

# The Design of Plastic Furniture Products Based on the Concept of Sustainable Development

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**Abstract.** With the development of society and the growing emphasis on the concept of sustainable development, sustainable design principles have increasingly permeated various product fields. Plastic, commonly used in furniture products, contributes significantly to environmental pollution, not only causing visual pollution but also posing a potential threat to the ecological environment. Building a circular economy and pursuing sustainable development have become global focal points and urgent tasks, and they are starting to guide the development of industries and human activities. As designers, when using plastic materials in furniture product design, it is essential to fully consider the basic requirements of sustainable development. By optimizing material selection, enhancing product structures, and promoting recycling, designers can upgrade and redesign products using waste materials through sustainable design approaches. This helps reduce resource waste, minimize environmental pollution, extend product lifecycles, and promote sustainable development.

**Keywords:** Sustainable development; Circular economy; Plastic materials; Furniture product design

## 1. Introduction

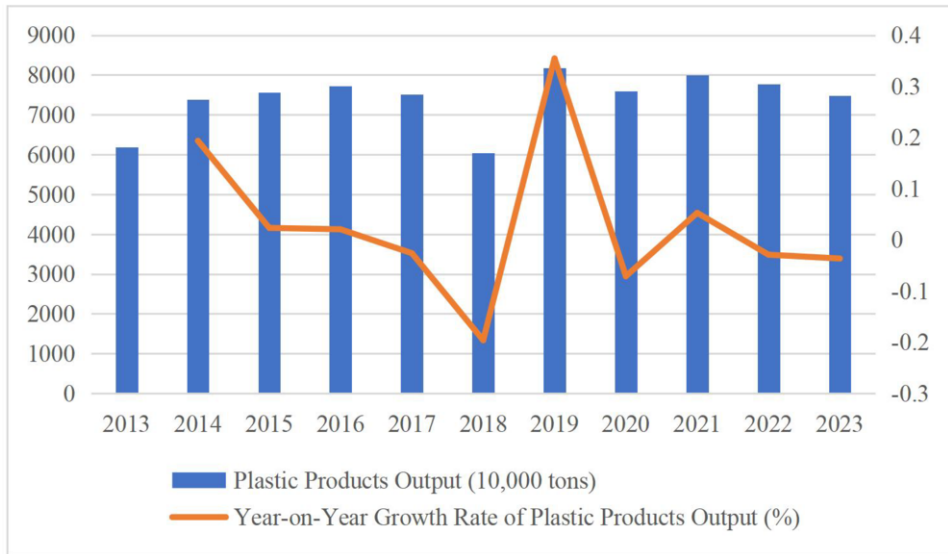
Since the 1972 United Nations Conference on the Human Environment in Stockholm, global concerns about environmental issues like climate change, pollution, and biodiversity loss have intensified. This growing awareness has driven international collaboration and the rise of sustainability as a central concept, fostering strategies for sustainable innovation and design.

Furniture, once primarily functional, has evolved into an art form, enhancing the aesthetic quality of living spaces. Designers face constraints related to materials, structure, and functionality, with material choice being the most crucial as it impacts both the feasibility and expression of the design concept. Maximizing material potential is key to successful design.

As timber resources dwindle and sustainability becomes more important, plastic has emerged as a vital material in furniture design. China, the world's largest producer and consumer of plastics, produced 74.885 million tons of plastic products in 2023, a 3% increase from the previous year.

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**Figure 1** Production and growth rate of plastic products in China

Plastic, as a primary raw material for household products, meets the demand for lightweight, flexible, and visually diverse items, especially among younger consumers. Plastic furniture offers versatility in form, color, and function, setting it apart from traditional materials like wood and leather. Moreover, advancements in biodegradable and recyclable plastics align with environmental goals, promoting low-carbon, sustainable development. These trends make plastic increasingly valued by designers and manufacturers for its innovative potential and environmental benefits.

## 2. Application Trends of Plastic Materials in Furniture Product Design Under the Concept of Sustainable Development

### 2.1. Sustainable Development and Furniture Design Materials

In the era of ecological civilization, fostering a moral responsibility to respect the ecosystem and plan for the future requires integrating sustainable development throughout the furniture lifecycle. Sustainable furniture design focuses on functionality and minimizing environmental impact at every stage—design, manufacturing, usage, and recycling. The aim is to conserve resources, reduce pollution, and create harmony between humans, furniture systems, and the environment, promoting both physical and psychological well-being. This approach balances economic, ecological, and social benefits, making low-carbon design the mainstream trend in contemporary furniture.

The use of energy-efficient, eco-friendly materials is key to achieving low-carbon furniture. Material selection should be guided by environmental certifications (e.g., FSC, LCA) and consider waste, resource consumption, and environmental impact. These certified materials are then incorporated into furniture through artistic and technical processes.

2.2. Development Trends of Plastic Furniture Under the Concept of Sustainable Development

In the 21st century, the push for a low-carbon lifestyle has increased the focus on material recyclability in furniture. With advancements in technology, plastic materials have evolved, giving rise to modern plastic furniture. Originally introduced in the 1920s and 1930s, plastics like thermosetting polymers were used in bonding, coating, and upholstery. Polyurethane, known for its antibacterial, pressure-resistant, and stain-resistant properties, became widely used in items like sofas, bar stools, and office chairs.

New eco-friendly composite plastics, integrating recycled materials with natural fibers like bamboo, hemp, or wood, have emerged as a solution to traditional plastic's environmental impact. These composites are biodegradable, recyclable, and help reduce raw material dependency and greenhouse gas emissions. They offer versatility, durability, and stable chemical properties, meeting diverse interior design needs. With the ability to mimic natural textures and colors, and their flexible manufacturing process, these materials provide designers with creative freedom to shape innovative, sustainable furniture.

3. Characteristics of New Environmentally Friendly Composite Plastic Furniture Products

Currently, most plastic furniture on the market is made from polycarbonate (PC). The use of PC in plastic chairs allows for varied shapes, strong design aesthetics, lightweight construction, and high impact resistance. Compared to furniture made from other materials, plastic furniture offers the following advantages (see Table 1).

Table 1 Analysis of the Advantages of Plastic Furniture

Advantages	
Color	Bright and rich; transparent
Design	Smooth lines; diverse and flexible; easy to mold and shape
Function	Foldable, combinable, stackable
Usage	Indoor furniture; public outdoor spaces
Features	Lightweight; easy maintenance; low humidity and temperature requirements

3.1. Environmental Friendliness

The use of new environmentally friendly composite plastics in furniture design reflects a deep commitment to sustainability. These materials, combining recycled plastics with natural fibers, offer a sustainable and functional alternative that reshapes the standards for environmental impact in material selection. By incorporating plastic waste, the production process reduces pollution, while natural fibers like bamboo enhance biodegradability, mechanical strength, and aesthetic appeal. This aligns with the growing emphasis on sustainable design in furniture, allowing designers to minimize environmental impact and support the circular economy. Additionally, these composite plastics diversify material innovation, mimicking natural materials while maintaining durability and efficiency, which further meets market demand for eco-friendly products.

### *3.2. Diversity and Aesthetic Appeal*

The integration of environmentally friendly composite plastics in furniture design blends material science with aesthetics, offering rich colors, textures, and forms that expand creative possibilities. These materials can imitate natural substances such as wood or stone, providing both sustainability and aesthetic appeal. Advanced surface treatments, including printing and lamination, enhance their realistic textures, durability, and resistance to wear, scratches, and moisture. As a result, these materials maintain their appearance over time, reducing maintenance needs. Their versatility allows designers to meet the demands of varied spaces, from playful children's rooms to sophisticated living environments, harmonizing with other design elements to create visually compelling and comfortable interiors.

### *3.3. Durability and Ease of Maintenance*

The durability and low maintenance of environmentally friendly composite plastics are essential for modern furniture design. Their water, corrosion, and wear resistance make them ideal for high-use, high-humidity environments such as kitchens and bathrooms. These materials, strengthened through advanced manufacturing techniques, retain functionality and appearance over time, reducing the need for frequent repairs or replacements, which yields both economic and environmental benefits. Additionally, surface treatments like antibacterial layers and waterproof coatings further enhance durability and ease of cleaning. Routine maintenance involves simple wiping, and even tougher stains can be handled with mild cleaning agents, minimizing the need for harsh chemicals. While initial costs may be higher, the long-term savings and reduced environmental impact align with sustainable development goals.

## **4. Application of New Environmentally Friendly Composite Plastics in Furniture Product Design**

### *4.1. Wood-Plastic Composite Materials*

Wood-plastic composite (WPC) materials are primarily produced by combining resin with waste plant fibers to form profiles or boards. Compared to traditional solid wood materials, WPC offers superior durability, including resistance to termites, corrosion, moisture, and dimensional stability. At the same time, WPC provides the aesthetic appeal of wood, aligning with popular aesthetic preferences. Figure 1 illustrates an outdoor leisure chair made from wood-plastic composite materials.

WPC combines the advantages of both plant fibers and plastics, making it applicable in almost all areas where raw wood, plastic, plastic steel, aluminum alloy, and other similar composite materials are used. This material maximizes the benefits of its components, overcoming the limitations caused by wood's low strength, high variability, and the low elastic modulus of organic materials. Additionally, WPC fully utilizes waste wood and plastics, reducing environmental pollution.



Figure 2 Outdoor leisure chair made of wood-plastic composite material

In the application of wood-plastic composite materials, they are primarily used for outdoor tables and chairs, dining tables, trash bins, and other urban amenities. With their distinctive visual effects and versatile designs, wood-plastic composites have gradually become a striking feature in urban landscaping. Not only do they offer convenience, but they also align with the needs of low-carbon, eco-friendly urbanization.

Indoors, wood-plastic composites are commonly used in kitchen cabinets, wardrobes, tables, stools, and bathroom furniture. Due to their excellent mechanical properties and wood-like appearance, research in this field has been extensive.

4.2. Biodegradable Foam Plastics

By recycling and reprocessing discarded foam materials and blending waste plastic products, the physical properties of used plastics can be restored to their original state. These can then be reprocessed into recycled pellets, which are used to design and manufacture furniture products. The technical process of melting and extruding polystyrene (PS) foam recycled pellets is shown in Figure 3.

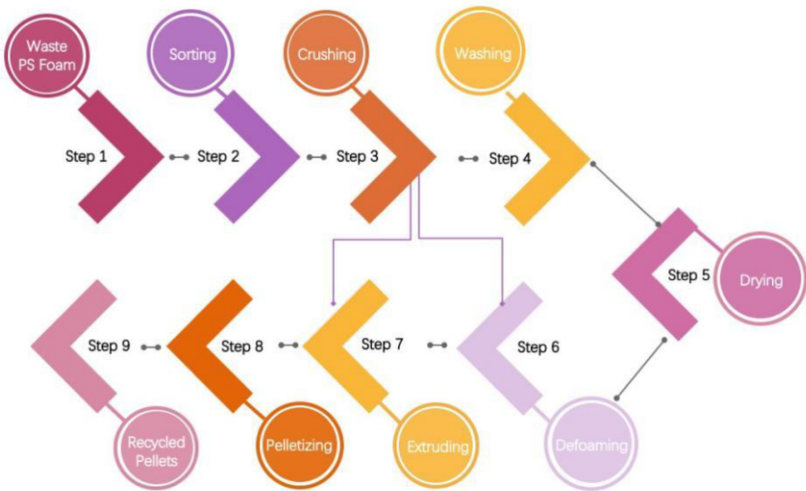


Figure 3 Technical Process Diagram for Melting and Extruding Recycled PS Foam Pellets

Among biodegradable materials, starch and polylactic acid have been the most researched. By adding ethylene-vinyl acetate (EVA), the moldability of these materials can be improved. Alavi [1] and others studied the co-extrusion of starch with polyvinyl alcohol and EVA, and found that the resulting products exhibited characteristics of low

density and high foaming rates typical of foamed materials. Additionally, Liu Xianfeng and others researched the production of starch-based foamed materials using a twin-screw extruder, examining factors such as extrusion temperature, moisture content, and screw speed[2]. Their study revealed a positive correlation between expansion ratio and screw speed/temperature, while moisture content significantly impacted expansion, with higher moisture content leading to increased expansion ratios.

Foam materials effectively enhance the comfort of furniture, and thus their usage in furniture design has been steadily increasing. Currently, the most commonly used foamed plastics in furniture include polyurethane, polyvinyl chloride (PVC), and polystyrene, which, after foaming, form highly elastic cushioning materials.

Polyurethane is widely applied in the furniture industry due to its wear resistance and high toughness[3]. In public seating, polyurethane is often used for sofas, bar stools, office chairs, mattresses, and more, offering long-lasting durability and promising application potential.

For indoor furniture, polyurethane's antibacterial, compression-resistant, wear-resistant, and stain-resistant properties make it a preferred material in homes, cinemas, and auditoriums. Beyond seating, polyurethane is also well-suited for mattresses. Mattresses made from pre-reinforced polyurethane foam provide excellent comfort and durability. When subjected to pressure, polyurethane foam can withstand high stress, while the presence of air pockets within the material provides superior elasticity[4].

Figure 1 illustrates the work of London-based designer Charlotte Kidger, who uses industrial waste polyurethane foam fragments to create vibrant furniture. She employs industrial waste generated by Computer Numerical Control (CNC) technology to craft tables, stools, and containers from this recycled material.



**Figure 4** IndustrialCraft collection by Charlotte Kidger

French furniture brand Mojow is renowned for its inflatable plastic furniture. To enhance both practicality and environmental sustainability in its sofa designs, the brand utilizes TPU (thermoplastic polyurethane), a new biodegradable material that is odorless, resistant to deformation, and capable of withstanding extreme temperatures. When used outdoors, even in hot and sunny conditions, the sofa's surface remains cool, thanks to its UV-resistant properties, meaning there is no concern about sun damage or aging.



**Figure 5** Inflatable sofa from Mojow

### *4.3. Other Eco-Friendly Plastics*

Thermoplastic resins are a widely applied material in the furniture sector, following the earlier use of thermosetting resins. Compared to thermosetting resins, thermoplastics exhibit better mechanical properties and improved processability, resulting in their broader use in furniture manufacturing. Furthermore, thermoplastics are recyclable, which promotes energy conservation and environmental protection.

Polypropylene, with its high strength and toughness, is particularly suitable for furniture materials, especially outdoor furniture. By adding plasticizers to polypropylene resin, its low-temperature performance can be improved, although this reduces the material's flexural modulus. On the other hand, adding reinforcing agents can effectively increase the flexural modulus. In addition to polypropylene, polycarbonate is another widely used material in furniture design. Polycarbonate boasts excellent insulation, soundproofing, oxidation resistance, impact resistance, and high transparency[5].

Initially, the application of polycarbonate in the furniture industry was limited due to its high cost. However, in 1999, French designer Philippe Starck designed a chair entirely made from polycarbonate for the furniture brand Kartell. This chair, launched in 2002, was modeled after the shape of the Louis XVI Chair, preserving the outline of the antique furniture while utilizing modern polycarbonate material. Starck aimed to achieve a "seamless, one-piece molding" process, resulting in a perfectly shaped chair. The final product had no joints or screws, ensuring that the chair would not freeze or crack in cold or rainy weather. Its transparent structure, always appearing to be in a state of vanishing, earned it the nickname "Louis Ghost Chair." The chair's features—excellent transparency, lightweight, durability, and minimalist design—have attracted attention from various countries.



**Figure 6** Louis Ghost Chair by Philippe Starck

Belgian brand EcoBirdy, based in Antwerp, has taken a direct approach to recycling, reusing discarded plastic to create new value in furniture products. Designers collect, sort, clean, and grind old or unused plastic toys. The resulting plastic granules are then sorted by color and transformed into furniture products with a distinctive speckled appearance. The current series includes Charlie the Chair, Luisa the Table, Kiwi the Storage Container, and Rhino the Lamp. Each piece of furniture features smooth edges and a silky surface, with rounded forms creating seamless transitions between support points in the designs. Thanks to rigorously researched ergonomic shapes, the products provide a comfortable and safe environment for children. Not only are these products pleasant to the touch, but they are also incredibly easy to clean.





**Figure 7** Charlie the Chair、Luisa the Table、Kiwi the Storage Container & Rhino the Lamp by ecoBirdy

## 5. Design Principles for Plastic Furniture Based on the Concept of Sustainable Development

### 5.1. Safety Principle

Safety is the fundamental attribute of all furniture design, encompassing both physiological and psychological safety. These are two key factors that must be considered in furniture design. In plastic furniture design, guided by the concept of sustainable development, safety includes the following aspects:

- **Material Safety:** While pursuing sustainable design, it is essential not to overlook the potential hazards posed by waste materials during the design process. Waste materials must be selectively reused, ensuring minimal environmental impact. At the same time, the materials must be non-toxic, harmless, radiation-free, and noise-free. The reprocessing of these materials should not cause environmental harm or pollution, and when they are reused or discarded again, they should not pose any risk or pollution to people or the environment.
- **Structural Safety:** The stability and safety of the connections between various parts of the product must be ensured. Moreover, the design should comply with ergonomic standards to guarantee both physiological and psychological safety during the user's interaction with the furniture.

### 5.2. Sustainability Principle

- **Material Sustainability:** The primary material used in plastic furniture should be thermoplastics, which inherently have the characteristic of being reusable. Packaging materials should be environmentally friendly, including biodegradable plastics, paper materials, and renewable bamboo materials, to reduce the environmental burden of the product. Through design approaches such as detachable and modular design, the lifespan of the furniture can be extended, thereby achieving the goal of sustainable design[6].
- **Functional Sustainability:** Functionality is the core element of plastic furniture design, and functional sustainability is reflected in the ability to meet the physiological and psychological needs of users at different stages. In addition to meeting basic functions, plastic furniture should be adaptable to different stages and usage scenarios, allowing adjustments to meet varying



functional needs[7]. For instance, a child's chair can be designed to adjust according to the different stages of a child's growth, meeting evolving needs over time.

- **Structural Sustainability:** Plastic furniture can be designed in a modular fashion, with each component being adjustable and replaceable. When parts are damaged, they can be replaced individually. Through modular adjustments, the furniture can change its size to cater to the needs of users at different stages. The modular, interlocking design also facilitates easy disassembly, storage, and transportation, saving energy and resources, thus embodying the principles of sustainability.

### *5.3. Design Strategies*

Emphasizing the novelty of design: Due to the excellent processing and design flexibility of plastic furniture, its shape and structure can be further optimized. By developing plastic furniture with innovative structures and complex functions, the use of plastic furniture can be effectively promoted, while also attracting the attention of more consumers.

Developing high-performance resin matrices: The performance of the resin matrix plays a crucial role in the service life of plastic furniture. Developing lightweight, high-performance resin matrices will have a positive impact on the promotion of plastic furniture.

Enhancing publicity efforts: Raising awareness of the advantages of plastic furniture can effectively reduce the consumption of wood. Promoting the use of plastic furniture carries positive significance for protecting the natural environment and reducing deforestation.

## **6. Conclusion**

With the development of society and the increasing emphasis on sustainable development concepts, the notion of sustainable design has gradually permeated various product fields. Plastic, as a commonly used material in furniture products, contributes significantly to environmental pollution, not only causing visual pollution but also posing potential threats to the ecological environment. Building a circular economy and pursuing sustainable development have become global focal points and urgent tasks, increasingly serving as guidelines for various industries and human activities. When designers use plastic materials in furniture design, they must fully consider the basic requirements of sustainable development. By optimizing material selection, product structure, and recycling methods, designers can upgrade and redesign products using discarded materials through sustainable design practices, reducing resource waste, minimizing environmental pollution, extending product life cycles, and promoting sustainable development.

## References

- [1] Alavi, S. H, Rizvi. & Harriott, P. Process dynamics of starch-based microcellular foams produced by supercritical fluid extrusion I: Model development. *Food Research International* **36** (2003), 309-318.
- [2] Liu, Xianfeng, Wang, Ling, & Yu, Lei. Effects of process parameters on starch extrusion foaming. *Modern Plastic Processing Applications* **19** (2007), 5-8.
- [3] Bai, Xue. Current status and development trends of environmentally friendly plastics in furniture materials. *Plastic Industry* **44** (2016), 1-4.
- [4] Zhang, Yihong.& Huang, Bin . Study on recycled plastic furniture design based on LCA theory. *Furniture and Interior Decoration* **1** (2020), 28-29.
- [5] Bai, Jiaqi. Research on product design requirements under the concept of green design. *Industrial Design* **1**(2019), 105.
- [6] Xu, Xiaoxia, Li, Long, Wang, Xiaoying. Exploration of sustainable concepts in children's bed product design. *Industrial Design* **9** (2019), 45-46.
- [7] Yang, Zubin. Environmental performance and development direction of packaging materials. *Packaging Engineering* **6** (2008), 182-184, 193.