material waste. Motors are also used in polishing and sorting machines, which improves surface finishing and enables effective sorting of wood-based materials. Overall, by automating these processes and reducing the need for manual labor, motors help make operations more efficient and support sustainable practices in the wood industry, promoting better use of resources and contributing to the circular economy.	Cascade refinement technologies for wood waste upcycling	Composite production	0.505395683
	Dust collection plays a key role in improving wood processing by making it more efficient, safe, and sustainable. In activities like wood carving and sanding, dust collection systems stop airborne particles from spreading, which helps protect workers' health and keeps the environment cleaner. Tools such as table saws and engraving machines use features like suction covers and extraction turbines to capture sawdust right where it is produced. This not only improves air quality but also reduces the time needed for cleaning up.			
Dust Collection	New technologies, including multilayer filter bags and electrohydrodynamic droplet systems, make dust capture even more effective by filtering particles more precisely and allowing equipment to run longer without maintenance. These systems help protect workers and also make it possible to recycle wood dust into products like composite boards, paper, or fuel. This supports a circular economy by reducing waste and the need for new raw materials.	Digital tools for improving circular flows	Material volume estimation	0.415467626
Dust Removal	By lowering fire risks and making it easier to recover and reuse materials, dust collection technologies help create safer, cleaner, and more sustainable wood processing. They support industry progress, reduce dependence on fossil fuels, and minimize waste.	Separation and sorting of CDW	Methodology development for the CDW separation and sorting system	0.183453237
	Dust removal plays a crucial role in wood processing and production by improving efficiency, safety, and environmental sustainability. In wood composite manufacturing, equipment with dust removal features—such as suction fans, filters, and collection chambers—captures wood chips and fine particles produced during cutting, sanding, or drilling. For example, dust removal systems in cutting machines stop airborne particles from contaminating the workspace, while suction and filtration units help maintain cleaner air and lower health risks for workers. Some systems also allow collected wood dust to be recycled into composite boards, which saves resources and reduces waste.			
Electrode Assemblies	On production lines, dust removal equipment ensures accuracy by removing residues that could affect bonding or surface quality during steps like gluing or cold pressing. These systems also reduce fire risks and help machines run more efficiently by preventing dust buildup. Overall, dust removal technologies lead to cleaner work environments, better product quality, and support for sustainable practices in the wood industry by following circular economy principles.	Energy, Gas and Ashes Volarisation	Fluidised Bed Gasification	0.323741007
	Electrode assemblies play a key role in converting wood into biofuels and renewable materials through thermochemical and co-gasification processes. They improve energy transfer and reaction speed, making these transformations more efficient. By adding sensors and conductive pathways, electrode assemblies allow for accurate monitoring of wood's condition and the surrounding environment. This supports the development of smart wood products and sustainable building methods.			
Electronic Components	Furthermore, electrode assemblies make it possible to create wood-based composite electrodes for energy storage systems like lithium-ion batteries. Using wood's natural qualities, these electrodes can conduct electricity better and help reduce dependence on fossil fuels. These innovations support the circular economy by turning wood waste into valuable, high-performance materials and encouraging environmentally friendly solutions.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.451438849
	Overall, electrode assemblies connect traditional uses of wood with modern technology, helping to make wood an important part of renewable energy and sustainable materials.			
Energy Efficiency	Electronic components are being integrated into wood-based products to improve their usefulness and environmental benefits. For example, protective sleeves made with electronics, cork, and resin are both degradable and help reduce carbon emissions, while still being strong and functional. Wood veneer display panels now include grooves for electronics and transparent resin, combining traditional wood looks with modern features like lighting and interactive displays. In addition, electronics are used in wood industry machinery to make processes more precise and efficient through simulation-based optimization. These innovations help lower dependence on fossil fuels, support recycling and reuse, and broaden the use of wood in technology. Overall, embedding electronics in wood products creates a balance between natural materials and advanced technology, encouraging sustainable progress.	Cascade refinement technologies for wood waste upcycling	Composite production	0.341726619
	This design reduces the amount of material needed while improving durability and thermal insulation. Wood-plastic composites are also discussed; these use recycled materials and advanced manufacturing methods to lower energy consumption during production, while still offering strong mechanical properties and resistance to environmental damage.			
Enhanced Bearing Capacity	In architecture, energy-saving wood structures such as insulated walls and composite doors are mentioned. These use multi-layered designs with heat-preserving layers and vacuum-sealed parts to improve thermal performance, which helps reduce the need for heating and cooling. The text emphasizes that these innovations decrease dependence on fossil fuels and support sustainable building practices. They also promote recyclability and help reduce waste, contributing to the circular economy. Overall, these energy-saving wood technologies improve environmental efficiency and expand the use of wood in various industries.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.129496403
	Recent innovations in construction materials have improved the performance of wood by combining it with other materials. Steel-wood composite beams use steel plates to handle pressure, which makes joints more stable and improves resistance to earthquakes. Wood-concrete beams include special connectors and pins that help distribute weight more evenly and prevent the materials from slipping against each other. Bamboo-wood composites use reinforcing grids to boost strength while keeping the material lightweight. These developments allow wood to be used in demanding applications such as structural beams, walls that resist shear forces, and container floors. By increasing wood's ability to bear heavy loads through these hybrid designs, the construction industry can rely less on traditional materials, support sustainable building methods, and contribute to a circular economy. As a result, these improvements make wood a more versatile, competitive, and environmentally friendly option for modern engineering and construction projects.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.129496403

Environmental Protection	New composite wall assemblies and integrated plates use advanced designs and natural materials, which reduce harmful glue emissions and improve durability, safety, and performance. Examples include FRP-reinforced bamboo-straw composites that turn agricultural waste and bamboo into strong, lightweight products, helping to solve disposal problems and encourage the use of renewable resources. Other eco-friendly materials, such as biodegradable wood-plastic composites and transparent wood, replace synthetic parts with sustainable alternatives, making products last longer and lessening their environmental impact. Additional processes, like anti-corrosion treatments, formaldehyde-free adhesives, and fireproof coatings, further improve wood's safety and usefulness.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.464028777
	These developments help decrease reliance on fossil fuels, conserve resources, and support a circular economy by reusing waste and focusing on renewable materials. They make wood a key material in eco-friendly industries, with applications in construction, furniture, and packaging, all while reducing harm to the environment. Some products, like composite plastic-wood boards, include activated carbon layers to absorb harmful gases such as formaldehyde, improving air quality and health. Environmental-protection paper-plastic trays made from rice straws use resources efficiently and recycle agricultural waste. Glue-free solid wood composite floors avoid toxic adhesives, keeping wood natural and reducing environmental impact. Reclaimed waste wood and plastics are also turned into durable wood-plastic composites, further supporting recycling and resource conservation. Overall, these innovations enhance wood's performance and sustainability, help reduce fossil fuel use, and promote recycling and safe construction practices. The wood industry, through these eco-friendly approaches, is better able to meet modern needs for efficiency, safety, and environmental responsibility.			
	Extrusion Molding			
Fiber Reinforced Layers	Extrusion molding combines wood fibers with thermoplastic resins to create strong, durable composite materials suitable for various uses. In this process, vegetable fibers are mixed with reactive binders under controlled temperature and pressure, which fills the fibers' pores and ensures even distribution and better structural strength. Co-extrusion techniques can add multiple layers, such as protective coatings, to improve water resistance and mechanical strength. This method also supports recycling by using wood waste and other materials, helping to reduce the need for new resources. Overall, extrusion molding allows for precise control over the materials, resulting in lightweight, high-performance wood products that support environmental conservation and circular economy efforts. Fiber-reinforced layers bonded to wood substrates enhance moisture resistance, edge strength, and load distribution, making them useful in applications like trailer flooring. Combining fiber composites with wood results in materials that are both lightweight and strong, suitable for demanding environments. Methods such as embedding fibers in thermoplastic matrices or laminating wood with fiber-reinforced polymers produce products with better mechanical properties, including greater flexural strength and fire resistance. These composites also support recycling wood waste into durable construction materials, contributing to sustainability. Innovations like self-sealing vapor barriers and multi-layered boards further reduce dependence on traditional fossil-based materials and support circular economy goals. Overall, fiber-reinforced wood composites offer ecological benefits and improved performance, making them important in modern construction and manufacturing.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.39028777
	Fire Resistance			
	Composite mats with fire-resistant additives, such as borate salts and organophosphorus compounds, help wood products maintain their structure at high temperatures. These mats are important in sandwich constructions, which are commonly used in fire-rated doors and building panels. They provide longer resistance to flames and help slow the spread of fire. New materials, like fire-resistant wood-polymer composites, use recycled plastics and nanosized additives to create strong, flame-resistant products for construction and furniture. Other treatments use mixtures of metal salts and hydroxides in water to turn wood into self-extinguishing composites, making them more stable under heat and resistant to damage from biological and chemical sources. These innovations reduce the need for fossil fuels and support the use of sustainable and recycled materials, aligning with circular economy goals. As a result, improved fire resistance leads to safer and more environmentally friendly uses of wood in various industries. Fireproof layers in wooden structures, such as composite floors and furniture boards, enhance fire resistance and maintain structural strength, making wood safer for residential and commercial use. Innovations like dual fireproof layers in bamboo-wood composites prevent deformation at high temperatures, while added moisture-proof and soundproof features increase wood's versatility. In architecture, fireproof coatings and materials like aluminum composites and rock wool help wood meet strict safety standards, reduce fire risk, and extend product lifespan.			
Fireproof Performance	These advancements also support sustainability by reducing dependence on fossil-fuel-based materials and promoting resource efficiency and circular economy principles. Fireproof layers address key safety concerns and allow wood to be used in more applications, making it a versatile and eco-friendly choice for modern construction and design. Specific innovations include integrating fireproof layers, using flame-retardant adhesives, and creating composite frameworks to improve wood's resistance to fire. For example, fireproof solid wood composite doors use multi-layer structures with fireproof felt and sealing layers to reduce deformation and increase durability. Fireproof wooden floors use flame-retardant adhesives and insulating layers to prevent fire hazards while keeping their structural integrity. Advanced techniques, such as sol-gel self-assembly, deposit silica within wood's cellular structure, maintaining its eco-friendly qualities while improving fire resistance. Overall, these developments not only make wood safer and more durable but also help it meet strict safety standards for a wide range of construction and interior design uses. By improving fireproof performance and reducing reliance on non-renewable materials, these innovations support sustainable practices and ensure wood remains a competitive, safe, and functional material in modern industries.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.208633094
	Fireproof Performance			
				0.472122302

Flame Retardant	Flame retardants enhance wood's fire resistance through methods like vacuum impregnation, layered composites, and chemical treatments, all while preserving the wood's strength. Examples include magnesium hydroxide and ammonium polyphosphate, which form strong barriers in wood-plastic composites, and silica sol treatments, which add waterproofing and impact resistance. These advances help wood meet strict fire safety standards, making it suitable for use in fireproof doors, flooring, and construction materials. Additionally, by using renewable resources such as cellulose fibers and bio-based additives, flame retardants reduce dependence on fossil fuel-based materials and support circular economy goals. Overall, these technologies make wood safer and more versatile, promoting sustainable and eco-friendly innovation in construction and design.	Cascade refinement technologies for wood waste upcycling	Composite production	0.78057554
Flexible Containers	Flexible containers made from multilayer films or composite materials are being combined with wood-based elements to create adaptable products. For example, by joining rigid wood layers with flexible materials using adhesives or laser-engraved textures, wood can become bendable and serve as decorative or functional parts in industries like furniture and fashion. There are also flexible containers with extendable or pop-up spouts that make it easier to store and pour wood-derived liquids, such as adhesives or finishes, while keeping them preserved. These developments increase the ways wood can be used, especially in situations that require flexibility. They also help the environment by making better use of materials and reducing waste. By blending wood's strength with flexible features, these innovations support a circular economy and encourage the creation of eco-friendly, versatile products.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.035971223
Foaming Layer	In wood-plastic composites, a foaming layer is combined with wood frameworks to enhance thermal insulation, soundproofing, and structural strength. Co-extrusion processes use these foaming layers to make manufacturing simpler, use less material, and remove the need for extra insulation steps, which streamlines production. In wood-based panels and flooring, foaming layers help create lightweight products that remain durable and resistant to deformation, cracking, and moisture. This approach also supports the circular economy by using recycled materials and reducing dependence on non-renewable resources. Overall, the foaming layer is important for improving the performance and environmental friendliness of wood composites, encouraging energy efficiency, and supporting sustainable building practices.	Cascade refinement technologies for wood waste upcycling	Composite production	0.56294964
Formaldehyde Free	Innovations in wood-based products are reducing harmful emissions and improving indoor air quality. New methods include using formaldehyde-absorbing layers, scavenging agents, and adhesives that do not contain formaldehyde. For instance, composite boards now use activated carbon and photocatalyst layers to neutralize formaldehyde. Bio-based adhesives made from lignin or soy protein replace traditional formaldehyde-based binders. These changes also make products more durable, water-resistant, and stronger, making them suitable for flooring, furniture, and construction. Other technologies, such as graphene electrothermal films and tourmaline-based coatings, help actively remove formaldehyde from the environment, further promoting healthier indoor spaces. By using renewable resources like straw and recycled fibers instead of fossil-based materials, these innovations support the circular economy. Overall, these advancements reduce environmental and health risks and make wood a safer and more sustainable material for many uses.	Chemical and Bioremediation	Liquefaction of mixed wood waste and green adhesives based on polyols	0.620503597
Glass Fibers	In composite materials, glass fibers are layered with wood to increase strength and stability. This combination helps prevent the material from warping when exposed to moisture or temperature changes, making it useful in many settings. Glass fibers also improve fire resistance and sound insulation, especially when used with wood veneers or fillers in products like wallboards and doors. Adding glass fibers to adhesives and coatings makes bonds stronger and lowers formaldehyde emissions, which is better for the environment. Overall, using glass fibers in wood composites creates lightweight but strong materials that are valuable in construction, furniture, and flooring, supporting sustainability and the circular economy.	Cascade refinement technologies for wood waste upcycling	Composite production	0.325539568
Graphene Oxide	Graphene oxide is used as a key modifier in wood composite materials, allowing wood to become conductive through methods like vacuum impregnation and thermal reduction. This process improves the wood's thermal and electrical properties, making it suitable for advanced uses such as energy storage and heating systems. When added to wood-based composites, graphene oxide also provides antibacterial and flame-retardant qualities, which help address concerns about durability and safety. Its ability to form layered structures with wood fibers increases the material's mechanical strength and stability. Additionally, graphene oxide interacts well with adhesives and coatings, improving bonding and surface protection. These advancements help reduce dependence on traditional materials and support sustainable practices by promoting energy efficiency and environmental conservation. Overall, the use of graphene oxide transforms wood into a multifunctional material, enabling new applications in green technology and expanding its role in modern industries.	Cascade refinement technologies for wood waste upcycling	Composite production	0.386690647
Heat Exchangers	Heat exchangers play a key role in wood fiber drying by recovering heat from exhaust gases and using it to warm the air for hot gas generators. This process reduces energy loss and improves the drying of wood chips and fibers, which is important for making wood-based products like boards. In biomass applications, heat exchangers help in co-gasification, where wood powder is turned into gas and charcoal. By preheating air and using leftover heat, they boost energy efficiency and lower environmental impact. In composite wood products, such as multi-layer bamboo plates, heat exchangers are used to improve heat transfer, which supports uses like indoor heating. Overall, these technologies help reduce dependence on fossil fuels, encourage recycling and reuse, and lessen the environmental impact of wood processing industries.	Energy, Gas and Ashes Volarisation	Fluidised Bed Gasification	0.185251799
Heat Preservation	Heat preservation significantly improves wood by making it more energy efficient, structurally strong, and environmentally friendly. In composite materials like gypsum boards and bamboo-wood fiber panels, adding heat preservation layers lowers thermal conductivity, keeps temperatures stable, and boosts insulation. This leads to more energy-efficient buildings. New technologies, such as phase-change materials, carbon nanofiber layers, and aluminum foil, make wood more durable, resistant to moisture, and stable under different temperatures. For products like flooring and doors, heat preservation features—including removable metal plates and composite insulation rings—help prevent warping, retain heat, and increase the lifespan of these items. Many of these improvements also use eco-friendly methods, such as recycling agricultural waste and avoiding harmful adhesives, which helps reduce environmental harm. By improving wood's ability to retain heat, these methods decrease the need for fossil fuels, lower energy use, and support recycling and sustainability. The combination of advanced materials and engineering makes wood a more versatile and sustainable choice for modern construction and manufacturing, supporting global efforts to increase energy efficiency and protect the environment.	Cascade refinement technologies for wood waste upcycling	Composite production	0.805755396

Heat Sealing	Heat sealing is used in wood-based composite materials to create strong bonds between layers, which improves their strength and resistance to environmental factors. In aluminum-clad wood windows, heat sealing enhances the connection between wood and aluminum, resulting in better thermal insulation and moisture protection. For wood packaging boxes, heat sealing ensures airtight closures, helping to preserve the contents and allowing the boxes to be reused. In wood flooring, heat sealing combines moisture barriers and soundproof layers, which helps the flooring stay stable and last longer.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.383093525
	This method reduces the need for mechanical fasteners or adhesives, leading to cleaner production and making recycling easier. By making wood products more durable and effective, heat sealing supports a circular economy and lessens reliance on materials made from fossil fuels. Its use in construction, furniture, and packaging highlights its important role in improving and modernizing wood-based industries.			
Hot Press	Hot pressing is used in making bamboo-wood composite boards and solid wood floors to ensure strong bonding, stability, and durability by applying controlled heat and pressure. Recent innovations, such as multi-layer alignment, formaldehyde-free adhesives, and better temperature control, improve material quality and reduce emissions and waste. For specialized products like fireproof acoustic boards and antibacterial panels, hot pressing allows the use of advanced materials, making these products safer and more versatile. Eco-friendly practices are also promoted through techniques like embedding nano-micelles and using recycled materials. Hot press technology supports efficient production, reduces dependence on natural wood, and encourages the use of renewable resources like bamboo. This approach supports sustainable manufacturing and fits with circular economy goals. As a result, hot pressing expands the possible uses of wood materials in areas such as construction and furniture, while also addressing environmental and resource efficiency concerns.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.70323741
Hybrid Building Materials	Recent innovations in building materials have improved the performance and sustainability of wood in construction. For instance, adding Struvite-K and Syngenite to hybrid materials strengthens wood and lowers heat production during manufacturing. Wood-plastic composites, which mix wood fibers with polymers, result in strong, weather-resistant products ideal for building. Embedding heat-preserving layers in composite wood floors boosts thermal insulation, helping address environmental and energy efficiency issues. Advances in wood glue plates that resist bacteria and mildew also make wood more durable and suitable for use in various climates. These developments not only enhance wood's strength and lifespan but also support eco-friendly practices by reducing the need for synthetic materials. As a result, such building materials are helping wood become a key component in modern, sustainable construction and design.	Cascade refinement technologies for wood waste upcycling	Composite production	0.174460432
Hydrophobic Layer	Hydrophobic coatings protect wood by making its surface resistant to water. This prevents problems like swelling, warping, and decay caused by moisture. These coatings work by using methods such as adding hydrophobic polymers or applying special coatings that block water from entering the wood. Examples include using hydrophobic nanofibers and wax emulsions, which create layered barriers that increase water resistance and protect against corrosion. Hydrophobic layers are also added to wood composites to make them stronger and last longer, especially in damp conditions. These improvements help reduce the use of synthetic materials and make wood more durable for uses like construction, furniture, and packaging. In summary, hydrophobic coatings help wood keep its strength and usefulness, supporting resource efficiency and environmental sustainability.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.487410072
Impact Resistance Materials	In construction, impact-resistant composite boards are made by combining layers for shock absorption and thermal insulation, which enhances wall protection and energy efficiency. New materials, such as wood-plastic composites using ABS and coconut coir, result in boards with better strength, fire resistance, and longer lifespans, while also addressing limited resources. Bamboo-plastic composites and solid wood structures use reinforcing layers and fillers to achieve high impact resistance, which lowers environmental impact and reduces production costs. These innovations support sustainability by using recycled materials like PET bottles and making better use of wood's strength. Overall, improving impact resistance helps create durable wood-based products, reduces reliance on fossil fuels, and encourages a circular economy.	Cascade refinement technologies for wood waste upcycling	Composite production	0.199640288
Insulation Layers	Composite wood products like doors and floors use insulating layers to reduce heat loss and improve durability. For instance, adding vacuum-insulated panels to wooden doors increases their ability to keep heat in and helps them last longer by reducing damage from temperature changes. In composite floors with built-in heating, insulating layers help transfer heat efficiently from the heating elements to the wood surface, making energy use more effective and providing greater comfort. These improvements support sustainable building by lowering energy use and helping wood materials last longer. Overall, insulating layers allow for better control of temperature and stability in wood products, encouraging new uses and supporting energy efficiency and environmental sustainability.	Cascade refinement technologies for wood waste upcycling	Composite production	0.113309353
Laminate Structure	Laminate structures significantly improve wood by making it more functional, durable, and sustainable. Using methods like bonding, extrusion, and heat and pressure fusion, laminate technology combines wood with engineered layers such as thermoplastics, adhesives, and recycled materials. This creates composite products that are stronger, more water-resistant, and better suited to different environments.	Cascade refinement technologies for wood waste upcycling	Composite production	0.479316547
	Innovations like arranging fibers in different directions and layering wood both lengthwise and across help make the material more elastic and resistant to impacts. Techniques such as resin infusion improve how well the layers stick together and reduce the chance of them separating. These advances allow laminated wood to be used in a wide range of products, including moisture-proof flooring, decorative panels, and hybrid wood-metal composites. As a result, wood's use has expanded in construction, furniture, and renewable energy systems.			
	Laminate structures also support sustainability by reducing the need for fossil fuels and making better use of resources, which fits with circular economy principles. By using fast-growing wood species and recycled materials, laminated wood helps conserve resources and reduces reliance on traditional solid wood.			
	Advanced layering techniques combine wood with wear-resistant and UV-stabilized laminates, improving both durability and appearance. Processes like thermal lamination and coextrusion add materials such as acrylic layers, nanofillers, and adhesives, resulting in products with better strength, fire resistance, and moisture protection. Laminated wood is now used in architectural beams, composite floors, furniture, and insulation, showing its versatility.			
	Overall, laminate structures redefine what wood can do by balancing performance, appearance, and environmental responsibility, making it a strong competitor in modern industries.			

Machining Efficiency	Technologies such as CNC machining improve wood fabrication by using software to achieve precise results, allowing for the creation of complex parts like molds for biomedical implants. This precision reduces defects and increases the durability of wood products. New methods, like action machining, combine cutting and grinding in one tool, making the process more efficient and reducing the need for extra finishing steps. Automatic machining systems, used in products like wooden windows, use advanced features such as rotary tables and synchronized clamps to deliver high-quality results while lowering the need for manual labor. Together, these innovations boost productivity, cut down on waste, and encourage sustainable practices that fit with circular economy goals. By improving wood processing and adding automation, the industry can use wood in more modern ways, lessen its environmental impact, and move toward more eco-friendly manufacturing.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.494604317
Manufacturing Methods	Techniques like lamination, embossing, and additive manufacturing improve wood-based materials by making them more durable, structurally sound, and visually appealing. For instance, combining wood pulp fibers with melt-blown technologies produces strong composite wipes. Additive manufacturing enables precise customization of architectural elements such as doors and frames, adding features like lightweight reinforcement and better thermal performance. Other processes, including UV coating and adhesive bonding, enhance wood's use in hybrid materials like veneered plywood and composite stone worktops.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.570143885
Mechanical Properties	These methods also support environmental goals by reducing waste, making recycling easier, and lowering dependence on fossil-based materials. By using renewable resources and improving production methods, these advances turn wood into a high-performance, eco-friendly material. This supports sustainable practices and expands wood's use in construction, design, and technology.			
	Innovative construction methods now combine bamboo and steel to create stronger, more stable building structures. For example, the deformation-adjustable bamboo-steel truss beam uses both materials to prevent excessive bending over time, making large-span structures more durable. Another design, the bamboo-steel net rack structure, uses engineered bamboo panels with steel frames to spread weight evenly and avoid collapse when compressed. High-viscosity energy dissipation systems are also used to absorb stress at key connection points, further increasing the structure's resilience. These advances allow engineered bamboo to compete with traditional building materials, reducing the need for construction materials that rely heavily on fossil fuels. By making use of the strengths of both bamboo and steel, these designs encourage sustainable building practices and help create a circular economy, making better use of renewable resources and supporting environmentally friendly development.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.458633094
Modified Lignin	Lignin, a substance derived from biomass waste, is transformed through processes like catalytic conversion and enzymatic hydrolysis into useful products that enhance wood-based materials. These lignin-based derivatives improve adhesives, making them strong and reducing harmful formaldehyde emissions to meet environmental standards. Modified lignin also strengthens wood-plastic composites, increasing their durability and resistance to fungi and aging. Additionally, lignin is used to create flame retardants that are less toxic, providing safer and more sustainable options for wood and coatings. These innovations help make wood products more effective and environmentally friendly, support the reuse of waste materials, and reduce dependence on petrochemicals. Overall, lignin plays a key role in advancing wood technology and promoting sustainable manufacturing. Moisture-proof technologies in composite wood flooring and related products help prevent water damage, dampness, and structural problems, especially in humid or high-stress environments. Innovations such as bamboo-wood ecological boards use moisture-proof layers and hot-pressing methods to stop warping and internal stress, overcoming the weaknesses of traditional materials. Moisture-proof coatings on solid wood layers also protect against bubbling and cracking. In modular furniture and decorative veneers, advanced designs absorb moisture, helping these products keep their appearance and strength.	Cascade refinement technologies for wood waste upcyclinq	Lignin treatment	0.20323741
Moisture Resistance	These improvements make wood more adaptable for various uses, including construction, interior design, and outdoor settings. They also help reduce waste and the need for synthetic materials by making wood products last longer and use resources more efficiently. This supports circular economy principles, which focus on sustainability and reducing environmental impact.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.482913669
	In energy production, processes like torrefaction and fast pyrolysis lower the moisture content in bio-oil, making it more efficient as a fuel. Composite materials, such as lignocellulosic composites and wood-plastic hybrids, use moisture-resistant resins and coatings to prevent swelling and deformation, further increasing the durability of wood products. Additives like isocyanate resins or polypropylene films in flooring and furniture protect against humidity damage while preserving both appearance and function.			
Molded Articles	Overall, these moisture-proof advancements help wood compete with synthetic materials, reduce reliance on fossil fuels, and promote sustainable practices. By solving moisture-related challenges, wood products become more resilient and environmentally friendly, encouraging their use in industries that value both economic and ecological efficiency.			
	Molded articles combine cellulose-based fillers, like wood fibers, with polymers to create composites that are stronger, more water-resistant, and more environmentally friendly. Manufacturing methods such as co-extrusion and injection molding allow for accurate shaping and the integration of wood elements into plastic materials. This results in hybrid structures that offer both the natural look of wood and the durability of plastics. Additional techniques, including thermoforming and blow molding, help produce complex wood-plastic composites suited for use in industries like automotive, construction, and decoration. These innovations help reduce dependence on fossil-based materials, support circular economy practices, and increase the range of ways wood can be used in modern manufacturing, making it a valuable option for sustainable and high-performance materials.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.46942446
Motor Vehicle Parts	Interior trim pieces in vehicles now use natural fibers like wood pulp or lignin to create surfaces that are durable, lightweight, and visually appealing. These materials are often combined with plastics such as polypropylene, which improves their strength while keeping them environmentally friendly. New developments include using wood in multi-layer composites for vehicle floors or even in chassis-free car bodies, which provides both strength and reduced weight. Wood is also used in specialized ways, such as compacted wood for wheel rims and bamboo-wood composites for truck floors, showing its flexibility for both structural and decorative purposes. By using wood in vehicle design, manufacturers help reduce dependence on fossil-based materials, support circular economy ideas, and encourage sustainable production methods. Overall, these innovations highlight wood's growing importance in modern automotive engineering.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.255395683

Multi Layer Coating	Multi-layer coatings in wood-based construction use reinforcing nets and strong film layers to make wooden surfaces harder and more durable, which helps prevent deformation and extends their lifespan. In furniture, these coatings include melamine-impregnated layers that provide resistance to scratches and have antimicrobial properties, making the furniture more hygienic and long-lasting. For flooring, nano-coating technologies add fireproof and moisture-resistant layers, while UV coatings with abrasion-resistant particles, such as diamond, protect against wear. These coatings also support environmental sustainability by using water-based paints with flame-retardant and anti-corrosion properties. Overall, by combining advanced materials and layered structures, multi-layer coatings make wood more versatile and resilient, support circular economy practices, and reduce the need for less sustainable materials.	Cascade refinement technologies for wood waste upcycling	Composite production	0.258992806
Multi Layer Sorting	Multi-layer sorting mechanisms, including vibrating screens, conveyor belts, and sorting assemblies, are used to separate wood chips and similar materials by size, density, or other features. Vibrating screens remove smaller particles, while conveyor belts move sorted materials to specific collection areas. This system can handle different grades of wood at the same time, which helps use resources more efficiently and reduces waste. By making it easier to recover and reuse wood byproducts, multi-layer sorting supports the circular economy and lessens the need for new timber. Using these advanced sorting methods leads to more sustainable wood processing, improving productivity and lowering environmental impact.	Separation and sorting of CDW	An advanced multilayer sorting system	0.670863309
Multi Layer Structure	Multi-layer wood composite products are designed to enhance mechanical properties such as wear resistance, moisture protection, and fire retardancy, making them durable and long-lasting for use in flooring, furniture, and construction. These layered structures allow for precise control over manufacturing processes, improving energy efficiency and reducing dependence on fossil fuels. Innovations in this field include embedding electronic features, creating modular systems, and applying advanced coatings, which expand wood's uses into areas like RFID systems, soundproofing, and renewable energy. By combining wood with polymers, metals, or other materials, these composites gain improved durability and versatility. For example, adding thermoplastic polymers or polyurethane adhesives increases moisture resistance and stability, which is important for flooring and furniture. Wood-plastic composites often use recycled materials, supporting sustainability and reducing waste in line with circular economy principles.	Cascade refinement technologies for wood waste upcycling	Composite production	0.446492806
Neural Networks	Manufacturing techniques such as hot pressing and lamination allow for precise control over thickness and properties, resulting in fireproof, waterproof, and soundproof products. Designs using zigzag or corrugated wood elements further optimize strength while minimizing material use. Advanced multilayer films and coatings protect wood from moisture, UV radiation, and abrasion, extending its lifespan and reducing maintenance. These films can also provide optical control, making wood suitable for decorative panels, optical devices, and energy systems. Additional features like pest control, security measures, and metallic finishes expand wood's role in various industries. The layered structure of these products improves stability and resistance to environmental changes. Techniques like adhesive bonding and resin impregnation ensure strong connections between layers, while features such as sound insulation, heat conduction, and antibacterial treatments increase their usefulness. Eco-friendly options use formaldehyde-free adhesives and activated carbon for healthier indoor environments. Automated manufacturing boosts efficiency and quality, while recyclability and modularity support sustainability. Overall, multilayer wood composites meet modern needs for performance, aesthetics, and environmental responsibility.	Separation and sorting of CDW	An advanced multilayer sorting system	0.606115108
Noise Reduction	Neural networks play a key role in improving wood processing and renewable energy production. In thermochemical conversion and co-gasification, they analyze complex data to optimize reaction conditions, increase energy output, and minimize waste, making wood a more effective renewable energy source. Neural networks also process images of wood to detect defects such as cracks or knots with high accuracy, which helps ensure efficient use of materials. In the production of bamboo-wood composites, predictive modeling with neural networks allows for nondestructive testing by linking physical features to mechanical strength, leading to more durable products and less resource waste. These networks also enable real-time adjustments in wood processing, which boosts scalability and operational efficiency. By adopting these computational tools, the wood industry can use resources more efficiently, depend less on fossil fuels, and support sustainable manufacturing and circular economy goals. Integrating sound-absorbing layers—such as sponge, polyester fiber boards, and honeycomb structures—into composite wood flooring greatly reduces noise from footsteps and outside sources. These improvements turn traditional wood products into high-performance materials that are well-suited for modern homes. Adding sound insulation and damping features to wooden doors and floors not only cuts down on noise but also makes these products more stable and comfortable to use. Additionally, using noise reduction techniques in wood-based items like ecological boards and decorative panels supports sustainability by using recycled materials and lowering noise pollution. These developments help create quieter indoor spaces, encourage environmentally friendly practices, and expand the uses of wood in building and industry. By solving noise problems, wood products become more useful and meet today's needs for sustainable and practical design.	Cascade refinement technologies for wood waste upcycling	Validation of new composite products through prototyping	0.598920863
Non Woven Fabric	Non-woven fabrics made with polypropylene or nylon are used to fight pine wilt disease by forming strong composites that trap insects carrying the disease. This helps protect forests and supports sustainable wood management. In wood pulp composites, spunlace non-woven fabrics improve how well liquids are absorbed and spread, making them useful for hygiene and medical products while also reducing the need for synthetic materials. Non-woven layers in wood-plastic composites make these materials stronger and help address environmental issues, such as absorbing radon. By combining wood pulp fibers with multi-layered non-woven fabrics and using processes like hydroentanglement and melt spinning, wood can be turned into versatile, high-performance materials for uses such as filtration, construction, and consumer goods. These advances help the circular economy by lowering dependence on fossil fuels, reusing waste, and increasing the use of wood in sustainable industries, leading to more environmentally friendly solutions in manufacturing and forestry.	Cascade refinement technologies for wood waste upcycling	Composite production	0.89028777
Packaging Materials	Packaging materials are important for improving wood by using new technologies and sustainable methods that make wood more functional, durable, and environmentally friendly. Techniques like heat-sealing with carbon-based heaters allow films to bond precisely to wood, keeping its structure strong and saving energy. Multilayer films with oxygen barriers and special polymers protect wood products during shipping and storage, helping them last longer. Composite packaging, such as using wood pulp paper in bottle caps or making biodegradable wood-plastic blends, takes advantage of wood's natural qualities and reduces the need for materials made from fossil fuels. Other innovations, like vacuum-sealed chambers and controlled atmospheres, help maintain wood's quality, while modular designs make packaging easier to transport and recycle. These developments make wood a more adaptable and eco-friendly choice, supporting efforts to create a circular economy and lessen environmental harm. By improving how wood is used in packaging, these materials encourage sustainable practices and support modern industry needs.	Cascade refinement technologies for wood waste upcycling	Composite production	0.627697842

Panel Types	Engineered wood panels are designed to improve both appearance and strength, demonstrating the flexibility of wood as a material. Some panels feature decorative surfaces, while others are made from wood-plastic composites (WPC) that combine recycled PVC and wood fibers. These WPC panels use interlocking systems to increase water resistance and durability, helping to reduce waste and support environmentally friendly building practices.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.543165468
	Other panels have composite cores made from thermoplastic or mineral layers, which boost strength and provide better thermal insulation. Decorative panels can also include digitally printed designs and textured finishes, allowing for more detailed and creative interior design options.			
	These innovations help decrease the use of non-renewable materials, support circular economies, and strengthen wood's role in sustainable construction. Overall, modern wall panels show how wood can adapt through new technologies and materials, ensuring it remains important in various industries.			
Phase-Change Materials (PCMs)	Phase-change materials (PCMs) can be added to wood-based composites, such as wood-plastic composites and wood-enhanced wall materials, to improve heat storage and release. This helps regulate indoor temperatures and increases energy efficiency. For example, paraffin-based PCMs placed in wood structures can store heat and release it as needed, keeping temperatures stable and reducing the need for external heating.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.154676259
	Wood and other biomass-derived carbon materials are also used in energy storage devices like battery electrodes. These materials have a high surface area and are porous, which helps them store and conduct energy more effectively.			
	Using wood and its derivatives in these ways decreases reliance on fossil fuels and supports a circular economy by making use of renewable resources. As a result, wood becomes a multifunctional material, serving both traditional uses and new roles in modern energy systems.			
Plastic Wood	By combining recycled plastics and plant fibers, wood-plastic composites become stronger, more durable, and adaptable. New methods like co-extrusion and composite molding allow these materials to be used for products such as hollow core flooring, soundproof walls, and fireproof panels, overcoming the weaknesses of traditional wood. Features like self-locking systems and modular designs make assembly easier, lower labor costs, and increase how long the products last. Additional processes, including thermochemical modification and the use of additives, further improve qualities like impact strength, flame resistance, and weather resistance, while using renewable and biodegradable materials. These improvements help reduce the need for natural wood, conserve resources, and support a circular economy. Overall, these innovations encourage environmentally friendly practices and broaden the uses of plastic wood, helping to make the wood industry more sustainable and innovative in construction, manufacturing, and design.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.75
	Innovations such as co-extrusion and multilayer integration use polymers like polyethylene, acrylics, and polyurethanes to make wood composites stronger, more durable, and resistant to moisture. For instance, acrylic coatings on bamboo doors protect against dampness and add antibacterial and soundproofing benefits, while polymer layers in wood-plastic composites improve resistance to UV light and increase lifespan. In thermochemical processes, adding polymers like polyethylene to bio-oil improves its thickness and stability, offering a sustainable alternative to petroleum-based products. Polymer adhesives and coatings, including silane-modified prepolymers and flame-retardant layers, also help strengthen wood bonds, extend product life, and lower environmental impact.			
	These developments help reduce dependence on fossil fuels, support recycling and reuse, and allow wood to be used in more areas such as construction, furniture, and energy. By combining wood with polymer materials, wood products become high-performing and environmentally friendly, meeting modern needs for sustainability and innovation in various industries.			
Polymer Matrix	Rigid polyurethane foam enhances wood-based composites by improving thermal insulation, fire resistance, and structural strength, making them suitable for demanding uses in construction and furniture. Soft polyurethane foam adds cushioning and impact resistance, allowing wood to be used in protective and ergonomic designs. Integrating polyurethane foam into wood composites enables innovations like honeycomb structures and multi-layer boards, which are lightweight yet strong, reduce material waste, and make transportation more efficient. Using bio-based polyurethane foam from renewable resources further supports eco-friendly practices and reduces dependence on fossil fuels, aligning with circular economy principles. These developments increase the lifespan and versatility of wood products, making wood a sustainable and high-performance material for industries such as construction and consumer goods.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.807553957
	Polyethylene terephthalate (PET) is also used in polymer composites, often with organic fillers, to create durable wood substitutes like deck boards, railings, and siding. This process recycles PET by blending it with polyethylene and other materials, helping to repurpose waste and support the circular economy. PET is involved in thermochemical processes like co-extrusion or pelletization, which improve the uniformity and mechanical properties of wood composites. PET-based composites offer greater strength, water resistance, and adaptability, making them suitable for applications such as railway sleepers and high-strength construction materials. By incorporating PET, these composites reduce reliance on fossil fuels and promote sustainability. Overall, adding PET to wood products provides environmental benefits and expands the range of wood applications in construction and design.			
	The text describes recent innovations in composite fiberboard and wood product manufacturing that focus on sustainability and improved performance. Pre-treatment processes bond wood with recycled fiber cloth, making the boards more waterproof and fire-retardant while also reducing environmental impact. Formaldehyde-free boards use plant fibers and phase-change materials to create panels that are energy-efficient, flame-retardant, and help regulate indoor temperatures, conserving wood in the process.			
Polyurethane Foam	Advancements in refining wood vinegar, such as demulsification, have increased its purity, allowing it to be used in specialized fertilizers that support sustainable agriculture. New synthesis methods add bioactive aniline copolymers to wood products, giving them antimicrobial properties for use in construction and packaging.	Cascade refinement technologies for wood waste upcyclinq	Validation of new composite products through prototyping	0.758992806
	Surface preparation techniques now allow manufacturers to mimic plant leaf structures on wood, resulting in superhydrophobic and adhesive surfaces that are both decorative and functional. Overall, these developments enhance the performance of wood materials, decrease dependence on non-renewable resources, and support circular economy principles, making wood a more versatile and environmentally friendly material for modern industries.			

Production Costs	Reducing the number of components in composite structural boards while increasing their strength helps lower manufacturing costs. For instance, adding evenly spaced protrusions and stiffeners to board designs makes better use of materials and simplifies assembly. Using bamboo barrels as fillers in composite doors decreases the need for solid wood, improves recyclability, and enhances sound insulation, which addresses both cost and environmental issues. Other innovations, like honeycomb paper core composite boards, use lightweight but strong structures to cut down on raw material use and speed up assembly. Together, these strategies reduce reliance on fossil fuels and support a circular economy by using resources efficiently and creating less waste. By focusing on affordable production methods, the wood industry can grow sustainably and meet the demand for strong, environmentally friendly products.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.374100719
Production Equipment	Production equipment is essential for improving how wood is processed and used. It makes production more efficient, allows for new uses of wood, and enhances the quality of wood materials. For example, machines used to make composite battens use hydraulic pumps and extrusion blocks to speed up production and ensure consistent quality. Equipment for producing wood pulp and polypropylene (PP) composite non-woven fabrics uses systems like melt-blowing and pressing rollers to create fabrics that absorb and retain water well. In making solid wood composite flooring, advanced machines use lifting presses and temperature controls to laminate and dry the wood precisely, resulting in more durable and attractive flooring. These technologies help use resources more efficiently, reduce waste, and support sustainability by recycling wood fibers and lowering the need for fossil fuels. Overall, modern production equipment encourages innovation in wood products and supports environmental and circular economy goals.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.482014388
Production Processes	The text describes advancements in the production of abrasion-resistant wood panels and composite wood flooring, highlighting how modern production lines integrate processes such as resin application, particle scattering, drying, and pressing. These automated systems ensure consistent quality, durability, and aesthetic appeal while reducing manual labor. By optimizing resource use and streamlining operations, these production lines support sustainability by minimizing waste and improving energy efficiency. The text also explains how clean production methods repurpose waste materials, like reed impurities and sanding powder, as fuel, which reduces emissions and reliance on external energy sources. Advanced techniques, such as ultrahigh-pressure extrusion, preserve the beneficial porous structure of wood-derived materials, enhancing their performance and reducing waste. Industrial innovations include using bamboo weaving and carbon nanotube dispersion to create eco-friendly composites with improved mechanical and electrical properties. Other processes, like selective laser sintering and hydrothermal treatments, produce recyclable wood-based materials for environmental uses. Further innovations in composite wood structures, such as wood-plastic composites and prestressed wood-concrete panels, improve durability, water resistance, and structural efficiency while reducing dependence on fossil fuels. Biological production methods use genetically engineered microorganisms to convert gases into ethylene glycol, a key ingredient for recyclable plastics, further supporting renewable manufacturing. Additional techniques, such as embedding heat-dissipating components, bleaching, and vacuum impregnation, expand wood's applications to electronics, solar cells, and packaging by improving thermal management, mechanical strength, and UV protection. Extrusion processes also create foam-reinforced plastic strips for energy-efficient building insulation. Overall, these advancements refine wood-based materials, promote the use of recycled resources, and align manufacturing with circular economy principles. This positions wood as a sustainable, versatile resource for construction, energy, electronics, and environmental applications, while minimizing environmental impact and reducing reliance on fossil fuels.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.473021583
Protective Layer	Protective layers play a crucial role in enhancing the performance of composite wood products. When impregnated with melamine resin, these layers improve abrasion resistance and dimensional stability, making composite panels suitable for flooring, wall panels, and furniture. They also allow for embossing techniques, which create textured surfaces and expand design options. In bamboo-wood composite pipes, protective layers made from waterproof and antiseptic materials protect against moisture and decay, increasing their lifespan in structural uses. For wood-plastic composites, these layers reduce thermal expansion and boost resistance to aging, fire, and impact, making them ideal for demanding construction applications. Overall, the integration of protective layers increases the resilience and sustainability of wood products, supports the circular economy, and lessens dependence on non-renewable resources. This innovation highlights the essential role of protective layers in making wood a more versatile and durable material for a wide range of industries. In composite wood products, reinforcing layers made from materials like fiberglass, carbon fibers, or metal alloys are added to wooden bases to improve their strength and durability. For example, solid wood composite doors often include steel plates or multiple layers to prevent warping and increase their lifespan by resisting impacts and environmental damage. In wood-plastic composites, metal ribs or fiber-reinforced polymers are used to make the material stronger while keeping it lightweight.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.604316547
Reinforcing Layer	These advancements allow wood-based materials to be used in challenging settings, such as fireproof doors, soundproof panels, and moisture-resistant flooring. Adding reinforcing layers helps wood products resist bending, cracking, and damage from the environment. This not only makes the materials last longer but also supports sustainability by reducing waste. The combination of traditional wood with modern reinforcement methods encourages wider use in construction, furniture, and industrial design. It also helps promote a circular economy and lessens dependence on non-renewable resources. Wind turbine rotor blades often use wood fibers or bamboo fibers as reinforcement in composite materials to improve strength and sustainability. These natural fibers help strengthen key blade parts, such as spar caps and shear webs, while keeping the blades lightweight, which is important for efficient turbine performance. Wood materials like balsa are also used in the core structures of blades, offering thermal insulation and further reducing weight. During manufacturing, wood-based composites are used in molds and filler bodies to ensure precision and durability. By incorporating wood fibers into rotor blade designs, the wind energy industry reduces dependence on non-renewable resources and supports environmentally friendly engineering. This approach not only advances renewable energy but also promotes sustainable development and aligns with circular economy principles.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.629496403
Rotor Blades	These natural fibers help strengthen key blade parts, such as spar caps and shear webs, while keeping the blades lightweight, which is important for efficient turbine performance. Wood materials like balsa are also used in the core structures of blades, offering thermal insulation and further reducing weight. During manufacturing, wood-based composites are used in molds and filler bodies to ensure precision and durability. By incorporating wood fibers into rotor blade designs, the wind energy industry reduces dependence on non-renewable resources and supports environmentally friendly engineering. This approach not only advances renewable energy but also promotes sustainable development and aligns with circular economy principles.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.035971223

Semiconductor Devices	Semiconductor devices, when integrated into power overlay structures, improve both heat management and electrical connections. This is important for processes such as turning wood into biofuels, as these devices use special layers and metal connections to transfer energy efficiently and release heat. This helps reduce the need for fossil fuels and supports more sustainable energy options. Additionally, semiconductor devices are used to create smart sensors that monitor wood during manufacturing. These sensors can measure things like moisture, density, and strength in real time, which helps manufacturers produce better quality products and cut down on waste. Overall, using semiconductor technology in wood-related applications highlights its role in supporting a circular economy. It allows for new and efficient uses of wood as a renewable resource, while also improving energy use and helping the environment.	Digital tools for improving circular flows	Data Collection, Management, and Sharing	0.550359712
Service Life	Advancements in wood-based materials have led to longer-lasting and more durable products. In wood-plastic composite flooring, strong layers and waterproof coatings protect against damage and water, making the flooring last longer. PVC bamboo-wood fiber boards use special core layers that absorb stress, helping them resist impacts and keep their shape over time. For fitness equipment, composite boards with alternating wood layers and melamine coatings are tougher and less likely to deform, which also increases their lifespan. These improvements help reduce material breakdown and improve performance, supporting sustainability and the circular economy. By making wood products more durable, waste is reduced and environmentally friendly building practices are promoted, ensuring these materials remain useful in modern construction.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.523381295
Shock Absorption	Integrating shock-absorbing layers—such as elastic materials, springs, and composite structures—into wood products increases their durability and resilience. For example, bamboo-wood composite floors use these layers and springs to improve comfort, reduce noise, and extend their lifespan. Sports wood floors include elastic cushions with spherical shapes to better absorb impacts and enhance ball bounce, making them suitable for active environments. Antibacterial wood floors use damping layers to stabilize the structure and offer added benefits like resistance to insects and water.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.196043165
Sliding Groove	These innovations not only strengthen the mechanical properties of wood products but also support environmental goals. By reducing material waste and making recycling easier, shock-absorbing features help create multi-functional wood products for use in construction, flooring, and packaging. Minimizing vibrations and impacts leads to safer and more sustainable designs, supports the circular economy, and lessens dependence on non-renewable materials. Sliding grooves in fireproof and moisture-resistant composite wood boards allow the pieces to lock together securely, which prevents them from shifting and makes them more stable when exposed to environmental stress. In modular furniture and doors, these grooves make it easier to put pieces together and take them apart, which increases flexibility and makes maintenance simpler. Sliding grooves are also used in hybrid materials like wood-plastic and aluminum-wood composites, helping with easier installation and stronger structures in products such as flooring, windows, and doors.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.710431655
Solid Wood	These design improvements help reduce material waste, make manufacturing simpler, and increase how long products last, supporting more sustainable practices. By making products more functional and efficient with resources, sliding grooves contribute to a circular economy and lessen the need for non-renewable materials. Overall, this innovation highlights the adaptability of wood as a renewable resource and encourages environmentally friendly solutions in construction, design, and manufacturing. Solid wood is playing a key role in advancing wood engineering by blending its natural look with modern technology to improve functionality, sustainability, and versatility. In composite flooring, new technologies like heated stirring tanks and dual painting rollers create even coatings, making floors more durable and reducing waste. Alloy solid wood combines wood with metal for better resistance to wear and corrosion, while photocatalyst layers help create eco-friendly indoor spaces. Lightweight, multifunctional flooring uses solid wood as a base, mixing it with materials like PVC to make floors more elastic and lighter. Biomass composite solid wood uses wood chips to produce renewable fuel, cutting down on fossil fuel use and making wood more important for energy efficiency. Lamination and layered designs help save resources, improve stability, and offer more design options, while also protecting rare tree species. Solid wood is also used in composite structures like fireproof doors and moisture-resistant floors, showing its flexibility for modern building needs. For example, combining solid wood with flame-retardant and soundproof layers improves fire safety and noise control, while waterproof coatings prevent damage and extend the life of flooring. Multi-layer composites, such as energy-saving floors and heat-insulating panels, reduce the need for synthetic materials and improve thermal performance. Eco-friendly products like negative oxygen ion boards use solid wood to clean indoor air and lower chemical emissions. Solid wood doors also benefit from these innovations, using multi-layer structures and traditional joinery techniques to boost durability, pest resistance, and fire safety without sacrificing appearance. Adding cork and aluminum honeycomb panels makes doors lighter and stronger, while reducing waste and improving efficiency. Overall, these advancements show how solid wood, combined with modern engineering, supports sustainability, resource efficiency, and healthier living environments.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.773381295

Sorting System	These devices use advanced features such as retractable needles, stirring rods, and conveyor belts to efficiently separate wood blocks from mixed debris, replacing manual labor and increasing sorting efficiency. A floating wood pool further enhances the process by isolating wood blocks, while mechanisms like magnetic chucks and vibration screens help achieve high sorting precision.			
	Multi-layer sorting systems use automated conveyors and vibration screens to classify wood by size or type, reducing waste and ensuring accurate separation. These technologies streamline wood recycling and processing, allowing for the extraction of usable wood and minimizing resource loss. By automating and refining the sorting process, these systems support sustainable practices, reduce the need for new wood, and promote the circular economy by enabling the reuse of wood materials.			
	Advanced sorting methods, such as digital image-based systems and composite sorting using vibration and wind power, further improve the classification of wood waste. These systems sort materials by size and density, extract high-quality wood particles, and separate lighter waste for recycling. Filtering and grading technologies in multi-layer devices ensure that wood particles are sorted into various sizes, enhancing the quality of the final product. Overall, these innovations reduce secondary pollution, promote resource reuse, and support sustainability in the wood industry. By improving efficiency and minimizing waste, sorting systems help reduce reliance on fossil fuels and position wood as a more sustainable and efficient material for industrial use.	Separation and sorting of CDW	An advanced multilayer sorting system	0.393884892
Sound Absorption	Sound absorption is important for making wood a more versatile material, suitable for acoustic, structural, and environmental uses. Recent innovations include adding sound-absorbing layers and using subwavelength acoustic metamaterials in wood-based composites. These improvements help reduce noise while keeping the wood strong. For example, composite wood floors with built-in sound absorption cavities can lessen the noise from footsteps, and wooden doors with special membranes and honeycomb cores can block sound more effectively. These methods combine wood's natural qualities with added materials like sound-absorbing cotton, foam plastics, or bamboo fibers to boost acoustic performance in various settings.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.762589928
	Using these sound absorption technologies also supports sustainability. By reducing the use of synthetic materials and including recycled components, these approaches follow circular economy principles. As a result, they not only help reduce noise pollution and improve living spaces but also make wood a more eco-friendly and efficient choice for modern building and design, supporting resource conservation and environmental protection.			
Sound Insulation	Integrating materials like honeycomb soundproofing cotton, polyurethane foam, and composite layers into wood products enhances their ability to reduce noise while keeping them strong and visually appealing. These improvements are used in products such as soundproof wooden doors, modular partitions, and composite flooring, which use multiple layers to boost sound insulation, reduce vibrations, and maintain structural strength. Additional innovations, including flame-retardant coatings, moisture-proof layers, and the use of recycled wood fibers, make these wood products more sustainable by lowering the need for synthetic materials and supporting circular economy practices. As a result, wood becomes a more versatile and energy-efficient choice for modern construction, offering quieter environments and supporting eco-friendly building methods. These advancements help wood compete as a high-performing, sustainable material in both architectural and industrial settings, encouraging further innovation and expanding its use in the market. Improved sound insulation technologies also contribute to better living standards and support environmental goals.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.863309353
	Splicing structures help connect composite boards securely, making it easier to assemble wood products in various shapes and sizes to fit different needs. Features like slots, insertion boards, and fastening rods provide both vertical and horizontal stability, which allows for quick and reliable assembly. In products such as composite floors and furniture, designs like splicing grooves, dovetail joints, and mortise-and-tenon joints improve strength and reduce material waste. Splicing structures also make it possible to add extra layers, such as soundproofing, fire-resistant, or waterproof materials, which increases the durability and performance of wood products. These methods reduce the need for adhesives, simplify manufacturing, and support environmental sustainability. By making wood products more modular and adaptable, splicing structures help use resources more efficiently and extend the useful life of these products, supporting a circular economy.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.582733813
Steel Frames	Steel-wood composite boards use steel frames with built-in pillars to reinforce the structure, making them durable and resistant to deformation during transport. This combination streamlines production, reduces costs for materials and shipping, and makes assembly easier for users. In wood-concrete composite floors, steel plates and connectors work together with wood parts to increase strength and stiffness, which improves both performance and construction efficiency. Steel frames are also used in bamboo-wood CLT (cross-laminated timber) panels, where they enhance fire resistance, insulation, and strength while supporting environmental sustainability. By merging the strength of steel with the adaptability of wood, these innovations lower dependence on fossil fuels, use resources more efficiently, and encourage recycling and reuse. Overall, steel frames play a key role in improving wood-based building materials, making them stronger, more sustainable, and easier to use.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.634892086

Structural Stability	Features like interlocking grooves, reinforcing layers, and modular designs help wood products remain durable and functional under various conditions. For example, composite wood flooring uses interlocking mechanisms to prevent deformation, while multi-layered boards with alternating fiber directions and reinforcing ribs resist environmental stresses such as moisture and heat. Honeycomb structures in wood panels distribute stress evenly, making them both lightweight and strong.			
	These innovations not only extend the lifespan of wood products and reduce material waste but also support sustainable practices by decreasing reliance on fossil-fuel-based materials. Improvements in tensile properties—such as strength and flexibility—allow wood composites to withstand significant stress. Techniques like layering wood with bamboo charcoal and graphene further enhance durability and resistance to environmental factors.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.372302158
	Support structures play a key role in these advancements. Traditional joints, such as mortise and tenon connections, are optimized with steel and wood combinations to increase strength and stability. In modular construction, panels with metal grids and wood composites allow for efficient assembly and reduced waste. Support structures are also used in floating ecosystems, manufacturing processes, and wood-plastic composite production to improve stability, efficiency, and product quality.			
Thermal Conductivity	Supporting plates, used in various wood applications, help maintain material stability during processing, ensure consistent pressure, and distribute forces evenly. This leads to greater durability, easier installation, and longer product life. Overall, these innovations promote sustainable development, support circular economy principles, and expand the use of wood in modern engineering, construction, and eco-friendly manufacturing.			
	Innovative materials are improving the performance of wood-based heating floors and other energy systems. For example, adding graphene to wood layers increases heat transfer, which helps distribute heat evenly and keeps the structure stable. Wood-plastic composites with honeycomb designs also use better heat conduction to spread heat efficiently while staying strong. In more advanced uses, wood treated with nanomaterials like graphite or metal composites conducts heat even better, making it suitable for geothermal systems and devices that manage heat. These developments help reduce the use of fossil fuels and support sustainable energy practices, fitting with the goals of a circular economy. By enhancing how well wood conducts heat, these technologies allow wood to be used in new, advanced ways, supporting both energy efficiency and environmental sustainability.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.446043165
Thermal Insulation	Innovations in aluminum-wood composite windows and doors use heat-insulating layers to improve energy efficiency by reducing heat transfer. These designs take advantage of wood's natural ability to insulate while also making the structures more durable. Advanced panels that include materials like aerogels and polyurethane foam further increase wood's resistance to heat, making them useful in construction, fireproofing, and soundproofing. These systems also help manage moisture and improve fire safety, which extends the life of wood-based products. By using renewable materials and cutting down on components that rely on fossil fuels, these insulation technologies support circular economy goals. As a result, wood becomes a more sustainable and energy-efficient choice in construction and other high-performance industries, encouraging both innovation and environmental responsibility.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.744604317
Thermoplastic Polymer	Thermoplastic adhesives are used in composite wood products to create strong, moisture-resistant bonds between wood and other materials like plastics and metals. New developments include combining biodegradable thermoplastics with wood particles to make eco-friendly composites for packaging. Aromatic thermoplastics, such as PEEK, are used to improve abrasion resistance in products exposed to high stress. Manufacturing methods like melt-mixing and extrusion help evenly distribute wood fibers in thermoplastic materials, resulting in lightweight and durable products for construction and consumer use. Thermoplastics also make it possible to produce laminated wood items with better appearance and functionality, such as flooring and furniture, while reducing the use of fossil-based materials. By using recycled and renewable resources, thermoplastic polymers support circular economy goals, turning wood into a sustainable and high-performance material for industries like construction, packaging, and design.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.739208633
Thermoplastic Resin	Thermoplastic resin is combined with wood flour and additives such as stabilizers and UV absorbers through extrusion and molding processes. This combination improves the material's resistance to weather, mechanical strength, and stability, allowing it to withstand moisture and sunlight. As a result, these wood-based materials are well-suited for outdoor uses like decking and furniture. The use of thermoplastic resin also enables the creation of eco-friendly wood-plastic composites, which help reduce dependence on traditional wood and fossil-based resources. By including renewable and recyclable materials, this approach supports sustainable manufacturing and the principles of a circular economy. The partnership between thermoplastic resin and wood is driving progress in industries such as construction, furniture, and automotive, turning wood into a high-performance material that meets today's environmental and practical needs.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.591726619
Veneer Layer	Composite wood panels are made by layering natural veneer sheets with adhesive-coated veneer strands, which improves both their strength and appearance. Techniques like hot pressing make these panels durable and stable, while monitoring their density ensures consistency throughout the material. By combining veneer with materials such as aluminum or plastic, the panels gain additional benefits like fire resistance, moisture control, and greater strength. Using veneer layers also supports sustainability by making better use of wood, reducing waste, and including recycled or engineered materials. These innovations help decrease dependence on fossil fuels and promote a circular economy by extending the usefulness and lifespan of wood products. In summary, veneer layers are essential in turning wood into strong, adaptable materials used in many industries.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.793165468
Ventilation Grooves	Grooves in wood panels help manage moisture by allowing air to flow through, which prevents dampness and reduces the chances of the wood deforming or decaying. In moisture-proof log boards, these ventilation grooves are carefully placed to direct humid air away, helping the wood stay strong and stable. In multilayer wood furniture boards, grooves improve air movement, which helps absorb formaldehyde and supports environmentally friendly uses. For sports wood floors, ventilation grooves increase breathability, preventing the wood from swelling and making the floors last longer, even with heavy use. Overall, these grooves support sustainable practices by reducing material damage and extending the life of wood products. By including ventilation grooves, wood products become more environmentally friendly, produce less waste, and contribute to a circular economy, showing their significant positive impact on the wood industry.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.383093525

Vibration Apparatus	Vibration apparatuses in wood-based composite materials help improve sound insulation and reduce vibration by adding damping layers or vibration-reduction plates that absorb energy and lower noise levels. Multilayer composite boards use these vibration mechanisms to increase both structural stability and acoustic performance, making them ideal for environmentally friendly construction and soundproofing applications. Vibration apparatuses also play a role in the precise sorting and processing of wood particles, as seen in vibrating screen equipment, which enhances material separation and minimizes waste. By using vibration-based technologies, wood products gain improved mechanical strength, durability, and overall functionality. This supports sustainable practices and broadens the use of wood composites in industries like construction and furniture manufacturing. Overall, integrating vibration apparatuses into wood-based materials helps reduce environmental impact and supports a circular economy, aligning with global sustainability objectives.	Separation and sorting of CDW	An advanced multilayer sorting system	0.821942446
Waste and Recycling	Waste wood residues and plastics can be combined to create wood-plastic composites. These composites are more durable, cost less, and offer environmental benefits. The process involves shredding, sorting, and extrusion to turn waste into useful products like composite boards, flooring, and construction templates. Other methods, such as anaerobic digestion and chemical treatments, recycle organic waste and polymers for wood-based uses, helping to minimize resource waste. By using waste materials in wood production, industries rely less on new resources, support circular economies, and reduce environmental harm. This approach helps make wood manufacturing more sustainable.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.618705036
Water Absorption	Moisture-proof furniture composite boards use water-absorbing materials to prevent mildew and extend the life of wood-based products, especially in humid environments. Wax coatings on composite wood also help by reducing water absorption, which strengthens the material and protects it from moisture damage. In wood pulp composites, superabsorbent materials are used to improve water retention and absorption, resulting in non-woven fabrics and sanitary products that perform better. Water absorption technologies are also applied to wood-based construction materials like wallboards and flooring, helping them resist moisture-related damage and adapt to different environments. These innovations make wood products more durable and functional while supporting sustainability by making better use of wood, reducing dependence on non-renewable resources, and promoting circular economy practices. By carefully controlling how wood absorbs water, these advancements improve the quality and environmental compatibility of wood products for both traditional and new uses.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.5
Water Resistance	Composite boards achieve water resistance through layered structures and specialized binders, making them suitable for furniture and flooring. New developments, such as sesame protein adhesives, give wood strong bonding and water resistance without releasing harmful formaldehyde, supporting environmentally friendly production. Applying carbon nanomaterial coatings to wood further increases water resistance, allowing use in tough conditions and providing extra benefits like fire resistance and protection from UV rays. Chemical treatments with hydrophobic agents also improve wood's water resistance and maintain its strength even when exposed to moisture for long periods. These innovations help reduce the use of traditional fossil-based materials, support sustainable practices, and fit with circular economy goals by making wood products last longer and usable in more industries. Recent innovations in composite wood structures have greatly improved their resistance to water damage. Techniques such as adding waterproof layers, using modified coatings, and applying hydrophobic treatments help protect wood from moisture. For example, wood-plastic composites use waterproof membranes and films to block water, while bamboo-wood composites use natural wax and aluminum for extra protection. Advanced manufacturing methods, like embedding waterproof agents into wood fibers or using resin-based coatings, help maintain the wood's shape and strength, reducing the risk of warping or damage.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.293165468
Waterproof Performance	These improvements allow wood products to stay stable and durable even in humid or wet conditions, making them suitable for uses like flooring and outdoor furniture. By making wood less likely to suffer water damage, these technologies extend product life, lower maintenance costs, and support sustainability by reducing waste and using renewable materials. In wood composite pipes, waterproof coatings protect both the inside and outside, ensuring they stay strong and leak-free for hydraulic uses. Composite boards and floors benefit from waterproof layers that stop water from seeping in, prevent swelling, and guard against mildew, which keeps them looking good and lasting longer. Advanced coatings, including nanoscopic films, make wood surfaces repel water and resist stains while still allowing them to breathe.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.309352518
Wood Board Types	Other innovations, such as adding aluminum oxide or silicon dioxide, improve abrasion resistance and flexibility, especially for outdoor products. Wear-resistant coatings like polyurethane or bio-based films protect against scratches and moisture, reducing upkeep and preserving appearance. UV-resistant and nano-coatings further boost durability for high-traffic or damp areas. These advancements help reduce the use of non-renewable materials, minimize waste, and support a circular economy by extending product lifespans. By combining water resistance with features like fireproofing and sound insulation, these technologies make wood a strong, eco-friendly choice for modern construction and design. Innovations in furniture boards, such as composite layering, UV coatings, and combining wood with materials like bamboo, steel, and polymers, have improved their durability, weather resistance, and strength. Techniques like high-temperature carbonization and flame-retardant treatments make wood more resilient and environmentally friendly. Furniture boards also allow for precise manufacturing methods—such as cutting, splicing, and hot-pressing—which ensure consistent quality and minimize waste. These advancements enable wood to be used for a wide range of purposes, from decorative surfaces to strong structural components, while promoting sustainability through recycling wood chips and using eco-friendly adhesives. By turning raw wood into versatile, high-performance materials, furniture boards help support the circular economy and reduce dependence on fossil-based products, making wood a sustainable and innovative choice in modern construction and design.	Cascade refinement technologies for wood waste upcyclinq	Composite production	0.478417266
Wood Chips	Wood chips play a significant role in modern wood processing and manufacturing. Advanced drying systems use vapor circuits and heat exchangers to recycle energy, making moisture removal more efficient. Once dried, wood chips are used in composite boards, where they are combined with adhesives and structural supports to create strong, durable products like road plates and building materials. Wood chips also help reduce environmental impacts. For example, during wood fiber production, special methods such as thermal treatments and washing are used to extract volatile organic compounds (VOCs), lowering harmful emissions. Additionally, wood chips support circular economy practices by being recycled into fertilizers or biofuels, making use of their organic nature for sustainable purposes. These innovations help decrease dependence on fossil fuels, enhance the quality of wood-based materials, and promote environmentally friendly manufacturing. Overall, wood chips have a transformative effect on the wood industry by improving efficiency, sustainability, and product performance.	Chemical and Bioremediation	Upcycled wood validation	0.374100719

Wood Clad Aluminum	Wood clad aluminum is used in products like composite windows and doors to improve strength and performance. Innovative designs, such as integrated sealing systems and multi-layered profiles, combine aluminum frames with wood cores and sealing strips. This approach increases air and water tightness while preserving the attractive look of wood. Aluminum-clad wood profiles with heat insulation cavities further boost energy efficiency by reducing heat transfer and improving soundproofing. These improvements make buildings more sustainable by extending the life of wood products and lowering maintenance costs. By combining the strengths of both wood and aluminum, this material supports a circular economy, reduces resource use, and helps move toward more energy-efficient building solutions.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.70323741
Wood Flour	Wood flour is used in making thermoplastic composites, such as those based on polycaprolactone, which are biodegradable and serve medical purposes like orthopedic splints. Adding wood flour to these materials improves their strength and ability to keep their shape. It is also used in micro-foamed polyamide compounds, where its low dielectric constant helps create materials suitable for 5G technology, while still providing high dielectric strength. Modified wood flour further improves wood-plastic composites by making them more flame-resistant, environmentally friendly, and durable. These uses help reduce dependence on non-renewable resources and encourage sustainable practices, supporting the principles of a circular economy. Overall, wood flour enhances the performance of wood-based products and contributes to both innovation in materials and environmental sustainability.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.800359712
Wood Plastic Composite	Wood plastic composite (WPC) is a material made by combining natural wood particles with synthetic polymers. This blend results in products that are more durable, functional, and sustainable than traditional wood. In construction, WPC is used to improve standard wood applications, such as creating moisture-resistant door frames and fireproof flooring, which last longer and withstand environmental challenges better. WPC also helps conserve resources by using recycled plastics and thermoplastic polymers, reducing the need for new wood and supporting the principles of a circular economy. Modern manufacturing methods like extrusion and molding allow for precise and consistent shapes, while protective coatings, such as high-pressure laminates, enhance both the look and strength of the material. Additionally, WPC supports environmentally friendly practices by reducing waste and using biodegradable or low-emission materials. By combining the natural appearance of wood with the improved performance of engineered materials, WPC broadens the possibilities for wood-based products. This contributes to sustainable development and increases the range of uses for wood in today's industries.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.848920863
Wood Pulp Fibers	Wood pulp fibers are increasingly used in composite materials to improve strength, water absorption, and durability, especially in products like nonwoven fabrics and thermoplastic composites. Techniques such as vacuum-assisted co-extrusion combine wood pulp fibers with polymers, making these materials more versatile for uses including wipes, packaging, and lightweight construction parts. The high cellulose content in wood pulp fibers provides softness, thickness, and resistance to wear. Advanced bonding methods further enhance how the fibers are distributed, leading to better product performance. These developments help reduce the use of synthetic materials and support circular economy goals by using renewable resources and making products easier to recycle. Overall, turning wood pulp fibers into adaptable, high-performing materials increases resource efficiency, lowers environmental impact, and highlights wood's important role in sustainable material science for modern industries.	Cascade refinement technologies for wood waste upcyclin	Composite production	0.762589928
Wood Veneer	Engineered flooring systems use wood veneer bonded to composite bases, which improves fireproof, waterproof, and moisture-proof qualities and reduces warping during installation. In composite panels, wood veneer is combined with materials like aluminum honeycomb or fiberboards, resulting in better stability, fire resistance, and sound insulation. New methods, such as embedding veneer in multi-layer structures or using adhesives and protective coatings, further increase durability and environmental performance. These techniques produce strong, lightweight, and adaptable wood products for uses ranging from furniture to construction. By combining wood veneer's natural look with advanced materials, these products help reduce resource waste, last longer, and support sustainable practices, meeting the goals of modern wood engineering and the circular economy.	Cascade refinement technologies for wood waste upcyclin	Validation of new composite products through prototyping	0.739208633