BIOLAB Lisboa

29st Oct. 2026



Workshop Alginate BioMaterials

- Bio-composites, Bio-plastics, Bio-yarns -



CIAUD Centro de Investigação em Arquitetura Urbanismo e Design

FACULDADE DE ARQUITETURA LISBON SCHOOL OF ARCHITECTURE UNIVERSIDADE DE LISBOA

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IFIMUP Institute of Physics for Advanced Materials, Nanotechnology and Photonics

fct Fundação para a Ciência e a Tecnologia

FABRICADEMY textile and technology academy

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Seaweed

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Seaweed clean water and sequestrate CO^2

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Remediation
and Blue carbon
(Fu et al., 2023; Cotas et al., 2023)

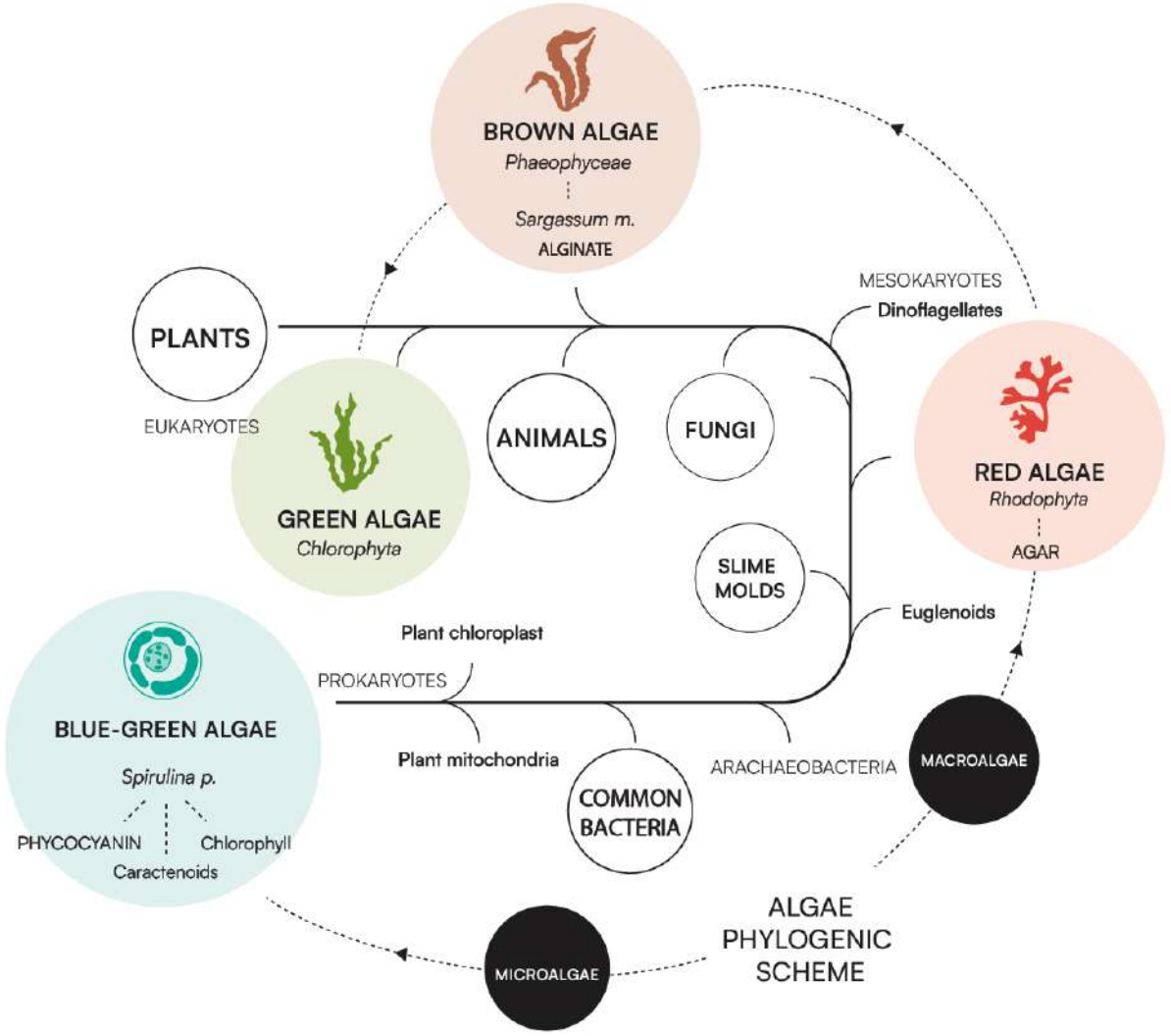


Fig. 1 – **Algae Phylogeny scheme** – genealogy diagram with Macroalgae and Microalgae, (based on Singh & Saxena), by Carolina Delgado (2025)



Alginate

Sodium Alginate is the sodium salt form of alginic acid and gum mainly extracted from the cell walls of brown algae. Alginate is a compound know as a **polysaccharide**.

Alginate Bioplastic can be made by combining two separate mixtures: one containing sodium alginate, water and glycerine (as a base) and a curing agent, calcium chloride.
Calcium has the ability to form two bonds which will hold the alginate into a long link forming this gel as a molecule called a polymer.
The result is **Calcium Alginate.**

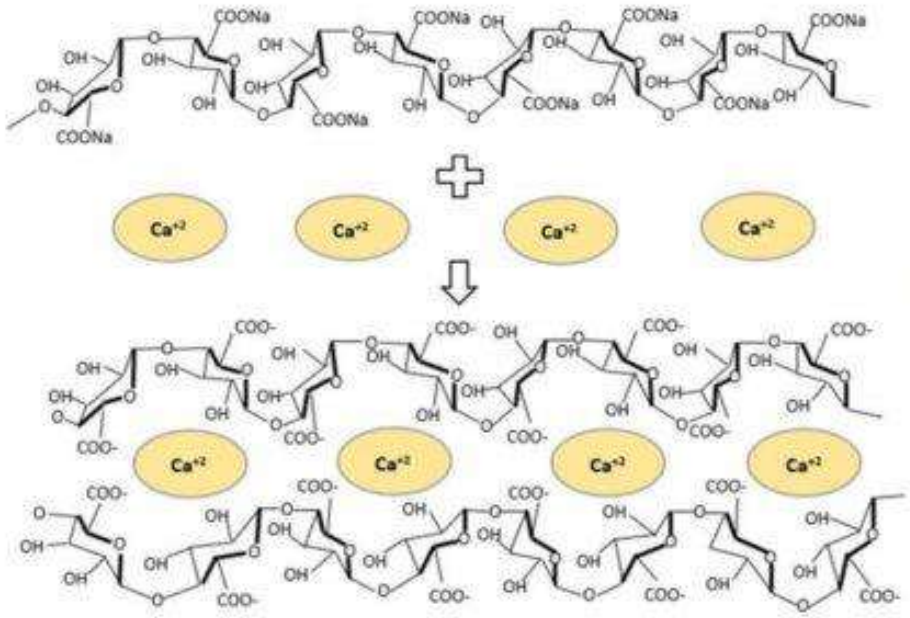
These gels withstand up to 150°C without melting (Fabricademy, 2020).

Fig. 2 – **Brown Seaweed**, Adobe stock photo

Cross-link Polymerisation

ideal water temperature between 13ºC to 28ºC

also known as Gelation (covert liquid to a solid)





Eggbox model

$$2NaC_6H_7O_6 + CaCl_2 \rightarrow 2NaCl + C_{12}H_{14}CaO_{12}.$$

Polymerisation
Sodium alginate ($NaC_6H_7O_6$) reacts with calcium chloride ($CaCl_2$) to generate calcium alginate ($C_{12}H_{14}CaO_{12}$)

Fig.3 – ***Eggbox model*** – The formation mechanism reaction for calcium alginate (Shalapy et al., 2020)

Bioplastic & bioyarns



Fig. 4 – **Alginate Bio-films and bio-yarns with different spirulina colours,** Delgado et al. (2024), photo ©Luís Silva Campos,

Extruded and knitted



Fig. 5 – **Knitted Alginate Bio-yarns,** photo ©Luís Silva Campos, Carolina Delgado, 2020

With fillers



Shell sand bio-composite

Eggshells bio-ceramic

Coffee grain bio-plastic

Fig. 6 – **Alginate Materials with Organic Waste**, photo ©Luís Silva Campos, Delgado et al. (2022)

Variations

- **Bio-chromes** – replace the water with a (diluted) natural colorant such as a vegetable dye or water-based ink (e.g. hibiscus, beetroot, madder), or condiment as turmeric powder, paprika, cinnamon.

- **Bio-plastic** – add sunflower oil to stronger and translucid bio-plastic, more like silicone

- **Stiffness and rigidity** – add less glycerine for a less flexible foil

- **Transparency** – remove sunflower oil and use 30% less alginate to cast thinner transparent foils

- **Fillers** – use different fibres and powders to extrude or cast in sheets, like bio-ceramic or bio-leather (e.g. eggshells, seashells, coffee grains, orange peels); (Bolumburu, 2018; Delgado et al. 2022).



Workshop Alginate Biocomposites

Prepare the moulds

70% Alcohol dry slower
96% Alcohol is stronger



Fig. 7 - **Cleaning, Sanitizing and Disinfecting**, by Andrey Golubtsov, Dreamstime

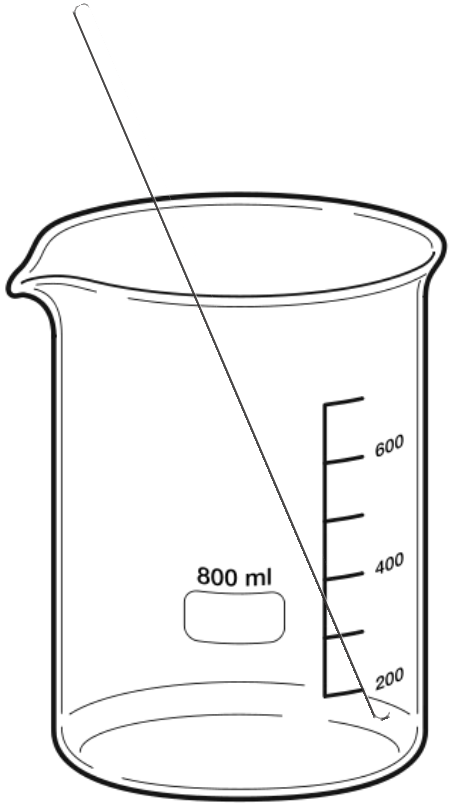
Disinfecting

1. Clean the moulds
2. Use Alcohol and Air dry or use Demineralised water; if necessary dry with a lab paper towel
3. Some moulds can be autoclaved or steamed in pressure cooker

Prepare the Bath

5% Calcium Chloride Sol.

- **20g Calcium Chloride**
- **380ml Distilled Water**
- **2 big bowls or beakers**



Steps

1. Measure 380ml Distilled Water and pour in a beaker
2. Measure 20g calcium chloride
3. Mix the calcium chloride using a wire whisk
4. Reserve in a big bowl
5. Fill another bowl with 500ml tap water

Prepare the Spray

10% Calcium Chloride Sol.

- **10g Calcium Chloride**
- **90ml Distilled Water**
- **1 spray bottle**



Steps

1. Measure 90ml Distilled Water and pour in a beaker
2. Measure 10g calcium chloride
3. Mix the calcium chloride using a wire whisk
4. Using a funnel pour in a spray bottle

Seashells and Eggshells waste prep

Seashells

1. Collect the seashells from the kitchen waste, restaurant or market.
2. Wash the shells and boil them for about 30 minutes above 140ºC to kill all bacteria (or autoclave them).
3. During this process, remove foams and dirt with a skimmer or slotted spoon.
4. To dry the eggshell, in the oven at 140 degrees for 15 minutes to dry out; brittle but not burnt (subtle crackling sound means that the eggshells are ready.
5. Using a bag and a hammer, break it into smaller pieces, grind it with a mortar or a high-power multi-grinder.

Eggshells

1. Collect the eggshells at your home, neighbours, restaurants, etc.
2. Wash the eggshells and boil them for approximately 30 minutes at a temperature above 140 °C to kill all bacteria (or autoclave them).
3. During this process, remove foams and dirt with a skimmer or slotted spoon.
4. Dry in the oven at 140 degrees for about 15 minutes to dry out; brittle but not burnt. A subtle crackling sound means that the eggshells are ready.
5. Grind with a coffee grinder or a mortar and pestle.

Nuts and fruits waste prep

Any Nuts shells

1. Collect the dry fruit shells (such as cashews, hazelnuts, and nuts).
2. Using a bag and a hammer to break it into smaller pieces, grind it with a mortar and pestle, or a high-power multi-grinder

Used coffee grains

1. Collect the used coffee grains and store them in a zipper bag in the freezer.
2. When needed, remove them from the bag and dry them in the oven at 100 degrees for 15 minutes.

Fruit peels

1. Collect the fruit peels from oranges, clementines, bananas, or other fruits, removing any remaining fruit pulp and store them in a zipper bag in the fridge.
2. Remove the interior white parts from orange peels and banana peels, as well as the stems.
3. Toast them in the oven at 150 degrees for 30 minutes, until they are dry and brittle but not burnt.
4. Grind it using a coffee grinder or a mortar and pestle.

1.Seashells Bio-composite

Alginate and seashells powder

- **50ml Distilled Water**
- **5ml Glycerine**
- **100gr Seashells**
- **2gr Sodium alginate**

- **10% Calcium Chloride sol. (in spray)**



Fig.8 – **Alginate and Seashells Bio-biocomposite**, photo ©Luís Silva Campos, Carolina Delgado, 2020

Steps

1. Measure the seashells and grain it to powder
2. Measure the remain materials
3. Mix the sodium alginate in the seashells bowl
4. Mix the glycerine with the distilled water
5. Add the water sol. to the bowl slowly, mixing with a spatula
6. Spray the moulds with 10% calcium chloride sol.
7. Pour the material into the moulds and spray again on top
8. Leave to dry

2.Eggshells Bio-ceramic

Alginate and eggshells powder

- **30ml Distilled Water**
- **30gr Eggshells**
- **2gr Sodium Alginate**

- **10% Calcium Chloride sol. (in spray)**



Fig.9 – **Alginate and Egghells Bio-biocomposite**, photo ©Luís Silva Campos, Carolina Delgado, 2020

Steps

1. Measure the eggshells and grain it to powder
2. Measure the remain materials
3. In a small bowl mix the seashell with the sodium alginate
4. Add the water to the bowl slowly, mixing with a spatula
5. Spray the moulds with 10% calcium chloride sol.
6. Pour the material into the moulds and spray again on top
7. Leave to dry

3.Coffee Bio-leather

Alginate and coffee grains

- **75ml Distilled Water**
- **10ml Glycerine**
- **20gr Coffee grains**
- **5gr Sodium Alginate**

- **10% Calcium Chloride sol.**
  (or 20gr + 180ml water)



Fig.10 – **Alginate and Coffee Bio-plastic**
photo ©Luís Silva Campos, Carolina Delgado, 2020

Steps

1. Measure the coffee grains and the remain materials
2. Mix the coffee with alginate
3. Mix water and glycerine in the beaker
4. Add the coffee and alginate slowly, mixing with a spatula
5. Spray the moulds with the sodium chloride solution
6. Pour into the moulds and spray on top.
7. Leave to dry

4.Banana Bio-yarn

Alginate and banana peels

- **100ml Distilled Water**
- **20gr Banana peels**
- **10ml Glycerine**
- **10ml Sunflower oil**
- **5gr Sodium Alginate**

- **5% Calcium Chloride sol.**
  (or 20gr + 380ml water)



Fig.11 – **Alginate Bio-yarn with filler**
photo ©Luís Silva Campos, Carolina Delgado, 2020

Steps

1. Measure the banana peels and grain it to powder
2. Measure the remain materials
3. Mix the banana with alginate
4. Mix water, glycerine and sun lower oil with electric blender
5. Add the banana and alginate slowly, mixing with a spatula
6. Fill syringe and extrude above cure bath to prevent clogging
7. Let bio-yarn harden for 5 minutes
8. Remove & wash in a bowl with tap water. Leave to dry



Workshop Alginate BioPlastics

1. Bio-film1

thin film



Fig. 12 – **Alginate Bio-film with food colour**, photo ©Luís Silva Campos, Carolina Delgado, 2020

- **400ml Distilled Water**
- **30gr Glycerine**
- **12gr Sodium Alginate**
- **pigment**

- **10% Calcium Chloride sol.**
  (or 10gr + 90ml water)

Steps

1. Prepare a cure spray – mix approx. 10gr calcium chloride with 100ml demineralized water, reserve in a spray bottle
2. Mix water and glycerine - emulsify with a blender
3. Add alginate – emulsify until uniform and add colour (ideally rest 8h to release bubbles)
4. Spray the moulds with the sodium chloride solution
5. Pour into the moulds and spray on top
6. Leave to dry

Note: To totally warerproof, after dry bath the material in a 10% calcium chloride sol., wash in tap water and let dry.

2.Bio-film2

sheet

- **400ml Distilled Water**
- **20gr Glycerine**
- **8gr Sodium Alginate**
- **pigment**

- **10% Calcium Chloride sol.**
  (or 10gr + 90ml water)



Fig. 13 – **Alginate Bio-films with food colour**, photo ©Luís Silva Campos, Carolina Delgado, 2020

Steps

1. Prepare a cure spray – mix approx. 10gr calcium chloride with 100ml demineralized water, reserve in a spray bottle
2. Mix water and glycerine - emulsify with a blender
3. Add alginate – emulsify until uniform and add colour (ideally rest 8h to release bubbles)
4. Spray the moulds with the sodium chloride solution
5. Pour into the moulds and spray on top
6. Leave to dry

Note: To totally warerproof, after dry bath the material in a 10% calcium chloride sol., wash in tap water and let dry.

3.Bio-plastic yarn

Alginate and sunflower oil

- **400ml Distilled Water**
- **40gr Glycerine**
- **24gr Sodium Alginate**
- **20gr Sunflower oil**

- **5% Calcium Chloride sol.**
  (or 20gr + 380ml water)



Steps

1. Prepare a cure bath – mix approx. 20gr calcium chloride with 400ml demineralized water, reserve in a bowl
2. Mix water and glycerine - emulsify with an electric blender
3. Add alginate slowly – emulsify until uniform and add sunflower oil (ideally rest 8h to release bubbles); divide and add colour
4. Fill syringe and extrude above cure bath to prevent clogging
5. Let bio-yarn harden for 2-5 minutes, remove
6. Remove & wash in bowl with tap water. Leave to dry

Fig.14 – **Alginate Bio-yarns with food colour**, photo ©Luís Silva Campos, Carolina Delgado, 2020

Note: Make biofilms casting into moulds spraying with a 10% calcium chloride sol.

4.Bio-sferification

Alginate and liquid

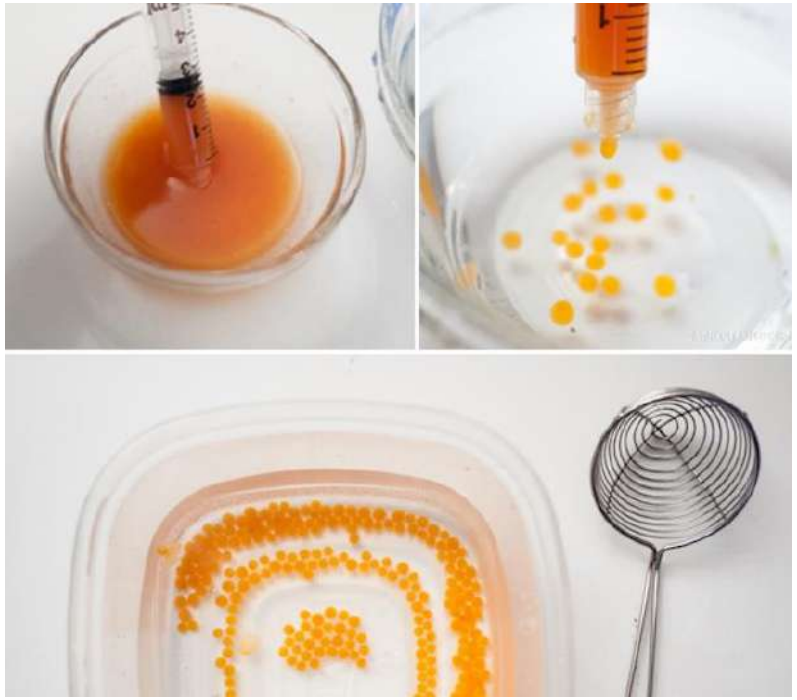


Fig. 15 – **Alginate Sferification,**
©Tiny Urban Kitchen, 2012

0,5 % Sodium alginate sol.

- **400ml Distilled Water** or juice, broth, or sauce
- **2gr Sodium Alginate**

0,5% Calcium Chloride sol.

- **2gr Cal. Chlroride + 400ml water**

Tools: Bowls, pipette, syringe, or spherification spoon

Steps

1. Mix 400ml of choosen liquid with 2gr Sodium alginate and, emulsify with an electric blender
2. Prepare a cure bath – mix 2gr calcium chloride with 400ml tap water, reserve in a bowl
3. Using a pipette or syringe, gently drop the alginate mixture into the calcium chloride bath.
4. Allow the droplets to rest for 1–2 minutes, during which a thin gel membrane will form around the liquid.
5. Carefully remove the spheres using a slotted spoon and rinse them briefly in clean water to remove any excess cal. chloride.

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Thank you!

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