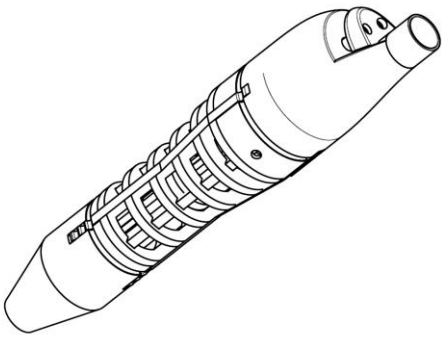
ASSEMBLY INSTRUCTIONS

www.fablab-neuch.ch/**pleco**

Hes·so
Haute Ecole Spécialisée
de Suisse occidentale



BEFORE STARTING

The Pleco is a newly designed, ergonomic and easy to use electrolytic pencil made from elements you can construct and assemble yourself. Built for local electrolytic treatment, it avoids the traditional treatment of artefacts by immersion.

The Pleco has been developed in close collaboration between the Conservation Research Department at the University of Applied Sciences Arc (UR-Arc CR) in Neuchâtel, the Saint-Maurice Abbey conservation workshop (Valais) and the Institute of Art History and Museology at the University of Neuchâtel. The ergonomics of the pencil were improved thanks to a partnership with the EDANA laboratory at HE-Arc Engineering, Neuchâtel. Its design and fabrication also benefited from the input of FabLab, Neuchâtel, which provided fast prototyping technologies (3D printing and laser cutting); thereby reducing the production cost of the Pleco.

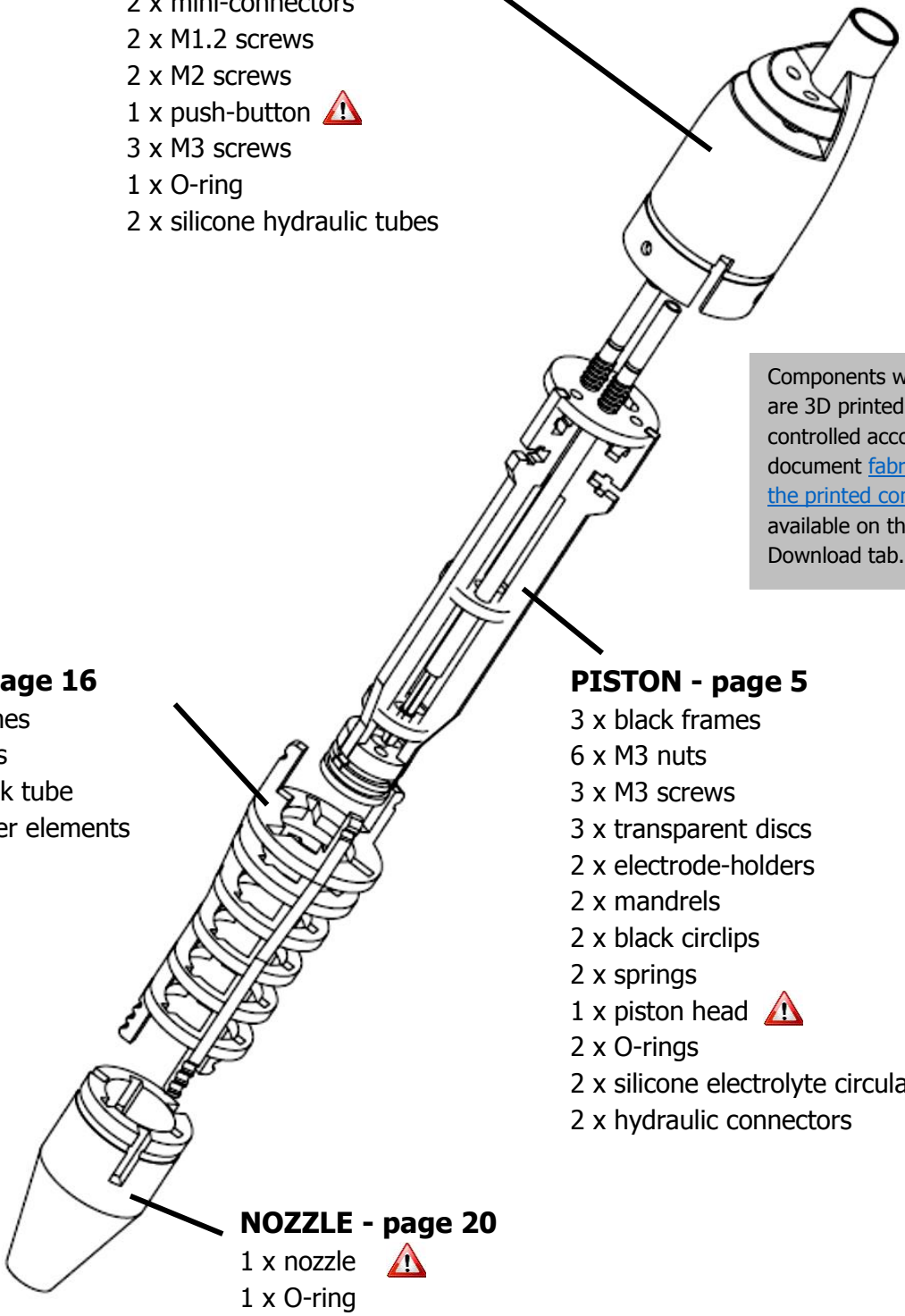
The Pleco is a unique tool which can be fully fabricated by using a FabLab. Like other objects produced in FabLabs, its fabrication should develop in a collaborative and open way: anyone can optimise the Pleco through the FabLab network.

The development of the Pleco is pursued by its end-users.

The objective of the Pleco is to provide a medium to share knowledge on electrochemistry, cultural heritage conservation and FabLab manufacturing. For this, a forum is available on the Pleco webpage (http://fablab-neuch.ch/pleco/). Do not hesitate to comment on the Pleco and its use, and to share any modifications or improvements you make to the Pleco.

You are encouraged to consult the Pleco webpage before you start assembling the Pleco. Videos are available and provide additional information on the assembly and proper use of the Pleco:
(http://www.fablab-neuch.ch/pleco/plus.php?id=17).

COVER - page 11
1 x cover ⚠
2 x mini-connectors
2 x M1.2 screws
2 x M2 screws
1 x push-button ⚠
3 x M3 screws
1 x O-ring
2 x silicone hydraulic tubes



Components with the icon ⚠ are 3D printed. Their quality has be controlled according to the document fabrication instructions of the printed components of the Pleco available on the website under the Download tab.

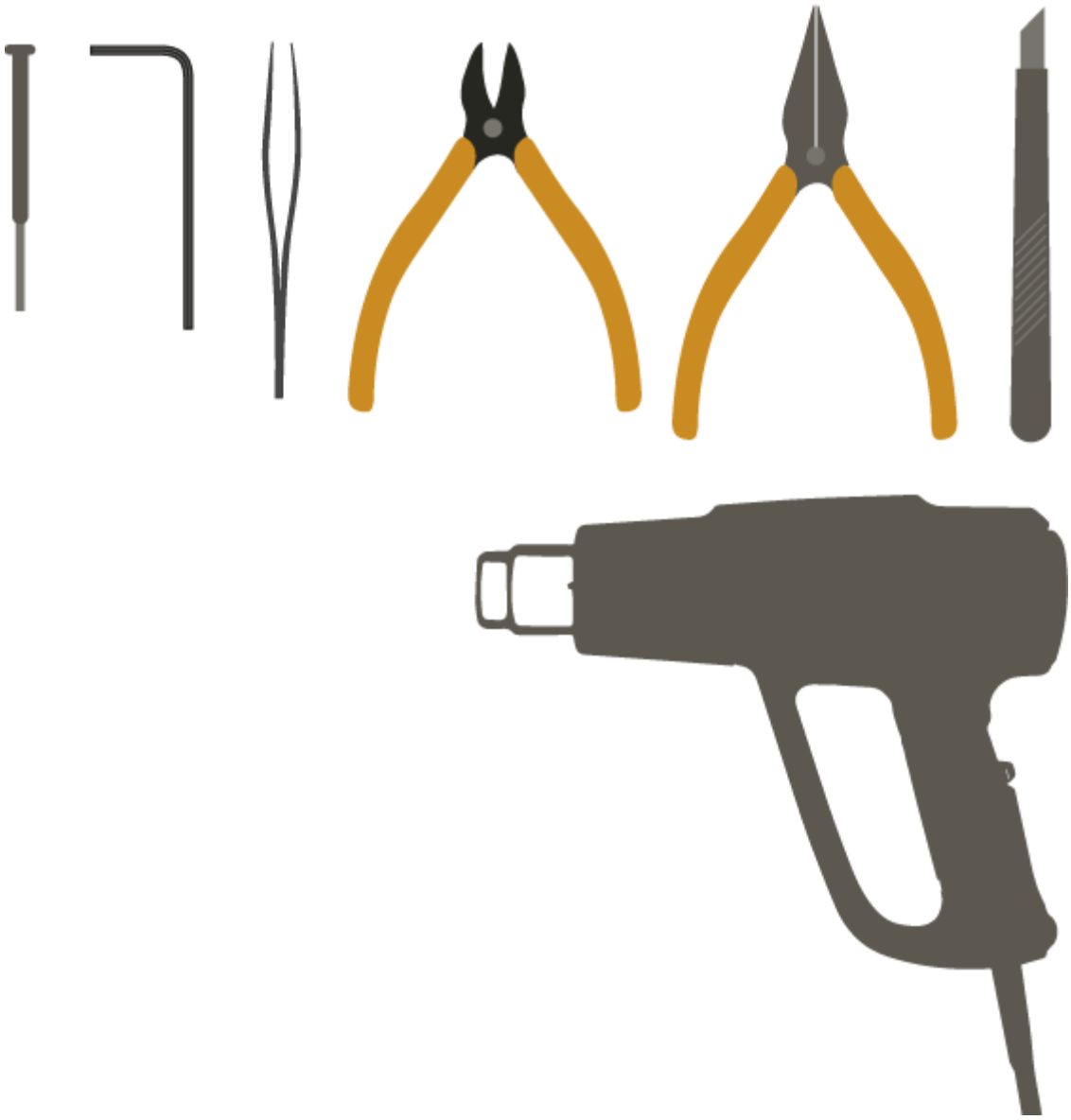
CASING - page 16
3 x black frames
6 x black rings
1 x heat-shrink tube
2 x MDF timber elements

PISTON - page 5
3 x black frames
6 x M3 nuts
3 x M3 screws
3 x transparent discs
2 x electrode-holders
2 x mandrels
2 x black circlips
2 x springs
1 x piston head ⚠
2 x O-rings
2 x silicone electrolyte circulation tubes
2 x hydraulic connectors

NOZZLE - page 20
1 x nozzle ⚠
1 x O-ring
1 x pad

REQUIRED TOOLS

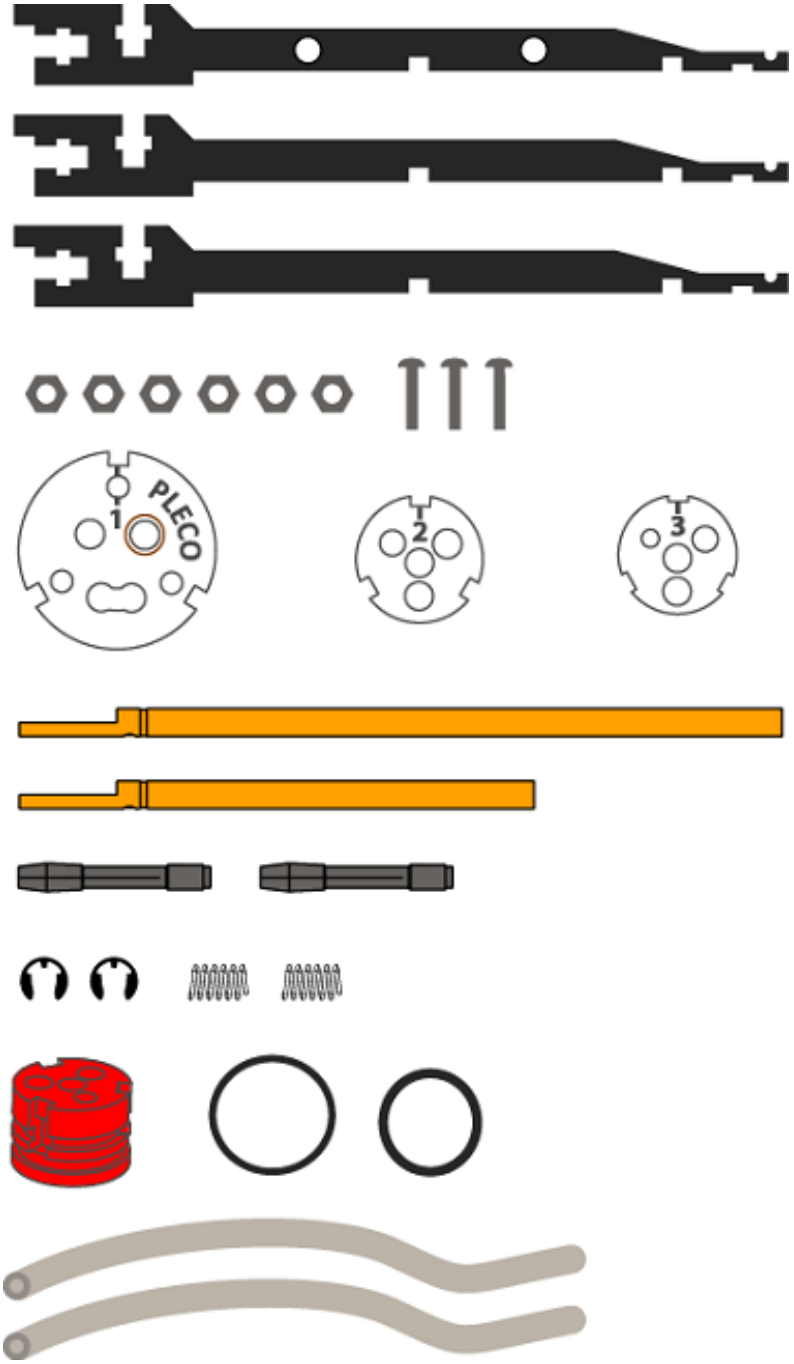
1 x screwdriver (included in the kit)
1 x 2 mm hex key (included in the kit)
1 x tweezers
1 x cutting pliers
1 x flat nose pliers
1 x scalpel (or cutter or scissors)
1 x hot air gun (or powerful hair-dryer)



1. ASSEMBLING THE PISTON

Contents of the sachet labelled "piston":

3 x black frames
6 x M3 nuts
3 x M3 x 10 mm screws
3 x transparent discs
2 x electrode-holders (short and long)
2 x mandrels
2 x black circlips
2 x springs
1 x piston head
2 x O-rings
2 x silicone electrolyte circulation tubes
2 x hydraulic connectors

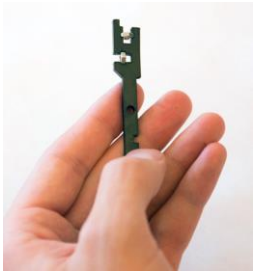


REMARK

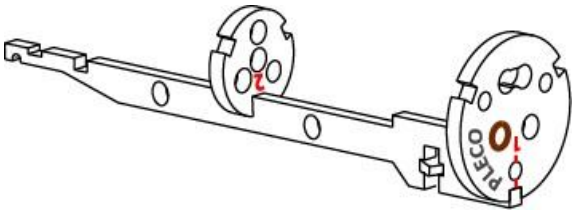
Check the printing quality of this component according to the document fabrication instructions of the printed components of the Pleco available on the website under the Download tab.

1. ASSEMBLING THE PISTON

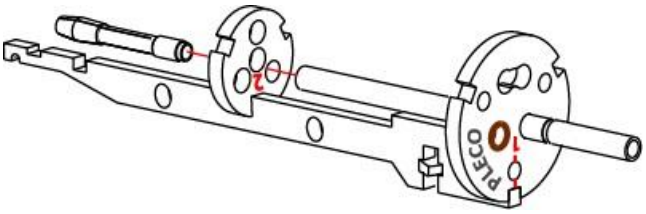
1.1
Insert the nuts into the notches provided in the 3 black frames. To keep the nuts in place, slightly bend the frames to reduce the width of the notches.



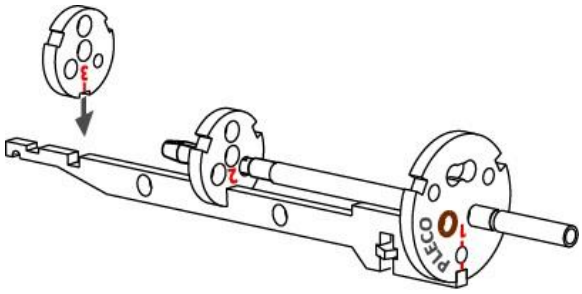
1.2
Position transparent discs 1 and 2 in the notches provided on the black frame which features two holes. Refer to the drawing below for the correct orientation of the numbered sides of the discs.



1.3
Insert the short electrode-holder in the grooved hole of transparent disc 1 and then in the corresponding hole of disc 2 (to the right of the disc numbering, as depicted). Position one of the mandrels under disc 2 and screw it into the short electrode-holder. Disc 2 must be confined between the short electrode-holder and the mandrel.



1.4
Position disc 3 in the second last notch of the frame. Ensure the discs are positioned so their labelled numbers are orientated as depicted. Insert the long electrode-holder through the brown hole in disc 1 and through the corresponding holes in discs 2 and 3. Position the second mandrel under disc 3 and screw it into the long electrode-holder.

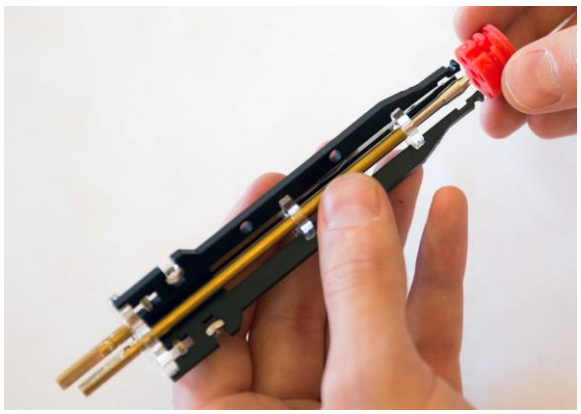


Tip:
When fixing disc 3, slightly bend the end of the frame to reduce the width of the notch, thereby ensuring that disc 3 remains in place.

1. ASSEMBLING THE PISTON

1.5
Position the two other frames in the notches on the three discs.

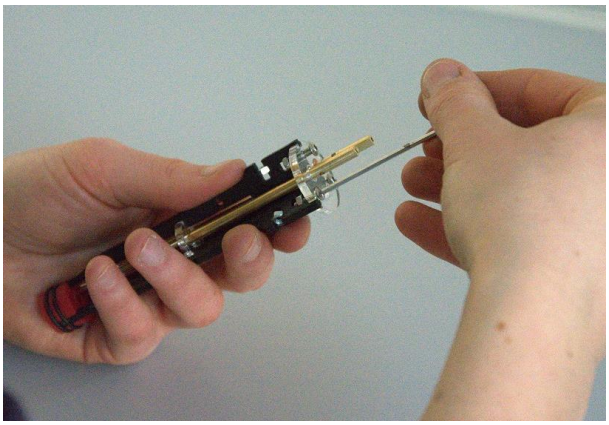
1.6
Install the red piston head on the lower part of the assembly. If the insertion is not easy, clean the notches under microscope. The mounting of the piston head must be made so that the end of the frame which features 2 holes is inserted into the notch in the head marked on both sides by red arrows.



1.7
Insert the O-rings into the grooves of the piston head. First the smaller diameter O-ring is inserted into the groove on the upper part of the head (towards the discs). Then the larger diameter O-ring is inserted into the lower groove.

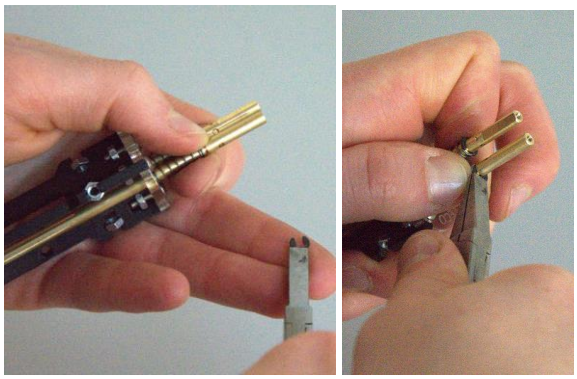
1. ASSEMBLING THE PISTON

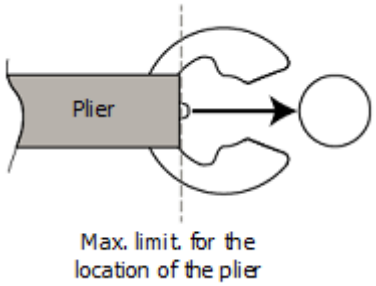
1.8
Position the M3 screws on top of disc 1. Tighten them with the hex key provided in the kit.



1.9
Insert the springs on top of the electrode-holders.

1.10
Insert the circlips in the grooves of the electrode-holders above the springs. The springs need to be compressed slightly to insert the circlips. Flat nose pliers should be used to help insert the circlips. Do not hesitate to force the insertion until a distinct clic is heard.

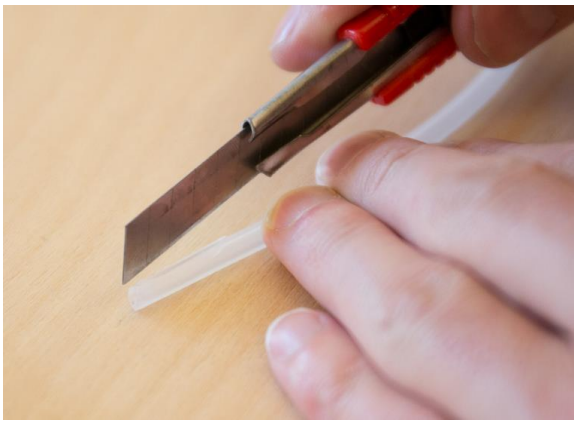




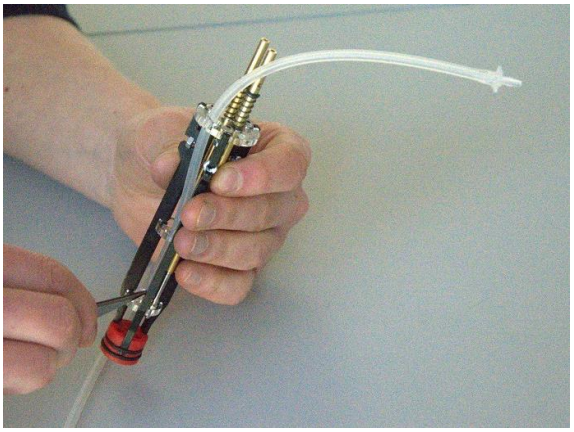
Remark:
The electrode-holders might not have exactly the same height on the upper side of the piston. This is not a problem for the rest of the assembly steps and the good working of the Pleco.

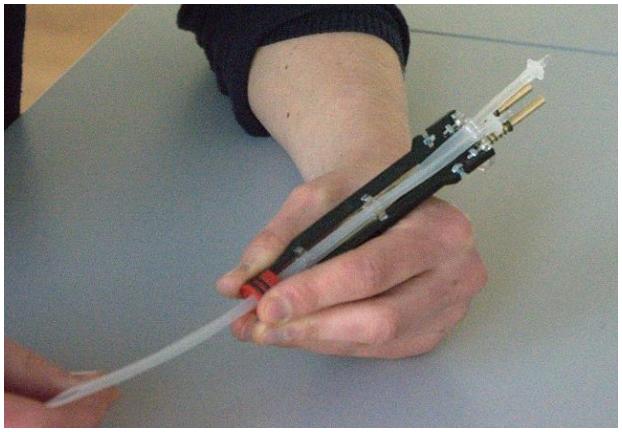
1. ASSEMBLING THE PISTON

1.11
Take the two silicone electrolyte circulation tubes and cut - at one end only for each tube - a bevel about 2 cm long. Use a cutter or scissors. This will facilitate inserting the tubes through the 3 discs and the piston head.



1.12
Insert the hydraulic connectors into the non-bevelled ends of the tubes. Thread then the bevelled ends of the silicone electrolyte circulation tubes, starting by the central one, through the holes in the discs (from disc 1 to disc 3) and finally through the piston head. The hydraulic connectors in the non-bevelled ends must be positioned against the top part of disc 1. Use tweezers to help thread the tubes through the discs and piston head.



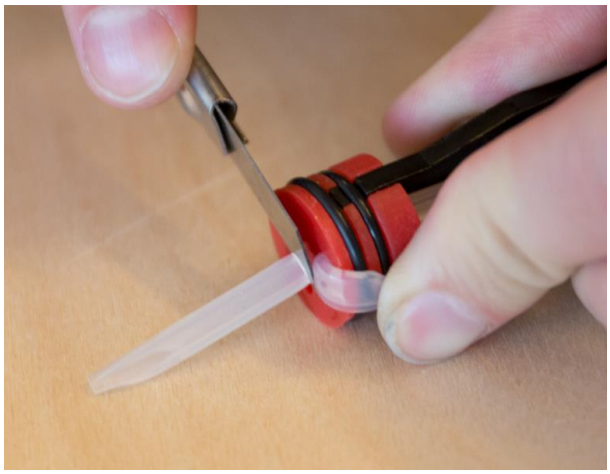


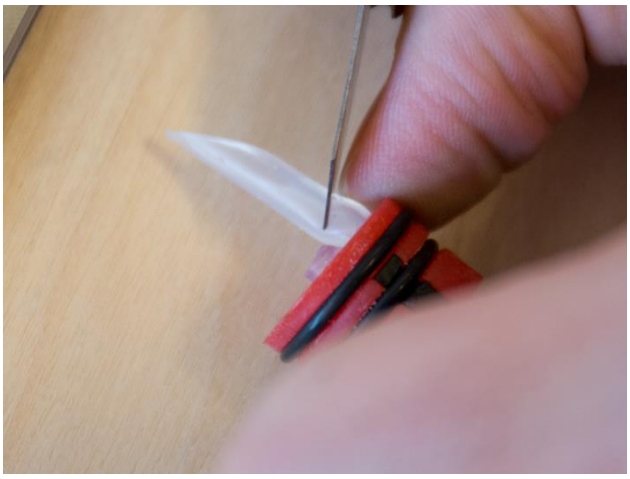
1. ASSEMBLING THE PISTON

Preliminary remark to 1.13:

It might be recommended to report step 1.13 to the end of the assembly. Indeed, if the nozzle and the piston head do not adjust well, the piston head might get detached from the piston during step 6. It might be complicated then to re-insert the tubes in the piston head without the bevelled end. Soap water can be used to facilitate this step in case the tubes have already been cut.

1.13
Cut the sections of tube which extend beyond the piston head. The tube in the centre of the piston head must be cut close to the face of the head (with a maximum protrusion of 1 mm). The other tube is bevelled near the centre of the piston head. The tallest side is 1 cm long while the shortest side is 0.5 cm, as shown on the figure below. The long and bevelled tube supplies the electrolyte, and the short tube in the centre of the piston head is for removing the solution.

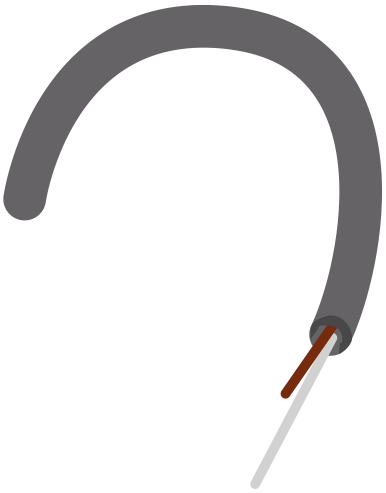


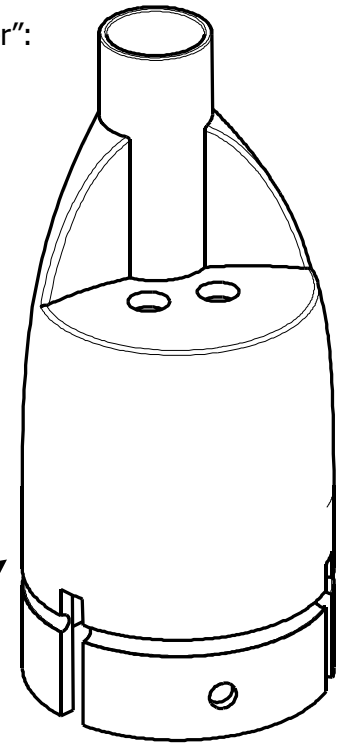


2. INSTALLING THE CONNECTION AND THE COVER

Contents of the sachet labelled "cover":

2 x mini connectors
2 x M1.2 x 3mm screws
1 x 2-core electric cable
2 x 1.5m long electrolyte circulation hoses
1 x cover
2 x M2 x 8 mm screws
1 x push-button
3 x M3 x 8 mm screws





REMARK

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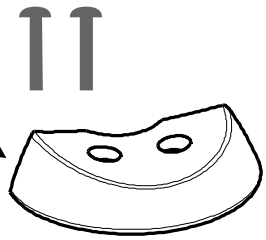
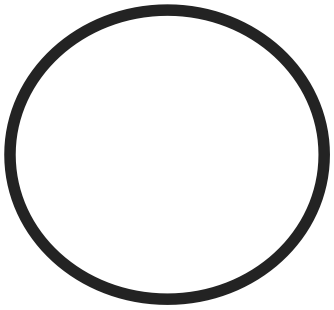
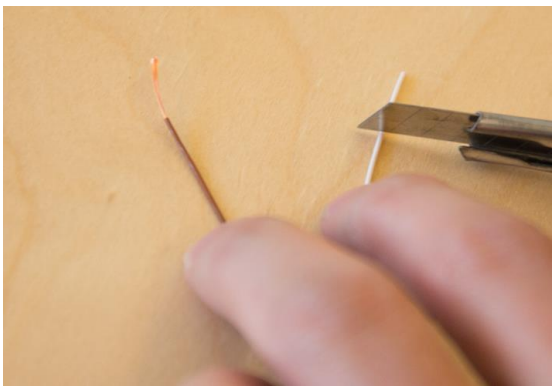


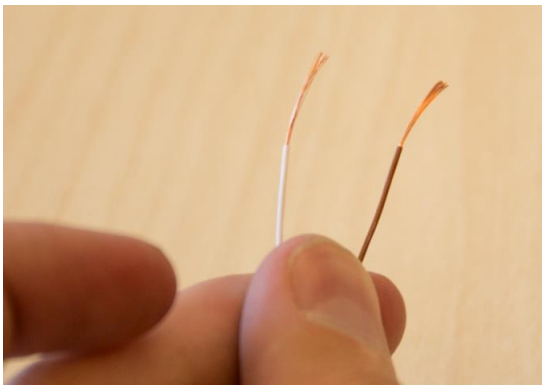


2. INSTALLING THE CONNECTION AND THE COVER

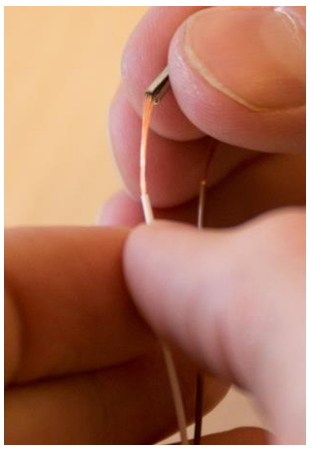
2.1
Strip with a cutter or a pair of wire-strippers about 3 cm of insulation from the 2-core electric cable. Insert the cable in the upper hole of the cover. The two separated cable-wires come out of the lower opening of the cover.

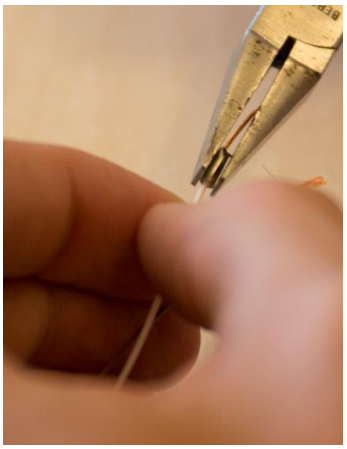
2.2
Similarly strip the insulation from the end of each cable-wire, but this time only remove 5 mm.

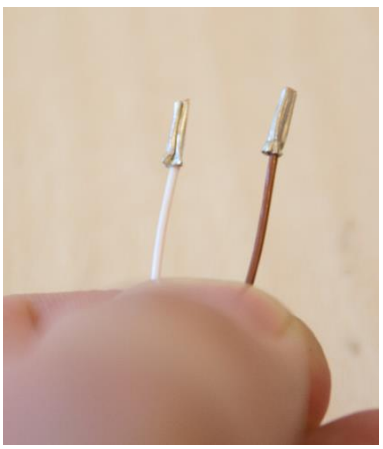




2.3
Place the mini-connectors onto each of the 2 stripped wires. Squeeze the connectors with flat nose pliers assuring an electric connection. **One part of the insulation must be tightened in the mini-connector to ensure a secure union and prevent the copper wires to get damaged with time.**

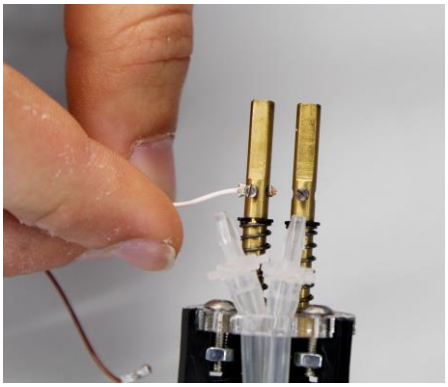
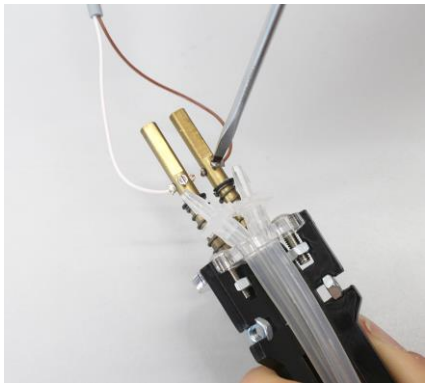




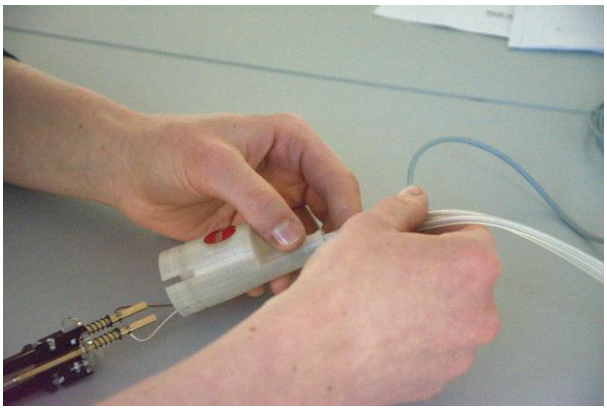
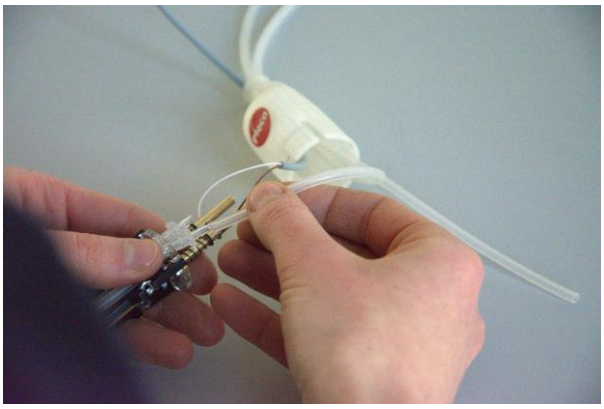


2. INSTALLING THE CONNECTION AND THE COVER

2.4
Place the M1.2 screws in the small holes on the upper part of the electrode-holders (those situated on the flat side). Turn the electrode-holders to face their flat sides towards the circulation tubes. Insert then the wires with their connectors into the side holes, from the outside. The wire with white insulation (reference electrode) must be connected to the shortest electrode-holder. Ensure a good contact between the screws and the connectors by tightly fastening the screws – pay attention not to damage the cap screws. Check the secureness of the connection by lightly pulling the wires. If it is not enough, relocate the wires and tighten them more.

2.5
Insert the two 1.5 m long electrolyte circulation hoses through the upper hole in the cover and connect them to the hydraulic connectors on top of the piston.

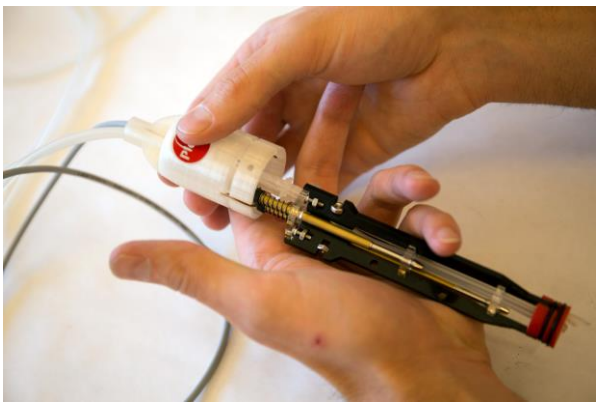



Remark:

The marking of the supply and extraction hoses to connect them correctly to the pumps will be done at the end of the assembly.

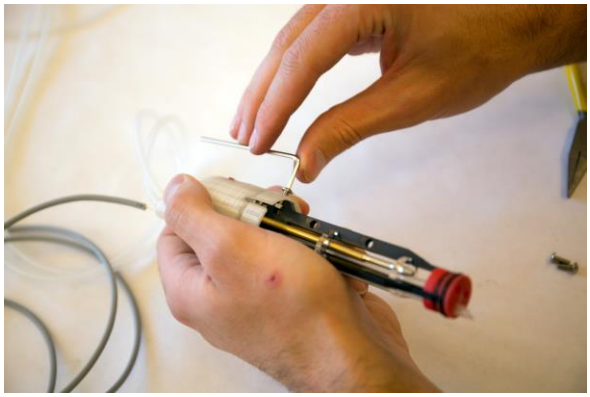
3. ASSEMBLING THE PISTON AND THE COVER

3.1
Slide the cover along the electric cable and the electrolyte circulation hoses until it is over the piston. The hydraulic connectors (installed at step 1.12), as well as the electric cable must be under the cover and be retained in place. Only the electric cable and electrolyte circulation hoses pass through the upper hole of the cover. **Ensure that the electrode-holders protrude out of the two corresponding holes on the cover. If needed rotate the electrode-holders with flat nose pliers in order to locate them face to face.**

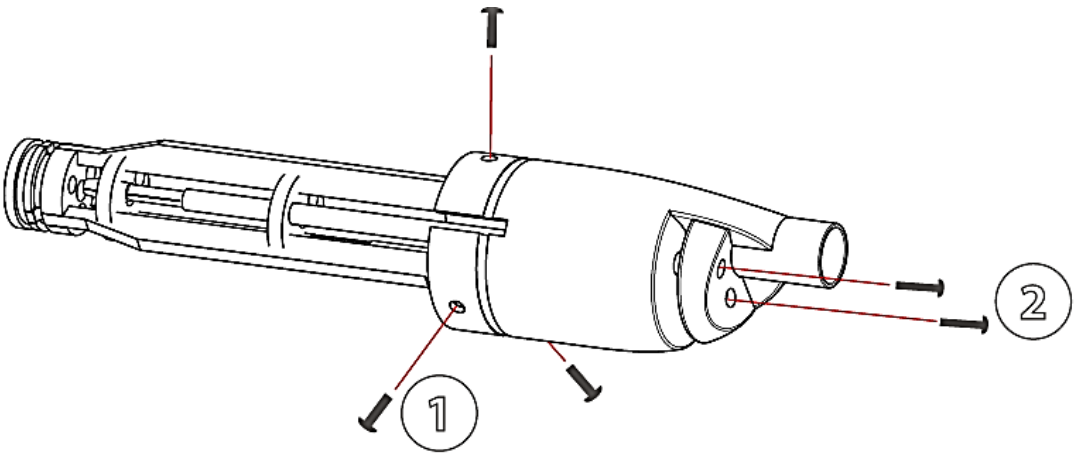


3.2
Insert the 3 M3 screws around the cover and fasten them with the 2 mm hex key included in the kit.

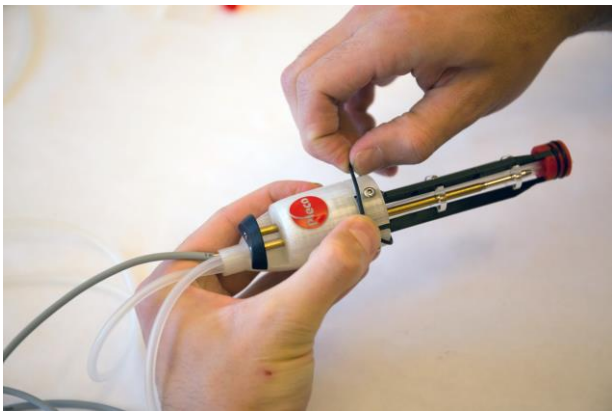
3.3
Put the push-button onto the visible ends of the electrode-holders and fasten it with the two M2 screws.



3. ASSEMBLING THE PISTON AND THE COVER



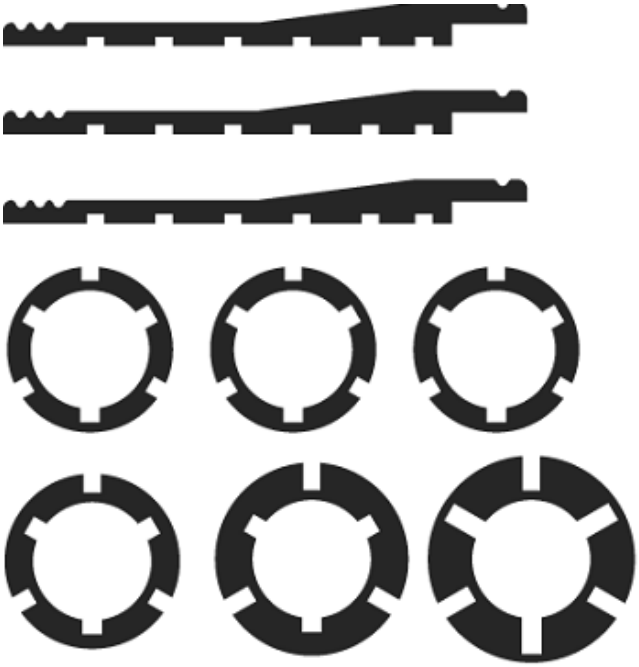
3.4
Place the O-ring on the groove of the cover. This step could be made prior to installing the cover.

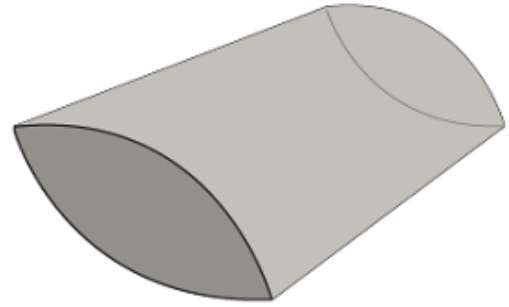


4. ASSEMBLING THE CASING

Contents of the sachet labelled "casing":

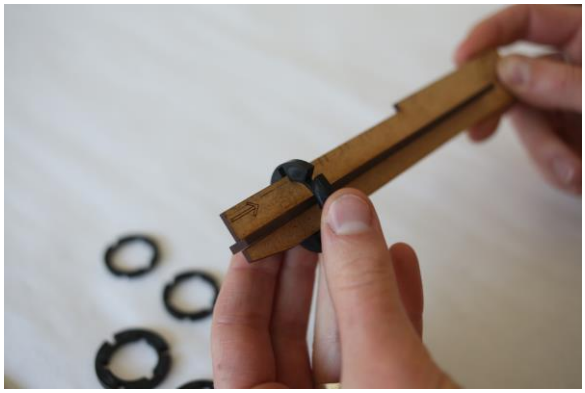
3 x black frames
6 x black rings
1 x transparent heat-shrink tube
2 x MDF timber elements



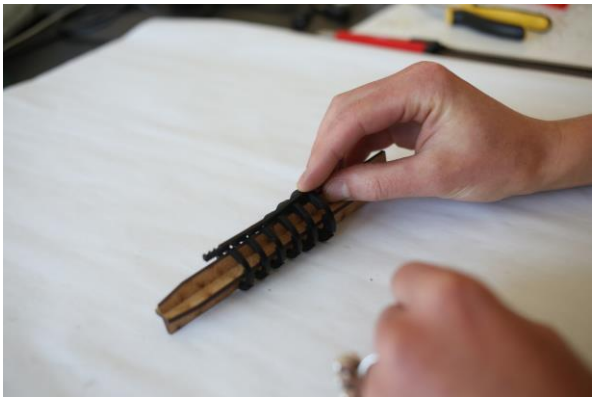


4. ASSEMBLING THE CASING

4.1
Slot together the 2 MDF timber elements to make the casing assembly jig. Slide the black rings over the assembly jig, ensuring that one of the notches in the rings fits onto the MDF element marked with the arrow. Start with the largest ring and position it on the first mark at the top of the casing assembly jig. Continue sliding the other rings into place; in order of their decreasing size.

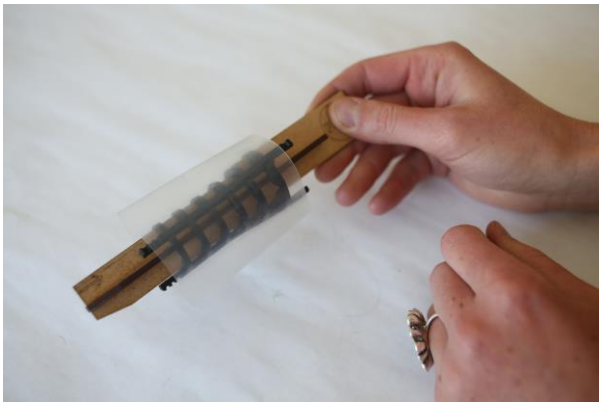
4.2
Gently install one of the black frames. It is recommended to start by fixing the upper notch of the frame with the larger ring and to finish with the lower notches.

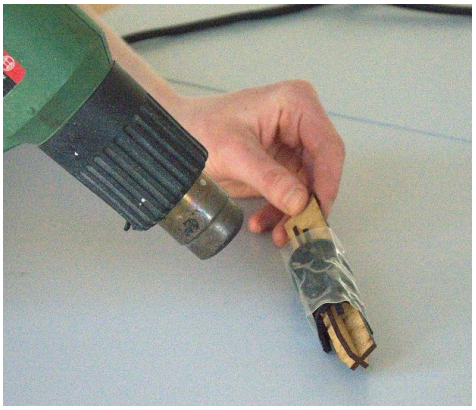
4.3
Install the two other frames in the same way. Check with your finger that the whole structure is in place; internally and externally. The surfaces between the frames and the rings should be flush with each other.


4. ASSEMBLING THE CASING

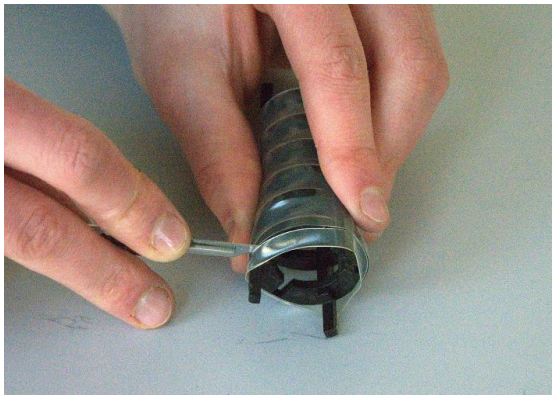
4.4
Insert this structure into the transparent heat-shrink tube. Ensure that it is positioned in the middle, with respect to both the length and width.



4.5
Heat the tube with a hot air gun (between 250 and 300°C), while continuously rotating the casing. **Do not overheat the heat-shrink tube that could fuse the notches of the black frames and make the insertion of the casing on the piston more difficult.**

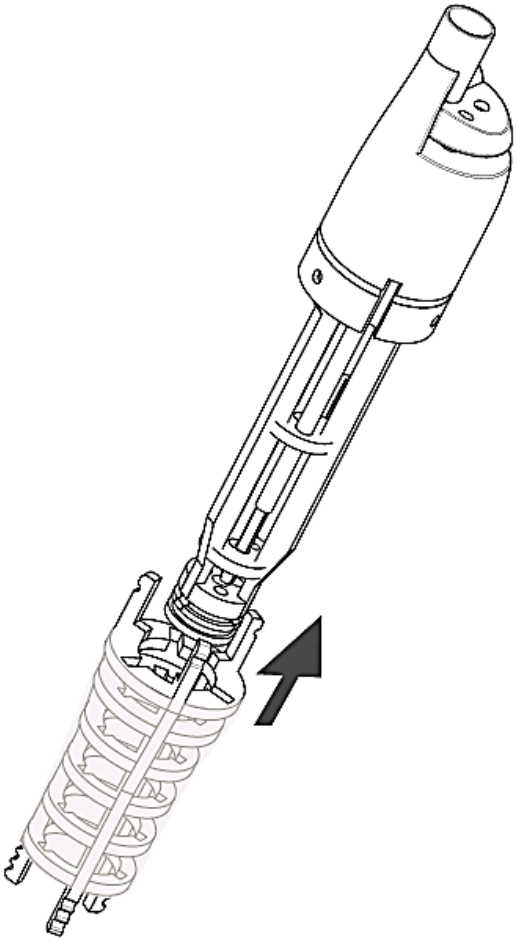


4.6
Once the transparent tube has contracted, trim the surplus from each end with a scalpel or cutter.



5. ASSEMBLING THE PISTON AND THE CASING

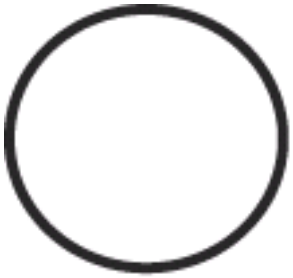
5.1
Slide the casing along the piston-assembly. Check that the upper ends of the casing framework are inserted into the notches beneath the O-ring on the cover.

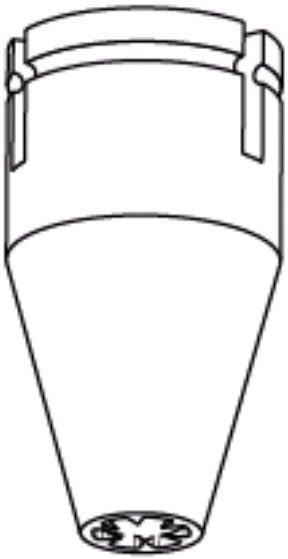


6. ASSEMBLING THE NOZZLE

Contents of the sachet labelled "nozzle":

1 x nozzle
1 x O-ring
1 x pad



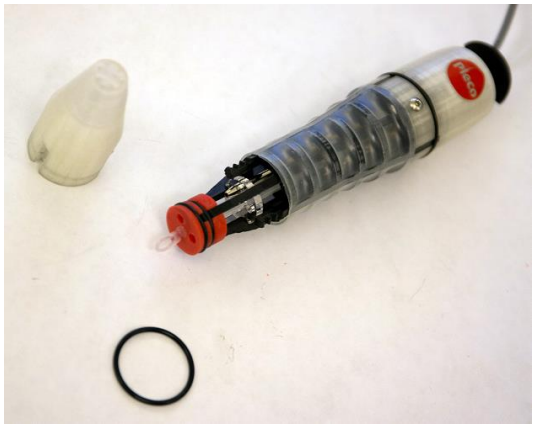


REMARK

Check the printing quality of this component according to the document fabrication instructions of the printed components of the Pleco available on the website under the Download tab.

6. ASSEMBLING THE NOZZLE

6.1
Install the O-ring into the groove in the nozzle.



6.2
Place the nozzle over the bottom of the piston, making sure to keep both components aligned. **If the adjustment piston head / nozzle is too tight, the inside of the nozzle must be wetted with water.** The lower ends of the black frames in the casing are inserted under the O-ring. They might have to be raised to properly position the nozzle.

Remark:
It is during this step that we control the proper dimensions of the piston head and the nozzle. If the adjustments are too tight, the piston head might get detached when the nozzle is removed. **The addition of PTFE tape (Teflon) around the piston head facilitates the insertion and the removal of the nozzle while at the same time improving the waterproofness.**

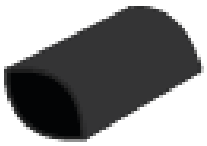
Additional accessories:
The kit contains some cell enlargement rings to increase the volume of the electrolytic cell (interior part of the nozzle). These rings are inserted during the assembly of the nozzle.

6. ASSEMBLING THE NOZZLE

6.3
The foam pad is inserted into the end of the nozzle. Beforehand, a slit is cut across the diameter of the pad and the pad is then wetted. To insert the pad into the nozzle it must be squeezed. Care should be taken to insert the end of the electrodes (counter-electrode and reference electrode) into the prepared slit in the pad.

7. INSTALLATION OF THE SHEATHES FOR THE CABLES AND ELECTROLYTE CIRCULATION HOSES

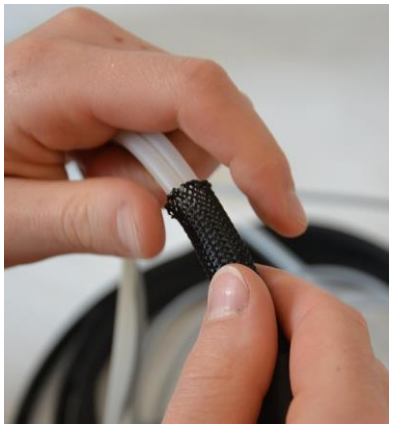
Contents of the sachet labelled “sheath”:



1 x small black heat-shrink tube
1 x braided sleeve

7. INSTALLATION OF THE SHEATHES FOR THE CABLES AND HYDRAULIC HOSES

7.1
Slide the heat-shrink tube along the braided sleeve, and insert the electrolyte circulation hoses and the electric cable into the braided sleeve. If the extremities of the braided sleeve fray, the flame of a lighter should be used to fuse the sleeve.
Tip: The braided sleeve can easily be twisted to enable the insertion of the hoses and the electric cable. The task remains tedious though.

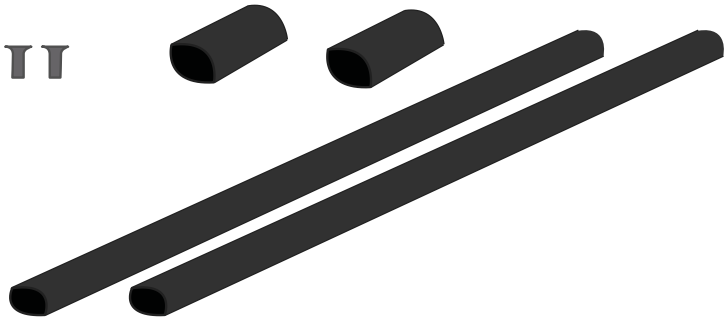

7.2
Once the hoses and electric cable are inside the braided sleeve, slide the latter over the tip of the cover, to the middle of the groove. Place the black heat-shrink tube so that it overruns of a few millimeters over the cover. This will ensure a proper fit in preparation for the heating to follow. Use the tweezers to pull the black heat-shrink tube into place.

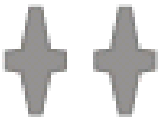

7.3
Heat the black heat-shrink tube with the hot air gun. Maintain the gun at a certain distance from the sleeve not to fuse it as well as the resin of the cover.


8. FINAL HYDRAULIC AND ELECTRIC CONNECTIONS

Contents of the sachet labelled "final connections":

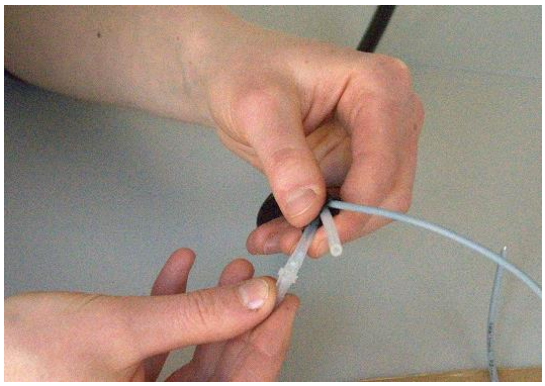
2 x mini electric connectors
2 x hydraulic connectors
2 x banana plugs (white and brown)
2 x heat-shrink tubes (20 cm)
1 x heat-shrink tube (3 cm)



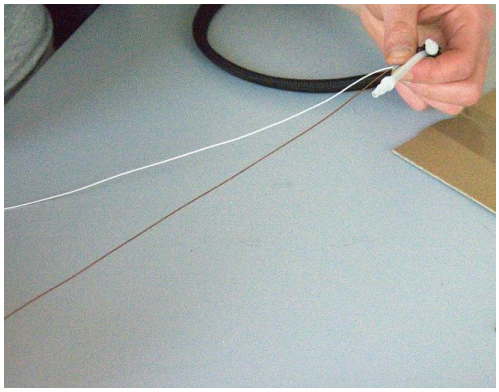


8. FINAL HYDRAULIC AND ELECTRIC CONNECTIONS

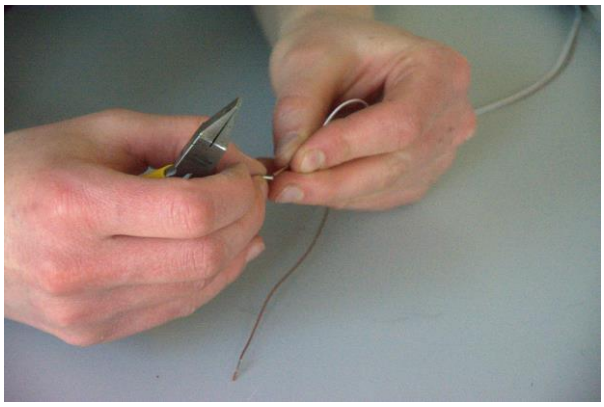
8.1
Insert the hydraulic connectors into the ends of the electrolyte circulation hoses.

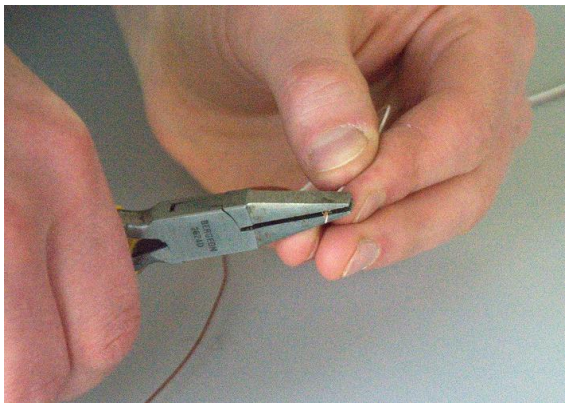


8.2
Strip 20 cm of the insulation from the electric cable (equivalent to the lengths of the heat-shrink tubes). To avoid damaging the wires, the external sheath must be cut superficially and separated.



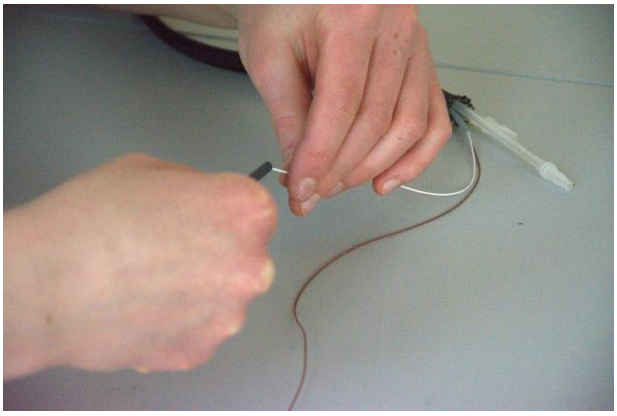
8.3
Strip 1 cm of insulation from the white and brown electric wires. Thread the mini-connectors onto the wires and position them close to the insulation. Squeeze the mini-connectors onto the wire with flat nose pliers.

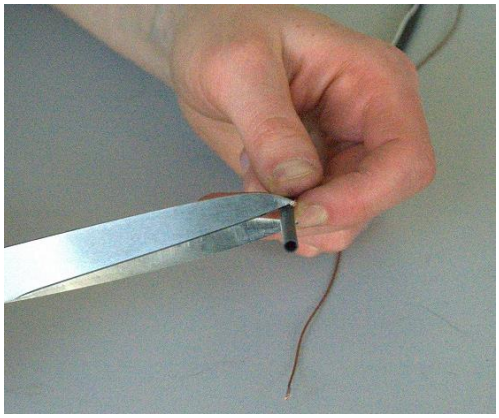




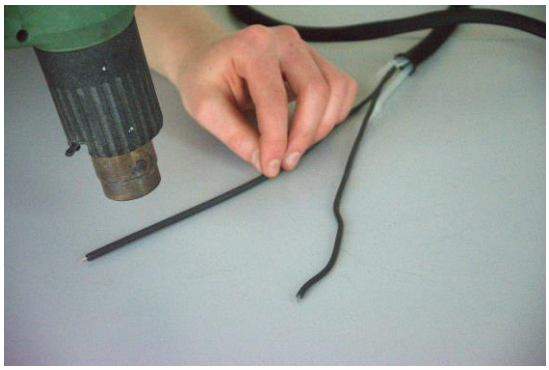
8. FINAL HYDRAULIC AND ELECTRIC CONNECTIONS

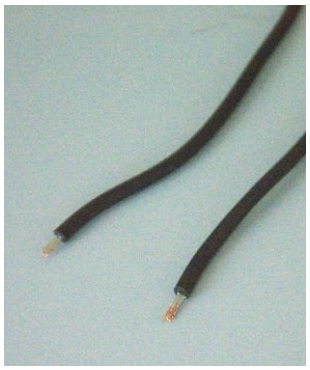
8.4
Slide the two 20 cm heat-shrink tubes onto each electric wire. Position the length of the heat-shrink tubes to reveal the connectors and the coloured insulation on the wires (for differentiation).





8.5
Heat the two heat-shrink tubes over the wires with a hot-air gun. Maintain the gun at a certain distance from the tubes not to fuse them. Slide the 3 cm heat-shrink tube to the junction of the two insulated wires and heat it.

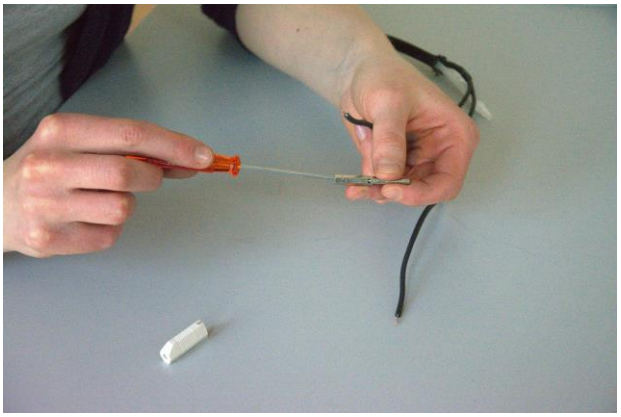
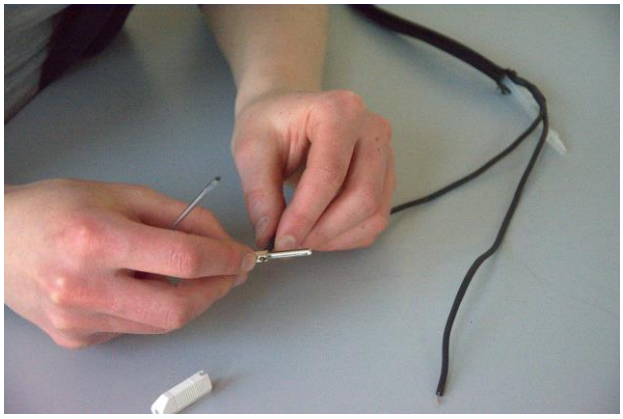
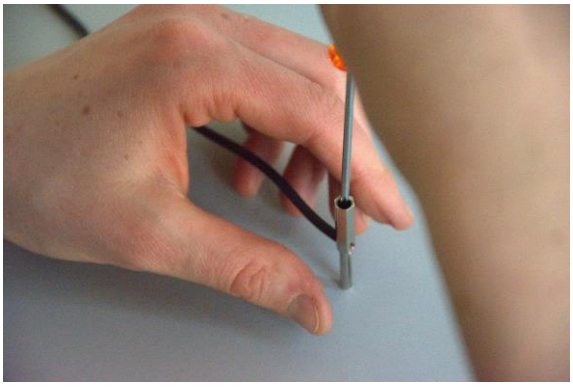
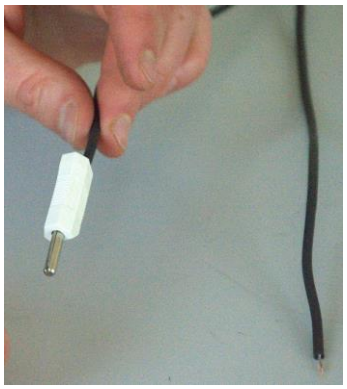
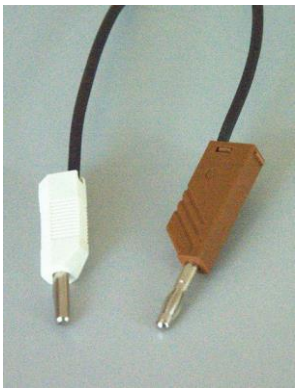




8.6
Slide and heat the second heat-shrink tube at the extremity of the sleeve braid to prevent it to fray with time.

8. FINAL HYDRAULIC AND ELECTRIC CONNECTIONS

8.7
To attach the wires to the banana plugs, first unscrew the fixing screw on each plug. Insert the wires in the banana plugs according to their corresponding colour. Re-screw the fixing screw and insert each connected banana plug into the plastic cover of the corresponding colour.

Your Pleco is now ready to use!!!