

Interactive Packaging with an Egyptian Identity Based on 3D Printing is a Promising Future for the Packaging Industry

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ABSTRACT:

Research areas of interactive packaging are greatly concerned with development and creation of attractive packaging items with environmentally, friendly, and healthy effect. An innovative relationship between 3D printing, environmentally friendly materials as replacing petroleum-based polymers (Polystyrene, Polyethylene) with packaging materials based on bio-based materials is a major challenge in the field of environmental research and packaging worldwide. Additionally, supporting Egyptian civilization history has essential role through novel design with an Egyptian identity on packaging items. Utilizing 3D printing to enhance interactive packaging with interactive design of the mug with an Egyptian identity was printed from PLA and ABS as a prototype. Interactive packaging science was applied to design attractive packaging mugs with crocodile, ancient Egyptian god and 3D body. Different designs were applied to mug shapes of different ancient Egyptian pharaonic items with information about them. 3D printing technology was used to produce two mugs from polylactic acid (PLA) filaments and acrylonitrile butadiene styrene (ABS) as a biodegradable and environmentally friendly polymer to achieve the principle of environmental sustainability. Through experimental approach, the 3D printed mugs were designed as a prototype for the consumer. PLA and ABS mugs were investigated as acceptable packaging materials with mechanical properties and total migration. The samples were analyzed for total migration and measured according to EC 2011/10. PLA and ABS showed good physical and mechanical properties with tensile strength of 42 and 76 MPa and elongation at break of 4.6 and 3.8%, respectively, as a rigid packaging item. The overall transformation was accepted according to EC 2011/10. The research fields of 3D printing, interactive design and sustainable packaging materials are combined to create sustainable packaging mugs for health and wellness applications. In general, 3D printing is adapted using environmentally friendly PLA and ABS to produce an interactive design mug with an Egyptian vision.

1- Introduction

Interactive packaging materials technology and applications are prospected future with polymer matrices as filaments for 3D printing. Combination of two main research science, materials and interactive packaging communication will be deal in the next introduced context.

Intelligent interactive packaging focuses on the emotional interaction between consumers and packaging with information transparency and mutual trust to keep pace with digital developments,

People's demand and concern for product packaging have gradually shifted from the material layer to the spiritual and emotional level. People are willing to engage and interact with the packaging. The innovative application of intelligent interaction technology based on user experience in modern packaging design improves the interaction between consumers and packaging.

In recent years, the field of 3D printing has witnessed remarkable advancements, revolutionizing various industries. Among the key beneficiaries of this technology are the packaging industry and the search for sustainable materials. PLA is a biodegradable thermoplastic derived from renewable resources such as corn starch or sugarcane.

ABS can withstand rough handling, providing adequate protection for delicate or fragile items during transportation and storage.

Combining PLA and ABS with 3D printing technology opens up new possibilities for sustainable interactive packaging solutions. By leveraging PLA's biodegradability and ABS's durability and high-performance mechanical properties, manufacturers can create interactive packaging that meets both environmentally friendly and functional requirements.

Using prototyping techniques to design a mug that reflects the Egyptian civilization using the

crocodile shape. And its proximity in the Egyptian consciousness as a symbol of good and evil.

This article explores the potential of two emerging materials, polylactic acid (PLA) (90% of applications) and acrylonitrile butyl styrene (ABS) (a high-performance polymer), as future sustainable packaging materials in the context of 3D printing. The use of 3D printing with its environmentally friendly material is suitable For interactive packaging applications with an Egyptian identity.

The research relied on the experimental approach to design a mug in the shape of a crocodile due to the importance of the crocodile shape to the ancient Egyptians, including evoking feelings of interaction with the interactive design and printing this design using 3D printing technology with (PLA and ABS) materials and conducting laboratory measurements to verify the effectiveness of the mechanical properties of these materials for effective use to achieve the principle of sustainability.

2-Theoretical background

Interactive communication relationship is established between, the producer and the consumer, making the packaging more human, intelligent and emotional. The "emotional interaction" of packaging design refers to the interactive communication behavior of consumers when contacting the packaging, Intelligent technology is a critical element of emotional experience design. In addition, interaction can be achieved a more interesting and intelligent packaging innovation design, various levels of emotional, interactivity, sharing and sustainability of intelligent interaction in modern packaging design, analyze the interaction design experience of packaging at different levels.as shown Figure1.

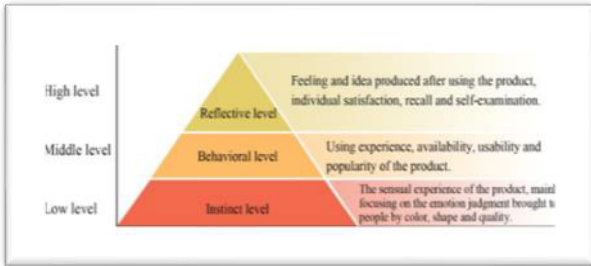


Figure1 levels of emotional, interactivity

1-2 Positive integration between 3D printing and interactive packaging design

To achieve the principle of sustainability by providing innovative modern design and a future design vision. Interactive packaging relies on the use of modern technological techniques in packaging design to serve as a marketing advertisement targeting the consumer. Interactive packaging technologies include QR codes and augmented reality AR. Figure 2.

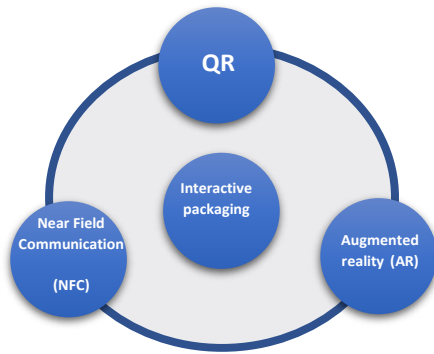


Figure2 Interactive packaging technologies

1-3 Integration of 3D printing and sustainability PLA and ABS

3D printing offers the flexibility to design packaging with intricate internal structures for cushioning and protection, optimizing material usage and reducing waste.

3D printing process. This stability enables the production of large-scale packaging components with

reduced risk of deformation, ensuring accurate and reliable results.

3D printing filament, PLA offers several advantages that make it an attractive option for sustainable packaging solutions. First and foremost, PLA is biocompatible, non-toxic, and safe for food contact, making it suitable for a wide range of packaging applications, including food and beverage containers. Additionally, PLA exhibits good printability, allowing for intricate designs and complex geometries, which can be particularly advantageous for customized packaging solutions. PLA also boasts excellent layer adhesion and dimensional stability, resulting in strong and durable printed objects.

Furthermore, PLA's biodegradability is a significant asset in the context of sustainable packaging. When properly disposed of in industrial composting facilities, PLA can break down into carbon dioxide and water within a relatively short period, reducing environmental impact and waste accumulation. However, it is important to note that PLA requires specific composting conditions to biodegrade effectively, and it may not degrade as efficiently in natural environments or landfills. PLA has a great vital role in packaging in EU as presented in the Figure 3.



Figure 3: PLA packaging in Europe

ABS is a durable, petroleum-based thermoplastic widely used in various industries, including automotive, construction, and electronics. While ABS is not inherently biodegradable like PLA, its potential for 3D printed packaging lies in its exceptional mechanical properties. ABS exhibits high impact strength, toughness, and resistance to chemicals and heat, making it suitable for robust and protective packaging applications.

it's important to consider the environmental impact of ABS, as it is derived from non-renewable fossil fuel sources and does not readily biodegrade. ABS is also known for its excellent dimensional stability, which reduces bending and shrinkage during printing.

1-4 The effectiveness of using 3D printing in the packaging system

3D printing technology evolves, advancements in material development and recycling techniques may lead to improved sustainability for PLA and ABS. Researchers are seeking ways to enhance the biodegradability of PLA in various environments, including home composting and landfills. Similarly, efforts towards developing more sustainable alternatives to ABS, such as bio based or recycled ABS filaments, are underway. Empower the sustainable development of packaging industry future trend to more effective visual and sensory forms of communicating.

3. Experimental and method

In order to achieve the research objective, an experimental study is conducted as following:

3.1. Materials and methods

The structure design mug was based on the program computer-aided design (CAD) 3D Max 2019. Zortax M300 plus 3D printer, Poland, was used to print the three designed bottles 650 ml Universal 3D printing filament, PLA and ABS was purchased from Zortax with average diameter 1.75 mm.

3.2. Mechanical properties

The mechanical properties should be taken into consideration to meet the desired processing and applications demands. Mechanical properties of casted films were evaluated; tensile strength (TS), and elongation at break (E) of films were measured by Zwick/RoellZ020 instruments, (Ulm, Germany) according to the ASTM-D412.

3.3. The overall migration

Many international regulations have been legalized regarding migration of specific substances such as heavy metals, degradation products and additives. These materials could have bad taste, odors, or suspected harmful effects to consumers. The overall migration (OM) simulants and conditions as detailed

in EU Regulation Nr. 10/2011 (The PIM), Simulant A, Simulant B, Simulant D2. All samples were compared to blank sample (Millipore water with resistivity 18.5 M Ω) as reference. The overall migration is expressed as the amount in milligrams of material lost from one decimeter square surface (mg/dm²). Overall migration results were calculated according to (EN 1186-5-single side contact in cell test).

4. Methodology (Applied study)

4.1 The innovative interactive design of the mug is inspired by the Egyptian identity.

The following designs (Figure (4) shows the PLA and ABS packaging mug was applied according to the ergonomic aspects of the packaging, including the photorealistic texture to prevent the mug from slipping as well as easy of gripping and handling, choosing the dimensions.



Fig. 4 shows the structure design of polymeric mugs by ABS and PLA

4.2 The role of interactive packaging in enhancing the Egyptian identity

The choice of the crocodile body design is the main purpose of arousing feelings towards the Egyptian civilization to consolidate and enrich the Egyptian identity. The design is convenient to use, the body of the mug is designed in a cylinder shape, the tail is created as a handle for the mug, and the design of the mug cover and the design of drinking from the back to the mouth are completed. The application of interactive design and innovation in packaging design will increase the added value of the product, interactive packaging design aimed at touching user's emotion and satisfying psychological. It can motivate experience generated from its interaction with users and make people resonate with it deeply and gain abundant aesthetic.

Ancient Egyptians consider crocodiles sacred. The crocodile was associated in the Egyptian consciousness as a symbol of both good and evil. The god Sobek is an ancient Egyptian god associated with Nile crocodiles and is represented in the form of a human with the head of a crocodile. It was considered a protective god against dangers with qualities that repel evil, such as the dangers of the Nile flooding.

4.3 Promoting positive integration between interactive design and the user are achieved functional and aesthetic values

Creating interactive designs with an Egyptian identity inspired by ancient Egyptian art for interaction and integration between the user and the design to enrich and consolidate the Egyptian identity. As graphics and pharaonic elements were designed on the mug that complements the user's face as present in the following Figures 5.



Fig.5 shows different designs vision of mugs was ancient Egyptian identity

In Fig. 6, various types of ancient Egyptian gods were applied as face form in mugs with identification information as a tourist announcement.

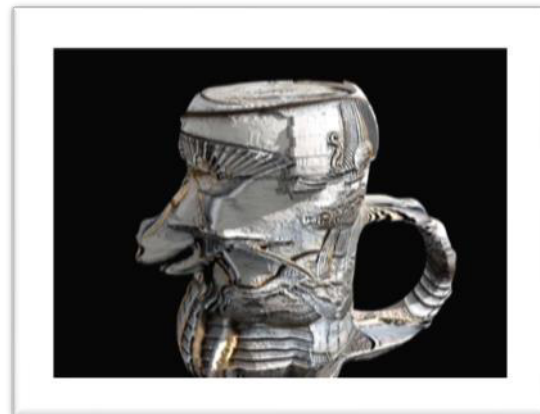


Fig.6 design vision of mugs

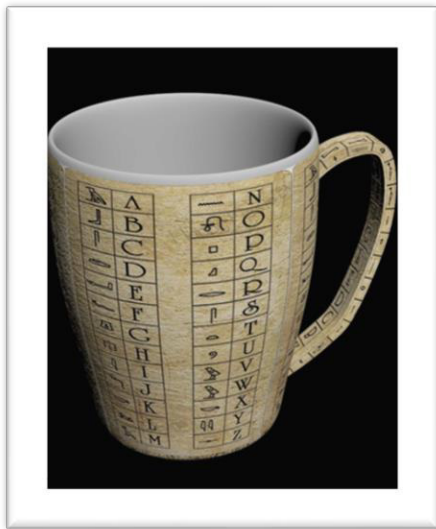


Fig. 7 shows innovative design for languages

The English alphabetical and related symbols in phonetics language of ancient Egyptian as shown in Fig.7. This design will give the user an option to highlight the symbols of his/her names. Such designs can be used to sell them in archaeological or coastal areas to enhance the role of the Pharaonic civilization in an interactive way.

From the designs the second hypothesis of the research is realized.

5. Results

5.1 Tensile strength (TS) and elongation

The mechanical testing of 3D printed dumbbell shape was illustrated in Figure 8 through measurement the tensile strength (TS) and elongation at break (E). The PLA and ABS dumbbell shape were presented the TS and E of PLA are 44 MPa and 4.7 %, where ABS 56 MPa and 3.8%, respectively.



Fig. 8 shows dumbbell shape

The measurable mechanical properties of PLA and ABS were agreement with most polymeric materials used in bottle production as hard packaging materials.

5-2The overall migration

The migration of any chemical substances from the 3D printed bottles have been studied according to the EU Regulation Nr. 10/2011. The stimulants were selected carefully to represent different food natures. As shown in Table 1, the 3D printed mug showed acceptable migration limits. The overall migration (OM) from the PLA 3D printed bottles were ranged from 0.1 up to 6.8 mg/dm². The regulation limits the accepted level up to 10 mg/dm².

Method	EN-1186-5	EN-1186-5	EN-1186-4
	Migration into	Migration into	Migration into Olive oil (simulant D ₂)
	10% v/v ethanol (simulant A)	3% w/v acetic acid (simulant B)	mg/dm ²
Replicates	mg/dm ²	mg/dm ²	
1	4.4	6.9	0.1
2	4.5	6.7	0.1
3	4.6	6.8	0.1
Mean result	4.5	6.8	0.1
Limit	10.0	10.0	10.0

Table 1. The overall migration from PLA 3D printing mug

On the other hand, the stimulants were designated cautiously to characterize different nature foods. As shown in Table 2, the 3D printed mug showed acceptable migration limits. The overall migration (OM) from the ABS 3D printed bottles were ranged from 0.2 up to 8.4 mg/dm². The regulation limits the accepted level up to 10 mg/dm²

- (simulant A) ethanol example milk products, alcoholic foods, Yogurt, caster.

- (simulant B) acetic acid example water, acidic foods, aqueous foods, Juices. Ketchup

(simulant D2) Olive oil example fatty food, butter

Method	EN-1186-5	EN-1186-5	EN-1186-4
Replicates	Migration into 10% v/v ethanol (simulant A) mg/dm ²	Migration into 3% w/v acetic acid (simulant B) mg/dm ²	Migration into Olive oil (simulant D2) mg/dm ²
1	7.2	8.5	0.1
2	7.1	8.3	0.3
3	7.3	8.4	0.2
Mean result	7.2	8.4	0.2
Limit	10.0	10.0	10.0

Table 2. The overall migration from ABS 3D printing mug

From the results of Table 1, 2 the first hypothesis of the research is realized.

6. Conclusion:

Interactive packaging designed with ancient Egyptian identity was successfully to produce crocodile mug as Egyptian spirit of pharaonic civilization. Polylactic Acid (PLA) and Acrylonitrile Butyl Styrene (ABS) demonstrate significant potential as 3D printed packaging materials of the future for interactive designing. PLA's biodegradability and non-toxic nature combined with ABS's durability and mechanical properties offer a compelling balance between sustainability and functionality. However, ongoing research and development are crucial to further improve the environmental impact and recyclability of these materials. With continued innovation and adoption of 3D printing technology, PLA and ABS could pave the way for a more sustainable and customizable future in the interactive packaging industry.

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