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Sustainability in Fashion: Project 03

The fashion industry is one of the most harmful industries in the world.[1] If you're looking at sustainability in fashion, this fact is hard to avoid. Vast amounts of water are wasted in textile production, and harmful chemicals are released into the environment. In particular, many garments are produced and dyed on a petroleum base. Thus, the question arises if there is an alternative to petroleum-based chemicals for dying fabric. Many naturally occurring bacteria produce colored pigments. Can they be used to dye textiles? If so, how can we co-design with a microorganism, guide it into the shapes we want to color and deal with their unpredictable nature when designing?

Textile dyeing experiments with Janthinobacterium lividum

There are a number of bacteria that produce colored pigments. Some of these are highly infectious to humans when alive and one needs appropriate devices to protect the body when working with them. For my project '03', I have enlisted the help of one species: Janthinobacterium lividum. These bacteria are non-toxic and non-pathogenic, meaning not harmful to humans. The bacteria naturally occur on the skin of the red-backed salamander. J. lividum protects the salamander from a contagious fungal skin disease called chytridiomycosis. The bacteria's dark purple pigment is actually how they protect against the fungus. This pigment is called violacein. It has both antifungal and antibacterial characteristics, as well as antibiotic effects. Because of that, the bacteria fight the disease, thus boosting the salamander's immune system.[2] Bacteria multiply infinitely. Only a small number of bacteria is needed to grow new colonies, in contrast to plant dyes, which are tied to relatively large-scale spatial and human resources, as well as intensive water use.

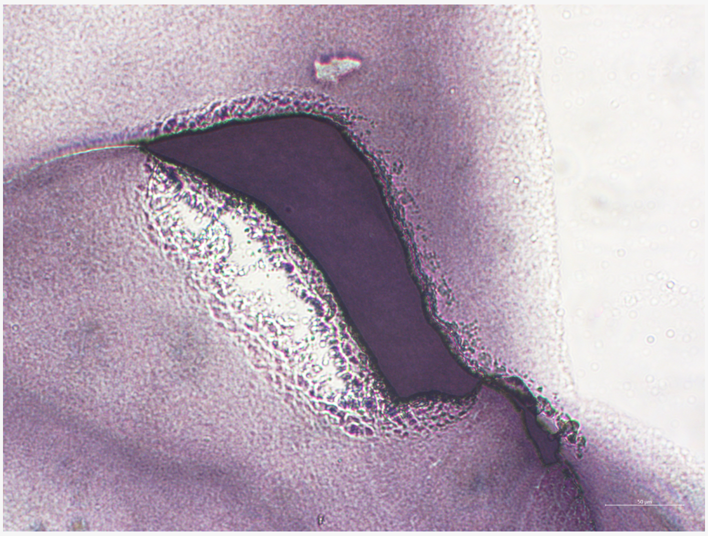

FIG 1 Textile dyeing experiments with Janthinobacterium lividum. Image: © Charlotte Werth

This project involves dyeing natural textiles blue/purple with Janthinobacterium lividum, or J. lividum. When working with bacteria, a high degree of cleanliness and sterility is required. Therefore, utensils, work surfaces, and hands must be sterilized and disinfected at the beginning. Glasses, vessels, spoons, and petri dishes are sterilized in a steam sterilizer, the work surface is disinfected with ethanol, and gloves and disinfectant spray are used for hands. Nutrient broth is used as a liquid culture medium for the bacteria to grow in. The fabrics must be dipped in the nutrient liquid, where the bacteria have the opportunity to grow and settle directly into the textile.

Nutrient broth recipe: Yeast extract: 2gr Pepton: 5gr NaCl (salt): 5gr Distilled water: 1000ml

To make the nutrient broth, the ingredients are mixed together in a vessel and heated to 85°C. During heating, it is important to stir the liquid. The liquid is then left to stand until it has cooled to 55°C. Now, the sterilized textile-dyeing vessels are placed on the workspace, called a sterile hood, and filled with nutrient broth. The textiles are sterilized in advance in the steam sterilizer and then placed in the broth-filled vessels. As soon as the liquid in the vessels containing the textiles has cooled down to room temperature, the bacterium can be placed directly on the textile in the culture medium with the aid of a cotton swab. The vessels are covered with aluminum foil and placed in the incubator. Here the bacteria need several days to grow.[3] After a few days, first blue streaks appear on the textiles; after a few more days, the color is dark purple to black.

As soon as the desired color tone is achieved as the bacteria multiply, the textile on which the pigment has settled is again sterilized. The bacteria are no longer alive and can be rinsed out. Only a small amount of water is needed to produce the pigments and washing them out after dyeing does not require several passes either, as the pigment settles directly into the textiles and is fixed there. Therefore, the bacteria themselves and the pigment production technology are more environmentally friendly than chemical or natural dyes.

FIG 2 Experiment No. 1: Stripes, edges and areas. Image: © Charlotte Werth

Experiment No. 1: Stripes, edges and areas

In a first iteration, the fabric was tied together to dye stripes. In the second, the piece of fabric was prepared in the same way but placed upside down in the container. In the third iteration, only the edges of the fabric are supposed to be dyed.

Incubation period: May 3 – May 14, 11 Days

Results: In these first experiments, I assumed the surface to be dyed must be directed towards the bottom of the vessel. I realized quickly that the bacteria grow from the surface of the liquid upwards, as they require oxygen to produce pigments.

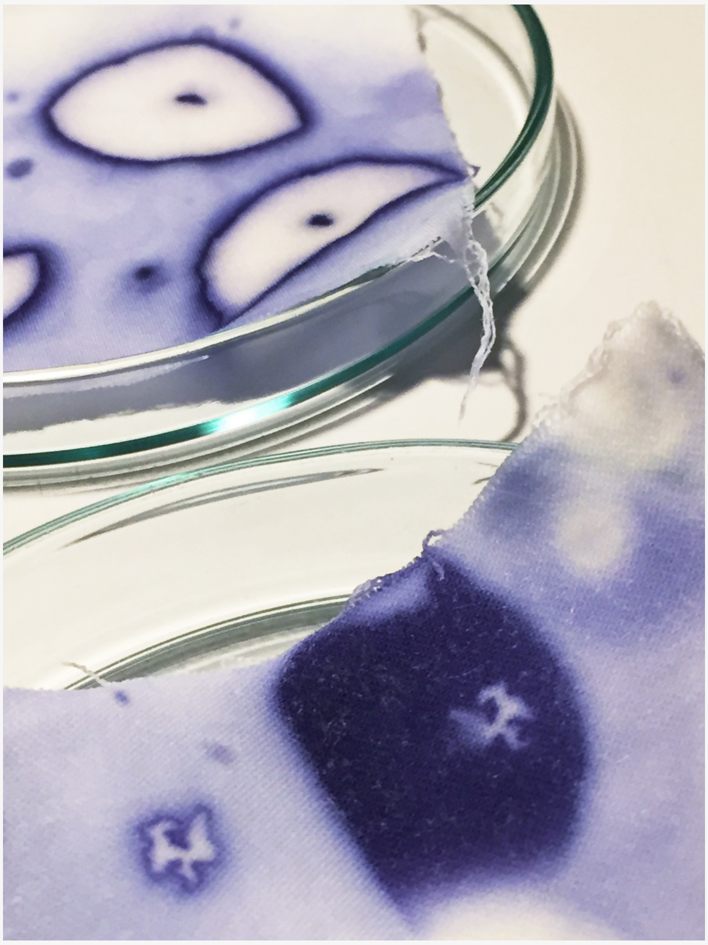

FIG 3 Experiment No. 2: Stamps. Image: © Charlotte Werth

Experiment No. 2: Stamps

For this experiment, nutrient agar was prepared. Small shapes were cut from the solid mass. These were placed on the flat piece of fabric in one petri dish and on the edge of a folded piece of fabric in the other. J. lividum was then placed on the fabric through the nutrient agar. For the piece of fabric that was lying flat, a dyed edge formed around the nutrient agar stamp. The stamp area on the folded fabric was completely dyed as oxygen could reach the area of the nutrient agar stamp.

Incubation period: May 3 – May 9, 6 days

Results: The bacteria need oxygen to grow. Since the nutrient agar stamp left no room for oxygen in the piece of fabric lying flat, the bacteria grew outward around the nutrient agar. With the folded fabric, a gap was created between the petri dish and the nutrient agar, allowing the bacteria to grow in the shape of the stamp.

FIG 4 Experiment No. 3: Grid. Image: © Charlotte Werth

Experiment No. 3: Grid

A folding technique was developed to guide the bacteria to grow in a clear grid structure. The piece of cloth was tied together to create a surface that faces up and can be dyed uniformly. The nutrient broth was poured to the upper edge of the folded fabric.

Period stuck: 5 hours; Incubation period: May 15 – May 20, 5 days

Results: Since the bacteria grow from the liquid nutrient broth upwards, it was important to tie together an area to be stained. As the spaces between the grid tiles are not supposed to be dyed, they must be tied together tightly. Since the rest of the fabric was submerged completely in the nutrient broth, the pigment settled only slightly, leaving it mostly blank.

FIG 5 Experiment No. 4: Living yarn. Image: © Charlotte Werth

Experiment No. 4: Living yarn

First, yarn was dyed in the nutrient broth. In a second round, a piece of fabric was sewn together with the dyed yarn. The bacteria are still alive at this point. The fabric was then again placed in nutrient broth.

Period yarn dyed: May 3 – May 9, 6 days; Period piece of fabric dyed: May 9 – May 18, 9 days

Results: Exciting here are the stitches that have been colored. On one side they are easily recognizable as strokes and on the other side in the form of dots.

FIG 6 Experiment No. 5: Lines. Image: © Charlotte Werth

Experiment No. 5: Lines

The pieces of fabric were dyed for ribbons and a collar for a vest. The outcome should be stripes or line patterns on the ribbons.

Incubation period: May 15 – May 24, 9 days

Results: The same substance and the same nutrient broth were used for the experiments. Each step was performed in the same way. Only in one of the experiments did the J. lividum grow, however. This suggests that there was not enough nutrient broth for the bacteria in the two failed experiments.

FIG 7 Experiment No. 6: Silk. Image: © Charlotte Werth

Experiment No. 6: Silk

First, a silk jumpsuit was sewn. Then the nutrient broth used in the previous experiments was filled in jars and stored. J. lividum already grew and produced pigments but was sterilized with ethanol. The bacterium thus was no longer alive, but the pigments remained. The silk jumpsuit was placed in a pot and the nutrient broth was added.

Period dyeing: 17 June – 22 June, 5 days

Results: The pigment settled in the silk and colored it light purple. The bacteria therefore do not need to be alive in order to use the pigments they produced.

FIG 8 Experiment No. 7. Image: © Charlotte Werth

Experiment No. 7

The jumpsuit was put into jars in separate pieces. Nutrient broth was added to provide sufficient liquid. The textiles were not folded or pretreated, but rather simply placed in the jars.

Incubation period: June 4 – still, 30+ days

Intermediate results: The bacteria grew very weakly. This is probably due to the thickness and quantity of the textile. The result would have become a tie-dye-like pattern. It is not yet possible to say exactly what the final result will be.

FIG 9 Experiment No. 8: Grid 2. Image: © Charlotte Werth

Experiment No. 8: Grid 2

For this jumpsuit, the grid pattern experiment was continued. The textile was folded and sewn, as the lines to be dyed were tied together in one area. Since the sterilizer and vessels prevented working with large textiles, the textile piece had to be divided to fit into the vessels. The two pieces of fabric were then dyed and the threads that held it together were unraveled.

Plugging and tying: 2 days; Incubation period: June 13 – June 22, 9 days

Results: Since the nutrient broth only went to half of the piece of cloth, unlike the first experiment, the color became darker as there was more surface area for the bacteria to grow on, settle against and dye. This made the shapes more organic and broke up the rigid grid pattern even more. In addition, during this process, aluminum was added to the vessels in the nutrient broth, which fixes the pigments.

Comparison with natural dye

In order to compare bacteria dye to other natural dyes, avocado and turmeric dyes were tested. Turmeric leaves a bright radiant yellow, while avocado pit and skin dye red to dusky pink. These vegetable dyes are as gentle to the skin as the pigments produced by bacteria. Both, turmeric and avocado waste are boiled in pots and the fabric pieces are added. After remaining in the pot for some time, the fabric is taken out and placed into another pot containing a vinegar bath. The vinegar fixes the color, but the color continues to fade during subsequent washes. Regarding plants that are used for dyeing fabrics, one is bound to the place and care of the plants. If we look at the avocado, for example, it only grows in certain regions of the world, it needs a lot of space to grow, a lot of care and a lot of water. Since only the pit and skin of the fruit are used for dyeing, collecting these waste products could be another solution. However, for the food industry to be able to dye in large quantities, the dyeing itself would still consume large amounts of water, in addition to generating transport costs and pollutants.

FIG 10 Comparison with natural dye. Image: © Charlotte Werth

Conclusion

In this project, I experimented with alternatives to chemical dyes in order to show how the human body and our environment can be better protected from harmful chemical influences. In the fashion industry, environmentally harmful chemicals are overwhelmingly used to dye textiles. Even dyeing with natural dyes from plants consumes a lot of water. Innovative methods are already applied in many areas of sustainable fashion. Production technologies are in constant development to make production more sustainable. As shown here, it can be an important approach to look deeper into the field of dyeing with bacteria. From the accumulated experience if this project, it can be concluded that co-designing textile patterns with living bacteria cannot go beyond an experimental stage for the time being. Many questions remain unanswered. Therefore, this technique is not yet suitable for industrial production. Fixing the pigments in the textiles also requires more research. It is not yet known, for example, how the textile patterns will change color over several months or years.

At present, the process remains an approach that needs to be researched further and pursued to make it suitable for mass use. At the same time, both, consumers and manufacturers, need to be made more aware of sustainability and environmental protection.

FIG 11 Conclusion. Image: © Charlotte Werth

Research into alternative production techniques currently is scattered among many small companies. Disclosure of experiences and findings could advance the development. Since it is difficult to obtain information about dyeing textiles with bacteria, the circle of people trying it is still small.

In conclusion, there are alternatives to natural and chemical dyed fibers. These still need time to be explored and applied on a large scale. An important component to sensitize consumers is the transparent handling of information about new methods, as well as education about the currently used methods. This way, protection of people and nature can go hand in hand.

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