Dutch Start-Up Develops Colored Anodizing with Plant-Based Dyes for Improved Sustainability

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The aluminum industry plays a pivotal role in sustainable change, as the lightweight metal is a critical component for many sectors such as transportation, building materials, and consumer goods. Although the extraction of bauxite comes with significant labor costs and environmental challenges, the metal's capacity for recycling with low energy consumption justifies the initial environmental expenditure. Consequently, the recyclability of aluminum should be enhanced to maximize its use and extend the metal's life cycle. In this context, opting for anodizing as a method for surface finishing presents a sustainable choice. Not only does anodizing augment the value of the product, but it also ensures the durability and recyclability of aluminum products.

Anodizing already has a lower environmental impact than other surface finishes, but every process can be optimized. Within the anodizing practice, anodizers can opt for more sustainable choices, such as low water usage, improved waste treatment, or energy reduction through pulse anodizing. A new approach to sustainable anodizing practices is the usage of plant-based dyes developed by the Dutch design studio Loop Loop.[1] Industrial designers Odin Visser and Charles Gateau use locally sourced plants to create bio-dyes as an alternative to petrol-based dyes,[2] making their anodizing process even more sustainable. The designer duo describes their work as "navigating the tension between industry and craft, between mass production and one-offs."

Can their plant-based approach be scaled up and create more sustainable anodizing coloring practices in the larger industry? This article takes a look at Loop Loop's new plant-based coloring method and discusses its potential impact on the anodizing industry, with insights from industry insider Tej Patel, director of the chemical supply company Techevon LLC.

Developing a Sustainable Approach to Anodized Coloring

Visser and Gateau first worked together on an aluminum light fixture, and it was this collaboration that initiated the launch of their design studio, Loop Loop. With a set of cradles, household products, and minimal energy, they built their first anodizing line, appreciating the low environmental impact of this surface finishing. Yet, there was one element in their supply chain that did not fulfill their requirements for self-reliance and sustainability. "The weakness in the process was the pigments, prompting us to think about how to replace them for greater independence from suppliers," said Visser.

An offhand comment between the designers about the dyes matching the color of wine sparked the idea to experiment with organic materials. Following their self-sufficient approach, the studio studied the petroleum-based dyes they had purchased from industrial suppliers. With Gateau's background in material science, they started to look for alternatives and found several plant-based substitutes they could produce themselves.

"Being self-reliant allows us to experiment and try something new, bypassing traditional industry norms," said Gateau. "It's not against the industry, but it's about exploring alternatives."

The dyes they obtained were exclusively from plants that were either naturalized or indigenous to the Netherlands and could be grown locally. For example, the dye chosen for the Madder Sunrise lampshade is made from madder root, a.k.a. *rubia tinctorum* (Figures 1-2). Madder has been grown in the Netherlands for a long time. It was cultivated as a dye until the end of the 19th century, when all cultivation stopped due to the invention of a synthetic alternative. Other plant-based dyes used throughout history stemmed from red cabbage, red onion, rhubarb, berries, and alkanet.

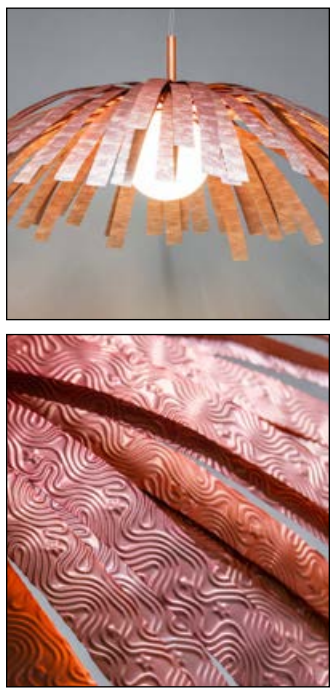

Figure 1. Madder Sunrise lampshade, which is embossed in aluminum foil anodized with madder-based dye. (Photo: © Loop Loop.)

Currently, Visser and Gateau are growing plants in front of their studio. Once harvested and dried, a new collection of objects will be dyed using the company's Local Colours line. "Every harvest, the pigments will probably act slightly different, creating unique collection items per season," noted Visser.

Loop Loop's innovative approach resulted in a grant by Stimuleringsfonds, a Dutch fund dedicated to supporting designers, artists, and architects. Through this financial backing, further research into plant-based dyes was made possible, and the designer duo discovered which plants worked for their anodizing dyes (Figure 3). "Indigo blue, a commonly used natural pigment, didn't work at all," explained Gateau. "We discovered that molecular structure, pH, and the presence of oxygen and hydroxy groups were critical for successful pigmentation."

Through research and experimentation, Gateau and Visser created anodizing practices that align with their commitment to local production, self-reliance, and mini-

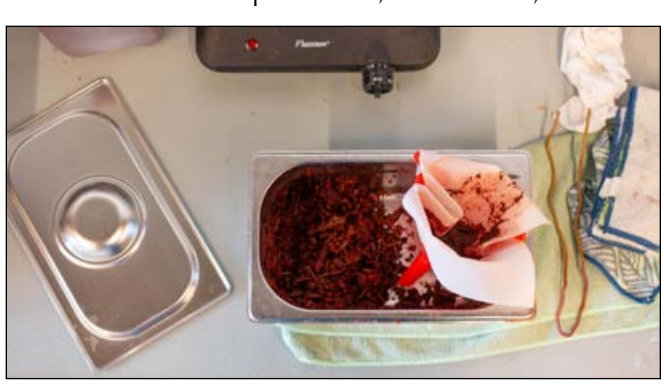

Figure 2. Madder root, which is used as a natural dye. (Photo: © Loop Loop.)

Figure 3. Anodizing chemical testing of yellow, pink, and red coloring baths made from plant-based dyes. (Photo: © Loop Loop.)

mal environmental impact. "Finding a way to produce the pigments ourselves, in a plant-based way, helps us to further close the loop," stated Visser.

For the Chelsea Garden Show, Gateau and Visser are working on a pavilion, the components of which will be anodized at Riano, the family-run anodizing workshop in Eindhoven. "Collaborating with local anodizing facilities could be a way to scale up the use of plant-based pigments," said Gateau. "While larger-scale production may not align with the idea of local production, licensing the knowledge or conducting in-shop workshops for smaller facilities could make small-scale anodizing more sustainable."

In April 2024, Gateau and Visser will present their designs and conduct workshops at Milan Design Week. Their goal is to "spread the knowledge and find ways to integrate natural pigments into various production scales."

The Feasibility of Plant-Based Dyes in the Anodizing Industry

While the plant-based coloring approach to anodizing is an innovative method to make anodized coloring more sustainable, boutique design studios like Loop Loop operate under different circumstances than commercial anodizing workshops. Tej Patel, director of Techevon, a global supplier of anodizing chemistry, shared his insights into the market demands. "The first question is always: 'How many colors can I get?'" said Patel. "We are always competing with paint, and not having a wide range of colors makes it hard to penetrate the dye market."

Patel also mentioned a critical issue that Visser and Gateau have also acknowledged: their plant-based dyes have low UV resistance. In commercial dyes, UV resistance results from metals—chrome, nickel, cobalt, copper—which cannot be released into wastewater. However, instead of seeing the lower light fastness as a deal-breaker, the industrial designers at Loop Loop have embraced the fading of color by incorporating it into their designs. Since the surface change does not compromise the strength or durability of the metal, the optical change can be seen as a feature rather than a shortcoming—like the aging of wood or a copper patina.

But Visser and Gateau are not the only ones striving for more sustainable practices. Patel understands the environmental impact of chemical supplies and creates sustainable practices through process optimization. "In our manufacturing process, we try to ensure an optimized yield and minimal discharge," explained Patel. Furthermore, Patel and his father, Pinakin Patel, who founded Techevon in 2008, are currently researching UV-stable, metal-free dyes for one of their customers in the automotive sector (Figure 4).

"There clearly is a demand for anodized aluminum," said Patel. "The more environmentally friendly coloring methods we can develop that meet the same requirements as metallized dyes, the more the industry is going to grow."

Figure 4. Anodized samples, showing a black dye with metal (left) compared to a black dye without metal (right). The metal-free sample exhibits a minimal color difference, with a delta E value of just 0.745, when compared to standard chrome metallized black dye. (Photo: © Techevon.)

Conclusion

Through regulations and customer demands, the aluminum industry is under pressure to scrutinize every supply chain and opt for more sustainable practices. With their plant-based dyes, Visser and Gateau have found an innovative approach to utilize organic materials for the anodized coloring process. However, to make their method suitable for commercial anodizing, they will need to make their dyes UV resistant and offer a wide range of colors. Nevertheless, plant-based dyes are an interesting alternative for boutique design studios like Loop Loop or small-scale anodizers that create art pieces, cosmetic cases, and other indoor applications.

In contrast, large-scale domains—such as the automotive, architectural, medical, aerospace, or energy and transportation sectors—will need to find other ways to reduce the environmental impact created by dyes. Further research could investigate the UV stability of metal-free dyes, the color spectrum of plant-based dyes, and the yield of such organic dyes to match the high volumes of commercial anodizing.

In sum, anodizing is an important surface, as it preserves the durability and recyclability of aluminum products. Therefore, innovative approaches like plant-based dyes are crucial to make anodizing competitive with more harmful surface finishings, such as paints and powder coating. While plant-based dyes are not yet feasible for the large-scale anodizing industry, boutique manufacturers and small-scale anodizers might be interested in exploring this alternative approach to anodized coloring to make their aluminum products more sustainable.

References

1. Frearson, Amy, "Loop Loop develops 'world's first plant-based aluminium dying process,'" Dezeen, August 9, 2023, www.dezeen.com/2023/08/09/anodising-aluminium-plant-based-pigments-loop-loop.

2. Loop Loop website, www.studiolooploop.nl. ■