RESEARCH-ARTICLE

Bio-e-Nails: a Sustainable Design Approach to Biobased Nail Interfaces

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Abstract

Wearable and beauty technologies face environmental sustainability challenges due to their material composition, electronic waste, and end-of-life disposal. In response, we introduce "Bio-e-Nails," a sustainable design approach for customizable, interactive artificial nails made from biobased materials. Our work considers the accessibility of creating these nails and explores the affordances of biobased materials, such as their potential for customization and design flexibility throughout their lifecycle. This pictorial covers: (1) two bioplastic formulations for Bio-e-Nails to adjust strength, color, interactivity, and biodegradability; (2) the low-tech fabrication process of Bio-e-Nails, including customization of shape, size, and interactive features like embedded NFC or external aesthetic decorations; and (3) three end-of-life strategies for Bio-e-Nails—mechanical, chemical, and biological—that offer insights for broader design contexts. We also discuss how our sustainable design approach focused on materiality can apply to temporary beauty and wearable technologies more broadly.

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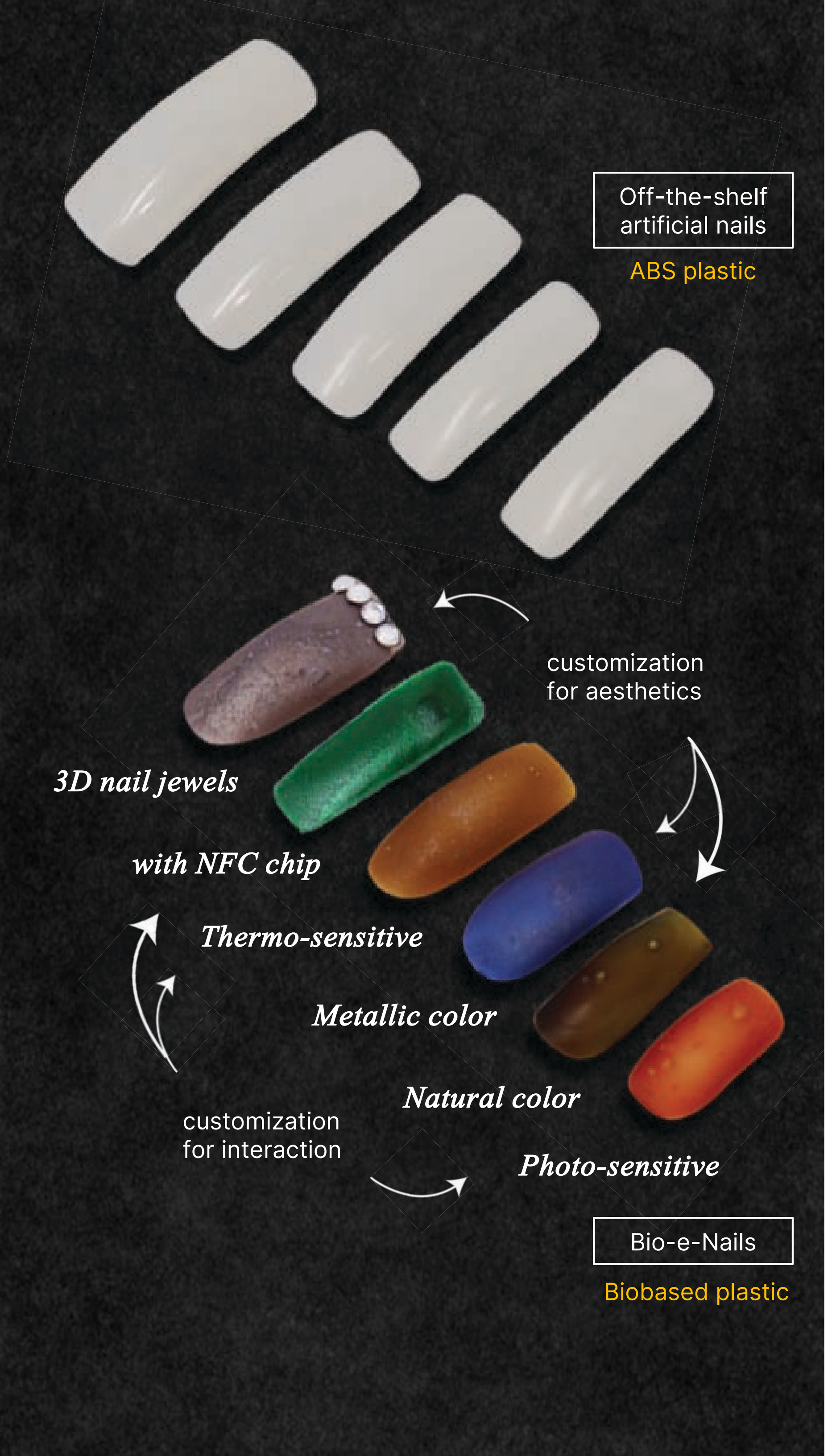
CCS Concepts

Hardware~Emerging technologies~Emerging interfaces



Wearable technology is now integral to daily life, enabling seamless interactions with our devices and environments. However, the growing field of wearable and beauty technologies [37] brings environmental challenges, including disposing of the combined waste stream of electronic components and composite smart materials. Recent surveys highlight unmanageable levels of e-waste, emphasizing the need for environmentally conscious design in wearables [21].

Some approaches in Human-Computer Interaction (HCI) emphasize integrating lifecycle considerations early in the design and prototyping of physical objects to support sustainability [30,46]. This allows sustainability to be explored and refined throughout the artifact's lifecycle. **Our research focuses on a sustainable design approach to beauty technology**, integrating values such as accessibility, and replicability. We explore this through ***Bio-e-Nails*[1], a project that explores customizable biobased nails[2] from biodegradable materials using low-tech fabrication.** These nails function as Biobased Nail Interfaces[3], combining material composition with interactive features in beauty technology, while balancing environmental impact with aesthetic expression.

Motivation: While interactive beauty products like conductive-coated eyelashes [53] and NFC-embedded acrylic nails [15] have been explored, sustainability remains underemphasized. **Bio-e-Nails address this gap by balancing functionality, aesthetics, and environmental impact through biobased materials.** We envision these customizable, interactive artificial nails as sustainable beauty options, designed with a closed-loop lifecycle approach from raw material selection to end-of-life considerations [30], such as re-use or disposal [23]. Recognizing that artificial nails generally last 1-2 weeks and are built to endure daily wear (e.g., washing and showers), our designs instead target shorter, single-use occasions, like special events or parties, where unique properties can be highlighted without the need for long-term durability.

Contribution: Bio-e-Nails exemplify our approach to integrating sustainability with beauty technology, specifically through Biobased Nail Interfaces. We introduce fabrication methods for two different bioplastic formulations that allow for customization of strength, color, interactivity, and biodegradability. This pictorial details the step-by-step fabrication process, highlighting customization options and interactive features such as embedded NFC or photo- and thermo-chromic pigments. Additionally, we explore three end-of-life options—mechanical, chemical, and biological—to offer insights into sustainable disposal. Finally, we discuss how sustainable design practices can be incorporated into the creation of transient beauty artifacts, fostering accessibility, replicability, and lifecycle considerations.

Glossary
[1]*Bio-e-Nails:* Our project that integrates a material-led design approach using biomaterials to create customizable artificial nails using low-tech fabrication methods.
[2]*Biobased Nails:* Refers to the composition of the nails made of a biodegradable material.
[3]*Biobased Nail Interfaces:* Describes both the type of material and interactive aspects of the nails, highlighting their role within the context of wearable and beauty technologies.

Sustainability Challenges in Wearable and Beauty Technologies

As wearable technology has seamlessly become an integral part of our daily lives, HCI research continues to provide innovative solutions that intersect multiple disciplines [22,41]. Significant effort has been made toward developing devices such as smartwatches [1,56], earbuds [26,43], and armbands [40] that enable individuals to monitor their health, ensuring hands-free communication and streamlined notifications for safety. Beyond these efforts, wearable technology has expanded its applications to include fashion items worn daily, such as rings [38], shoes [2,47], and jackets [10,39].

A more recent trend includes fashion items worn for aesthetic enhancements, such as artificial nails, eyelashes, hair, and makeup, collectively referred to as beauty technology [53]. Embedding electronics, beauty technology adds functionality to the typical cosmetic use [52]. FX e-makeup [51], for example, embeds electronics to sense and use facial muscle movements as inputs for performing commands (e.g., turning on a TV). iSkin [54] and DuoSkin [24] apply on-skin smart tattoos that utilize touch as input.

Similarly to fast fashion, beauty technology presents sustainability challenges influenced by factors such as material composition, production processes, and end-of-life disposal, with the added caveat of e-waste. For instance, the wearables for beauty technology integrate electronics or conductive coatings, posing difficulties for proper recycling due to the challenges in separating the electronic components from the off-the-shelf cosmetics.

Concerned as well with sustainability, recent HCI research shows a growing interest in biobased materials, such as mycelium skin [50], mycelium composites [19,30,49,55], bioplastics [6,27,57], biofoams [28,29], bioclays or biopastes [8,12,42], and bacterial cellulose [7,18,34-36]. This interest is driven by the ability of these materials to break down in a home-compostable environment enabling the reuse or recovery of electronic components at the end of the wearable or interactive artifact's life.

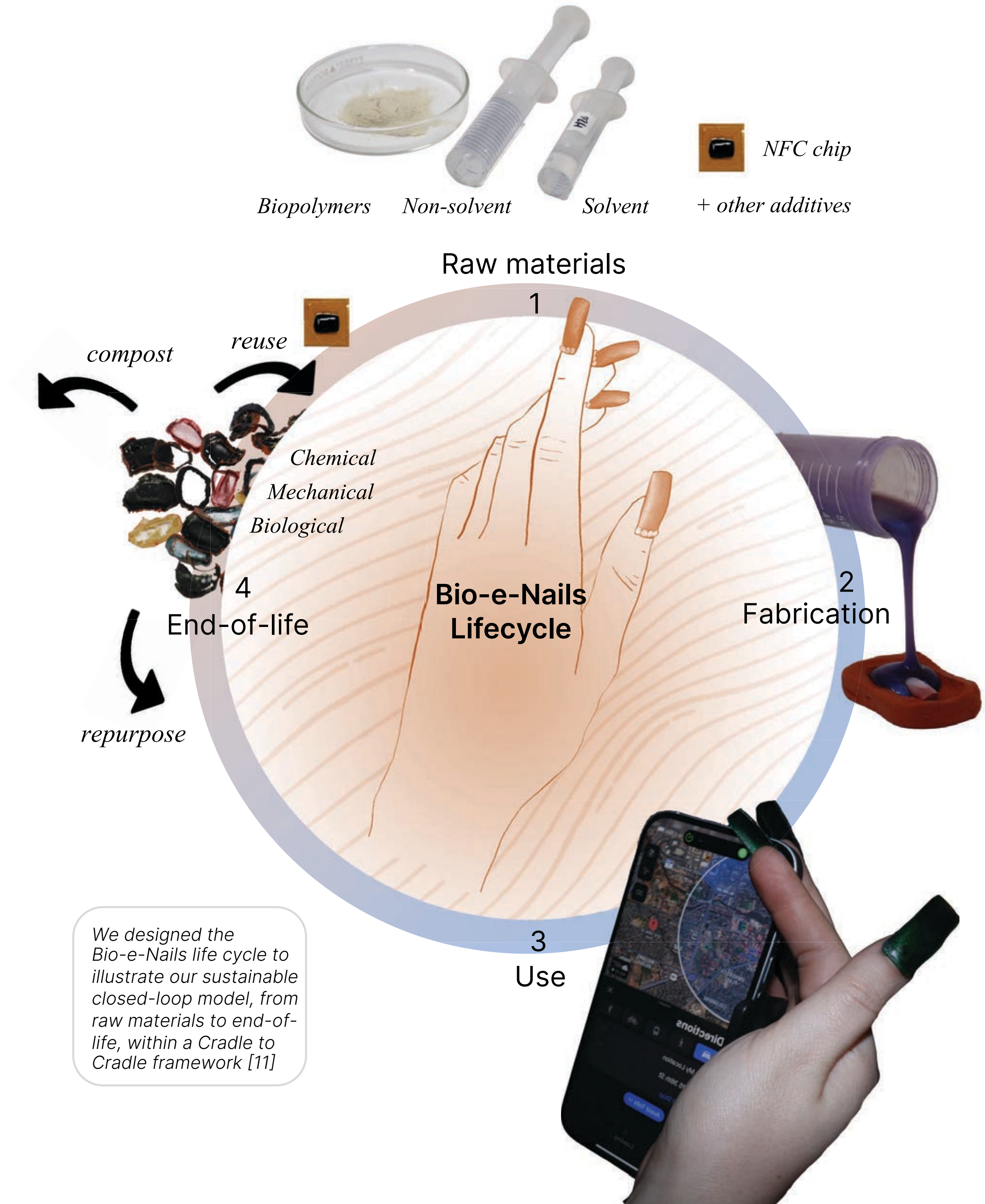
Bio-e-Nails illustrate our commitment to fostering sustainability in beauty technology by exploring new biomaterial formulations tailored to make artificial nails. Our sustainable design approach includes low-tech fabrication, to enable customization, and flexibility in design as important design values when prototyping biobased nails.

To address any disposal challenges of our Bio-e-Nails, we intentionally chose the substrate material based on its sustainable qualities. Taking inspiration from existing attempts to make nails out of biobased materials [9,14,33,45], we explore two different bioplastics, one that we formulated drawing from open-source algae-based recipes and cookbooks [6,17] and another developed based on existing literature on chitosan biofilms [16,48]. We iterate through various formulations to create a biodegradable material that emulates artificial nails. Our fabrication process includes aesthetic customization and embedding interaction through color-changing pigments and Near-Field Communication (NFC) chips. While biodegradability is a key feature, our approach also offers opportunities for reusing nails embedded with electronics or photo- and thermochromic pigments.

The nail/art industry faces sustainability challenges, including frequent replacement of nails, microplastics from filing down acrylic nails, and various health concerns affecting both professionals and wearers [20]. For instance, the methyl methacrylate in the acrylic powder can be inhaled and produce aerosols that irritate the eyes [4]. Solvents like acetone and toxic glues further exacerbate these health and environmental problems. The nail industry is currently clouded by concerns over the choice of materials, such as plastics that can be ingested through nail biting, and the respiratory issues associated with breathing toxic chemicals and particles in the air.

Being aware of these concerns, our project explores the potential of biobased materials in beauty technology through Bio-e-Nails. Despite limitations like the short lifespan and specific mechanical properties of some biobased materials, we leverage their potential to introduce more sustainable alternatives.

Beyond the specific application of aesthetic nails, our explorations eliminate the reliance on off-the-shelf products and showcase bioplastics' potential for not only biodegradation but also customization and low-tech fabrication. Bio-e-Nails aim to unlock a unique design space in beauty technology by embracing bioplastics' suitability for temporary use cases such as artificial nails, and by exploring three end-of-life strategies to extend Bio-e-Nails' lifecycle, or to enable the reuse of materials or electronic components when desired. Readily available ingredients and low-tech fabrication methods contribute to Bio-e-Nails' design versatility in terms of aesthetics (color, shape, and size) and interactivity.



We designed the Bio-e-Nails life cycle to illustrate our sustainable closed-loop model, from raw materials to end-of-life, within a Cradle to Cradle framework [11]

Raw materials phase:
Bio-e-Nails are made using either agar or chitosan. Agar is combined with water (solvent) and vegetable glycerin (plasticizer) for flexibility, while chitosan is dissolved in white vinegar (solvent) and water (buffer). For customization, we use water-based food dyes, NFC chips, photo- and thermo-chromic pigments, and reusable 3D nail jewels. To address the non-biodegradability of electronics and some pigments, we extend the nails' lifespan through reuse.

Fabrication phase:
We use low-tech methods such as layering and casting to create the Bio-e-Nails. Agar-based bioplastic is processed through layering, while chitosan-based nails are formed using casting techniques. Reused off-the-shelf artificial nails are incorporated into both methods. Customization features include water-based food dye for agar-based nails and pigments for chitosan-based nails, with NFC chips embedded in both version. This phase also involves curing and shaping the nails to finalize their form. The list of equipment and tools we used are detailed in the next section.

Use phase:
This phase relates to the application, functionality, user interaction, durability and performance, maintenance, and usability tests of the Bio-e-Nails. In this pictorial, we have so far explored programming the NFC chips embedded in the nails before use and after its first end-of-life phase, through reusing the chip and biobased materials. We also describe some of the application scenarios we envisioned for future work.

End-of life phase:
We explored three different methods for end-of-life: chemical, mechanical, and biological. Depending on material composition and how the Bio-e-Nails were customized, these methods can be combined to extend the life of the Bio-e-Nails' components and even material substrate. In our approach, we consider composting (biological degradation) as the last end-of-life of the biobased nails. Using the other two methods, we reduce the need for new virgin raw materials.

Material Exploration

Our material exploration process followed a material-driven design approach [25], iterating through multiple bioplastic formulations specifically to achieve a nail form factor, starting with agar-based and expanding to chitosan-based recipes. We focused on six key properties we considered important for artificial nails: functional (hard to break, holds shape, and water resistance) and aesthetic (smoothness, homogeneity, and thinness), recognizing that some properties may fall into both categories. Furthermore, we adapted low-tech crafting methods to support the accessibility and replicability of our fabrication process. In this section, we present the specific material formulations that led to functional and aesthetic Bio-e-Nails. Our exploration included more than 20 iterations, as well as experimenting with potato starch and glucose syrup, which did not lend a material able to hold its shape. See Supplemental Material for bill of materials for Bio-e-Nails; biomaterials exploration, iterations, and annotations; low-tech fabrication of clay molds; and biodegradability test of chitosan-based nails.

Agar-based solution

Agar is a jelly-like polysaccharide biopolymer extracted from the cell walls of certain red algae species. It is commonly used as a gelling agent, thickener, and vegan substitute for gelatin.

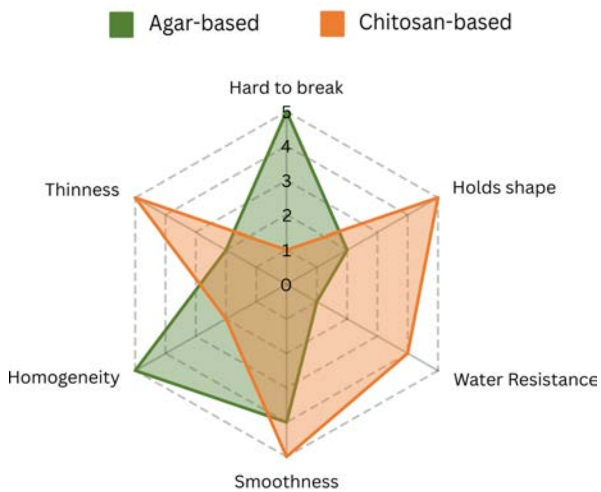
8g agar-agar
250ml water
6g glycerin
2g pigment

Chitosan-based solution

Chitosan is a biopolymer from chitin in seashells, often used in drug delivery for its biocompatibility and biodegradability, and has superior mechanical properties compared to agar.

2.38g chitosan
10ml water
22ml vinegar
0.07g pigment

Comparison of Bio-e-Nails Material Properties



Additives used to customize Bio-e-Nails for:

Aesthetics
- 3D nail jewels
- Water-based food coloring
- Metallic pigment

Functionality/Interaction
- NFC chips
- Photochromic and thermochromic pigments

Comparison of the Bio-e-Nails Fabrication Process

The two formulations described in this pictorial for creating Bio-e-Nails use distinct techniques, equipment, procedures, and finishing methods, as detailed in the table below. Both were customized for aesthetics and functionality, with interventions during material formulation, core fabrication (procedure), or finishing steps.

	AGAR-BASED	CHITOSAN-BASED
TECHNIQUE	Layering, cutting, and ironing.	Molding and casting.
EQUIPMENT	Household equipment such as nail clipper, heat gun, cloth, scissors, binder clips.	Household and lab equipment needed such as a water bath and falcon tubes.
PROCEDURE	(1) Pre fabrication of the bioplastic (2) Assembly with added electronics.	(1) Single casting with embedded electronics.
	Less accuracy is needed.	Precision is needed.
	72 hrs for drying the pre-fabricated bioplastic and 24 hours post ironing and assembly.	72 hours for curing before demolding the nails.
	Approx. 7 days total from beginning to end for a set of 10 nails, including embellishments.	Approx. 5 days total from beginning to end for a set of 10 nails, including embellishments.
FINISHING	Nail shaping with an electric filing machine and adjusting curvature if desired with a heat gun.	Nail shaping with an electric filing machine.

Step-by-step Bio-e-Nails Fabrication

agar-based

Step 1: Preparing ingredients

For a set of 10 nails, measure: 250 ml water, 8g agar, and 6g vegetable glycerin. You will need a pan for mixing, a hot plate for heating and a non-stick heat-resistant surface for pouring.

Step 2: Making the bioplastic

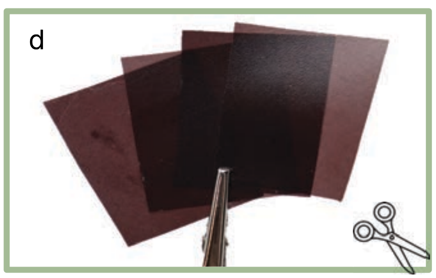
Mix the agar and water in a saucepan (Fig a) and stir for an even mixture, then add the glycerin (Fig b). Bring to heat at a max of 80ºC for 5 mins until the mixture becomes highly viscous.

Note: Our formulation was tailored to make a stronger bioplastic by increasing the biopolymer concentration and reducing the amount of plasticizer by almost half compared to Alganyl [6].

Step 3: Pouring

While hot, pour the mixture slowly onto a flat surface, with a controlled and centered stream. In 2-3 days, the mixture will cure in a circular material sheet of approximately 20 cm in diameter (Fig c). Once cured, peel off the surface and use scissors to cut it into rectangles approximately of 5 cm x 4 cm (Fig. d)

Note: After curing, the material will have a smoother side (toward contact with the surface) and a slightly textured side (toward contact with the air).



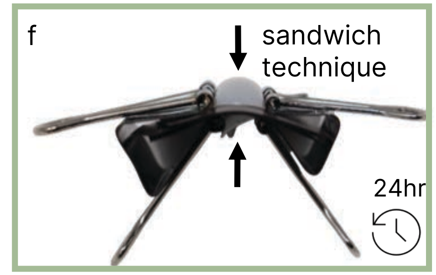
Step 4: Layering & Customizing

Hold together 3 bioplastic layers on a flat surface. Place a cloth on the layers, then use an iron to press the 3 layers together. Line up an NFC chip in between the pressed layers and a 4th top layer (Fig e). Iron again, covering the layers with a cloth first.

Note: We used the highest heat setting on the iron.

Step 5: Shaping & Sealing

To shape the bioplastic into a nail, place one plastic nail on the top and one on the bottom of the four already joined bioplastic layers (Fig. f). Perform one final heat pressing with the iron to securely seal the edges while avoiding heat directly onto the plastic nail. Ensure the closure and evenness of the material. Hold this swatch in place with clamps for another 24 hours to mold to the nail shape (Fig. g). The binder clip configuration allows the bioplastic to conform to the curvature of the plastic nails. After 24 hours, cut out the Bio-e-Nail using scissors. Finalize the shape by cutting excess material and filling its edges with an electric nail drill until the desired shape is reached (Fig. h).



Step 1: Preparing ingredients

For a set of 3 nails, start by measuring the ingredients: 2.38g of chitosan, 10ml of water, and 22ml of white vinegar in separate containers. We used syringes for liquids, petri dishes for solids, and a falcon tube for mixing (Fig. i). We set up the water bath to 85ºC before moving to the next step.

Step 2: Making the bioplastic

Mix the water and vinegar in the falcon tube, then add chitosan using a stainless steel barspoon (Fig. j). Close the lid of the falcon tube and shake it for about 30 seconds. Then, place the falcon tube inside the 85ºC water bath. After 5 minutes, stir for 30 seconds to break down any chitosan clumps. Take the tube out of the tub at 10 minutes. The gel should be transparent and consistent.

Note: The water bath ensures a constant temperature throughout the entire mixture.

Step 3: Cooling

Remove the falcon tube from the water bath and shake it for 5 seconds, then let it sit for 24 hours on a rack. After cooling, any air bubbles observed on the surface are removed using a stainless steel barspoon. Fig. l (left) shows a falcon tubes with air bubbles and Fig. l (right) without.

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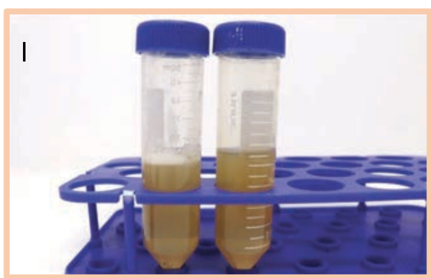

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Step 4: Molding

Prepare a clay mold with an elevated area in the center for the off-the-shelf artificial nail to sit on (Fig. m). Ensure the surrounding area of the nail is not too deep to reduce excess material (see Supplemental Material for details).

Step 5: Customizing

Optionally, to customize the aesthetics or interactivity of the Bio-e-Nail, add 0.07g of pigment to the mixture in the falcon tube and continuously stir for 30 seconds. We used a metallic purple pigment to customize the color of the biobased nail, however, photo or thermochromic pigments can be added in this step using the same ratio.

Note: The amount of pigment affects the overall look.

Step 6: Casting and Shaping

Pour the mixture carefully and slowly into the mold (Fig. o) and leave to dry for at least 48 hours. Finally, carefully remove the biobased nail from the mold. Any excess parts are cut with scissors, and then the biobased nail is filed using an electric nail drill into the desired shape (Fig. p).

Note: The final aesthetics of the biobased nail might vary based on the designer's level of expertise. The use of a heat gun is recommended to soften the excess material in the nail for easy cutting with scissors.

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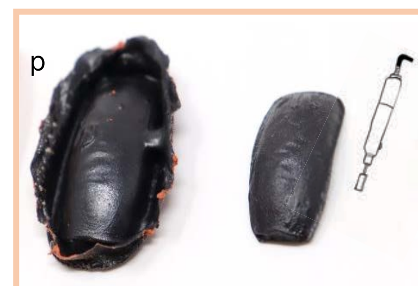

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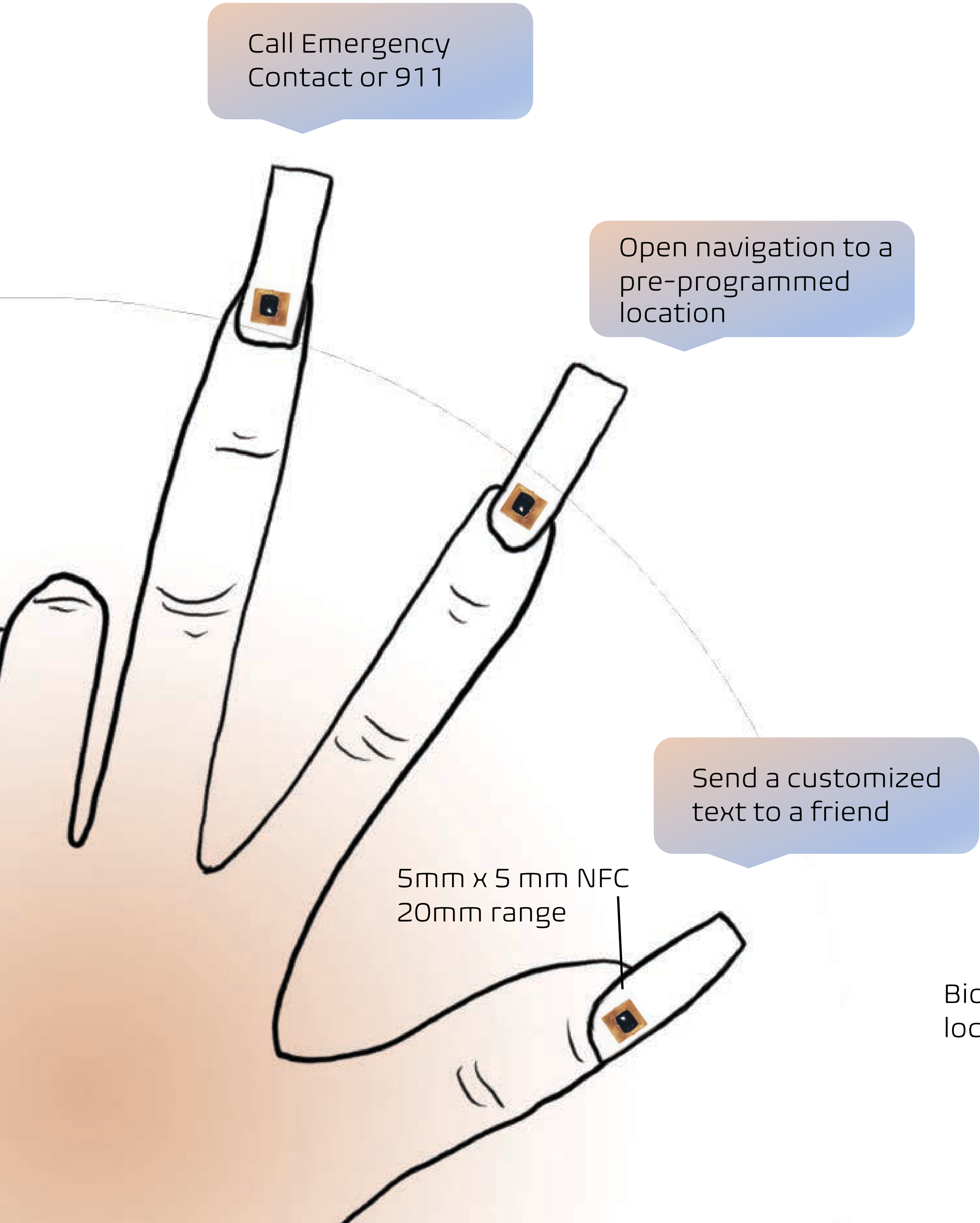
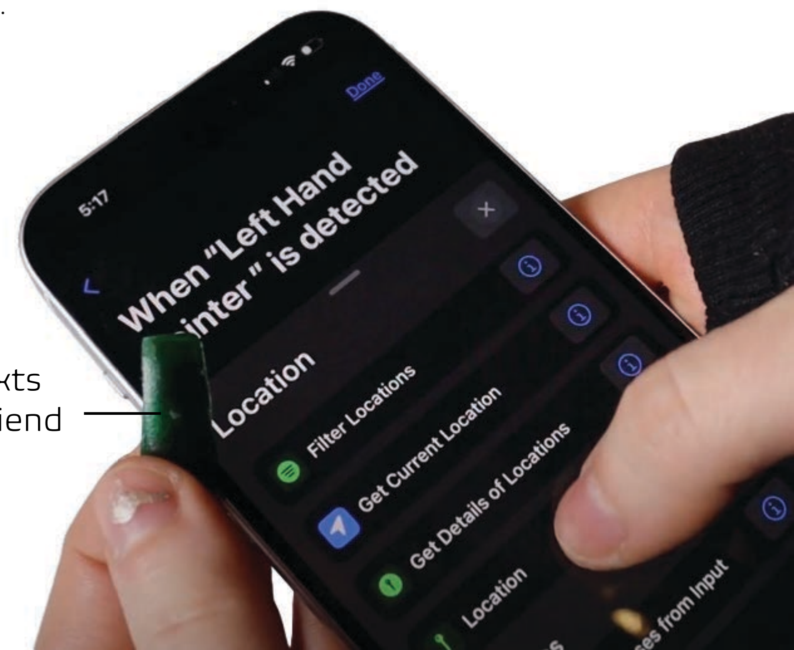


Exploring Interaction Beyond Aesthetics

Our proposed fabrication processes enable a wide variety of customization of the Bio-e-Nails beyond aesthetics to functional applicability. Aligning with existing trends in HCI research, we explored embedding interaction through electronics and photo and thermochromic pigments. These explorations led us to think about the multiple end-of-life strategies we can rely on besides composting when non-biodegradable materials are involved in the artifact. We describe our approach in detail in the next slide.

In the case of algae-based bioplastic, we embedded Near Field Communication (NFC) chips in the nails during their fabrication and programmed them to text the wearer's current location, as shown in the image and prior work [3]. We imagine that this feature can be helpful in contexts when the wearer may not be able to type or use speech-to-text, such as during medical conditions (seizures, anxiety attacks) or at the end of a late-night party. In the case of the chitosan bioplastic, we embedded photochromic pigment that changes color from brown to dark red in the presence of sunlight, potentially reminding the wearer about the need for sunscreen protection.

Given that Bio-e-Nails are a biodegradable artifact mainly meant for temporary self-expression, introducing interaction complicates their disposal as electronics and photo- or thermochromic pigments are complex materials that cannot biodegrade and need to be either harvested or re-used. We present methods for both processes in the following.



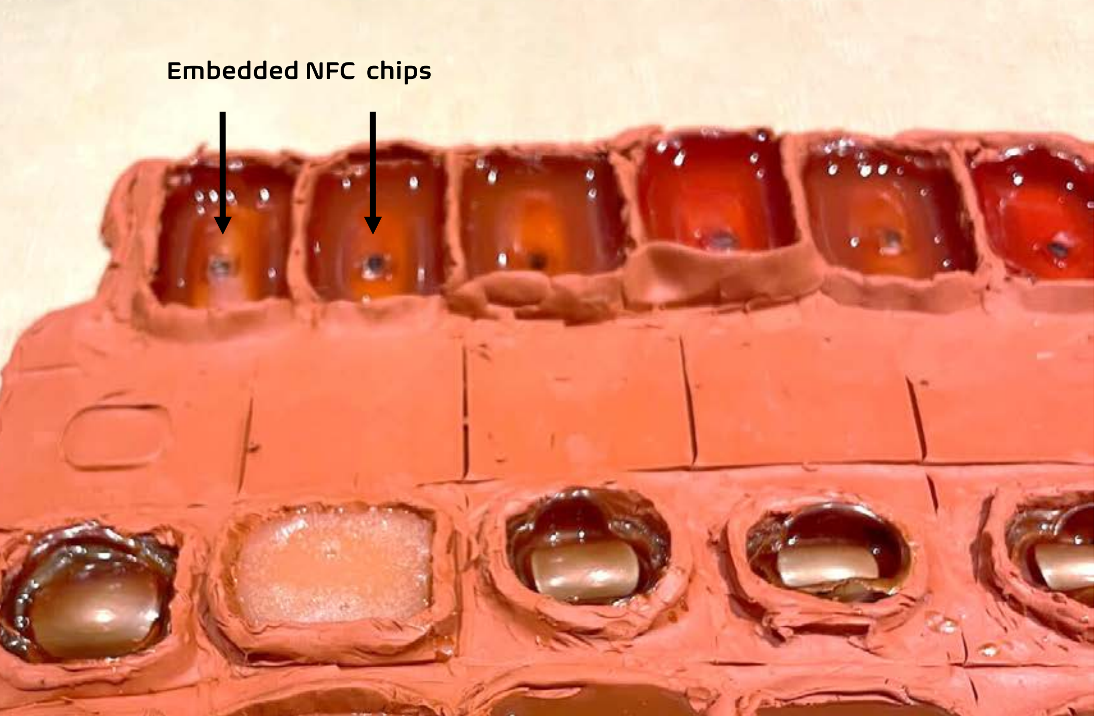
End-of-Life Strategies for Biobased Nail Interfaces

Our approach aligns with broader sustainability strategies, specifically by extending material lifespan through a closed-loop system for Bio-e-Nails. We explored three end-of-life methods: chemical, mechanical, and biological, which can be applied independently or combined to offer wearers flexibility based on their needs and available resources. In all cases, NFC chips should be retrieved once the covering material loosens and then dried to ensure functionality for re-use. Additionally, we provide findings of our re-use process for Bio-e-Nails.

		AGAR-BASED	CHITOSAN-BASED
CHEMICAL		Material is soluble in water at low temperatures (< 50°C)	Material is soluble in vinegar at room temperature (22 °C)
	HOW	pour 20 ml of warm water	submerge in vinegar for 30 mins
	NFC CHIP	functional	functional
MECHANICAL		The nail has 4 layers that are sandwishing the chip through thermo-adhesion.	The nail is molded in one pour, thus has a single layer embedding the NFC chip.
	HOW	first use warm water, then peel the layers apart	submerge in vinegar at room temperature for 30 mins
	NFC CHIP	functional	functional
BIOLOGICAL		Study [6] shows 60-day biodegradation in soil of the agar-based material.	Chitosan needs specific fungi to break down (see supplemental material for data)
	HOW	60 days in soil with composting micro-organisms at 40°C and high humidity	33 days in soil with composting micro-organisms at 40°C and high humidity
	NFC CHIP	non-functional	non-functional

Re-use is a sustainable end-of-life strategy often overlooked in favor of recycling or composting. We experimented with re-using Bio-e-Nails by leveraging their chemical end-of-life method. Using small amounts of vinegar as a solvent—just enough to cover the nail—we heated the thermochromic nail in the microwave for one minute and poured it back into the clay mold. The new nail retained its thermochromic properties but was thinner and more transparent than the original due to the added solvent. We achieved a thicker result when re-using the material for a smaller nail.

Iterative low-tech fabrication process of Bio-e-Nails using hand-crafted clay wells for chitosan-based nails.



Technical Considerations

Mold making
To create the mold for the chitosan-based Bio-e-Nails, we firmly secured the model nail against clay and then, shaped a pouring well around it. Our first explorations were led by playfulness, and a hands-on direct engagement with the material. While the process is simple to understand, and accessible to designers at large, we noticed several technical considerations that improved our results.

The aspect ratio of the clay mold impacts significantly how the nail cures. If the mold is too shallow, there is not enough solution to cure, so we obtain a very thin and transparent nail. If the mold is too deep and narrow, the sides cure slower and pull over the surface of the nail (see top image).

Viscosity and Homogeneity
Adding pigments to the solution changes its viscosity and homogeneity. Our nails improved significantly in terms of smoother surface, and homogeneous pigment distribution, once we learnt more about each pigment's physical and chemical properties. To keep a consistent viscosity of the solution, for the agar nails, we used water-based food coloring, and for the chitosan nails, we used pigments that have a heavier density, such as metallic makeup pigments.

Embedding Electronics
When embedding electronics, keeping them in place can be difficult (see bottom image). For the chitosan-based nails, we used a little bit of clay to hold on the NFC chips to the surface of the model nail. We also experimented with layering (first pouring a thin layer, waiting for it to solidify but not dry completely, then sticking the chip and pouring the final layer on top.

Flexibility in End-of-life
When embedding electronics (such as an NFC chip), ending the life of a Bio-e-Nail becomes a combination of mechanical, chemical and biological processes. For example, for the agar-agar Bio-e-Nails we first recover the electronics by removing mechanically the layers and then we choose the path for the bioplastic material: dissolve to re-use or biodegrade. The chitosan bioplastic sticks to the surface of the electronic and cannot be mechanically removed without leaving residues, so we start by biodegrading the nails, and once the electronics get revealed (around day 21), we mechanically harvest them.

Discussion

Accessibility and replicability

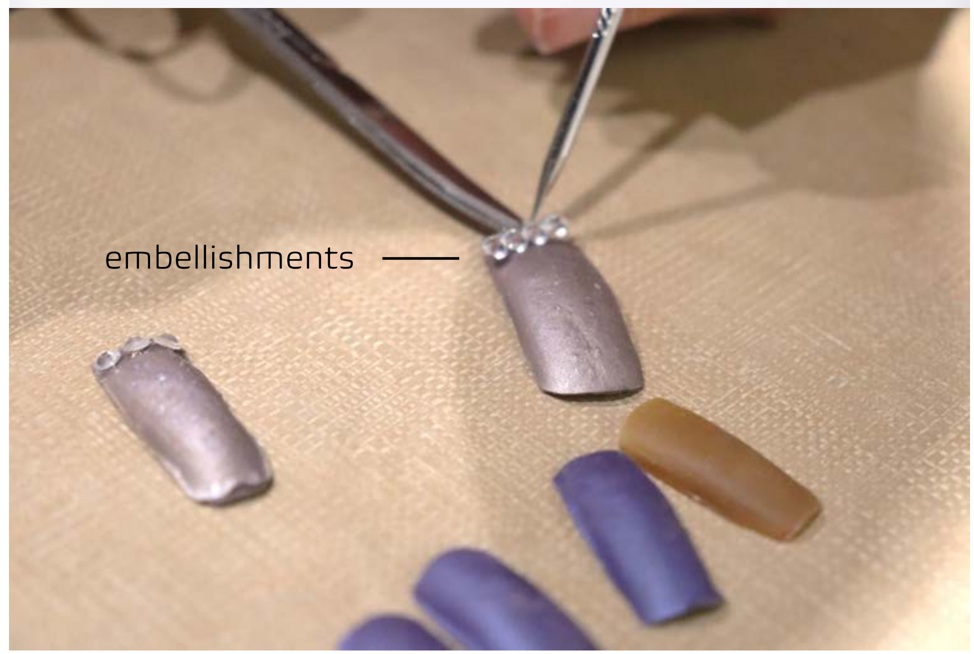
By prioritizing accessibility and replicability, our approach to Bio-e-Nails reimagines beauty tech design, enabling both designers and wearers to create temporal, customizable objects using a material-led framework. Accessible materials and low-tech methods not only democratize beauty technology design space but also encourage users to engage with the artifact's lifecycle. However, they might also raise trade-offs. Does replicability limit performance or aesthetics, or open new pathways for innovation? Embracing qualities traditionally seen as flaws, such as variations in homogeneity in the nails, challenges norms and redefines beauty tech standards. This shift from uniformity and high performance to systems balancing usability, creativity, and sustainability positions accessibility and replicability as catalysts for rethinking beauty tech and opening new design possibilities for sustainable interactive systems more broadly.

Broader Implications and Lessons from Bio-e-Nails

Integrating a material-led [13,25,44] and Intimate Making [8] approach in our design and fabrication processes afforded the materials to guide our exploration, informing design decisions that range from functional to aesthetic. This attunement to materiality—encompassing various felt experiences [5,36]—was central to our design process. Observations of material behavior—such as agar's inherent flexibility and chitosan's ability to provide rigidity—informed both functional and aesthetic choices. These insights guided the development of accessible, low-tech fabrication techniques tailored to Bio-e-Nails.

Previous work [35,50] has emphasized lifecycle considerations for sustainable wearables focusing on end-of-life options like compostability and recyclability. While these approaches highlight sustainable materials, the end-of-life is framed as a static conclusion. In contrast, our approach to end-of-life in this work, was drawn from observing how biomaterials interact with solvents. Attuning to the process, we identified an opportunity for three dynamic end-of-life strategies for Bio-e-Nails. These strategies encourage wearers to engage with the material's lifecycle beyond its use phase, while also prompting designers to rethink possibilities for keeping materials in a closed-loop, fostering a more interactive and thoughtful engagement with temporary beauty technologies.

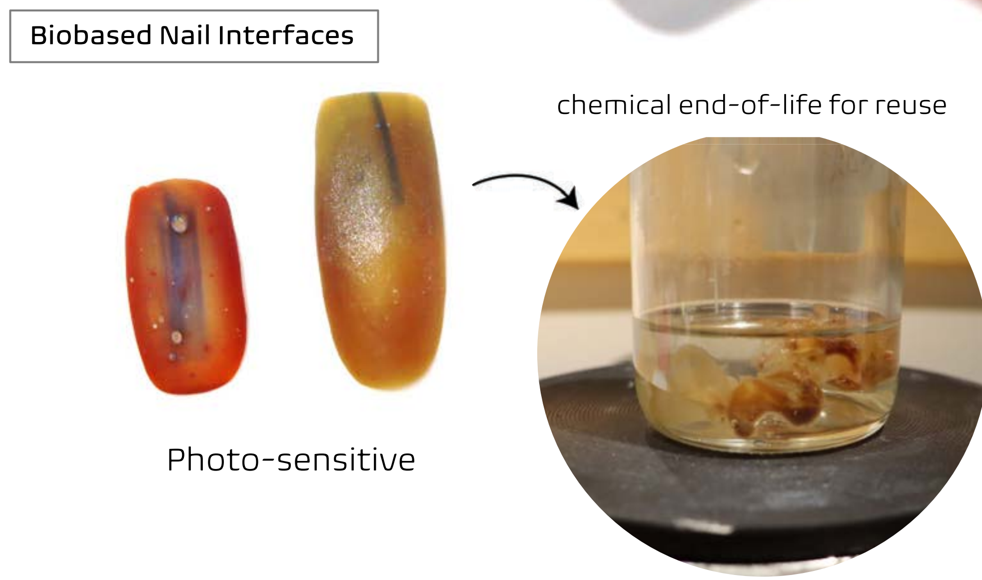
The insights from this pictorial—on bioplastics, accessible fabrication, and end-of-life options—can inform the design of devices with limited lifespans, such as food-safe interfaces or smart packaging. By prioritizing material agency and lifecycle considerations, designers can foster more sustainable and contextually thoughtful design practices across various fields.



Implications of Temporary Beauty Tech Artifacts

Trends in beauty products and accessories often revolve around consumer desires for new objects that elevate self-expression, presenting challenges to sustainable practices. By acknowledging the high demand for customization and disposable fashion, we provide a space for design, creativity, and sustainability in temporary wearables like aesthetic nails. Our work highlights the often-overlooked static end-of-life phase in the lifecycle of materials and devices. Instead of viewing this phase merely as disposal, we position it as an opportunity for new design possibilities, contributing to a growing body of work in HCI that sees end-of-life as a phase rich in design opportunities [28, 31, 32].

Our exploration can also open new possibilities for other devices that are close to the body, such as menstrual or medical single-use devices. By prioritizing the lifecycle of materials and closely observing their behaviors, designers can find new design opportunities for innovation in temporary beauty tech. The focus on materiality allows for a deeper connection between the device and its user, advancing both design and sustainability practices in beauty tech and wearables.



Limitations

Our team consisted of designers and HCI researchers with at least two years of experience in biobased materials, potentially creating an entry barrier for novice designers. However, a new lab member successfully replicated our experiments (described in detail in Supplemental Material), indicating that prior knowledge, while helpful, is not essential.

The mechanical properties of biobased materials can affect nail performance. For example, agar-based nails perform better when kept short, as longer versions tend to bend. We explored chitosan for its improved strength, but it presents challenges, such as requiring higher temperatures for preparation and a heat gun for shaping, which can slow the fabrication process. In terms of comfort, Bio-e-Nails require adjustments compared to plastic nails due to differences in fragility, texture, and weight. Agar-based nails are heavier, so the number of enhancements should be carefully considered. As biomaterials are sensitive to heat and water, Bio-e-Nails are designed for temporary wear, lasting about a week during typical tasks when re-applied everyday and suitable for a night out.

For Bio-e-Nails with embedded NFC chips, the communication range is limited to 2.5 cm, needing close interaction with a phone and restricting use to the thumb, index finger, and middle finger due to the dexterity required.

Future Work

While we have explored customization at the raw material, fabrication, and end-of-life phases, future work will focus on the use phase of the Bio-e-Nails. We have examined programming the NFC chips, harvesting them for reuse, embedding them in new sets of nails, and reprogramming them for speculative scenarios. Our next steps will involve conducting user tests to understand how Bio-e-Nails integrate into daily lifestyles of different user demographics. Additionally, we aim to explore the use of vacuum forming to shape the agar-based bioplastic more accurately without binders. Similarly, using silicone molds to pour the chitin-based bioplastic will allow us to experiment with a variety of nail sizes and shapes, following the initial designs created with clay wells.

Conclusion

Through this work, we initially intended to develop a sustainable alternative to nail enhancements that can hold the same fashionable status and functionality. Through our research and design, the scope of this idea expanded past the aesthetics of fashion nails as we delved deeper into the meaning of temporary wearables. Recognizing the sustainability challenges stemming from material composition, electronic waste, and end-of-life disposal, we designed the Bio-e-Nails to explore the affordances of bioplastics in beauty technology. Finally, we discussed the accessibility and replicability of our fabrication process and the implications of temporary beaty tech artifacts.

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