

## Bio-plastic Utilization in Sustainable Furniture Design

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### ABSTRACT

The Kingdom of Saudi Arabia is leading efforts toward sustainable development through its ambitious Vision 2030, which aims to diversify the economy and enhance environmental and social sustainability. Within this transformative framework, interior design plays a key role, influencing various aspects of daily life from residential and office spaces to commercial and industrial environments. A vital aspect of sustainable interior design is the use of bio-based and eco-friendly materials, which help balance urban growth with the need to preserve the environment and ensure healthier indoor spaces. Among these materials, bioplastics stand out as a promising alternative to conventional plastics. Derived from renewable sources and biodegradable, bioplastics offer an innovative solution to reducing environmental harm and promoting cleaner production practices. This research explores the potential of integrating bioplastics into interior design in Saudi Arabia as part of the broader sustainability goals outlined in Vision 2030. It highlights how these materials can drive innovation in the design industry while addressing major challenges such as the overuse of petroleum-based plastics, growing coffee waste, and increased carbon emissions from traditional furniture materials. These factors significantly impact air quality and user well-being, making the shift toward sustainable materials both urgent and beneficial. In conclusion, the research advocates for greater adoption of bioplastics as a strategic step toward achieving a greener, healthier, and more sustainable interior design sector in the Kingdom

### 1. Introduction

The Kingdom of Saudi Arabia has been accelerating its efforts to accomplish the goals of the “Saudi Vision 2030” and fulfill its objectives and initiatives through economic diversification and sustainability enhancement; in order to achieve a productive substantial transformation in both the society and the economy. On the other hand, interior design can play a prominent role in supporting such goals and efforts, as it affects all life aspects, e.g., homes, working spaces, small projects... etc. Also, biological and eco-friendly raw materials can be used as main tools to achieve sustainable objectives of interior design, as such materials can attain the balance between urban aspirations and environment preservation; by creating an internal environment that is both healthy and aesthetic. Bioplastic is an excellent example for biological eco-friendly materials; it is extracted from renewable resources and is characterized by its ability to decompose within the eco-system, making it an innovative alternative for traditional petroleum plastic and a key element to achieve sustainability. This study aims to support the Kingdom’s efforts to achieve its vision, by affirming the pivotal role of biological raw materials in developing and improving the design field. It highlights the advantages of utilizing bioplastic interior design and reducing the consumption of plastic petroleum in the furniture industry. The non-biological materials used in the furniture industry produce carbon emissions which pollute the air and affect the health of the individuals within the living or working spaces, decreasing their efficiency and productivity. On the other

hand, the Kingdom of Saudi Arabia has a very high rate of coffee wastes, which negatively impact the environment, therefore; bioplastic can be the solution for this double threat as this biological decomposable plastic can be produced from coffee wastes and utilized in the design of sustainable furniture. The research focuses on the possibility to use bioplastic; produced from coffee wastes; in the field of interior design, by designing sustainable quantitative furniture which achieves efficiency and design quality, in order to create internal spaces that reflect positively on their users. This study is an attempt to support the Saudi Vision 2030 in regard to; reducing harmful petroleum emissions and decreasing food wastes caused by the high consumption of coffee in the Kingdom. Through the course of its study, the research used eco-epoxy as an alternative material for bioplastic to conduct its initial experiments; and through these experiments, the characteristics of coffee were proven to be effective in manufacturing sustainable quantitative furniture. Therefore, the researcher recommends that designers, factories and the Saudi “National Center for Waste management” focus on bioplastic as an industrial raw material. It is also advisable that the competent authorities should raise awareness among consumers regarding the harm caused by plastic petroleum.

### **1.1 Problem**

- 1- The negative impact of using petroleum plastic in the furniture industry; this impact doesn't only affect the environment, but expands to include the furniture users as well, as plastic furniture may reduce their efficiency, thus; their productivity.
- 2- The increasing rate of food wastes due to the high consumption of coffee in the Kingdom of Saudi Arabia.
- 3- Carbon emissions caused by non-biological materials which are largely used in the furniture industry; these emissions negatively affect humans within the living and working spaces.

### **1.2 Objective**

This research aspires to.

- 1- Support the “Saudi Vision 2030”; by focusing on the environmental and sustainable development aspect as one of the main goals of this vision.
- 2- Provide suggestions on how to utilize bioplastics to design sustainable furniture, in accordance with the requirements of the Kingdom's Vision.
- 3- Achieve a quantum leap in the field of sustainable development; which is a pivotal aspect in infrastructure planning and establishment; by utilizing clean energy to reach zero neutrality in order to protect the environment and reduce harmful emissions.
- 4- Invest the enormous produce of coffee wastes in the Kingdom of Saudi Arabia to manufacture sustainable quantitative furniture.

### **1.3 Significance**

The research focuses on bioplastic as a leading futuristic and eco-friendly material that can be utilized in the furniture industry specifically, to enhance many design elements and provide exceptional experiences to the users; which in turn can play an important role in improving the production approach currently used in the furniture industry.

### **1.4 Hypothesis**

The research suggests that.

- 1- The utilization of bioplastic interior design can achieve the design efficiency and quality required for internal spaces.
- 2- Bioplastic enhances the quality of internal designs; including the materials used in them; and aligns with the environmental and economic aspects of Saudi Vision 2030.
- 3- High-quality sustainable furniture can be manufactured using bioplastic produced from coffee wastes.

## **1.5 Targeted Group**

Interior designers – factories owners – researchers – individuals interested in raw materials

## **1.6 Methodology**

The research follows the analytical-descriptive approach, as well as the experimental and practical methods.

## **2. Previous Studies**

### **2.1 Iman Ahmed Elsayed Mahmoud Aloqby; “Bioplastic towards Reducing the Carbon Footprint and Enhancing Human Health in Interior Construction” – 2023 – Alexandria University - Egypt**

Despite the light weight of petroleum plastic, as well as its flexibility and sustainability; it is a main cause for pollution and environmental problems, due to the increase of carbon footprint. On the other hand, recent studies have discussed the probability of developing a biological plastic which can decompose in a way that returns it back into nature. The objective of this research was to study bio-plastic materials and their role in reducing carbon footprint within the environment, because this type of plastic excels in the ability to reduce greenhouse gases throughout its life span. This research follows an inductive analytical method to detect ways for interior construction to effectively utilize bioplastic and determine its effect on human health. The research presents conclusions and recommendations which affirm the importance of utilizing bioplastic as a future sustainable alternative in the design of internal spaces.

### **2.2 Maii Ibrahim Eldesouky; “Using Recycled Natural Materials in Interior Design in Light of Sustainable Economy” – Journal of Architecture, Arts and Applications – 2023 – Vol. 5, Issue 2**

The whole world is facing economic problems which affect many fields; this research specifically focuses on interior design and furniture industry problems; it states that one of the major effects of economic problems on interior design is cost reduction and the usage of alternative materials which are cheaper than their natural counterparts. Therefore, utilizing recycled natural materials in interior design represents a key approach towards economic leadership and sustainability, as using such materials to design internal spaces can achieve unique and innovative design solutions, as well as sustainable solutions which can enhance the quality of life. Furthermore, utilizing recycled natural materials in interior design can have a positive impact on a sustainable economy, because they can assist in developing high quality design solutions, as well as an aesthetic and creative design; and at the same time; preserve natural resources, reduce waste and decrease carbon emissions. Thus, investing in recycled natural materials in the field of interior design can contribute to achieving economic, social and environmental sustainability in any given society.

### **2.3 Yasser Ali Me’bed, Ahmed Ismail Awaad, Effat Tawakol Mohamed Deif; “Bio-Furniture and the New Industrial Era” – 2021 – Faculty of Applied Arts – Damietta University – Egypt**

The industrial revolution which thrives on fossil fuel threatens all ecological systems, because any industrial advancement achieved results in a backward step in the balance of the ecosystems. This research suggests that the integration between bioscience, technology and design sciences is capable of developing techniques with positive outcomes. It highlights a new path in the art of design and furniture industry, which contributes in the transformation from negative industry framework – CNC manufacturing – to other positive frameworks based on a biological method. This research concludes that bio-furniture design methods follow a revolutionary trajectory which can free the designer from all the restraints forced upon them by the traditional manufacturing methods; and that the increased efforts to apply nature-mimicking methods in design will lead to a novel design method and a more vibrant world.

## 2.4 Yusuf Sakingobir, Abdulmudalib Abdullahi Lawal; “Bio-Plastics: Their Advantages and Concerns” – Journal of Material & Metallurgical Engineering – 2021 - Vol. 11, Issue 1

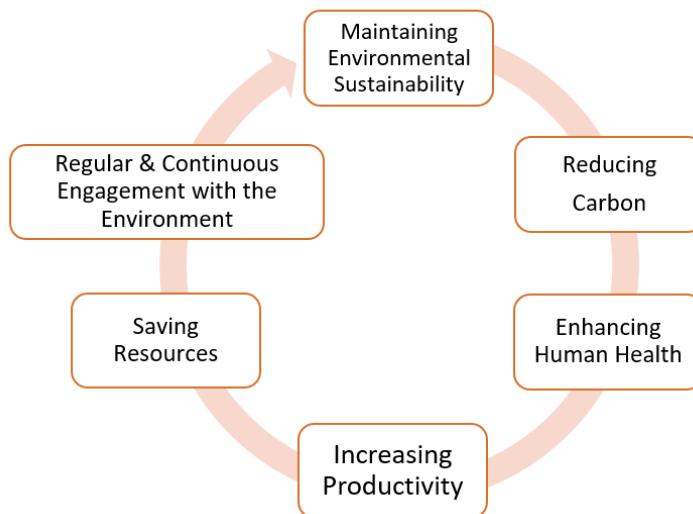
It is an established fact that plastic exists everywhere and that it is a threat for both humans and ecosystems. Petroleum plastic is a major cause for greenhouse gases which accumulate and harm living creatures, therefore; it is crucial to find an alternative material to replace petroleum plastic. Bioplastic is a potential alternative for traditional plastic products; it includes various new groups of plastics which are produced using renewable resources, such as crops and plants; which are distinct with the ability to decompose within short periods, making it an eco-friendly, decomposable and recyclable material. The bio-plastic current average production rate is 1% in comparison to the traditionally produced plastic, but this rate is expected to increase; especially with the promising potential advantages of bioplastic, e.g. the ability to decompose.

### 3. Theoretical Studies

#### 3.1 Bio-Design

##### 3.1.1 The Concept of Bio-Design

Bio-design is a group of principles which aim to construct internal spaces that imitate the features of natural environments; it is one of the key hypotheses to integrate natural elements in constructed environments. These principles indicate that when individuals are in frequent contact with nature, their mental health and prosperity can be enhanced, which in turn positively affects human general health, society flexibility and environmental quality. Bio-design is also a desire for improvement and growth, as well as to achieve balance between environmental, economic and social aspects with human needs.



**Fig.1** The advantages of Bio-Design

### 3.1.2 Bio-Design Methodology

Bio-design at its core employs biological principles, integrating living materials into the creation of structures and tools. This approach emphasizes the utilization of natural resources, such as fibers and plants, to facilitate organic growth and eventual decomposition. By moving away from traditional design materials like wood, glass, and plastic, bio-design significantly broadens the potential scope and capabilities of design[3] .

### 3.1.3 Biological Simulation

Biological simulation represents a prosperous multidisciplinary field, its fundamental methodology relies on understanding the core concepts of biological processes and applying this knowledge to overcome technical challenges encountered in the development of bio-designs[9].

### 3.1.4 Biological Modeling

Bio-modeling is a multidisciplinary science that seeks to apply the study and philosophy of natural phenomena by observing and analyzing biological characteristics. Its goal is to enhance various fields while maintaining the global perspective on environmental preservation and interaction. This scientific domain develops models that simulate natural systems and integrate their key elements into products designed to meet human needs [4].

## 3.2 The Relation between Bio-Design and Environment

Bio-design has a positive impact on the environment by enhancing sustainability and reducing the carbon footprint; it helps in creating a better environment in which humans can live, work and enjoy nature at the same time. Bio-design seeks to establish balance between fulfilling human needs and respecting the environment and biological systems, thus; it plays an vital role in improving and preserving the environmental quality. [1]

### 3.2.1 The Impact of Bio-design on the Environment

**TABLE 1**

The following table illustrates some of the bio-design positive impacts on the environment:

Table 1: Bio-design positive impacts on the environment	
Environmental Aspects	Positive Impacts
Sustainability and preservation of resources	Bio-design provides the ability to continually and effectively use natural resources with no harm to the environment.
Improving air quality	Bio-design enhances air quality and reduces pollution through the integration between natural elements and sustainable design and construction.
Reducing waste & controlling loss	Bio-design improves resources management, reduces environmental damage and increases the awareness of recycling.
Pollution reduction	Bio-design uses eco-friendly, renewable or naturally decomposable materials.
Effective usage of recycling	Bio-design utilizes both biomaterials & recycling methods, in order to support sustainability, environment preservation and life quality improvement. [6]

### 3.2.2 Achieving Comfort and Design Efficiency within Internal Spaces through Bio-Design

Bio-design adds depth and individuality to the interior design; it represents a key element in improving functional, physical and mental health, as well as general prosperity within internal spaces. This type of design works on achieving an ideal balance between environmental, aesthetic and functional elements. Applying bio-design in internal environments results in many physical advantages, such as enhancing fitness, reducing blood pressure, increasing comfort and reducing illnesses, thus improving general health. Similarly, bio-design can result in many mental advantages, such as increasing satisfaction and motivation, reducing stress and anxiety, as well as improving creativity and problem-solving skills. [5]

## 3.3 Bioplastic

### 3.3.1 The Concept of Bioplastic

Bioplastic (biopolymers) is given its name due to its composition of organic materials; whether in whole or in part; or due to its ability to decompose biologically; it dissolves without any harm to the surrounding environment; whether natural or artificial. Thus, the ability to decompose biologically is the most recognizable characteristic of bio-plastic, as well as the minimal harmful emissions caused by its manufacturing and decomposition phases. [11]

### 3.3.2 A Comparison between Bioplastic and Petroleum Plastic

**TABLE 2**

A comparison between bioplastic and petroleum plastic

Comparison	Bioplastic	Petroleum plastic
Composition	Composed of: - Plastic biopolymer - Renewable materials (biologically based)	Composed of: - Plastic polyethylene polymer - Nonrenewable materials (crude oil)
Characteristics	Advantages: ratio of using bioplastics was 47% in 2021. [7] Disadvantages: its production costs have increased between two and eight times.	Advantages: the most used, as it represents 99.3% of the plastic used around the world. Disadvantages: the worst is that it does not decompose; but breaks into tiny particles that cannot be disposed of; these particles exist in water and food, as well as inside living beings.
Ecological impact	Bioplastic doesn't have any ecological impact if disposed of correctly; making it eco-friendly; also; it does not cause any harmful waste due to its ability to biologically decompose.	Plastic particles surpass planktons in the oceans with the ratio of 36:1, which causes pollution of the marine food chain. Chemicals used in plastic production might leak into aquifers and soil and become permanent ecological pollutants.
Impact on users	One type of bioplastic is manufactured from food, which can be harmful for the food chain.	Flame retardants and bisphenol are added to plastic; to give it flexibility and solidness; these are oily poisons which cause illnesses such as cancer, birth defects and bladder weakness.

### 3.3.3 Types of Bioplastics

Bioplastic includes several [1] groups which vary in their properties; among which:



- 1- Plastic with an organic basis that can biologically decompose, such as poly lactic acid – PLA and poly hydroxy alkenoates – PHAs.
- 2- Plastic with a petroleum basis that can biologically decompose, such as polyethylene – PBAT.

### 3.4 Biological Raw Materials`

#### 3.4.1 Biological Stones

Biological stones is a type of natural or artificial construction material which contains biological or organic elements; such as plant/animal fossils, algae or bacteria. The biological stone is distinct with its ability to be naturally decomposed and multiplied over time; it can have a positive ecological impact on oceans and marine environments.

**TABLE 3**

Biological stones	Biological Concrete
Biological bricks	Biological Concrete
Basic manufacturing materials:	Basic manufacturing material:
- Sporosacinapasteurii bacteria	- Micro organisms (bacteria)
- Sand	
- Added calcium chloride, urea and yeast.	
Bio-bricks are used in the construction of external architectural structures.	Micro-bacteria provides bio-concrete with the feature of cracks self-repair.
	
Fig. 2: Bio-concrete example <a href="https://www.buildnews.it/articolo/biomason-mattone-organico-di-sabbia-e-batteri">https://www.buildnews.it/articolo/biomason-mattone-organico-di-sabbia-e-batteri</a>	Fig. 3: Using of bio-concrete <a href="https://www.tudelft.nl/en/innovation-impact/pioneering-tech/articles/the-enormous-potential-of-self-healing-bio-concrete">https://www.tudelft.nl/en/innovation-impact/pioneering-tech/articles/the-enormous-potential-of-self-healing-bio-concrete</a>

#### 3.4.2 Biological Fabric

Bio-fabric is sustainable and eco-friendly textile materials; it is made of natural decomposable materials, such as organic cotton, wool or glitter; bio-fabric is manufactured and used according to methods that reduce its impact on the environment.

TABLE 4

Biological Fabric

Tissue sewn to solid materials	Payet fabric (organic glitter)
Basic manufacturing materials: Sporosarcinapasteurii bacteria	Basic manufacturing materials: Natural biological cellulose extracted from trees
Used in architectural design and construction	Used chairs upholstery



Fig.4: Bio-fabric made from bacteria

[https://archi.ru/news?offset=3&div\\_type=news\\_short&article\\_topic=17](https://archi.ru/news?offset=3&div_type=news_short&article_topic=17)

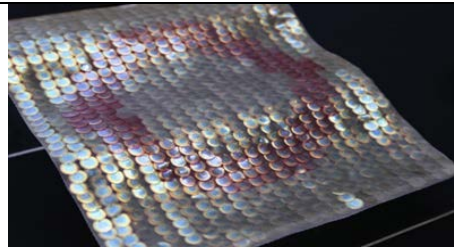


Fig.5: Bio-fabric made of natural cellulose

<https://www.designboom.com/design/elissa-brunato-bio-iridescent-sequins-wood-03-08-2020/>

### 3.4.3 Biological leather

Bio-leather is a term used to describe artificial leather made from biological or organic materials instead of using natural animal leather. Bio-leather aims to decrease the reliance of the industries on animals to obtain leather, in order to preserve the environment and livestock.

Bio-leather contributes in achieving balance between the needs of industry, consumers and environment.

TABLE 5

Basic manufacturing materials: - Pineapples - Bioplastic	Basic manufacturing materials: - Palm leaves - Glycerol solution
Used in fashion and furniture industries	Used in carpet industry



Fig.6: Bio-leather made from pineapple

<https://formatex.com.mx/blogs/informa-tex/vol-17-un-futuro-sostenible-para-la-industria-textil>



Fig.7: Bio-leather made from palm leaves

<https://form-faktor.at/das-design-des-lebens-selbst-biodesign>



### 3.5 Sustainable (Biological) Furniture

#### 3.5.1 The Concept of Sustainable Furniture

Sustainable furniture design is a revolutionary advancement that helps to release the designer from all the limitations imposed on them by the traditional manufacturing methods. Preserving the environment, understanding the product life cycle, recycling waste into new products and conserving energy for future generations; all are major concerns for sustainable furniture design. Sustainable furniture design is characterized by refraining from using materials that are harmful to the environment and utilizing materials which don't consume a lot of energy during its manufacturing and production processes; sustainable furniture is also characterized by its products which are either recyclable or can decompose in the shortest possible period. [6]

#### 3.5.2 Characteristics of Sustainable Furniture

**1<sup>st</sup>:** A sustainable furniture design must have moral values which take into consideration both the environment and the society. It is essential to respect ecological values; and to design products, systems and furniture which seek to largely reduce the harmful impact on the environment, as well as the pollution caused by them; this is achieved by using eco-friendly materials and manufacturing methods that decrease pollutants emissions. This means that sustainable design must be more efficient in managing resources, such as energy, water and raw materials; the consumption of natural resources can be reduced, and environment sustainability can be improved. Therefore, the moral aspects of the sustainable design aim to obtain balance between environmental and social objectives, as well as to respect environmental values, which in turn contribute to developing sustainable products and systems which serve the society and protect the environment at the same time. **2<sup>nd</sup>:** The sustainable design must be innovative and progressive from the prospective of providing sustainable solutions by developing new products and processes; this can include creating new materials or manufacturing methods, or developing fresh ideas which can contribute in improving the environmental impact. The sustainable design must also be capable of effectively handling environmental issues, such as reducing harmful emissions, increasing the efficiency of resources management and protecting the natural environment. Thus, a sustainable design must be creative and advanced in order to assist effectively solve environmental challenges and achieve sustainable development. **3<sup>rd</sup>:** The sustainable design must be aesthetic, original, attractive and unique; it also must be qualified for future competition. The authenticity of sustainable design lies in being exceptional, singular and respectful of the cultural heritage and creativity of a specific society; to highlight its cultural and innovative identity. Sustainability must also be achieved from a commercial perspective, meaning that design can compete and maintain its future position in the market; it also has to respond to the consumers' needs and trends, as well as environmental developments. [10]

1

**Indoor air quality;** sustainable furniture are often made of natural materials, free of harmful chemicals; such as formaldehyde and lead; which improves indoor air quality and reduce the individuals' exposure to internal contamination.

2

**Allergy and skin irritation;** the natural materials used in sustainable furniture can be less likely to cause allergies or skin irritation in comparison with artificial materials.

3

**Psychological effect;** sustainable furniture is usually produced in aesthetic and inspirational designs, which can improve mood and psychological wellbeing.

4

**Personal sustainability;** investing in sustainable furniture can be a manifestation of personal sustainability and environmental awareness; which promotes a sense of pride in taking environmental healthy decisions.

Fig.8: The Positive aspects of using sustainable furniture

### 3.5.3 The Impact of Sustainable Furniture on Users

In general, sustainable furniture can provide its users with positive experiences; on both physical and psychological levels; as shown in the following table:

### 3.5.4 Sustainable Furniture Industry and Manufacturing Methods

The step of selecting the materials to be used in sustainable furniture should be precisely conducted during the design process; taking into consideration all renewable materials which can naturally decompose with the least amount of energy and effort.



Furniture made from Renewable and Eco-friendly Materials

<https://www.pinterest.com/pin/AYYJheh0kyBMW26e9GWricsWT0d0ploQpB3y5EH0vfd-RFOs6qraOhg/>



Furniture made from Recycled Wastes

<https://pietheineek.nl/en/product/buizen-ligstoel>



Furniture Manufactured from Woodlands Wastes

<https://www.ellifurniture.com/product/Superglue-Chair.html>

**Fig.9:** Types of sustainable furniture

### 3.5.4.1 Furniture made from Renewable and Eco-friendly Materials

#### 3.5.4.1.1 Bamboo

Many furniture designers are greatly interested in this natural material which originally comes from China, it can grow rapidly in an environment free of pesticides; which makes it an eco-friendly material in both its production and usage stages; bamboo is used to manufacture sustainable furniture, floors, shutters and blinds. [10]



<https://www.pinterest.com/pin/666532813624812413/>



<https://www.pinterest.com/pin/15973773668090445/>



<https://www.pinterest.com/pin/798263102719755499/>

**Fig.10:** Bamboo applications in sustainable furniture design, including a room divider, eco-friendly sunshades, and a novel chair.

#### 3.5.4.1.2 Hemp plant

Hemp plant fibers are used to manufacture natural slabs; and it is categorized as an eco-friendly material because it can be remanufactured, thus; it has no negative impact on the environment or human beings.



<https://www.pinterest.com/pin/2322237298767803/>



<https://www.pinterest.com/pin/72/1209327840317665>



<https://www.pinterest.com/pin/702561610642980166>

**Fig.11:** Hemp fibers are employed in chair manufacturing, durable panels, and upholstery fabrics.

#### 3.5.4.2 Furniture made from Recycled Wastes

##### 3.5.4.2.1 Lumber-mills Junk

There are factories with specific production lines that only use old wood or unwanted old furniture to manufacture new furniture, in order to eliminate wood waste.



<https://www.forestalmaderero.com/articulos/item/muebles-ideas-soluciones-el-uso-del-osb-en-interiores.html>



<https://www.forestalmaderero.com/articulos/item/muebles-ideas-soluciones-el-uso-del-osb-en-interiores.html>

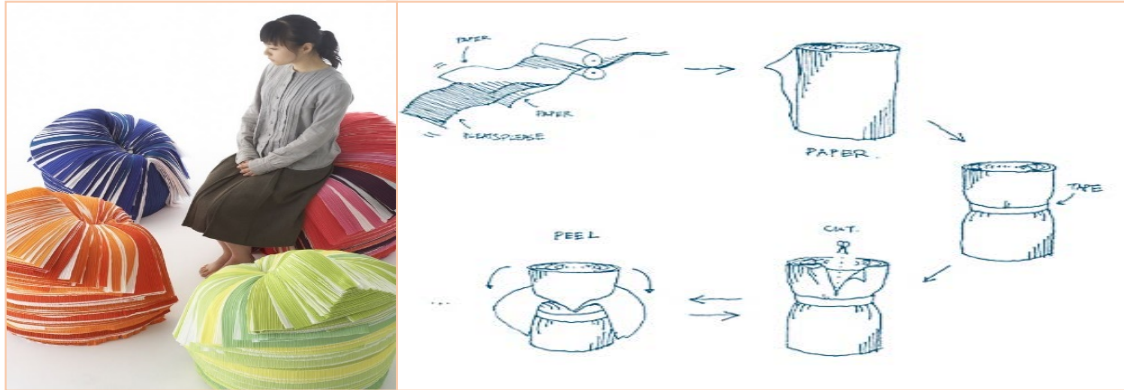


<https://www.pinterest.com/pin/653303489733232370/>

**Fig.12:** Utilizing factories junk to produce untraditional furniture

### 3.5.4.2.2 Paper Waste

Among the innovative ideas to re-use paper is to recycle it into uniquely designed chairs; these chairs come in the shape of sealed paper rolls, when the external layer is cut; the internal layers drape to form a comfortable seating.



<https://www.nendo.jp/en/works/cabbage-chair-2/>

**Fig.13:** Recycling paper into chair

### 3.5.4.2.3 Polyethylene Plastic Wastes

The polyethylene plastic is recycled to manufacture foldable furniture, in these designs; the connection elements; e.g. screws and cables; are discarded. [8], [2]



<https://www.pinterest.com/pin/953707658585365736>

<https://www.pinterest.com/pin/370913719295417205>

[https://acrylshik.ru/articles/show/160/Akrilovaya\\_mebelorigami](https://acrylshik.ru/articles/show/160/Akrilovaya_mebelorigami)

**Fig.14:** Utilizing and recycling of polyethylene plastic in furniture designs

### 3.5.4.3 Furniture Manufactured from Woodlands Wastes

#### 3.5.4.3.1 Reclaimed Trees

Bio-furniture also depends on reclaimed wood to design and re-manufacture daily used pieces; such as chairs & tables; using sustainable materials which can biologically decompose.





<https://www.pinterest.com/pin/108/2693566642168450>



<https://www.pinterest.com/pin/490399846938760912/>



<https://www.pinterest.com/pin/77468957341/5343205>

**Fig.15:** Utilizing proclaimed trees to produce furniture with various uses

#### 3.5.4.3.2 Tree lumps Wastes

Some designers attempt to revive wasted and unwanted tree lumps, proving the role of designers in sustaining the environment. These creative designs include chairs and beds, among other ideas to reuse old tree lumps.



<https://www.pinterest.com/pin/863424559/823529562>



<https://www.pinterest.com/pin/4472638067/57783804>

**Fig.16:** Utilization of old tree lumps to produce middle tables

#### 3.5.4.3.3 Tree Trunks Wastes

Large furniture factories which rely on trees in their manufacturing processes produce a lot of tree wastes; such as branches and trunks. Some designers see that it possible to reuse these wastes to produce pieces of furniture; such as tables; with innovative designs.



<https://www.pinterest.com/pin/327285097933444605/>



<https://www.pinterest.com/pin/830703093790897275/>

**Fig.17:** Using wasted tree trunks to design unique middle tables and chairs

## 4. The Analytical Study

### 4.1 Debate (Dissemination of the study)

#### 4.1.1 Ford® pioneering experiment in the utilization of bioplastic

Coffee various hot and cold beverages are largely popular, but the making of these beverages produces enormous quantities of coffee husks and beans which, some may say; are unusable. Nonetheless; Ford® has started using coffee wastes to produce bio-plastic to make their cars headlights covers. Moreover; since Ford® needs a lot of coffee wastes, it has signed a contract with McDonald's®; to buy their coffee wastes and turn them into bio-plastic needed for their car parts; these new parts are of less weight and density making Ford® cars more efficient in regards to energy consumption.



<https://www.rcnmag.com/news/sema-2019-recap>



[ps://bioplasticsnews.com/2019/12/05/ford-mcdonalds-bioplastics/](https://bioplasticsnews.com/2019/12/05/ford-mcdonalds-bioplastics/)

**Fig.18:** Recycling coffee wastes to produce car parts at Ford factory

#### 4.1.2 Cups and Coffee Husks

Every year; tons of coffee husks are collected as wastes, the accumulation of these organic materials with no sustainable method to process them has created a problem of how to handle these massive amounts of husks. This problem has gained interest with some promising results, among which is “Huskee” coffee cups, which are made of coffee “husks” and are reusable and recyclable.

The “Huskee” cup is designed to keep the coffee hot for a longer time, making it a comfortable cup that can be regularly used and is worth keeping.



<https://qahwaworld.com/ar/news/global-coffee-industry-advances-sustainability-with-circular-economy-initiatives/>



<https://arabic.alibaba.com/g/organic-cocoa-shells.html>



[https://www.kickstarter.com/projects/1366930566/huskee-cup-waste-made-beautiful/?utm\\_source=Youtube&utm\\_medium=referral](https://www.kickstarter.com/projects/1366930566/huskee-cup-waste-made-beautiful/?utm_source=Youtube&utm_medium=referral)

**Fig.19:** Recycling coffee husks to produce cardboard cups

## 4.2 Utilizing Biomaterials Made from Coffee In Interior Design (Practical Aspect Of The Study)

In light of the global interest in sustainability and reducing petroleum-based plastic products; it has become crucial to find environmental-friendly alternatives which are derived from natural renewable resources. Some materials made from ground coffee can be used as solid items, such as plastic, marble and tiles; and utilized in the interior design, this way; enormous amounts of wasted materials can be processed and used to create useful and aesthetic objects. Coffee waste is one of the most abundant organic wastes around the world, making it a promising resource for innovative bio-based materials; and this study aims to utilize coffee waste to develop a bio-plastic material suitable for interior furniture design. During the practical phase of the research, which was to design sustainable furniture using bioplastic; Eco-Epoxy was used as a feasible substitute for bio-plastic due to its superior material properties and greater commercial availability. While bioplastics offer environmental benefits, they often present limitations in terms of structural strength, moisture resistance, and long-term durability. These factors are important in furniture design applications. Bioplastics are generally difficult to process using simple or small-scale manufacturing methods, which poses challenges during the prototyping phase. Eco-epoxy offers excellent mechanical performance, high transparency, and adaptability to shaping and finishing, making it fully compatible with the functional and aesthetic requirements of furniture design. Eco-epoxy is engineered with biocomponents, consistent with the sustainability goals of design, while ensuring the feasibility of manufacturing and prototyping. This choice represents a balanced compromise between environmental duty and material performance within the limits of available resources and technologies.

### 4.2.1 Objectives:

1. To study the properties of mixing coffee waste with Eco-Epoxy to create a bio-plastic material.
2. To evaluate the suitability of the developed samples for furniture manufacturing.
3. To analyze the effects of different mixing ratios on physical characteristics (hardness, thickness, aroma, texture).
4. To test the aesthetic and sensory qualities resulted from using coffee as a primary organic component.

### 4.2.2 Materials and Tools:

#### 4.2.2.1 Materials

- Eco-Epoxy (binding agent)
- Organic desiccant (150g)
- American coffee grounds (105g)
- Arabian coffee grounds (90g)

#### 4.2.2.2 Tools

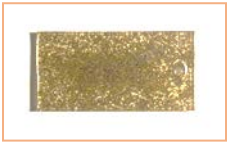


- Precision digital scale
- Silicone molds
- Wooden stirring sticks
- Plastic mixing containers

### 4.2.3 Methodology:

1. Preparation: a safe working environment was prepared within which tools were thoroughly cleaned and sterilized.
2. Measuring: equal weights of Eco-Epoxy and desiccant (50g each) were prepared to produce three test samples with different amounts of coffee (10g, 15g, 20g).
3. Mixing: Eco-Epoxy and desiccant were blended until homogeneous, then coffee grounds were gradually added with continuous stirring to ensure even distribution.
4. Molding: the mixture was poured into silicone molds (designed for potential furniture components) and air bubbles were removed.
5. Treatment: samples were left to dry and harden for a minimum of 24 hours in a moisture-free, temperature-controlled environment.

**TABLE 6**

**COMPARISON OF ARABIAN COFFEE SAMPLES**

Test No.	1	2	3
Coffee Quantity (g)	10	15	20
Thickness (cm)	0.7	0.7	0.8
Texture	Smooth	Smooth	Smooth
Scent	Light	Light	Light
Hardness	Rigid - Flexible	Rigid - Flexible	Rigid - Less Flexible
Durability	Medium	Medium	Medium
Picture			

**TABLE 7**

**Comparison of American Coffee Samples**







Test No.	4	5	6
Coffee Quantity (g)	10	15	20
Thickness (cm)	0.5	0.5	0.7
Texture	Smooth	Smooth	Smooth
Scent	Medium	Medium	Medium
Hardness	Rigid - Flexible	Rigid - Flexible	Rigid - Less Flexible
Durability	Medium	Medium	Medium
Picture			



TABLE 8

<b>Comparison of Arabian Coffee (A) &amp; American Coffee (U) Samples</b>			
Test No.	7	8	9
Coffee Quantity (g)	A: 20 / U: 20	A: 15 / U: 20	A: 10 / U: 20
Thickness (cm)	0.8	0.8	0.8
Texture	Smooth	Smooth	Smooth
Scent	Medium	Medium	Medium
Hardness	Rigid - Flexible	Rigid - Less Flexible	Rigid
Durability	Medium	Medium	Medium
Picture			

#### 4.2.4 Results and Observations:

- A semi-rigid material with a smooth surface and noticeable coffee aroma was successfully produced.
- Increasing the amount of coffee in the mixture has increased the hardness of the produced material; and decreased its flexibility.
- The produced material showed good compressive resistance, making it suitable for flat surfaces; such as tabletops and decorative furniture panels.
- A distinct coffee scent emitted from the material when exposed to heat; which can be integrated within a sensory-focused internal design.

#### 4.2.5 Practical Application:

The proposed designs were developed as part of the practical aspect of the research to study the potentiality to integrate bioplastics into furniture design.

##### 4.2.5.1 First Design: Coffee table

The produced material was used in a decorative table design which was inspired by Arabian coffee culture and incorporated Islamic motifs as well as a symbolic geometric shapes.

This design table was created to suit different environments and can be used as a main piece of furniture or as a complement to a furniture set.





**Fig.20:** Design 1 Table design utilizing bioplastic produced from coffee wastes.

- **Design Description:** This design demonstrates the utilization of the bio-plastic material produced from coffee wastes, in the design of a modular decorative table. The design incorporates Islamic ornamental motifs to reflect the cultural aesthetics associated with Arabian coffee culture and traditions.

The presented layout includes both the technical orthographic drawings (top, front, and side views, with precise measurements in millimeters), as well as 3D perspective renderings that visualize the volumetric composition and aesthetic details of the designed piece.

In addition to the design renderings; figure (20) illustrates a material swatch of the actual fabricated bio-plastic sample; and as shown above, it is a dark brown, semi-rigid material with visible suspended coffee particles and a smooth, glossy surface finish, this tangible sample proves that the produced material can successfully be utilized in furniture design.

The designed table is constructed of a cubic wooden frame, the top panel includes four recessed compartments; each of them is covered with a slab made from semi-transparent bio-plastic containing fine ground coffee particles; creating a rich, speckled texture that retains visible depth and color variation.

These top inserts feature two distinct graphic motifs:

1. A stylized geometric Arabian lineal pattern, inspired by Islamic interlaced knotwork.
2. A minimalist coffee bean silhouette, as a direct reference to the organic material from which the bio-plastic was produced.

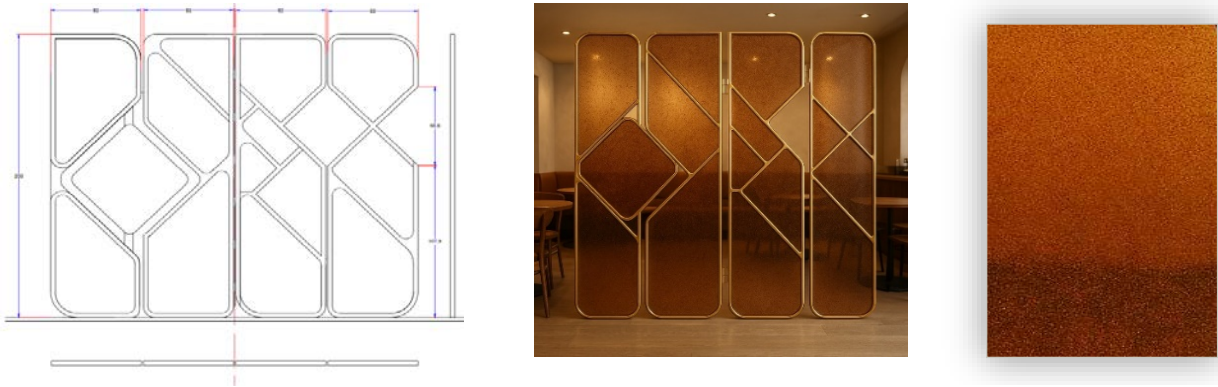
The design cultural reference, tactile characteristic and sustainable construction makes it suitable for both contemporary hospitality environments, as well as modern household interiors.

**Key Features:**

**Material:** cubic wooden frame, bio-plastic slabs with embedded coffee particles.

**Functionality:** easily reconfigured for flexible uses

**Usage:** can be used as a central table, side table, or even as a seating unit when reconfigured.



**Fig.21:** Design 2 elev. and side views of a partition design utilizing bioplastic produced from coffee wastes.

#### 4.2.5.2 Second Design: Partition

- **Design Description**

This design merges Islamic-inspired-geometry with a contemporary modular expression; this foldable room divider is designed for upscale internal environments; such as boutiques, cafés, lounges and hotel lobbies.

The designed partition consists of four interconnected panels supported by elegant golden metal frames; with softly curved corners and rounded vertical edges; that convey both structure and sophistication.

The partition panels feature an intricate lattice pattern composed of intersecting diagonal and vertical lines, forming diamond and triangle motifs with slots in between. Bio-plastic is used as semi-transparent surfaces infused with coffee-ground textures, its color fades from dark brown at the bottom to a lighter tone towards the top allowing light diffusion; and at the same time; symbolizing the natural essence of the organic material.

A standout detail is the golden geometric motif located off-center within one of the panels; this motif resembles interlocked squares or an abstract knot representing unity and continuity; it adds a focal point of artistic and cultural significance.

The modern beige armchairs and minimalist wooden tables in the background emphasize the partition's double-role as a functional space divider and an aesthetic sculpture within the interior area.

#### **Key Features:**

**Material:** powder-coated golden aluminum frame, bio-plastic panels with embedded coffee particles.

**Functionality:** freestanding and foldable, can be easily reconfigured.

**Visual Effect:** light and shadow interplay through transparent color gradients and perforated geometry.

**Usage:** ideal for cafés, hotel lounges, or as artistic dividers for commercial interiors.

#### 4.2.6 Output:

The experiments conducted within the practical aspect of the research demonstrated the feasibility of converting coffee waste into an eco-friendly material (bioplastic). This innovative material supports the progressive shift away from petroleum-based plastics in the field of interior design; it also promotes the role of designers as active advocates for environmental and social development.

## **5. Conclusions and Recommendations:**

### **5.1 Conclusions**

1. The researcher has successfully produced a semi-rigid bio-plastic material utilizing coffee wastes as the primary component, which confirms the capability to repurpose these abundant amounts of waste as an eco-friendly material for sustainable applications.
2. The produced bio-plastic exhibited characteristics suitable for certain furniture applications; specifically flat surfaces such as tabletops and decorative panels; due to its compressive resistance. The material's hardness and flexibility were found to be adjustable by changing the amount of coffee grounds in the mixture.
3. The research has successfully integrated the bio-plastic material into furniture design; as demonstrated in the proposed design ideas; which proves the material's potential to achieve cultural aesthetics and contribute in visually appealing designs.
4. The utilization of coffee wastes to create bio-plastic aligns with the broader goals of sustainability, by minimizing wastes and reducing the reliance on petroleum-based plastics, thus; potentially lowering carbon emissions associated with traditional plastic production.
5. The research directly supports the objectives of Saudi Vision 2030 by promoting sustainable development, economic diversification, and the utilization of local resources.

### **5.2 Recommendations**

1. Additional research should focus on optimizing the bio-plastic formulation to enhance its durability, flexibility and resistance to various environmental factors. This could involve exploring different binding agents, additives, and processing techniques.
2. The application of bio-plastic should be expanded beyond the proposed design ideas; more research and efforts should be conducted to explore its potential uses in other pieces of furniture; such as chairs, storage units, and structural elements.
3. Awareness campaigns should be initiated to educate consumers about the benefits of bio-plastic furniture and the importance of supporting these sustainable products; which can help increase the demand and encourage manufacturers to adopt bio-plastic in their products.
4. A comprehensive life cycle assessment should be conducted to fully evaluate the environmental impact of bio-plastic furniture; from bio-material production to end-of-life disposal; this shall help identify areas for further improvement and ensure true sustainability.

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