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HOUSEHOLD AND AGRO-WASTE UPCYCLING INTO SUSTAINABLE UNBREAKABLE ARTWORKS AND FURNITURE PIECES BY ECO-FRIENDLY ORGANIC CHEMICAL REACTIONS

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ABSTRACT:

Millions of tons of agro waste and household waste have been generated that end up in landfills, which in turn affect human health. Waste has serious impacts on the environment through greenhouse gas emissions. Waste is a huge economic burden on governments and distorts the civil and aesthetic appearance. The invention primarily converts waste into crystallized capsules by eco-friendly organic chemical reactions. Secondly, the capsule undergoes a covering by a second chemical reaction to form the final product, which is artwork or furniture pieces that are sustainable and unbreakable. The final product can be manufactured on a large scale since the raw materials are affordable and available, as explained in the feasibility study. Circular Economy is the core concept of the project, which involves upcycling elements that are supposed to be wasted and valorizing them, such as household and agro-waste in potato peels. Moreover, the invention provides practical solutions for the previous technical issues in previously designed inventions. Both stages of the project are safe and non-hazardous. The core components of the first capsule are stone salt and natural stabilizers, and the second stage's reagents are unbreakable resin-making components. The project conducted has not only environmental benefits but also social and economic values; it can be applied in large-scale production, in specialized contemporary museums, and/or exported as artworks and furniture in other countries.

KEY-WORDS: Sustainable-Designs, Eco-Friendly-Polymers, Waste-Upcycling, Circular Economy, Waste Encapsulation .

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1. INTRODUCTION

1.1. Invention Highlights

Millions of tons of Household waste and Agro-waste are sent annually to landfills, they not only have exaggerated amounts of air footprints (Carbon Dioxide, Methane and Nitrogen), but also drastically threaten the public health and civil aesthetics.

The aim of the project is to optimize resources (human, economic, and environmental) by Circular Economy 4 Rs of Reuse, Recycle, Recover, and Reduce, without sending waste to landfills or incinerators. Waste products are fully crystallized into a compact capsule made from rock salt with potato peel starch, then the capsule undergoes a second capsulation by an eco-friendly reaction of:

ECH (Epichloro hydration) + Bisphenol A Diglycidyl ether+ waste
= final product, which is a sustainable, unbreakable body that can be converted into Artwork or Furniture pieces.

1.2. Technical Information

Treatment and upcycling of household waste and agro-waste into Artworks, Sculptures, and Furniture pieces. The project was conducted by eco-friendly chemical reactions with a primary target of resources optimization, additionally circular economy methods are adopted to prevent waste from being discarded in landfills or incinerators.

1.3. Previous Projects in the Same Domain

- **CN109912270A**
  This invention was carried out in China in 2019 when waste materials were recycled by burning methods, then they turned into dust and ashes after careful grinding and chemical additives, and the final products were mixed with concrete [5].

- **JP4004252B2**
  This invention was carried out in China in 2019, when waste materials were recycled by burning methods, then they are turned out into dust and ashes after careful grinding and chemical additives, then final products are to be mixed with concrete [6].

- **CN102060456A**
  In this project, China recycled waste incineration final products and turned them into construction materials by solidifying the dust by chemical reagents and turning them into solid concrete [7].

1.4. Technical Issues in Previous Attempts

The first aforementioned trial relies on solid waste only that can be ground finely. Moreover, it uses cement, which harms the environment. Generally, cement results from burning fossil fuels; this industry is considered as the Third-Largest air pollutant and air footprint emitter. In the second trial waste products are exposed to extremely elevated temperatures which in turn wastes environmental resources and deplete energy supply. In the third previous project, waste is not upcycled or recycled, only the waste byproducts which accumulate in the incinerator.

1.5. The Solution Introduced in the Project

The invention adopts a concept of circular economy approaches in designing the final product; No product, by-product, or waste of any kind is sent to landfills or incinerators. Agro waste from potato peel extracts is used as thickner and stabilizer.

Rock salt is used for capsulizing waste and absorbing remaining moisture which is eco-friendly and has net-zero climate emissions. Hazardous substances are totally avoided such as cement, excessive heat is also avoided throughout the whole process.

Final products are used as Artwork and Furniture pieces of different shapes and sizes, which can be sold, massively produced, and exported, which in turn can be of a huge economic benefit. The chemical reaction involved in the waste final product is: ECH (Epichloro hydrin) + Bisphenol A Diglycidyl ether+ waste = final product

2. STATISTICS

2.1. Statistics-Plastics

- **Statistics-Plastics | PVC (polyvinyl chloride)**
  This polymer has many applications, from pipes to toys and window frames, but is not widely recycled in household waste. It includes acrylic, nylon, and other mixed plastics.

  These are almost not recyclable in household collections [9].

- **LDPE-low-density polyethylene**
  In terms of plastic carrier bags. These can be recycled but not commonly in household recycling [1].

2.2. Statistics-Aluminum

Although aluminum can be infinitely recycled, 7 million tons of aluminum are still not recycled each year [2].

2.3. Statistics-E-waste

Globally, electronics waste (e-waste) volumes grew to 53.6 million metric tons in 2019, an increase of 21% in only 5 years since 2014 [3].

Only 17.4% of e-waste discarded in 2019 was recycled.

In the U.S, only 15% of the 6.92 million tons of e-waste discarded in 2019 was recycled.

2.4. Toy Industry Waste

The UK's toy industry has been a massive year; consumers spent £370m on them [4].

However, environmentalists say this is contributing largely to the amount of plastic ending up in landfills and oceans.

2.5. Statistics on Household Waste Recycling

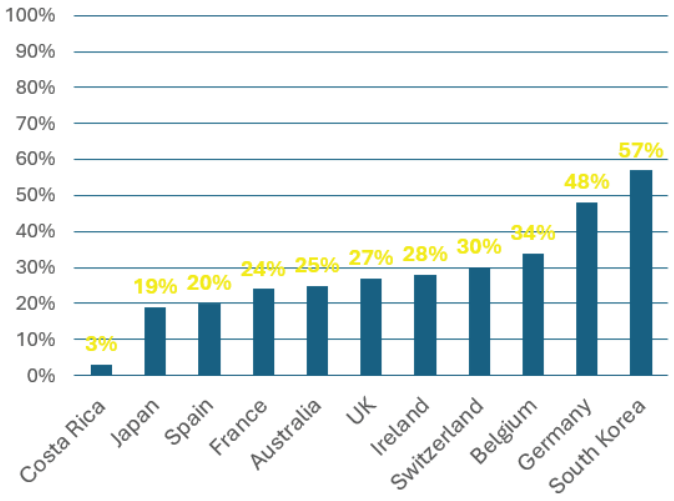


Figure 1. Statistics on how much household waste is recycled globally; South Korea comes as the largest recycling country, contributing 47% of total household waste, while Costa Rica recycles only 3% [8]

3. METHODOLOGY

- **First Stage:** conversion of waste products into crystallized capsules using rock salt and potato peel extracts as stabilizer agents. Primarily, peels are sun-dried and finely ground without resorting to any kind of fossil fuel energy.

  Peel extract: rock salt ratio is 2:1.

  Real case scenario: 500 grams of rock salt and 1000 grams of potato peels are used to capsulate 50 plastic waste bags.

- **Second stage:** the waste capsule is covered by a chemical reaction to make a solid, unbreakable polymer net product.

Table 1: Approximate weight of Waste Encapsulated

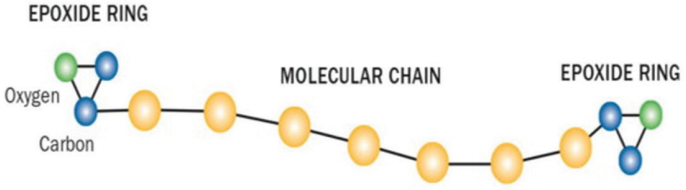
Items no:	Weight of waste (gm)	Weight-encapsulation (gm)
1	90	290
2	100	300
3	120	320
4	150	350
5	110	310
Mean/SD	114/23.02	314/23.02

3.1. Chemical Reaction

ECH (Epichloro hydrin) + Bisphenol A Diglycidyl ether+ waste
= final product

The first chemical reagent is a liquid substance that is added to the second chemical reagent, which is a solidifying agent with a ratio of 4:1 with 10 minutes of stirring. For instance, 1000 ml of sub. 1 is added to 250 of sub. 2 with 10 minutes of stirring; low heat is generated from this reaction, and the final polymer is formulated and solidified after 24 hours. The net product is transparent. However, it can be colored or stained to cover the waste capsule and make the final Artwork and Furniture pieces of a variety of sizes and shapes to suit people's preferences.

Reaction 1: *Enclosed Carbon Oxygen epoxide rings with long chains inside.*



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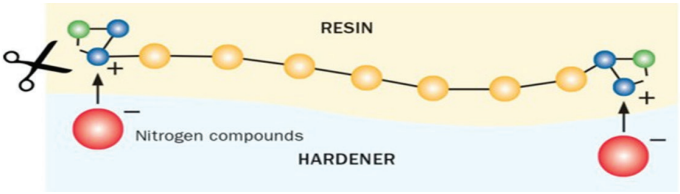
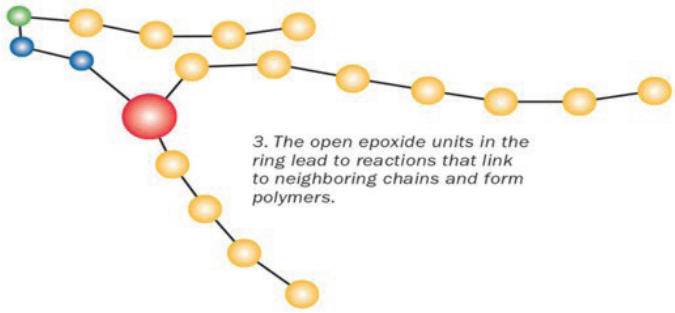
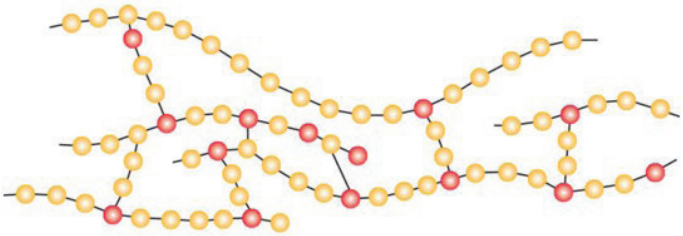
Reaction 2: *Cutting carbon rings and adding Nitrogen for elongation and hardening.*



Reaction 3: *Formation of long hard polymers.*



Reaction 4: *Polymers continue cross-linking with neighbor chains.*



3.2. Project Feasibility

Most of items are free of charge since the project is based on circular economy method of taking, reusing and upcycling waste from Households.

Household waste is FREE of charge.

Starch from potato **peels** is a FREE by-product from food enterprises.

Solid salt costs:

White: **0.05 USD** per kg for 28,000kg **Himalayan 0.05 USD** per kg for 500kg.

Artwork outer **reagents'** materials cost **6 USD** per kg for 100 kg. Estimated cost of an artwork holding waste of 30 plastic bags: **7 USD** for 50 cubic cm final artwork.

Table2: Project feasibility and cost analysis

Item:	Cost:	Large-scale production:
Waste	Free	Consistent supply from waste management facilities
Potato peels	Free	Reliable supply from food processing enterprises
White rock salt	0.05 USD per kg for 28000kg	Bulk discounts
Himalayan rock salt	0.05 USD per kg for 500kg	The previous option is more feasible
Outer reagent	6 USD per kg for 100kg	Negotiating prices
Estimated cost	7 USD	Automation
Energy cost	Minimal heating	Energy-efficient equipment
Equipment cost	3D printers	Maintenance

4. RESULTS

Figure 2. Steps of waste upcycling into a crystallized capsule primarily and then a secondary covering as a finish product

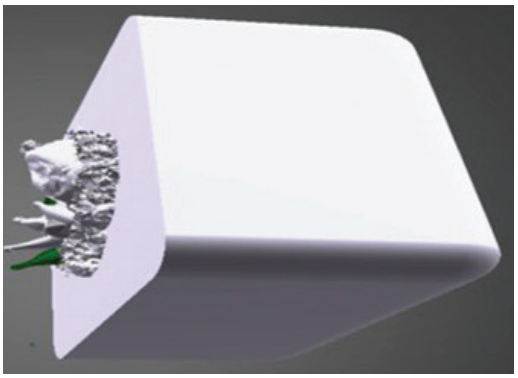


Figure 3. 3D Shape for the stages of upcycling waste into art products

Artwork products (which carry different household waste inside) can be furniture pieces, home décor, and geometrical sculptures that are unbreakable, eco-friendly, and sustainable.

The final executed prototype has successfully

upcycled 50 plastic bags in a pyramid shaped artwork of 35cm height and the same width and weighed about 1kg. It took approximately 24 hours for the polymers to fully harden, finally the cube is extremely strong and durable which can withstand extreme pressure without breaking, which was confirmed by pressure testing.

4.1. Processing Efficiency

The whole process can be automated and computerized for faster and larger-scale waste management solutions.

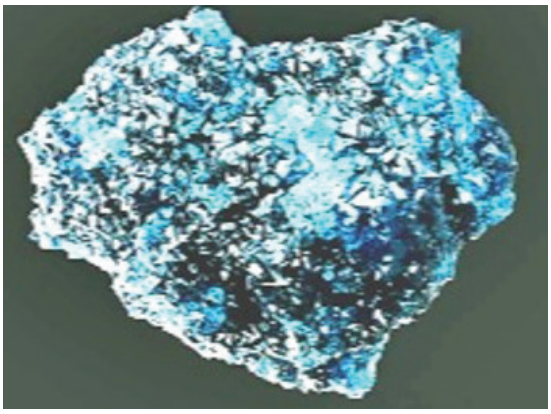


Figure 4. Prototype of the capsule which contains the waste products

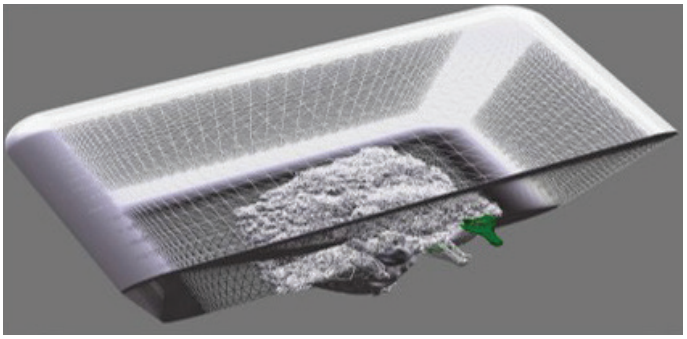


Figure 5. Internal view of the artwork with the subsequent layers

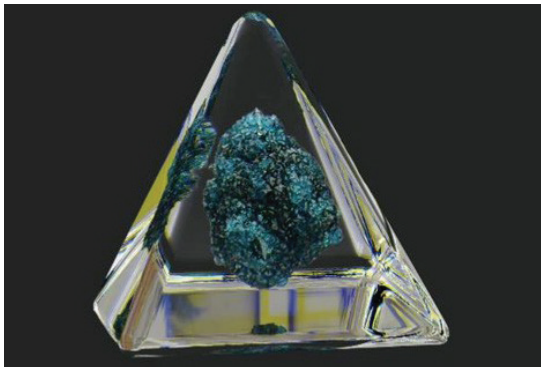


Figure 6. 3D Shape as an example for the artwork final product

4.2. Product Durability

The polymer materials gives the net product durability and hardness with some elasticity to make it unbreakable and long-lasting artworks that can be placed both indoor or outdoor.

Table3: Durability assessment of upcycled artwork and control material

Items	Upcycled waste (n=5)	Control (n=5)	P Value
Mean breaking height (m)	20 ± 2	18±1.5	0.11
Mean compression force (N)	1500 ± 50	800 ± 40	<0.001

4.3. Environmental Impacts

When waste is converted into net products, emissions will be reduced by preventing waste from being sent to landfills or incinerators, especially methane gas generated from household waste, which is 25 times more potent than CO2.

5. DISCUSSION

Millions of tons of waste (non-recyclable and non-recycled) are generated each year, which end up in landfills and incinerators. Waste impacts the environment through greenhouse emissions, which in turn affects human health and aquatic life and is a huge economic burden for governments. The idea of the project is to encapsulate household waste, toys, stored junk, and plastics into an eco-friendly crystallized form, which will undergo a second covering by a chemical reaction to form non-breakable artworks, decoration or furniture pieces. The product goes through two major pathways: based on circular economy method of reducing, reusing, recovering and recycling, so that nothing ends up in landfills.

1st Phase

Household waste is capsulated by the following reaction: Waste+ Solid Stone Salt+ Starch from potato peels (sun dried and milled) + water= solid crystallized capsules.

2nd Phase

Waste capsule undergoes covering step to form the final piece of artwork which is unbreakable and sustainable. As following: Waste capsule+

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ECH+ Bisphenol A diglycidyl ether = final product of Artwork.

5.1. Environmental Benefits of the Invention

1. Significant reduction of GHG emissions from household waste.
2. Cutting down water pollution.
3. Preservation of Aquatic life.

5.2. Social Benefits

1. Better health of populations due to lower emissions.
2. More vivid artistic houses and cities by the final artwork product.

5.3. Economic Benefits

Significant reduction in waste control budgets from the governments.

More importantly this new contemporary "Waste into Art" will definitely be of a huge economic benefit, artworks can be sold, exported and exhibited in museums and tourist attractions.

5.4. Technology Role

By using 3D printers to form a wide variety of molds for artwork formation. This will provide various options of artwork designs that match people needs and taste.

6. CONCLUSION AND RECOMMENDATIONS

The art world is always expanding, with approximately 125 to 250 million artworks created annually. The new art revolution should start to save the planet from waste, where waste is integrated into artworks. Not only will a new contemporary method of art be generated, but huge economic opportunities will also be created. The invention has a pivotal role in shaping the next generation of contemporary Art and furniture industry. Furthermore, Pieces can be sold and exported and can become part of legislation for decorating cities and districts as well as being launched in specialized Museums of Contemporary art.

Disclaimer

There are no hazardous biological substances involved in the whole project.

Ethical Considerations

No consent or official agreements were needed for this research project, and no human participants were involved in the trial.

Competing interests

The study was conducted and funded at the National Research Centre in Cairo, and no external funding bodies were involved in the whole project.

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