Alginate Materials for Circular Fashion: from Consumptive to Regenerative Systems

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Abstract

With growing attention towards environmental issues and impact of current production systems, research on new materials and processes has broadened significantly, with particular interest for the fashion field, one of the most consumptive industries on Earth. As renewable and circular resource then, algae and its derivatives as sodium alginate, started to be a focus of many design researches and projects. The research, aimed at fabricating and cataloguing a palette of sodium alginate material samples in order to showcase its potential for the textile field, providing a contribution to the growing community of researchers operating in the field of bio-materials. The collection was the result of the combination of both traditional and innovative manufacturing techniques, and explored the material from the technical-productive point of view, as well as from the aesthetic-perceptual one, with the aim of contributing to its diffusion fostering a shift towards regenerative circular production.

Keywords

Biomaterial Research, Sodium Alginate, Algae Derivatives, Circular Fashion, Digital Fabrication.

1. Consumptive systems: unsustainability of the fashion industry

The fashion system is among the main contributors to the environmental crisis which has been putting a strain on the planetary ecosystem over the last century. As the majority of global industries, it is a consumptive system following the paradigm take-make-discard, therefore based on linear growth, resources depletion and waste production. Textiles fabrication is responsible for the 10% of global carbon emissions, more than international flights and marine shipping combined (EEA, 2019; EP, 2020). Besides emissions, it has repercussions on multiple levels as water and land use and deterioration, health and safety, waste production and last but not least labour exploitation, in confirmation that consumptive systems which don't take into account environmental sustainability doesn't care about working conditions or child labour either. Investigations on the textile and clothing industry highlighted how only in 2015 were used 79 billion cubic metres of water (EPRS, 2019). As regards land use and habitat destruction due to conversion to agricultural use, the textile system ranks second after the food one. A large part of such impact is due to cotton cultivations, responsible for huge water consumption (requiring the largest amount of water among all agricultural crops), soil erosion and degradation, water and land pollution, but also forced and child labour (ILO, 2016).

During the fabrication process moreover, textiles undergo several chemical treatments, such as pre-treatment, dyeing, print and finishing. About 3500 substances are employed in this process, 750 of which are classified as dangerous for humans and 440 for the environment (solvents, pesticides, synthetic dyes, cleansers, etc.), affecting soil and groundwaters. Water contamination continues also during the use, since washing synthetic clothes is the primary source of microplastics ocean pollutions (European Parliament, 2020). The fashion industry also produces a high amount of solid waste deriving from fibres leftovers, cutouts and obsolescence. Every year around 90 million clothes are sent to landfills or incinerated (the main part made of synthetic fibres), and only the 1% is recycled or regenerated. It therefore appears essential to make a paradigm shift which would allow us to move from a linear to a circular system.

2. Algae and bio-material innovation in the fashion field

With the aggravation of the environmental crisis, growing attention has been directed towards the impact of humans' production systems on Earth ecosystem, resulting in exponential growth for research on circular materials and processes. Among the several resources, particular attention has been paid to algae: abundant, available worldwide, fast-growing and requiring way much less land and water than terrestrial plants. Algae can thrive also in the adverse conditions brought by climate change and sea acidification, they are beneficial for the environment fostering the life of many marine species, and essential to life on earth for oxygen production and CO_2 absorption. They have always proven extremely versatile finding application in many fields from food to medicine and trespassing today in the world of materials and design. An example is the work of Viiolaine Buet, who combines material innovation with traditional weaving and knitting techniques, establishing a dialogue "between nature and manufacture" (Buet, 2020). Another designer working with algae is Nienke Hoogvliet with her "Sea Me" project. She first created a rug made of kelp yarn knotted by hand in an old fishing net, then continued the research on seaweed exploring its potential to be turned into natural dyes and yarns. Twenty different species were collected in the Netherlands, showing a broad colour palette reflecting the local natural reserve. Recently, new algae-based companies are emerging as LivingInk from Colorado, producing ink products grown from algae, or AlgiKnit from Brooklyn, producing durable yet rapidly degradable yarns from kelp, one of the most regenerative organisms on the planet, imagining closed-loop product lifecycle models for the textile industry.

The algae derivative Sodium Alginate, resulting from the extraction of alginic acid, a polysaccharide present in brown algae cells, in the last few years has been the subject of several design researches and projects, thanks to the ease of handling and its characteristics which make it of particular interest for the textile field. Once hydrated, it forms a viscous gum used as a thickener or gelling agent in the food, pharmaceutical and cosmetic industry. Making it react with a calcium chloride solution – same reaction used for spherification in molecular kitchen – turns it into a hydrophobic, edible material.

The material's water resistance opens up a wide range of applications compared to the majority of hydrophilic bio-polymers. The London-based start-up Skipping Rocks Lab for instance, realised "Ooho" as an alternative to plastic bottles, edible bubble made of a thin sphere of alginate encapsulating drinking water. FabTextiles instead, cross-disciplinary education and research platform for experimental and digital open source couture, developed a collection of clothes and bags made of an alginate and coffee grounds bio-composite. The designers Susana Jurado and Elisenda Jaquemot, also experimented with organic waste and waterproof bioplastic in FabLab Barcelona, using alginate and orange skin to make biodegradable clothing and accessories as the "Squeeze The Orange" raincoat.

Fig 1. Alginate Materials Samples Collection (Credits: Giulia Colarieti, Supervisor: Sabrina Lucibello, Co-supervisor: Lorena Trebbi)

3. Alginate Materials Samples Collection

Design research has been exploring alternative solutions provided by circular materials and processes. In particular, the paper illustrates an applied research activity carried out in SAPeri&co, research and service centre of Sapienza University, aimed at manufacturing and cataloguing a palette of sodium alginate material samples in order to showcase its potential for the textile field. The collection born from this experimentation demonstrates how important it is to deal scientifically with the topic, experimenting with traditional processing techniques as well as with new ones such as laser cutting or filament extrusion. The experiments started from four different base recipes, collected from open source design databases. The recipes differ mainly in the density: by varying the proportion between water and glycerine it has been possible to control the mixture's viscosity and adapt it to the different manufacturing needs.

Fig 2. Alginate Materials Samples Collection: textures & patterns Collection (Credits: Giulia Colarieti, Supervisor: Sabrina Lucibello, Co-supervisor: Lorena Trebbi)

The collection was structured as follows:

- *Colours*, changing them according to the ingredients used as organic matrix or natural dyes. The use of an organic matrix is also affecting the overall appearance of the material, resulting in more tactile, matte and porous surfaces. On the other hand, the samples realised using liquid dyes present a glossy and plastic-like look [fig. 1].
- *Fibres*, used to reinforce the material, ease the sewing and change the material's aesthetic-perceptual features. In order to keep the material compostable, the fibres used must be natural and raw, which means they didn't undergo any chemical treatment. Of particular interest is the use of waste fibres resulting from the spinning process.
- *Textures*, realised by casting the mixture on several moulds, textiles or processed surfaces in order to impress the surface texture onto the sample, as well as by engraving the material with a laser cutting machine.
- *Patterns*, cut out using a laser cutting machine to create geometric, organic and auxetic patterns which can affect the material flexibility and malleability [fig. 2].
- *Processing*, applying some manufacturing textures traditionally used in the textile field as machine sewing, folding and plisse, drapery, gatherings. The alginate samples have also been paired with other fabrics to create reinforcements, an essential part of many garments.
- *Extrusion*, to produce a filament to be used for weaving. After some manual experiments with syringe, a clay 3D printer was used to turn the alginate mixture into a long yarn, providing constant pressure and velocity.
- *Textiles*, obtained by weaving the filaments obtained to turn them into a textile, as happens with traditional fibres. A small manual loom was used to create the textiles samples, mounting a cotton warp and sodium alginate weft threads [fig. 3].

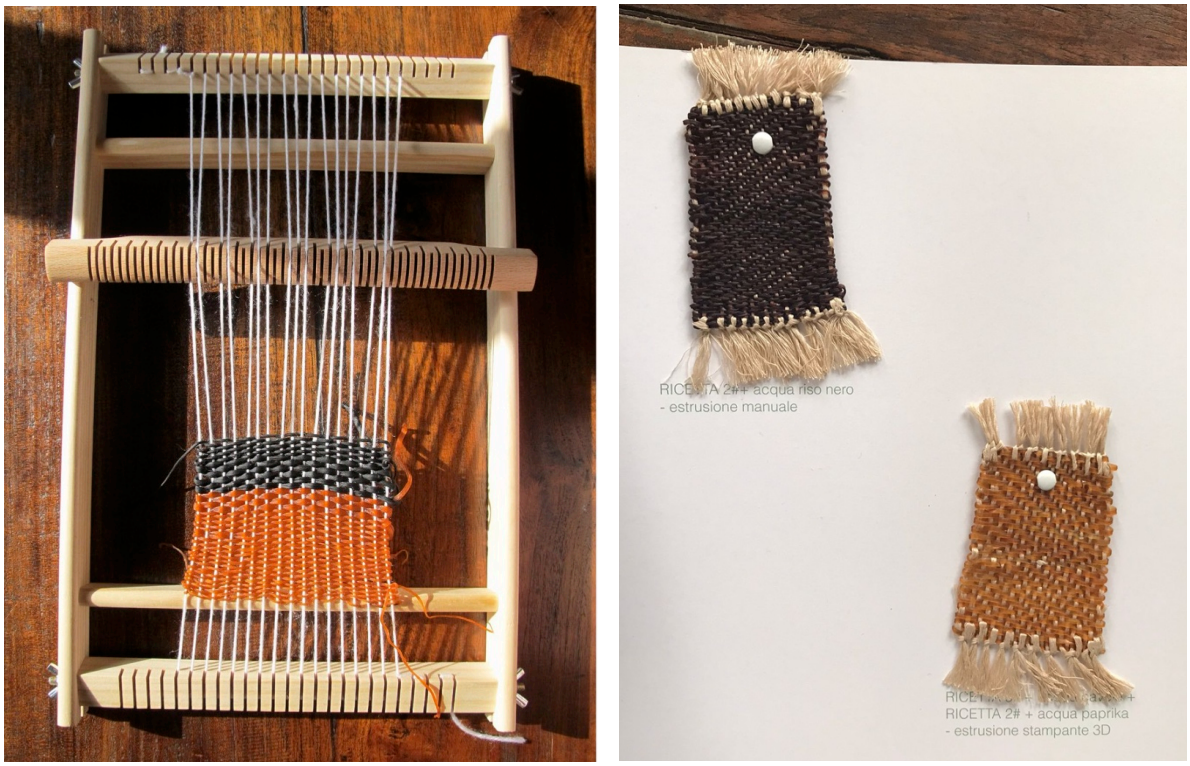

Fig 3. Alginate Materials Samples Collection: textiles Collection (Credits: Giulia Colarieti, Supervisor: Sabrina Lucibello, Co-supervisor: Lorena Trebbi)

4. Conclusions

The collection is meant to be a tool for dissemination, but also a tool to support designers and producers in the application of the material. The research was grounded on the approaches of learning-by-doing and action research, highlighting the central role of experience as a tool for knowledge building. It was focused on a hands-on experimentation which allowed the designer to get acquainted with the material, understand its behaviour and learn how to interact with its features. The methodology used was then the result of a hybridisation between the complementary approaches of science and design (Trebbi, 2021; Carullo et al., 2017), learning from science to be able to provide accurate data collection and repeatability, but never losing the design inductive perspective, able to shift our view from micro to macro and provide an overall understanding integrating in the project technical, cultural, social and environmental aspects.

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