An Application of Plant-based Solution Patinated Brass to Fashion Accessory Design

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Received: 23 August 2024
Revised: 13 January 2025
Accepted: 27 January 2025

Abstract

Intentional patina on metal is traditionally accelerated using highly corrosive, inorganic chemicals. Plant-based solution is a safer alternative, uses plant parts to induce patina on copper and brass. Although mildly corrosive, it produces distinctive patinas on 0.1 mm-thin brass and copper sheets. However, the sensitivity of its patinas and the thin metal sheet presented a challenge for application to craft/design objects. This research was set to explore a safer metalsmithing process by combining plant patination on brass sheets with cold connection and demonstrating it on a fashion accessory. The study was divided into four parts: 1) Patination Experiment, 2) Cold Joining Experiment, 3) Design, and 4) Production. Rose apple solution on brass was selected for its colors and durability. The types of cold joining experiments were Wire Hoop Joint and the Interlocking Tab and Slot Joint. The results: Interlocking Tab and Slot Joint can be well applied to plant-patinated 0.1 mm-thin brass sheets. The fashion accessory (shoulder bag) incorporated aesthetic value of the patina created by sustainable method and demonstrated an application of the material through the adoption of modular system. The result can be further applied to surface design, product design, and interior design. Further research should explore different modular shapes and sizes that allow the unique visual characteristic of plant-induced patinas to take center stage and to create more possibilities in design.

Keywords: Sustainable, Plant-based, Brass, Modular System, Fashion Accessory

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Introduction

Patina refers to the accumulated changes that occur to the surface over time. For metals commonly used in arts, design, and crafts, patina typically means the layer of corrosion products that forms on the surface of copper and its alloys as a result of chemical reactions. While this process happens naturally through weathering, it can also be accelerated by human intervention using chemicals. This attribute has been utilized for its aesthetic value since ancient times.

Metalsmithing exposes individuals to metal dust, corrosive chemical solutions, and welding fumes. Fumes from brass welding, which contain copper and zinc, can cause asymptomatic systemic inflammation (Markert et al., 2016). Corrosive chemicals commonly used for patination, such as ammonium hydroxide, sodium hydroxide, cupric nitrate, and ferric nitrate (Runfola, 2014) can irritate the eyes, skin, respiratory system, and digestive systems (National Center for Biotechnology Information, 2024a, 2024b, 2024c, 2024d), which are toxicity frequently associated with metalsmiths (Zuskin et al., 2007). Additional risks include pregnancy complications and developmental issues in unborn children from cupric nitrate explosion, which may also be carcinogenic (National Center for Biotechnology Information, 2024c). The disposal of untreated toxic wastewater from metalsmithing studios into soil or water can also contaminate groundwater and harm aquatic life ("Disposal of Studio Toxics," 2009). Alternative environmentally friendly metalcraft techniques can provide safer working conditions for the industry while catering to environmentally conscious businesses.

Previous studies have explored the use of alternative patina solutions on copper and copper alloys. In a research article by Roubroumlert and Thongnopkul (2017), different cleaning products (toilet cleaner, dish detergent, window cleaner, floor cleaner, detergent, and bleach) created copper patinas in different colors corresponding to pH levels. A study on Non-toxic patina solutions by Jerman-Melka (1996). included condiments (soy sauce, salt, vinegar) and plant ingredients (garlic, rice, lemon juice) which could create patinas on copper and brass for jewelry making. Despite their potentials, alternative solutions are mostly applied to craft and design products in personal experimental metalcraft projects. There is a need to expand their use within the craft and design academic field and industry.

The Plant-based patination method uses solutions derived from plants, applied at room temperature directly to copper and brass. The results show unique colors and texture that resemble organic media used in the process. Its visual characteristics contribute to the philosophical value of Wabi-sabi that embraces the natural imperfection and the impermanence of nature that progresses towards decay. Although less corrosive compared to traditional chemical solutions, plant-based solutions with pH of 2-6 generate distinctive results on 0.1 mm-thin copper and brass sheets. This is likely due to the reduced structural integrity of thin metal sheets, making them more prone to

corrosion compared to thicker sheets (Cramer and Covino Jr., 2003) and therefore more compatible with plant-based solutions.

The physical requirement of the material presents challenges to design, creating opportunities for innovative technical problem solving. In this study, plant-based patination method, a sustainable material with philosophical aesthetic, is integrated with cold metalsmithing process and applied to a fashion accessory. This demonstrates sustainable metal crafting while presenting a long-lasting aesthetic value that embraces change and the passing of time. This approach offers benefits to industries often associated with toxic materials, emissions, and wasteful production, helping to extend the lifespan of a product and creating an opportunity for recycling.

Research Objective

1. To explore a safer working process for metal crafting by developing a sustainable metal surface design using plant-based patination on brass sheets and cold metalsmithing techniques.

2. To demonstrate the application of plant-based patinated brass sheets, a material that embraces wabi-sabi aesthetics and recyclability, in a fashion accessory, a design product typically shaped by fast-paced trends.

Literature Review

Plant-based Patination Method is one of many alternative patina-accelerating techniques. It uses ingredients derived from plants, particularly fruit juice containing natural acids, and plant fiber as the medium. The patination process involves the decay of the plant solution as it gradually reacts chemically with the copper or brass surface, creating a layer of corrosion products that give unique colors and organic textures.

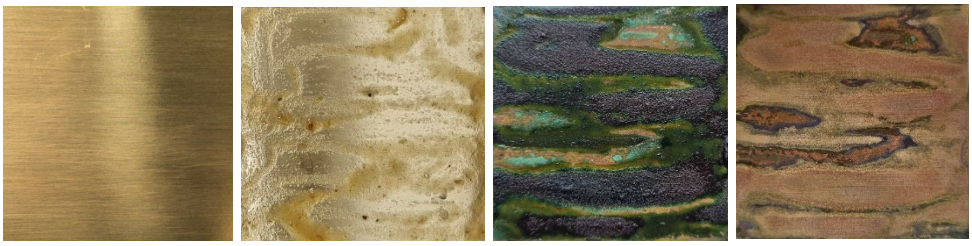


Figure 1 The progress of patination from tamarind pastes on a 0.1 mm-thin brass sheet (Author, 2022)

Both traditional and plant-induced patinas are sensitive to changes caused by heat application, though their susceptibility may vary. It is preferable to apply patina as the final step to ensure the product's finish is flawless. However, plant-based solutions require a controlled environment due to the messy nature of the procedure, making it challenging to apply them to an already completed product.

Cold Joining is a metalsmithing technique of connecting materials without the use of heat (McCreight, 1997). While soldering or welding is commonly used to seamlessly join metal, heat can damage or alter the desired characteristics of the metal, especially its patina.

Figure 2 Cold Joining bracelet using tube hinges and rivets (Hong, 2016)

Modularity as a concept was introduced in 1965 and later developed into a design approach that divides a system into smaller parts called modules, which can be independently created, modified, replaced, or exchanged. (Baldwin and Clark, 2000).

In the 1960s, Paco Rabanne introduced modularity to fashion design. Known for creating dresses from unconventional materials such as metal, plastic, and paper, he used wire hoops inspired by chainmail to join the components (Pasquinelli, 2023).

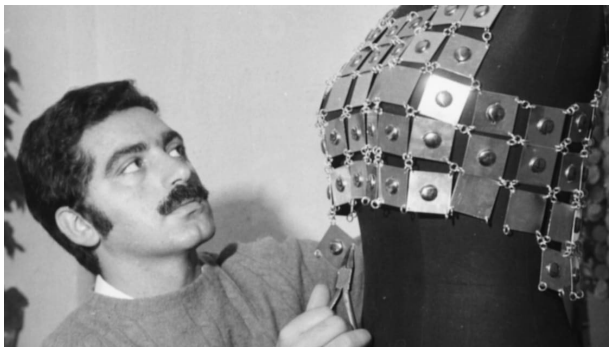


Figure 3 Paco Rabanne in 1968 (Schneider, 2023)

By crafting modular units from recyclable materials and assembling them through cold connections, he eliminated the need for heat applications and made the surface of his dresses flexible, adjustable, and reusable. This method is advantageous and has remained a staple in fashion from the time it was introduced.

In 2008, Soepboer and Balgooi created 'Fragment Textiles' according to the Cradle-to-Cradle design framework. The modular system allowed fragments of the textile to be made from fabric waste. The modules were connected through interlocking tabs and slots, sustaining the fabric by themselves.

Figure 4 Fragment Textiles by Soepboer and Balgooi (New Material Award, *2009*)

The tab and slot joining technique in 'Fragment Textiles' has the potential to be applied with various kinds of material, especially in small pieces, including brass sheets.

A 2020 study by Chen and Lapolla explored modular systems using various tessellations that share the same unit shape—a circle, a form without sharp points, making it well-suited for wearable items. The demonstration of square tessellation shows a connected surface in grid alignment that can be built bigger or smaller according to the purpose. The overlaying tabs reveal the inner square areas that can be utilized for different textures. This can be well applied to fashion accessory designs that benefit from the simplicity of the form as well as the surface areas for texture applications.

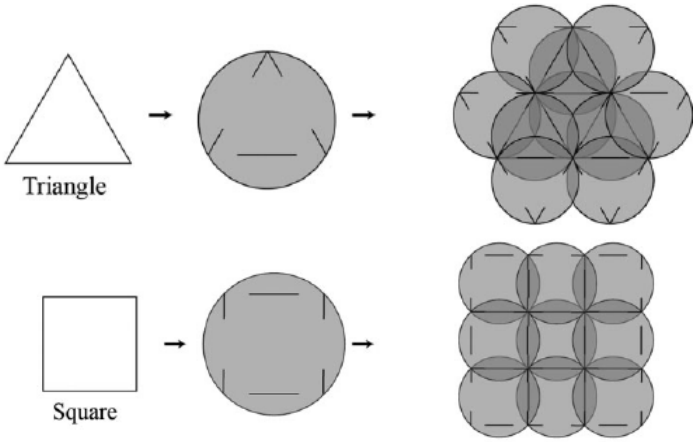


Figure 5 Circle Interlocking Units with Triangle and Square Tessellation (Chen and Lapolla, 2020)

Research Methodology

By providing a new approach to production, this study is an apply research. Ultimately, it is practice-led. The study is divided into three parts. 1) Patination Experiment, 2) Cold Joining Experiment, 3) Design, and 4) Production.

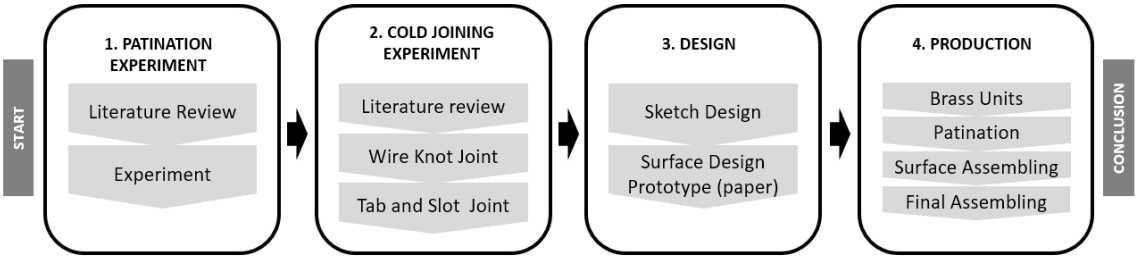


Figure 6 Research Framework (Author, 2024)

Findings

1. Experiment with Patination

Rose apples, with their pH 6 acidity, can create a well-adhering multicolored patina on copper. Its patina has the suitable visual attribute and durability desired for the modular surface for a fashion accessory.

Figure 7 Rose Apple Solution Patina on 0.1 mm-thin Copper Sheet (Author, 2024)

The researcher experimented by applying the solution on a 0.1 mm-thin brass sheet. The experiment yielded a similar result with small differences due to the alloy composition. The patina was durable with an organic texture formed by the fruit pulp. The mixture of the iridescent areas, the muted green areas, the copper-colored areas, and the exposed brass area created an interesting balance between shiny metallic texture and the muted natural texture that resulted from decay.

Figure 8 Process of Rose Apple Solution Patination on 0.1 mm-thin Brass Sheet (Author, 2024)

2. Cold Joining Experiment

In this practice-led study, the researcher looked for a method of joining metal suitable for the application of plant-based patination for a fashion accessory design. The researcher put into consideration the strengths (safe patina induction process, unique colors and textures) and limitations (thickness, size, and possible joining techniques of the metal material) combined with the information acquired by the literature review.

Wire Hoop Joint: The researcher applied wire hoop joints, a cold connection technique, to circle brass sheet units. The connected surface had flexibility and flourished in its movement. However, the thin brass sheets could easily slip through the closing gap of the wire hoops. This method might work if the metal units were thicker, but thicker sheets would result in a heavier surface and meet with limitations with plant-based patination.

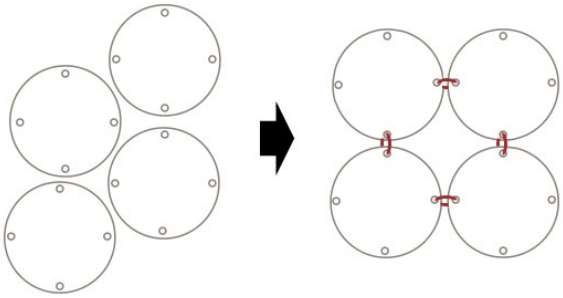


Figure 9 Wire hoop joint experiment (Author, 2024)

Tab and Slot Joint: In the second attempt, the researcher adopted the interlocking method presented by Chen and Lapolla (2020). The circle unit shape with an underlying square tessellation, was chosen to achieve grid alignment, emphasizing the clean geometric form in contrast with the organic texture from the plant-based solution patination method. The circle's circumference, divided into four parts by the square tessellation, served as the interlocking tabs.

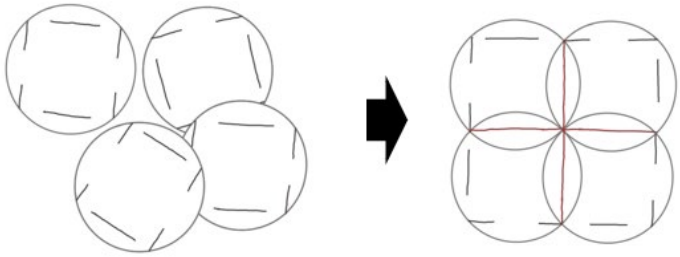
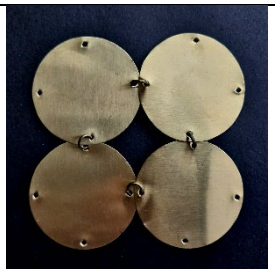


Figure 10 Circle modular units with tab and slot joints for a paper prototype (Author, 2024)

Table 1 Comparison Between Types of Joints

	Image	Method	Result
1.		**Wire hoop joint**	**Pros**: Flexible with movement, large surface for patination **Cons**: Not suitable for 0.1 mm-thin brass sheet as the brass units slip easily through the gaps in the wire hoops.
2.		**Tab and slot joint**	**Pros**: Durable, interlocking, flexible, interchangeable. Suitable for 0.1 mm-thin brass sheet material. **Cons**: The ends of the tabs were sharp The joining of the tabs created some creases on the brass, but this was not an issue, as the creases are a characteristic of the material.

Adjustment: for the tab and slot joint, the ends of the tabs presented sharp angles that were too sharp for wearable products. The researcher made a modification by trimming them into rounded ones.

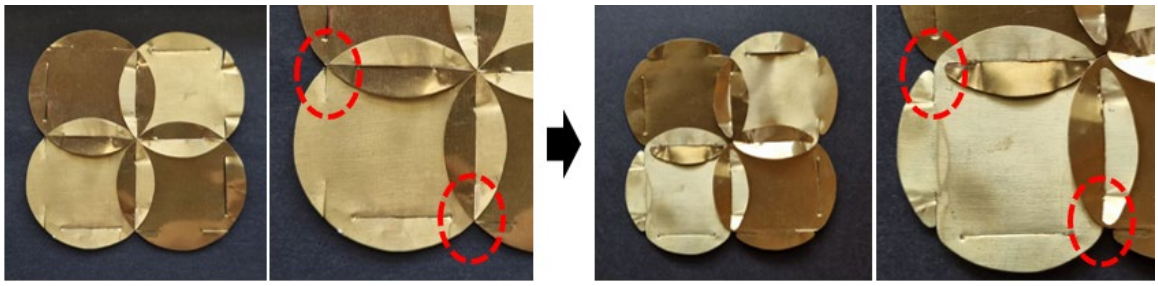


Figure 11 The Modification to Remove Sharpness (Author, 2024)

Discussion: The Metal hoop joint was not suitable for very thin metal sheets. However, the interlocking tab and slot joint was applicable to 0.1 mm-thin brass sheets. The square tessellation was well-suited for a geometric shape of the product. The interlocking surface was secured and durable for a bag design.

3. Design

Design Sketch: In this step, the researcher made a drawing to illustrate the effect of patination on the modular surface. The bag was aimed for individuals with experimental mindset who prioritizes sustainability. For the plant-based patina solution, the researcher chose rose apple solution, as it generates a durable patina with an interesting texture balancing between the shiny metallic areas and the muted colors aligning with Wabi-sabi aesthetic.

Image 12 – Rose Apples (Author, 2024)

Figure 13 Sample of Brass with Rose Apple Solution Patina (Author, 2024)

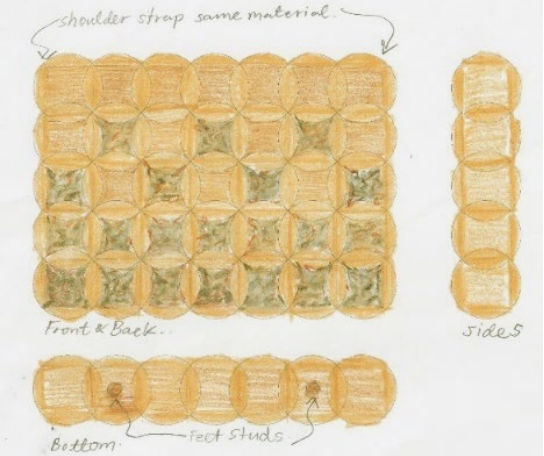


Image 11 – Design Sketch (Author, 2024)

Surface Design Prototype (paper): The researcher made a paper prototype of the modular surface in 1:1 scale, measuring 20 x 15 x 2.5 cm.

Figure 12 – The Prototype in 1:1 size (Author, 2024)

4. Production

Brass Units: the researcher began the working process on brass modular units (diameter 4 cm, thickness 0.1 mm). In this study, this process was done by hand with cutting tools typically used for leather, a metal hammer, and scissors.

Patination: To achieve the patina gradation in the design, the researcher used masking fluid typically used in watercolor painting.

Image 13 – Brass Modules with Masking (Author, 2024)

Figure 14 Rose Apples Applied to Brass Modules (*Author, 2024*)

The fruit solution was left to interact with the partially masked brass surface for 7 days at normal outdoor temperature in Bangkok (average 32c). After 7 days, the brass units were collected, cleaned with water and dish soap, and patted dry.

Figure 15 Brass Modules in Rose Apple Solution after 7 days, Cleaning, After Cleaning (Author, 2024)

Protection finishing: A layer of matte acrylic spray to seal the patina. It can protect the colors and texture from fading through touch and weathering.

Surface Assembling: The researcher trimmed the sharp corners of the module's tabs, removed unwanted tarnish, polished the brass, and added the non-patinated modules to create the gradient pattern according to the design sketch.

Figure 16 Assembling the Brass Modules (Author, 2024)

Final Assembling: The lining bag insert was applied to the brass bag. It was made from unbleached cotton, a natural material that is easy to recycle. The shoulder strap made from connected brass modules was attached to the body of the bag as the final step.

Figure 17 The Complete Shoulder Bag (Author, 2024)

Figure 18 Patinated Surface Detail (Author, 2024)

Summary

This research article focuses on the application of plant-based solution patinated brass, to fashion accessory design, a shoulder bag.

The material explored is thin brass sheets patinated with plant-based solutions, particularly fruit juices, which are mildly acidic by nature. This method results in a slower patination process but avoids emitting toxic fumes, making it an eco-friendly alternative to chemical patination on copper and brass. While offering a safer working environment for metalsmiths, this technique also introduced certain technical challenges. Due to the mild corrosiveness of most plant-based solutions, they are most effective on brass sheets with a thickness of approximately 0.1 mm. This limitation created opportunities for innovative problem-solving in design. As a result of this study, the interlocking tab and joint—a cold connection technique utilizing modularity, as explored by Chen and Lapolla (2020)—successfully connected units of 0.1 mm-thin brass sheets into a surface while accentuating the patina's colors and texture. The surface was crafted into a shoulder bag.

At the beginning of the study, two objectives were set to be met: (1) Exploring a safer working process for metal crafting by developing a sustainable metal surface design using plant-based patination on brass sheets and cold metalsmithing techniques. (2) Demonstrating the application of plant-based patinated brass sheets, a material that embraces wabi-sabi aesthetics and recyclability, in a fashion accessory, a design product typically shaped by fast-paced trends. The researcher found that both objectives were met by the end of the study.

Combining the plant-based patination method with cold joining technique resulted in a metal crafting process that didn’t require corrosive chemical solutions or heat to create a metal

surface design. The Cold Joining Experiment led to an interlocking modular system with tab and slot joints, producing a sturdy and flexible surface.

The production stage of the study was a demonstration that used plant-based patinated brass, the recyclable metal sheet induced with plant materials, aligning with the Wabi-sabi aesthetic, as a material for a fashion accessory, an item which is normally expected to follow fast-pacing trends.

Discussion

In this study, combining the plant-based patination method on brass with a cold-connection interlocking modular system unlocks limitless possibilities for sustainable surface design. The product from this study serves as a prototype for a modifiable metal surface. While this experiment utilized circular units with square tessellation, other geometric shapes and sizes could be explored to create diverse textile or surface designs for various applications. The material and joining technique also hold the potential for use in interior and product design fields.

The plant-induced patina technique offers a unique surface created by the decay of plant materials, resulting in an organic texture in contrast with the inorganic nature of brass. The application of this material to a fashion accessory challenges the perception of trendy accessories by infusing a surface created by the gradual, natural decay, aligning with the Wabi-sabi aesthetic, which embraces aging and changes, extending the expected life of the accessory before being discarded. Ultimately, when discarded, brass material can be recycled entirely.

In terms of production sustainability, the circle brass units were cut from sheets with minimal margin waste. Any leftover brass material could be melted down and remade into new sheets, enabling a closed-loop system that feeds back into the production process. This approach promotes a cost-effective and resource-efficient production cycle, particularly at a large scale. For end users, the interlocking modular system used in fashion accessories allows for reassembly and modification, ensuring the sustainability of the product by extending its usability and adaptability.

Recommendation

Modular systems can be well applied with thin brass sheets suitable for plant-based solutions, especially ones with pH levels between 4-6 which are well-attached to the brass surface and won’t be easily disturbed by the assembling of the interlocking tabs. However, the shape and size of the modular units can be further explored to create more possibilities in design. For example, bigger modular units allow for larger patina surface area, enhancing the visual impact of this material.

An assembly of compatible modules in different sizes can create an interesting tessellation that gives variety to surface design.

Regarding the visual relationship between the polished brass surface and the plant-induced patinated surface, the researcher observed that the polished brass surface tends to dominate due to its reflective brightness. Future models could benefit from redesigning the modular shapes or proportions to enlarge the patinated areas and minimize the overpowering effect of the polished brass. Additionally, applying brush texture or different patination to the tab areas could further harmonize the different areas better.

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