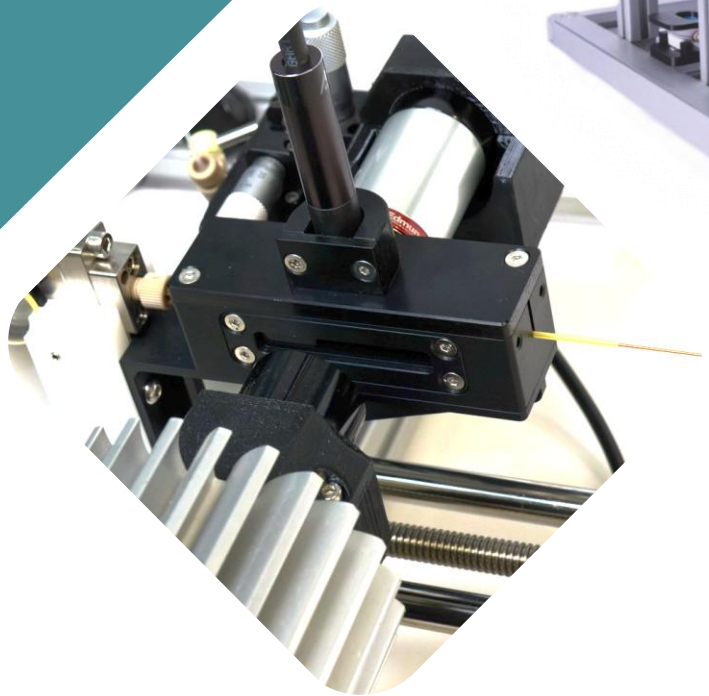
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UV Module for RayDrop Platform
User Manual





Ref: UVM0523/6

UV Module for RayDrop Platform

Table of Contents

1 Safety precautions 2

2 UV module description 3

3 Using the UV module with the RayDrop 4

3.1 Standard RayDrop operation 5

3.2 Operating RayDrop with the glass output capillary 7

3.3 Operating RayDrop with the UV-LED 11

4 Destabilized capsule production 13

Annex - UV module installation 14

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1 Safety precautions

Only trained personnel should be allowed to use this equipment.

Operators must comply with the safety information in all sections of the RayDrop Platform manual.

The user manual must be read and fully understood by the responsible specialist personnel/operators prior to use.

The contents of the user manual must be available at all times to the specialist personnel on site.

The operator is responsible for ensuring compliance with all local regulations not taken into account in this user manual.

Unattended operation of the platform should only be permitted after a thorough risk assessment has been performed, and with appropriate safety and monitoring measures in place.

Do not exceed maximum operating parameters.

Always wear appropriate personal protective equipment:


safety glasses


suitable gloves


lab coat

Pressure applied to the 50 mL test tube must not exceed 4 bar.

When using organic solvent, the platform must be used under a fume hood.

The UV light must be switched off before assembly or disassembly of the UV module.

When using UV light, the operator must wear UV-protective glasses and UV-protective clothing.

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2 UV module description

The UV-module is illustrated in Figure 1. It is composed of four parts:

1. The RayDrop holder
2. The output capillary holder
3. The UV-LED holder
4. The UV-LED

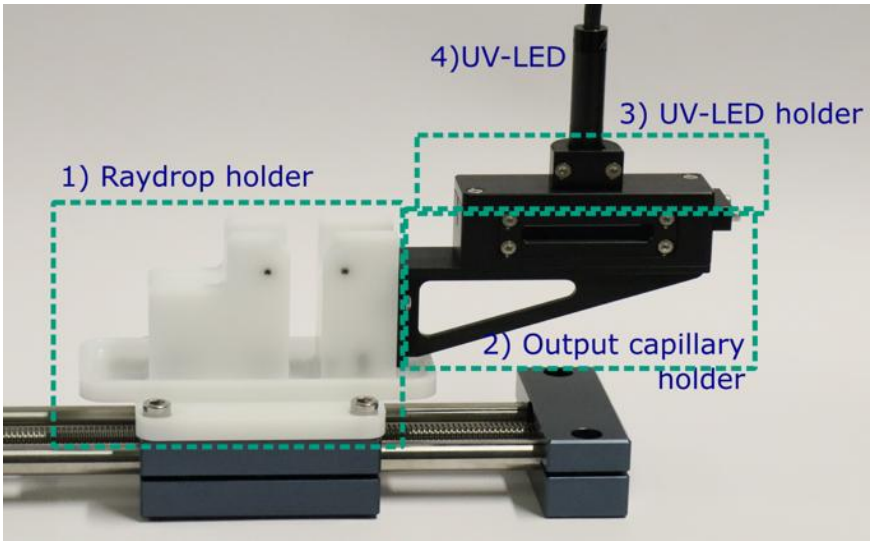


Figure 1: UV module overview

The RayDrop holder of the UV module is made of POM to improve its chemical compatibility. Two ball screws fix the RayDrop in a specific position to avoid any unwanted movement of the RayDrop when placed inside the RayDrop holder.
The output capillary holder supports the glass capillary and maintains it in a straight position with two clamps. These clamps prevent breakage of the output capillary by preventing any bending along the uncoated length where the glass capillary is most fragile. Once the clamps are in place, it is not possible to move the RayDrop without damaging the output capillary. Two UV-filtered windows (cut-on wavelength 50% T: 415nm) placed on either side of the output capillary holder allow users to visualize emulsion stability with the optical system with no risk of UV exposure to the user. The UV-filtered windows also prevent any undesired UV light from illuminating the glass capillary.

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The UV-LED holder holds the UV-LED in a vertical position above the glass capillary. It can easily be adapted to most common UV light sources.

3 Using the UV module with the RayDrop

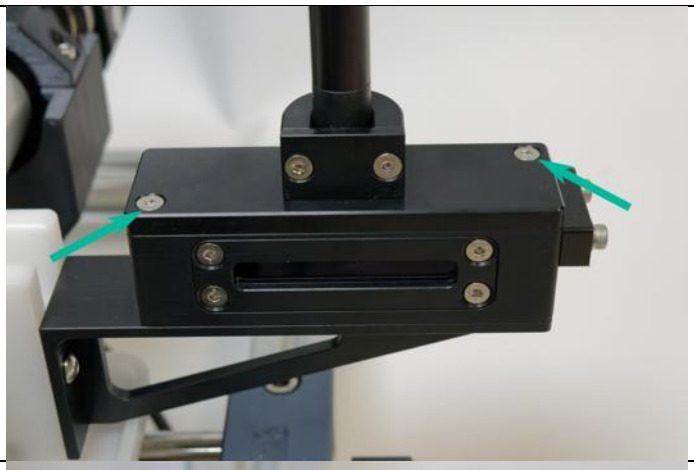
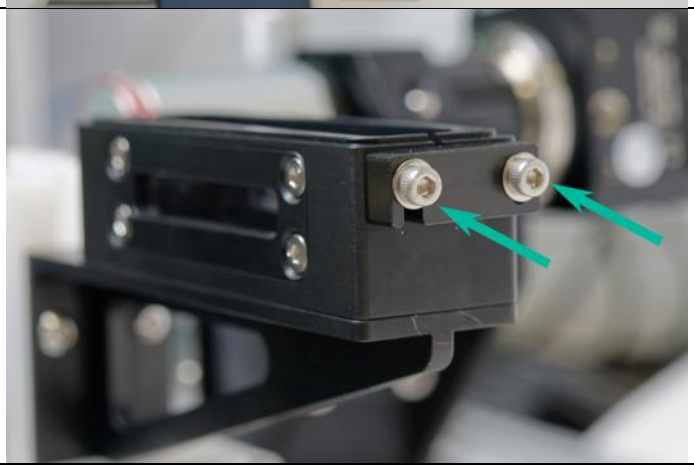
To minimize the risk of permanently clogging the glass output capillary, it is strongly advised to separate the UV process into the following steps:

1. Standard RayDrop operation:
    a. Prime the RayDrop and use the RayDrop with PFA tubing as the outlet tubing from the RayDrop. To familiarize users with the RayDrop's operation, it is important to use the RayDrop extensively for producing double emulsions with standard PFA tubing.
2. Operating RayDrop with the glass output capillary
    a. Replace the PFA output capillary with a glass output capillary.
    b. Install the clamps.
    c. Produce double emulsions without cross-linking material
3. Operating RayDrop with the UV-LED and glass output capillary
    a. Add the UV-LED holder with the UV-LED to the UV module
    b. Switch from the shell phase without cross-linking material to a shell phase with cross-linking material.
    c. Ensure that a stable double emulsion is being produced (stable flow rates, train of regularly spaced droplets inside the output glass capillary) by observing the emulsion through the UV-filtered windows.
    d. Once everything is stable, switch on the UV-LED.
    e. During production, always check that the production is stable. If the droplet train becomes unstable for any reason, see the section on "Destabilized capsule production".
    f. After production, switch off the UV-LED and switch the shell phase to solvent without cross-linking material to wash the tubing.
    g. After thoroughly rinsing the tubing, stop the flow.

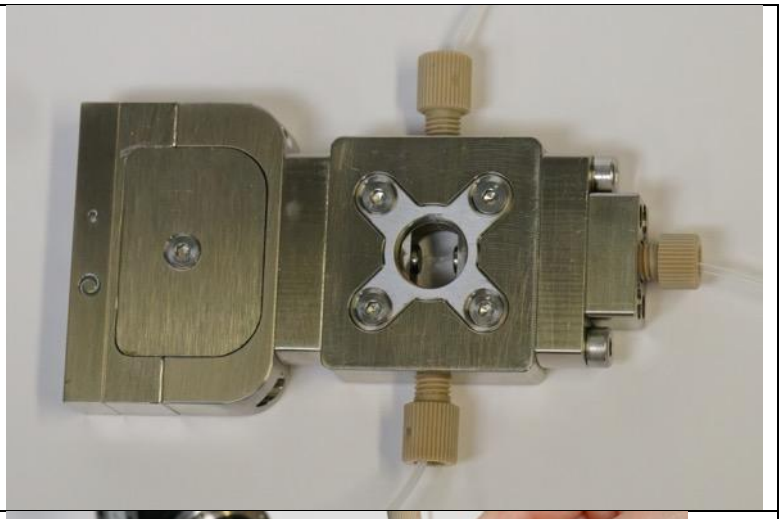
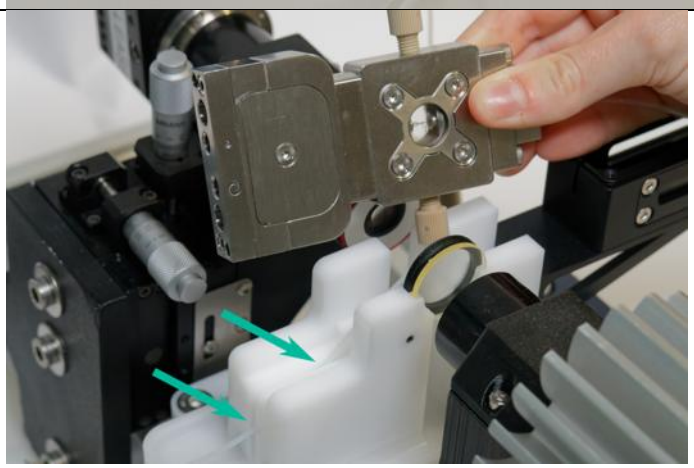
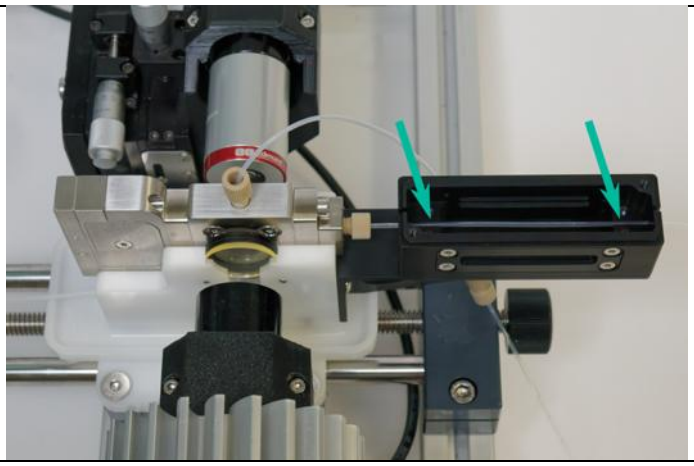
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3.1 Standard RayDrop operation

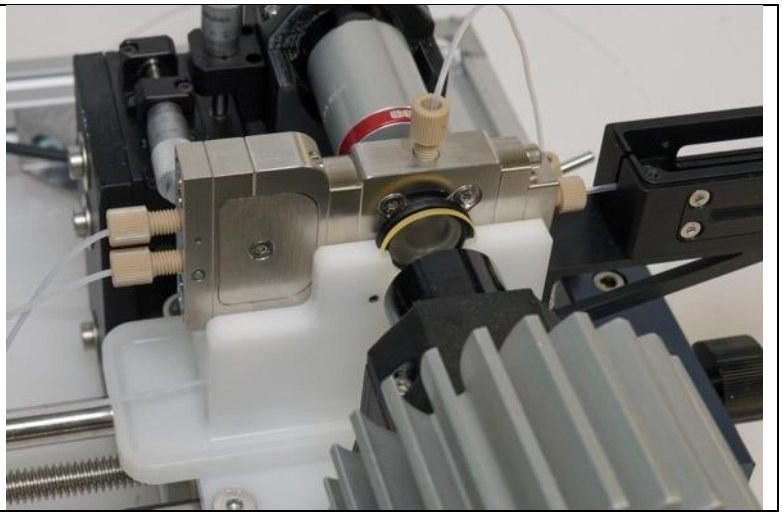
Important: For safety reasons, the UV-LED must be switched off during this procedure.

To place the RayDrop with its tubing in the UV module, remove the UV-LED holder by removing the 2 screws. Tool: 2mm Allen key	
Remove the clamps by removing the 4 screws. Tool: 2.5mm Allen key	
Remove the bending piece at the end of the UV module by removing the two screws. Tool: 2.5mm Allen key	

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Prepare the RayDrop by placing the continuous phase capillary, the purge and the collection capillary.	
Place the RayDrop in the RayDrop holder with the purge positioned at the top of the RayDrop, while keeping the continuous phase capillary in the groove. Note: in contrast to the standard RayDrop holder, the RayDrop can slide slightly along the X axis in the RayDrop holder of the UV module. However, two ball screws prevent the RayDrop from moving along the optical axis.	
Push the collection capillary into the groove of the output capillary holder.	

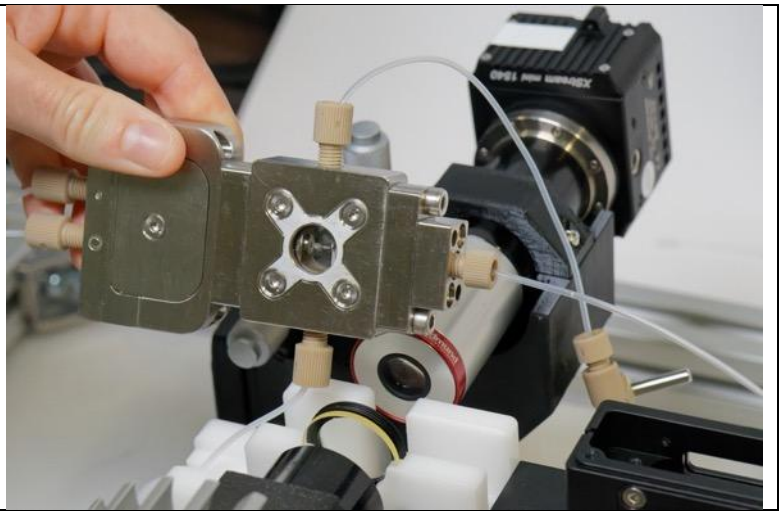
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Prime your system and connect the shell and core phase tubing.	

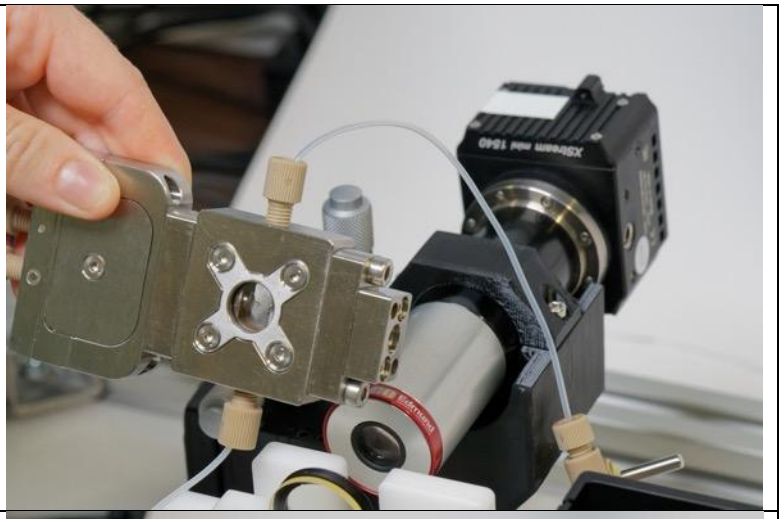
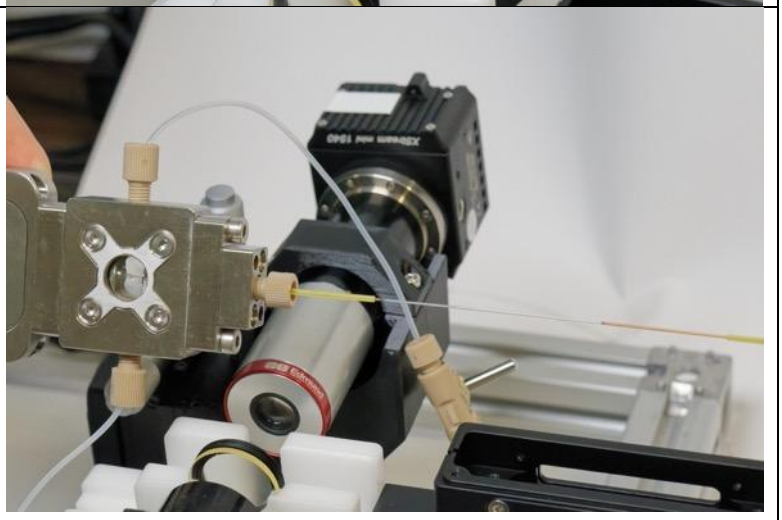
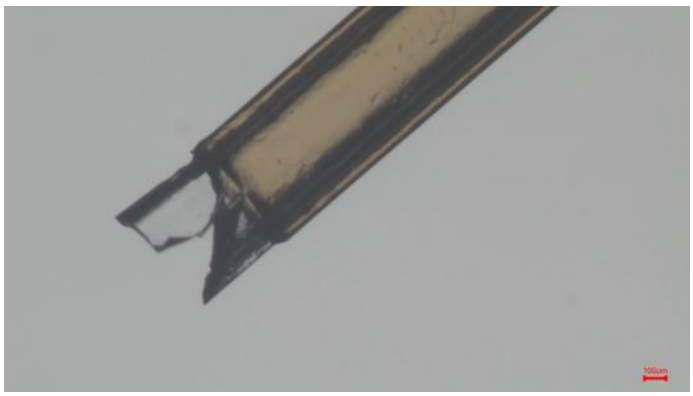
The platform can now be used to create emulsions with solvents that do not contain any UV-curing material.

3.2 Operating RayDrop with the glass output capillary

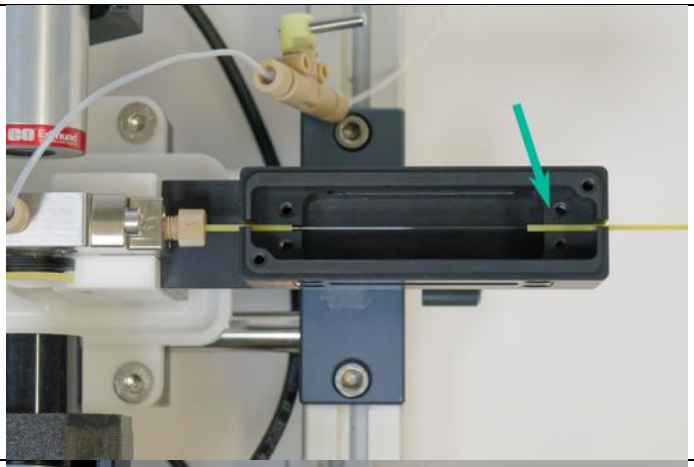
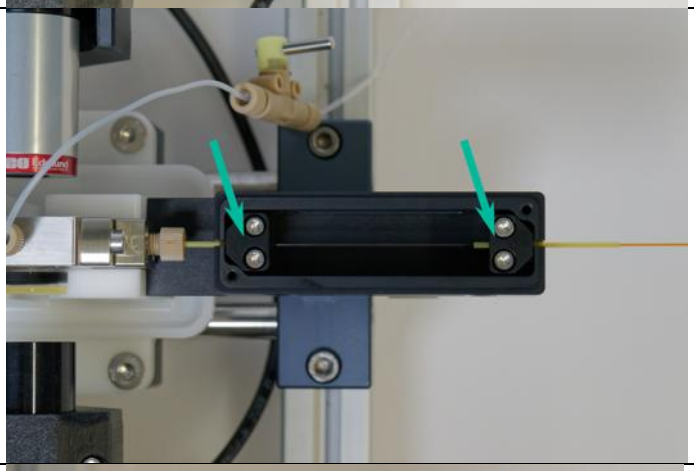
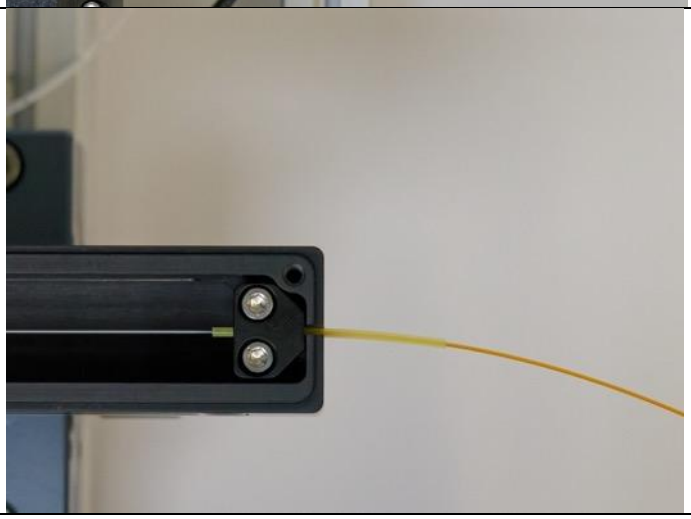
In the next step, the PFA output capillary is replaced by a glass capillary provided with the UV Module.

First, set the valves to the "waste to waste" position to prevent unintentional flow during handling, then set the system pressure to 0 mbar to stop the flow inside the RayDrop.	

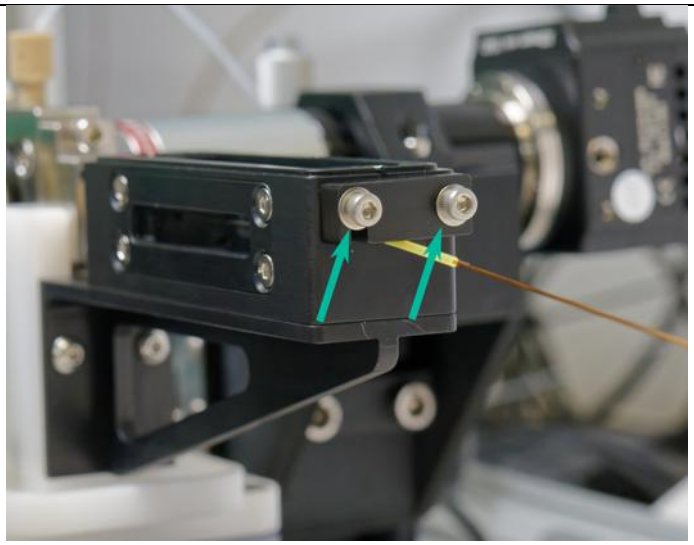
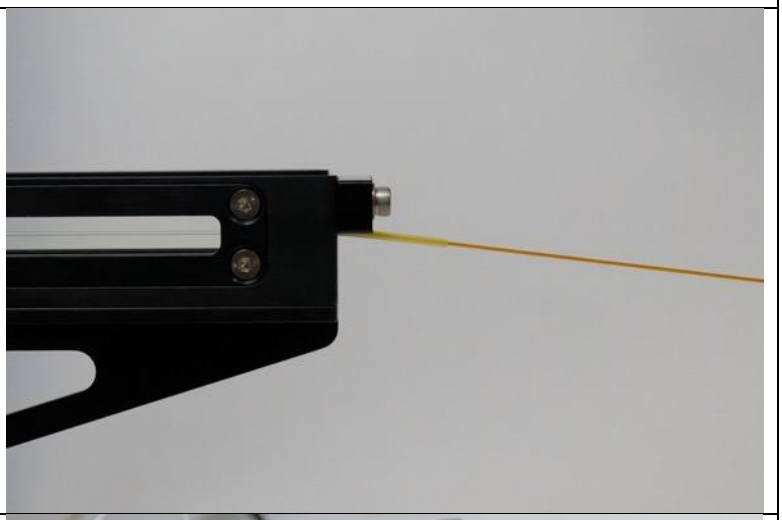
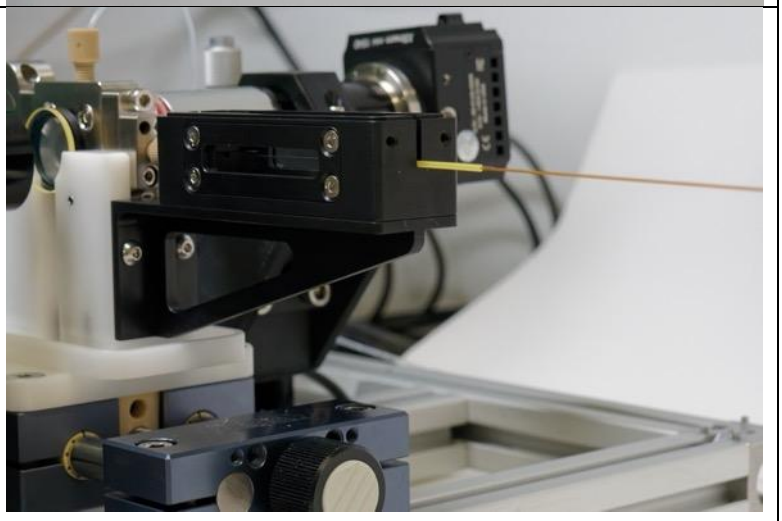
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Remove the PFA output capillary.	
Carefully place the glass capillary at the outlet of the RayDrop. Note: The uncoated part of the glass capillary is extremely brittle. Handle with care. Before placing the glass capillary, check under the microscope that the screw-on end is not broken. Note: A sleeve is used on the glass capillary to ensure it has the right diameter to fix the ferrule and the nut. If the sleeve is not set, the continuous phase will leak because the connection between the RayDrop and the capillary will not be watertight.	  Example of a broken end of a glass capillary

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Insert the RayDrop in the RayDrop holder and place the output capillary in the output capillary holder. Note: The yellow sleeve on the right must be placed in the groove.	
Set up the two clamps by tightening the four screws. Note: once clamps are set up, do not move the RayDrop from its position. Otherwise, the output capillary might be damaged. Tool: 2.5mm Allen key	
The clamps have two purposes: • Maintain the glass capillary in a specific position to ensure a repeatable process • Avoid any bending of the uncoated part of the output capillary, which is extremely brittle.	

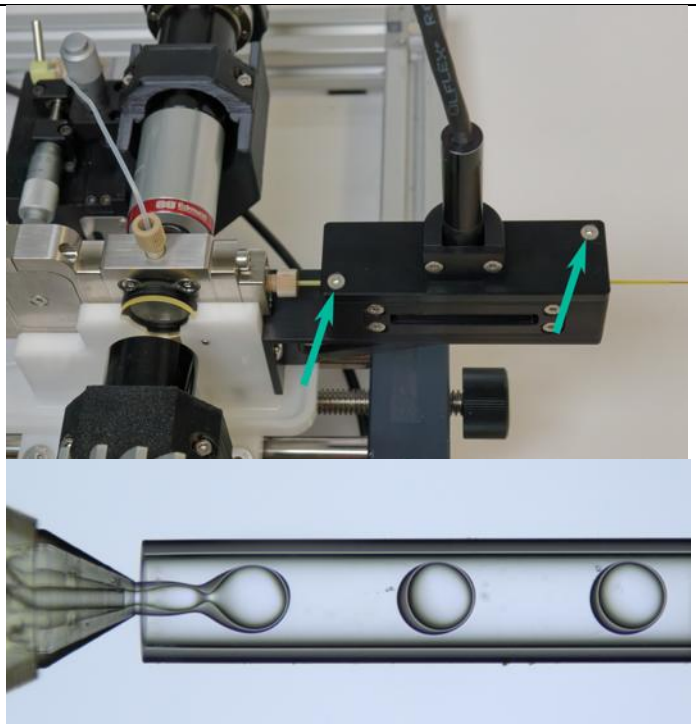
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Finally, you can place the “bending piece” at the end of the UV module if desired. Use it to slightly bend the output capillary toward the ground. Its purpose is to minimize the buildup of liquid at the exit of the output capillary. Note: The use of this piece is not mandatory. The decision to use it will depend on the way liquids are collected. Tool: 2.5mm Allen key	
Illustration of the output capillary slightly bent toward the ground through use of the “bending piece”.	
In this photo, the “bending piece” is not used.	

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Note: The RayDrop can now be used to produce double emulsions with solvents that do not contain any UV-curing material. It is strongly advised to use the RayDrop extensively in this operating condition before moving on to UV-curable resin.

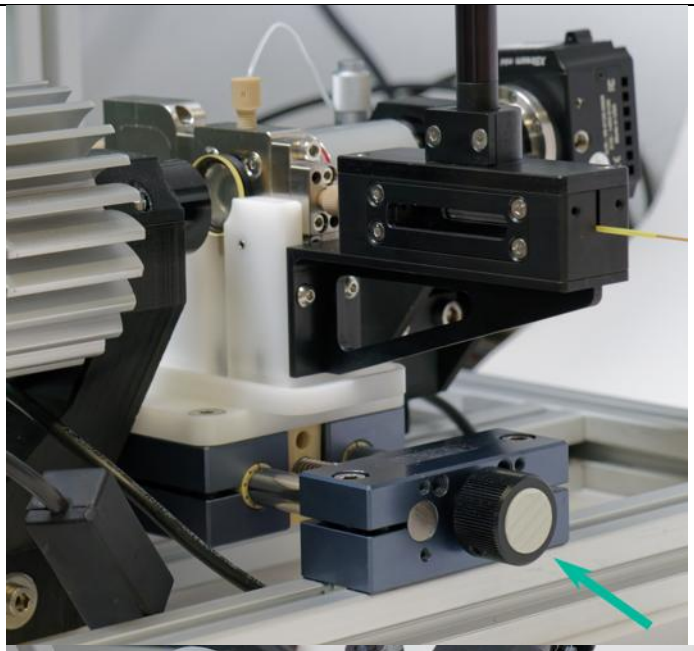
3.3 Operating RayDrop with the UV-LED

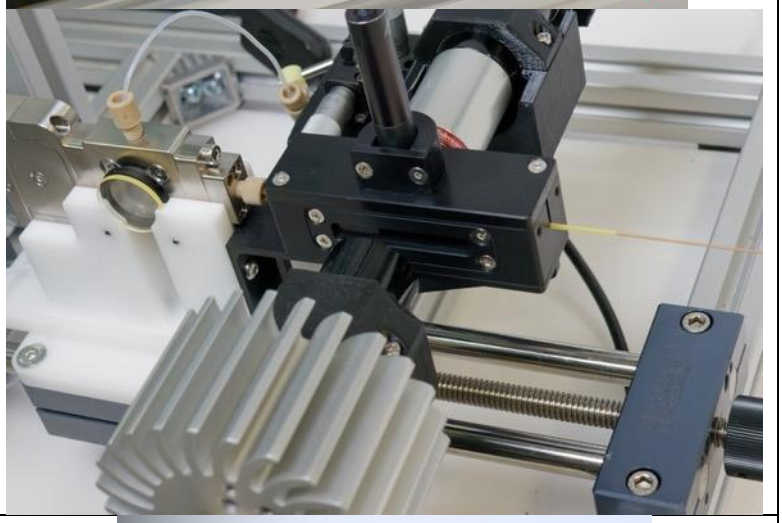
Replace the UV-LED holder and tighten the 2 screws. In this configuration, capsules can be produced with UV-curing material with no risk of unwanted cross-linking. Note: Do not start the UV-LED light as soon as you have a double emulsion production within the RayDrop. The train of capsules in the output capillary must be stable before starting the cross-linking process. Tool: 2mm Allen key	 View from the RayDrop holder

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To verify that the train of double emulsions is stable in the output capillary, move the UV module along the X-axis with the knob and place the output capillary window in front of the camera.

Note: The camera focus may need a slight adjustment.
Note: Adjust the flow rates to produce a stable train of capsules.





The double emulsion can be considered as stable when the space between droplets is regular and constant.

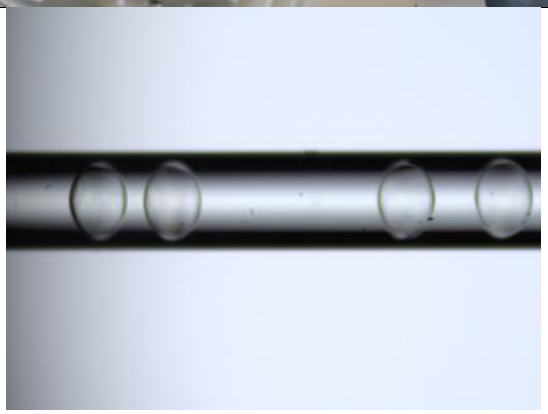


Stable train of droplets



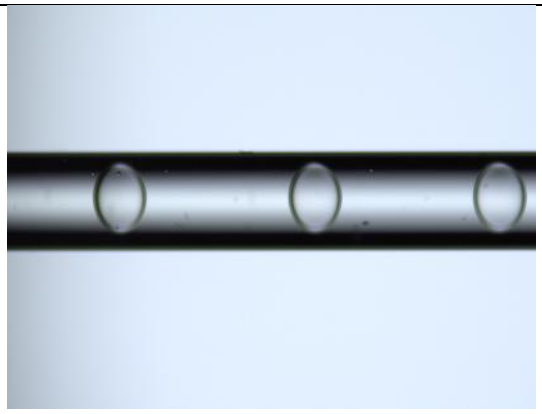
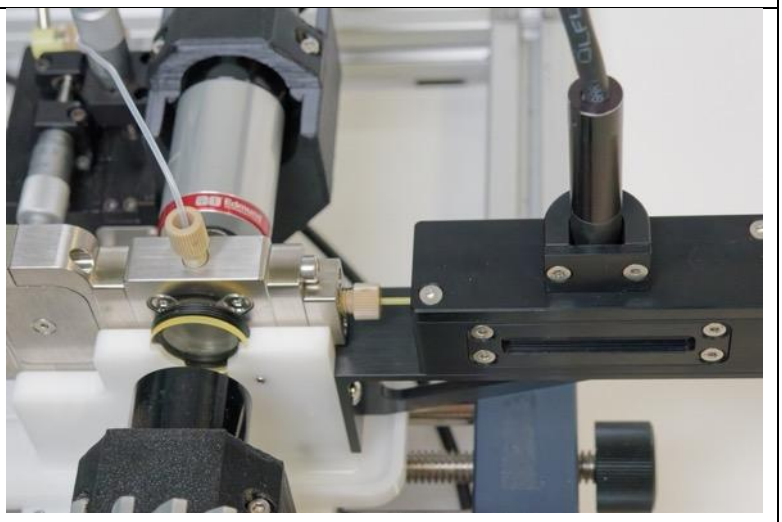
Instable train of droplets

To stabilize the droplet train in the glass outlet capillary, the flow rates must be adjusted. The flow rate of the core phase should be lower



Unstable train (view from the UV module)

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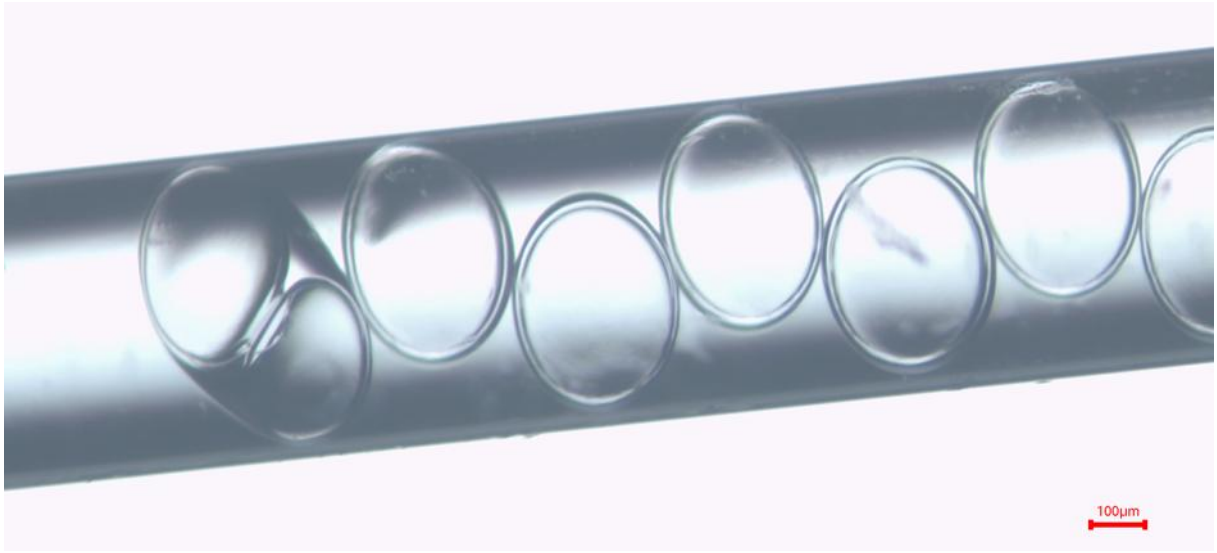
than the flow rate of the shell phase, but not too low to prevent droplets with double cores from being produced. If the double emulsion is still not stable when observed in the RayDrop outlet capillary after adjusting the shell and core flow rates, the flow rate of the continuous phase can be increased. This will reduce the size of the droplets, but the fluid velocity serves to regularize the space between droplets.	 Stable train (view from the UV module)
Once the train of droplets is stable, the RayDrop can be slid back in front of the camera to provide a visualization of the emulsification process. The UV cross-linking process can then be started by switching on the UV-LED. Note: Stable flow rates and stable double emulsion production must be established before switching on the UV-LED. Otherwise, cross-linking of coalesced capsules can occur, which will lead to the clogging of the output capillary. If this situation arises, please refer to 4. Production destabilization.	

4 Destabilized capsule production

If the flow rate varies and destabilizes the capsule production, the outlet tubing may become clogged.
If the outlet tube is clogged, turn off the UV lamp as soon as possible and immediately switch the shell phase valve from reservoir to waste to prevent the

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RayDrop chamber from filling with curable shell. For the same reason, switch the core phase valve to the “reservoir to waste” position.
In addition, the glass capillary must be changed quickly. To do this, remove the UV-LED holder by removing the 2 screws. Remove the clamps by removing the 4 screws, then remove the bending piece at the end of the UV module by removing the two screws. The glass capillary can then be removed from the UV module, unscrewed from the RayDrop and replaced with different tubing.
Once a different outlet tubing has been connected to the RayDrop, you must evacuate any cross-linkable shell that may be present in the RayDrop by pushing the continuous phase at a high flow rate (e.g., 400µL/min for 10 min).



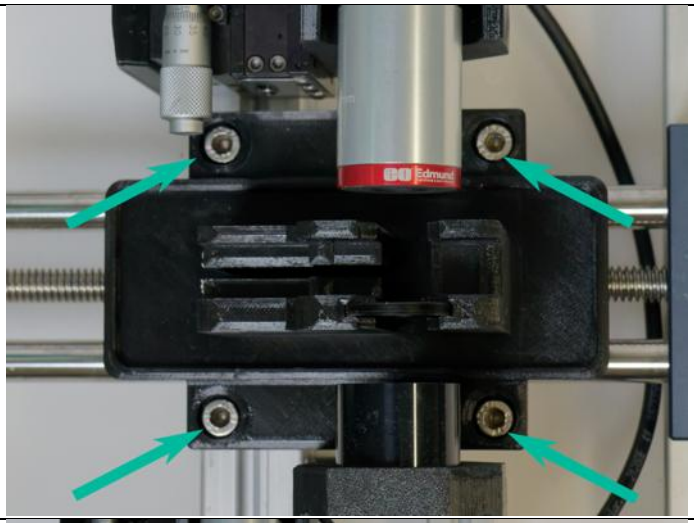
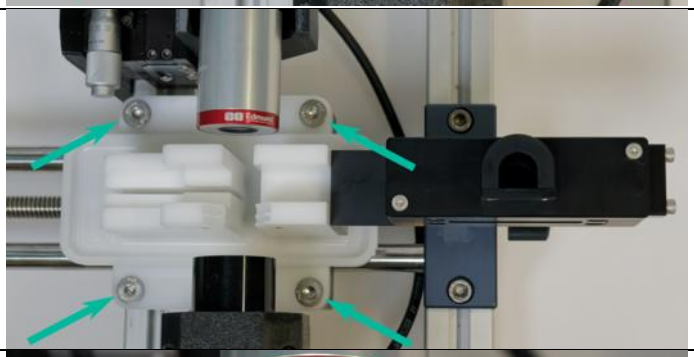
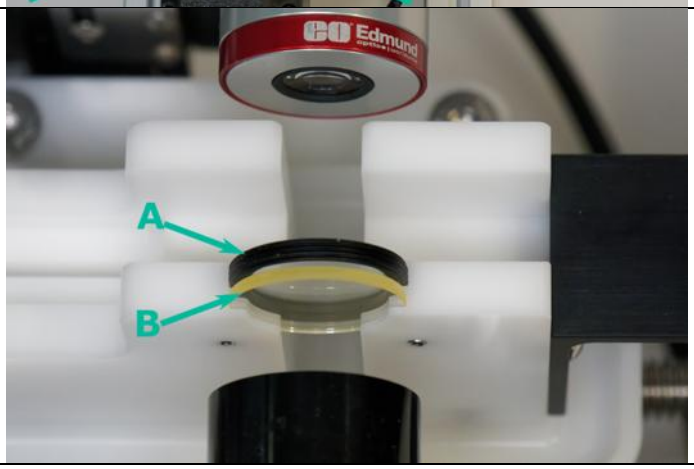
Example of a clogged glass capillary. Here the capillary was clogged by one droplet containing two cores instead of one.

Annex - UV module installation

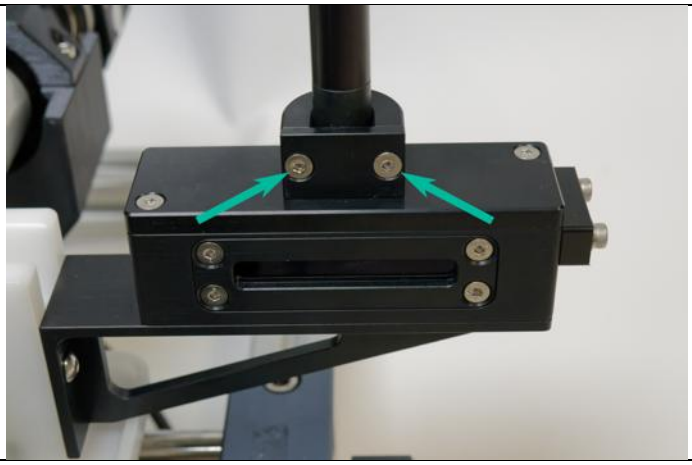
If you already have the Complex Emulsion Production or FACS Platform, it is possible to install the UV module. You will need 2.0, 2.5, 4.0 and 5.0 mm Allen keys. The following steps describe how to install the UV module:

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UV Module for RayDrop Platform

Remove the standard RayDrop holder by removing the 4 screws Tool: 5mm Allen key	
Place the UV module where the RayDrop holder was and tighten the 4 conical-head screws provided. The output capillary holder will extend past the base of the RayDrop Platform. Tool: 4mm Allen key	
Place the light diffuser (A) into the groove closer to the RayDrop. The light diffuser is provided with the RayDrop platform and should be in the groove of the standard RayDrop holder. Place the yellow UV filter (B) into the groove closer to the illumination LED. The yellow UV filter is provided with the UV module.	

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Slightly loosen the two screws and slide the UV-LED into the UV-LED holder. When it reaches the bottom of the UV-LED holder, tighten the two screws. Tool: 2mm Allen key	

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