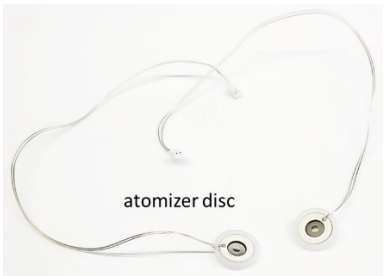


Nebulizer assembly instruction

Nebulizer

Materials	Qty
Glass plate 200 mm x 200 mm x 1 mm	1
Ultrasonic Piezo Atomizer Disc, Ø 16 mm, 108 kHz, 5 µm pore size	2
Ultrasonic Piezo Atomizer Disc, Ø 16 mm, 108 kHz, 11 µm pore size	2
JST PH2 Pin cable male header 2 pins, 20 cm	2
3D-printed nebulizer_base (PLA)	1
3D-printed nebulizer_extension (PLA)	1
3D-printed nebulizer_lid (PLA)	1
3D-printed nebulizer_atomizer_part-1 (PA12)	2
3D-printed nebulizer_atomizer_part-2 (PA12)	2
3D-printed nebulizer_atomizer_washer (PA12)	2



### 3D-print instructions

The PLA parts were printed on a Smooth PEI Steel Sheet with standard slicer settings; supports on build plate only for the extension.

The PA12 parts were printed on a PA Nylon Powder-coated Steel Sheet. A Textured Powder-coated Steel Sheet with glue stick can also be used. Slicer settings: 0.1 mm layer height, infill 15 % (gyroid), combine infill every 2 layers, top and bottom infill pattern concentric, no supports.

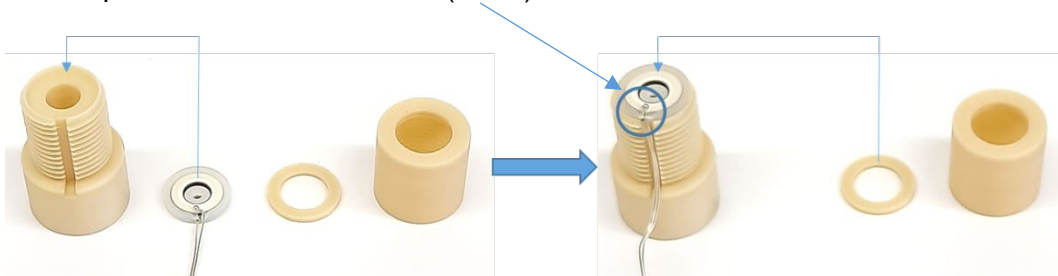
### Assembly instruction

- Insert the glass plate into the slit of the nebulizer\_base; clean the slit before from printing residues.

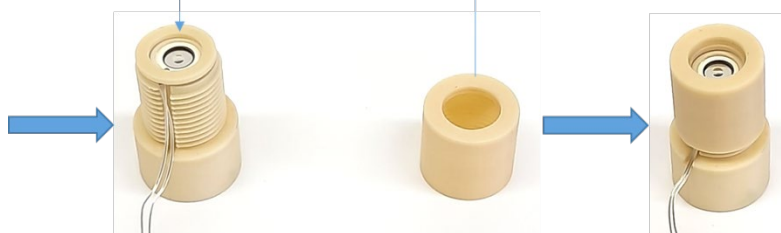


- Place the nebulizer\_extension on top of the nebulizer\_base, and the nebulizer\_lid on top of the extension.

- Insert the atomizer into the atomizer\_holder\_part-1, so that the solder pad and the wires point to the cable channel (circle).



- Place the washer onto the atomizer and tightly screw the atomizer\_holder\_part-2 onto the part-1. Be careful guiding the wires and do not pull on the wires!



- Insert the mounted atomizer holders into the round cutouts of the nebulizer\_lid.



The atomizers can simply be connected to the 2LabsToGo-Eco mainboard.

- Connect two JST PH2 Pin cables to the respective plug to be inserted into the mainboard.
- Connect the atomizer discs to the JST headers.

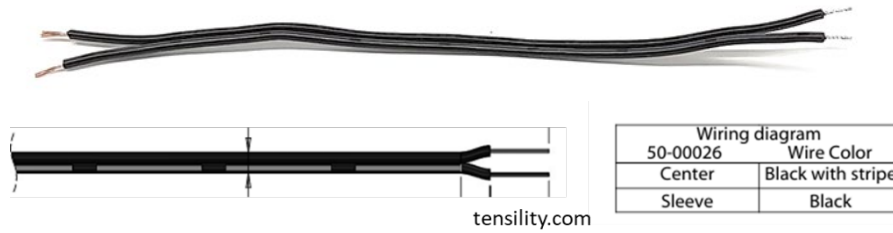


## Exhaust unit

Materials	Qty
Glass bottle, 250 ml, GL 45 screw cap	1
Micro Vacuum Pump, 12 V	1
Silicone tube, 4 mm x 6 mm, 1 m	1
Hose coupling, 4-5 mm tube	1
DC Chassis Mount Socket, 5.5/2.5 mm	1
Cable Assembly, 2.5mm ID, 5.5mm OD, Plug to Wire Leads (1.83m)	1
Extension spring, 30 mm => 80 mm	1
3D-printed nebulizer exhaust-unit base	1
3D-printed nebulizer exhaust-unit pump-holder	1
3D-printed nebulizer exhaust-unit lid	1
3D-printed nebulizer hose mount	1

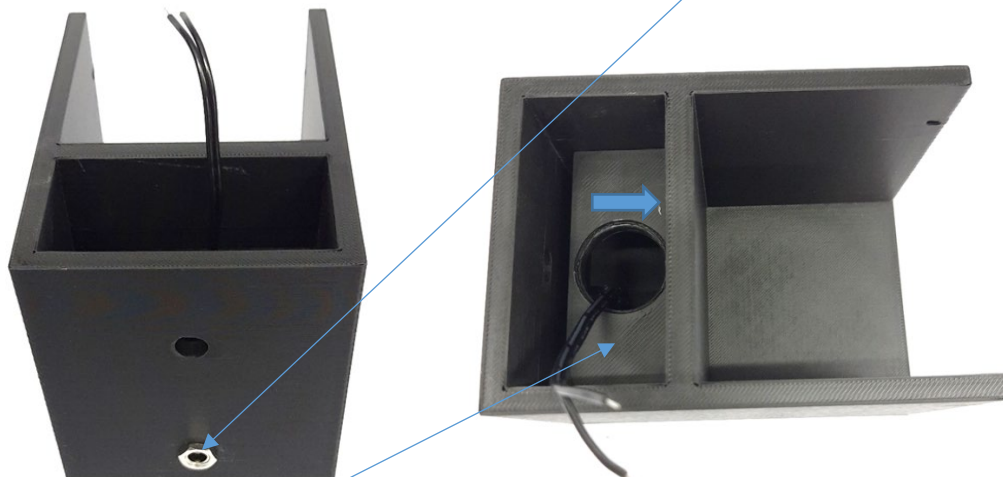


- From the end of the cable assembly, cut 15 cm and strip 5 mm from both wires. The black wire with the stripes is (+).



[The rest of the cable assembly is used for the control unit.]

- Solder the black wire with the stripes (+) to the center pin of the DC Chassis Mount Socket and the black wire to the sleeve (-).
- Insert the socket from inside the exhaust-unit\_base into the round cutout near the bottom and fix it with the screw.

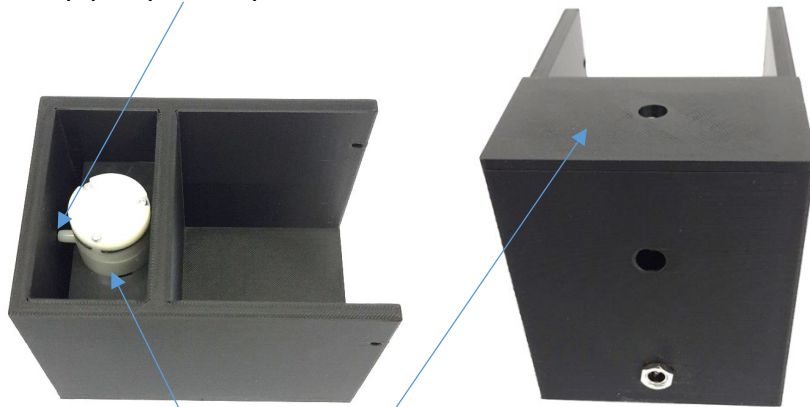


- Insert the pump-holder into the exhaust-unit\_base and push it down and towards the middle wall while guiding the wires through the hole upwards.



- Place the vacuum pump top-down into the exhaust-unit\_base and solder the two wires to the solder tags. There is a red mark on the pump (circle) marking + (wire with the stripes).

- Insert the vacuum pump into the pump-holder while guiding the wires under the pump-holder.  
The vacuum pump outlet points to the round cutout on the left side.

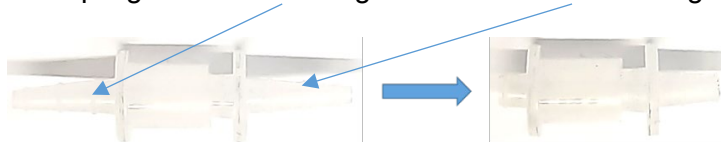


- Fix the pump with two drops of glue on both sides.
- Press the lid onto the exhaust\_base.

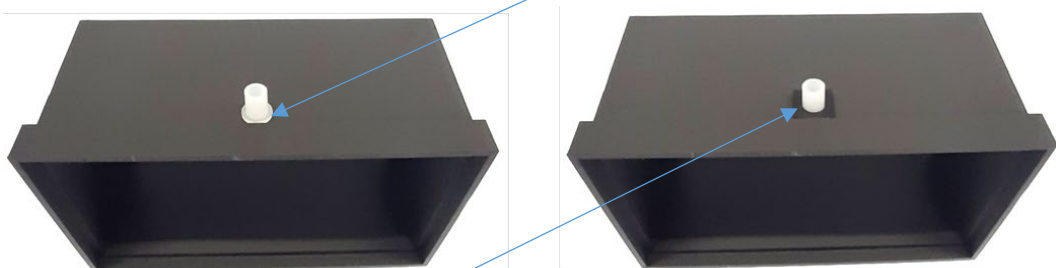
- Drill two holes of 6 mm into the screw cap of the 250-mL bottle, and screw the cap onto the bottle.
- From the silicone tube, cut 30 cm; press one end onto the out-port of the vacuum pump and guide the other end through the cap to the bottom of the bottle. For the use, fill 100 mL of water into the bottle.
- Connect the rest of the silicone tube to the in-port of the vacuum pump.



- Cut the hose coupling after the first ring and after the second ring of the olives.



- Disconnect the hose coupling and press the short olive into the round cutout on the back of the extension.



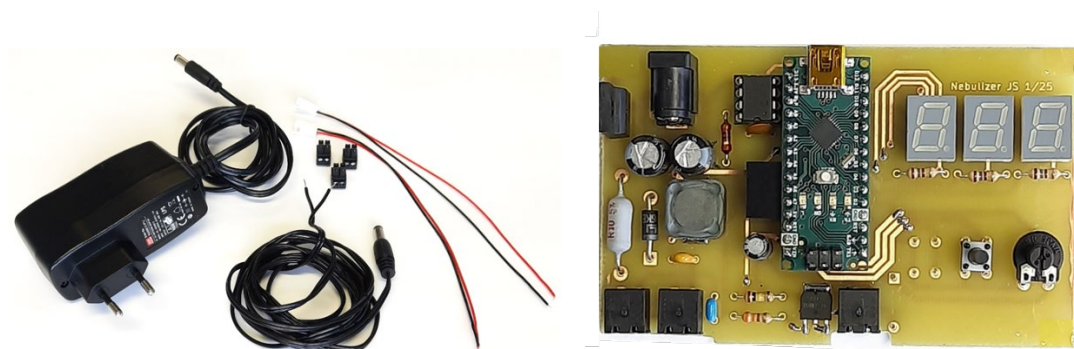
- Glue the 3D-printed hose\_mount onto the extension to fix the hose coupling [polypropylen cannot be glued directly].
- Connect the long silicone tubing to the other part of the hose coupling.  
This way the exhaust unit can be connected/disconnected to/from the nebulizer.

The exhaust unit (vacuum pump) can separately be powered by a 12 V (1 A) power supply or by using the Control unit described next.



## Control unit – stand-alone use of the nebulizer

Materials	Qty
Electronic board	1
M3x10 screws, DIN 912	3
Self-adhesive rubber feet	4
2-Position terminal block	3
Power supply 12 V, 1.5 A, plug 2.5 mm x 5.5 mm	1
3D-printed nebulizer board housing	1
3D-printed nebulizer board housing bottom	1



The cable assembly, 2.5mm ID, 5.5mm OD, Plug to Wire Leads (1.83m) was already listed for the exhaust unit, and the JST PH2 Pin cables male header 2 pins, 20 cm, were already listed for the nebulizer.



### 3-D Printing instruction

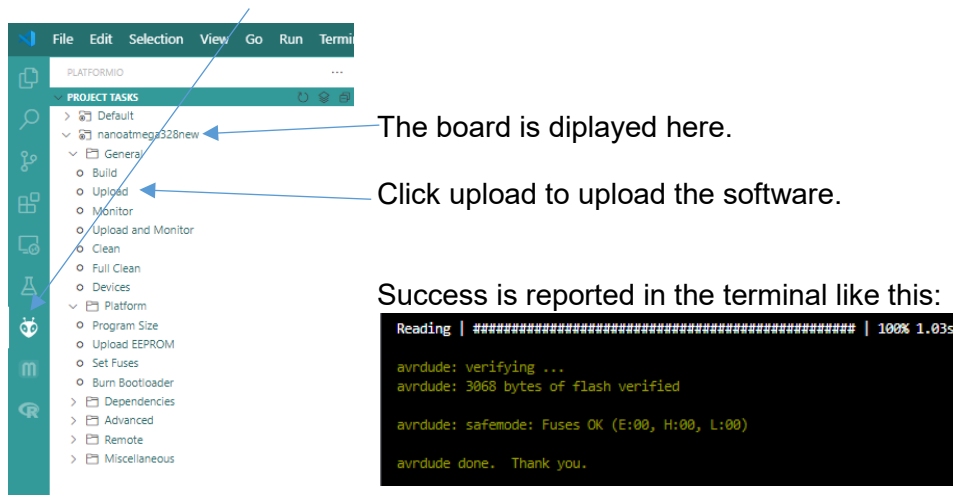
The 3D-parts were printed with PLA and standard printer settings. The housing needs support material everywhere, but the support should be blocked in the three screw holes of the nebulizer\_board\_housing.

### Uploading the software

- Download the GitHub repository <https://github.com/OfficeChromatography/Nebulizer> and unzip the downloaded file.

The easiest way to upload the software onto the Arduino nano is to use Visual Studio Code, freely available at <https://code.visualstudio.com/download>.

- Connect the board by an “USB 2.0 A-Male to Mini-B cable” to a PC and wait to be recognized.
- Start Visual Studio Code and, in the File menu, open the unzipped folder “Software”.
- Wait until the PlatformIO processes are finished.
- Click the PIO button.



The board is displayed here.

Click upload to upload the software.

Success is reported in the terminal like this:

```

Reading | ##### | 100% 1.03s
avrduide: verifying ...
avrduide: 3068 bytes of flash verified

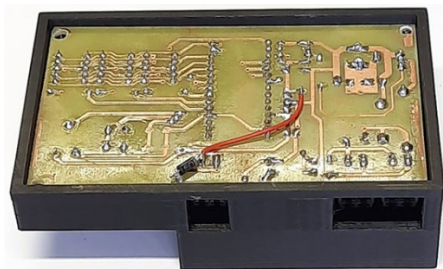
avrduide: safemode: Fuses OK (E:00, H:00, L:00)
avrduide done. Thank you.

```

- Disconnect the board.

## Assembly

- Place the electronic board inside the nebulizer\_board\_housing.

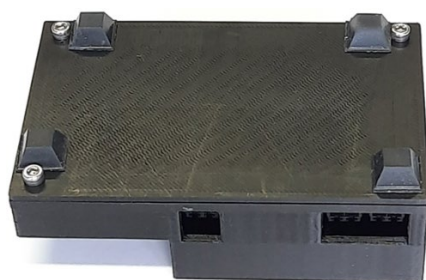


[The red wire and the diode on the board as shown here were from the development phase and are not present in the final board.]

- Place the bottom plate onto the housing and drill (3 mm) marks through the three holes into the board.

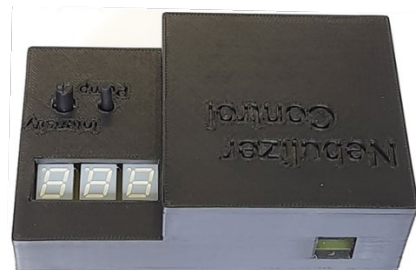


- Remove the board from the housing and drill (3.5 mm) three holes into the board, as shown in the image above.
- Insert the board again into the housing and mount the bottom plate with three M3x10 screws.
- Fix the four self-adhesive rubber feet onto the bottom plate.



Ports for the atomizers

12 V port for the exhaust unit



12 V port for the power supply

- Connect each JST PH2 pin cable to a 2-position terminal block (polarity does not matter for the atomizers).



- Connect the rest of the cable assembly (2.5mm ID, 5.5mm OD, Plug to Wire Leads) to a 2-position terminal block (polarity important).



- Insert the terminal blocks into the respective ports of the board (s. images above).
- Connect the 2.5 mm x 5.5 mm plug of the cable assembly to the exhaust unit.
- Connect the 2.5 mm x 5.5 mm plug of the 12 V power supply to the board.

## Operation

- Place the HPTLC plate under the nebulizer.
- Connect the board to power.
- Turn the knob for intensity on the control unit counterclockwise until the display shows zero.
- Connect the atomizers to the JST PH2 pin cables.
- Fill in the same volume of reagent for nebulization into both atomizers.
- Turn the knob for intensity clockwise to reach the desired nebulization intensity.
- After the nebulization is finished, turn the knob for intensity again to zero.
- Let the fumes settle down for some minutes.
- Start the exhaust unit by pressing the knob for the pump on the control unit.
- Stop the exhaust unit by pressing the pump knob again.



- Take off the HPTLC plate.
- Clean the atomizers by rinsing inside and outside followed by nebulizing a suitable solvent onto paper towels.
- Disconnect the atomizers, take them out of the nebulizer and dry them inside and outside with a paper towel.
- Clean the nebulizer parts with water and methanol or ethanol. Do not use acetone!

### Adjusting the frequency for a different atomizer

- Open the file main.cpp (folder src) with visual Studio Code and scroll down to this section:

```
void setup(){
  noInterrupts();
  TCCR2A =
    1 << COM2A0 |
    1 << WGM21;
  TCCR2B =
    1 << CS20;
  DDRB =
    1 << DDB3; // PWM pin D11 (PB3) as output
  OCR2A = 73; //this value must be changed for a different atomizer's frequency
  interrupts();
}
```

### Calculating the value for OCR2A

For example:

CPU frequency = **16000000** Hz (16 MHz), Arduino nano V3.x

atomizer frequency = 116 kHz

2 \* atomizer frequency (toggled 50 %) = 232 kHz = **232000** Hz

$$OCR2A = \frac{16000000}{232000} - 1 = 67.96551724 \approx \mathbf{68} \text{ (must be integer)}$$

Check:

$$\text{adjusted atomizer frequency} = \frac{16000000}{68 + 1} = 231884.058 \text{ Hz} = 231.88406 \text{ kHz}$$

$$\text{divided by 2 (50 \%)} \Rightarrow \text{resulting frequency} = 115.94203 \text{ kHz}$$

- Exchange the value 73 by the new value 68.
- Save the file and upload the software.