Proteus Alpha Cell Product Information

A Brief Product Overview

Pine Research is pleased to offer the Proteus Alpha Cell. The Proteus Alpha is a versatile cell designed primarily for use with flat-sample corrosion-based measurements, or alternatively, for photoelectrochemical-based experiments. As a corrosion-based measurement cell, the Proteus Alpha design features an easy-to-use system that prevents the requirement of machining or purchasing custom sized flat electrode samples. This brief product overview will highlight the design features and specifications of the Proteus Alpha Cell.

1. Introduction

The Pine Research Proteus Alpha Cell is simple to use, quick to assemble/disassemble/clean, sturdy, flexible, and versatile (use for corrosion as well as photoelectrochemical applications, see: Figure 1). Corrosion scientists and engineers colloquially refer to a cell like the Proteus Alpha as a "Flat Cell." A flat cell is a commonly used tool for studying corrosion of metal samples (coupons), often modified with paint or other types of coatings. Further, a flat cell is especially suited to thin and planar samples without the need for expensive sample holders or the need to spend funds machining rather inexpensive materials.

In many applications, the Pine Research Proteus Alpha Cell can simplify the physical setup of electrochemical experiments. The following characteristics guided the design of the Proteus Alpha Cell: sturdy design, flexible system to accommodate several types of research, versatile for use in non-conventional ways, and as with any Pine Research product, quality of construction/manufacture, service, and value.

On the Pine Research website, the Proteus Alpha cell is available in two versions. One version includes the standard glass cell with two 14/20 ports. Another includes the jacketed cell, which also has two 14/20 ports.

Figure 1. Fully Assembled Proteus Alpha Cell with Standard Glass

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2. Critical Specifications and Dimensions

Provided below are the general specifications for the Proteus Alpha Cell with standard glass cell (see: Table 1). The general specifications assume the components consist of the stock offerings listed on our website. Custom modifications will change product specifications accordingly. Certain user preferences may cause a difference between the product specifications and actual presentation during use. All specifications are subject to change without notice.

Overall Dimensions	
Size (length x width x height)	$40.6 \times 16.5 \times 16.5\ cm$ $(16 \times 6.5 \times 6.5\ in.)$
Cell Volume	Up to $500\ mL$
Cell Length	$15.24\ cm$ $(6\ in)$
Material	Borosilicate Glass
Sample (Electrode) Dimensions	
Minimum Sample Size	$7.62\ cm$ $(3\ in.)$
Sample Hole Outer Diameter	$5.08\ cm$ $(2\ in.)$
Area Exposed	$20.3\ cm^2$ nominal
Electrode to Electrode Distance	$20.3\ cm$ $(8\ in.)$
Maximum Sample Thickness	$2.54\ cm$ $(1\ in.)$

Table 1. Proteus Alpha Cell Specifications

3. Advanced Product Features

Because the Proteus Alpha Cell can be used in many different configurations, specific product use instructions would be rather vague. Instead, consider the following list of advanced product features. From this list, you may be able to gather additional insight into how this cell will work for your application.

- Large bore opening ($5.08\ cm$ / 2" OD) allows for a large exposed electrode area. Custom bore adapters can be designed upon request if a user wants to work with a smaller surface area.
- Three radial seal clamps, instead of only one. The Proteus Alpha Cell radial arrangement reduces mechanical stress on the sample thereby minimizing stress corrosion at the point of clamp-to-sample contact. The radial arrangement also improves the seal between sample and end assembly.
- Flexibility in sample size. With the Proteus Alpha Cell, use samples that vary from thin to thick (up to 1") with ease. There is no limitation on the lateral dimensions of the sample as long as it is larger than the exposed area defined by the O-Ring.
- Seal clamps with pivoting feet. The seal clamps terminate with pads that can pivot in any direction. Such pads accommodate samples with some degree of curvature in addition to flat samples.
- Glass cell for a variety of conditions. Suitable for both aqueous (water) and non-aqueous (organic solvents) electrolytes. Most corrosion is aqueous based; however, the glass cell can be used with other solvent systems without risk of damaging the cell.
- Low resistance electrode connection made possible by a unique electrode connection assembly.
- On demand change of one metal sample without having to drain cell possible by holding the cell in a vertical geometry while changing out samples.
- Common 14/20 joints across all parts of the cell for ease in making gas tight seals and connections around probes.
- Versatile design can accommodate a cell to fit specific research needs. For example, a water jacket can be added for thermal control, a different configuration of cell ports can be designed, and the length of the cell can be altered. Contact Pine Research Instrumentation for any custom needs!
- Two-in-one cell system. Simply replace flat metal samples with quartz windows to convert the corrosion Proteus Alpha Cell into a photoelectrochemical cell.

4. Product Overview

4.1 Corrosion-Based Use

Briefly, the Proteus Alpha Cell is a glass chamber (electrochemical cell) open on both ends. The glass chamber has a large flange on either end that connect to sturdy end assemblies. The inner (cell-facing aspect) end assembly holds a fluoroelastomer O-ring to seal against the flanges of the cell. A flat sample, which is most often bare or coated metal, mounts one or both ends of the cell. The sample mounts against the outer end assembly and is held in place by tightening a radial arrangement of swivel feet onto the sample. The sample sits against a fluoroelastomer O-ring. In this arrangement, the end assembly bore and its corresponding O-ring define the area of the metal sample exposed to solution.

Typically, the cell is filled with solution indicative of media that the metal experiences in the field. The electrodes seal tightly to O-Rings thereby creating a sealed cell. An electrode connector placed between the swivel feet and the backside of the metal sample provide electrical connection to the metal sample. Each end assembly contains a machined 14/20 port, located directly next to each metal sample. Typically, the end assembly 14/20 port holds a reference electrode. The unique radial seal clamps with pivoting feet allow the use of slightly curved (but smooth) samples.

The sample of interest is always the working electrode, while the counter electrode could be a bare sample at the opposite end of the Proteus Alpha Cell. In other cases, only the corroding sample of interest is the working electrode and the user supplies an external reference and counter electrode (graphite or platinum, for example). Each metal sample electrode connects appropriately to the potentiostat to measure corrosion current (see: Figure 2).

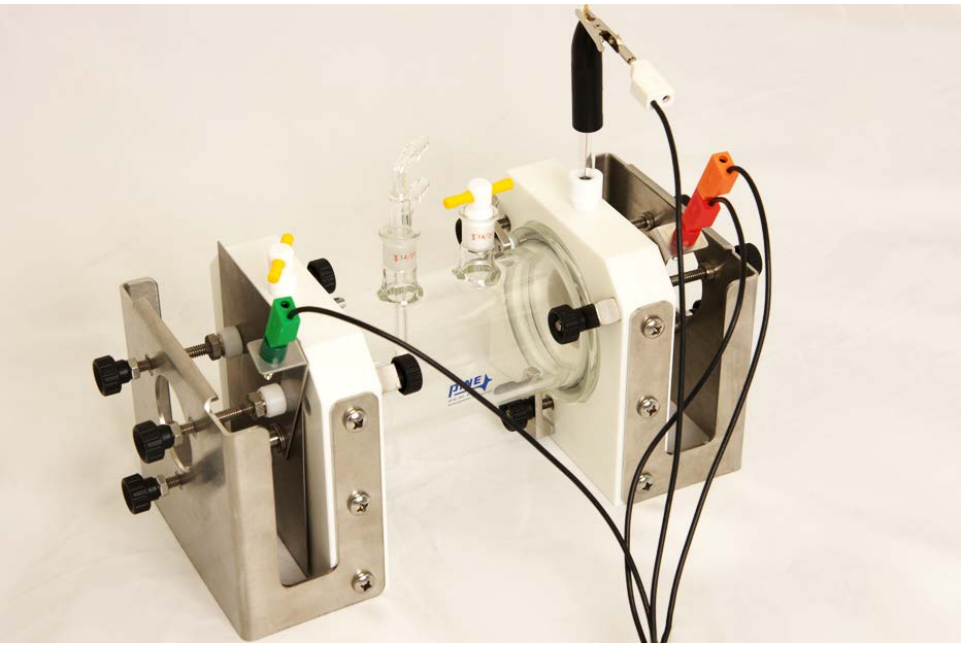


Figure 2. Connections to the Proteus Alpha Cell from the Potentiostat

4.2 Photoelectrochemical Cell Use

In a similar fashion to corrosion-based use, the Proteus Alpha functions as a flexible photoelectrochemical cell. By replacing the flat metal sample with quartz window(s) (Pine Research part #: RRPG246), the Proteus Alpha can be used for photoelectrochemical-based experiments. Each end assembly of the cell features a circular bore in line with the length of the installed cell. This design allows for a light source to direct light through an end assembly. Quartz windows permit the passage of UV light, unlike less expensive glass windows that will block UV light.

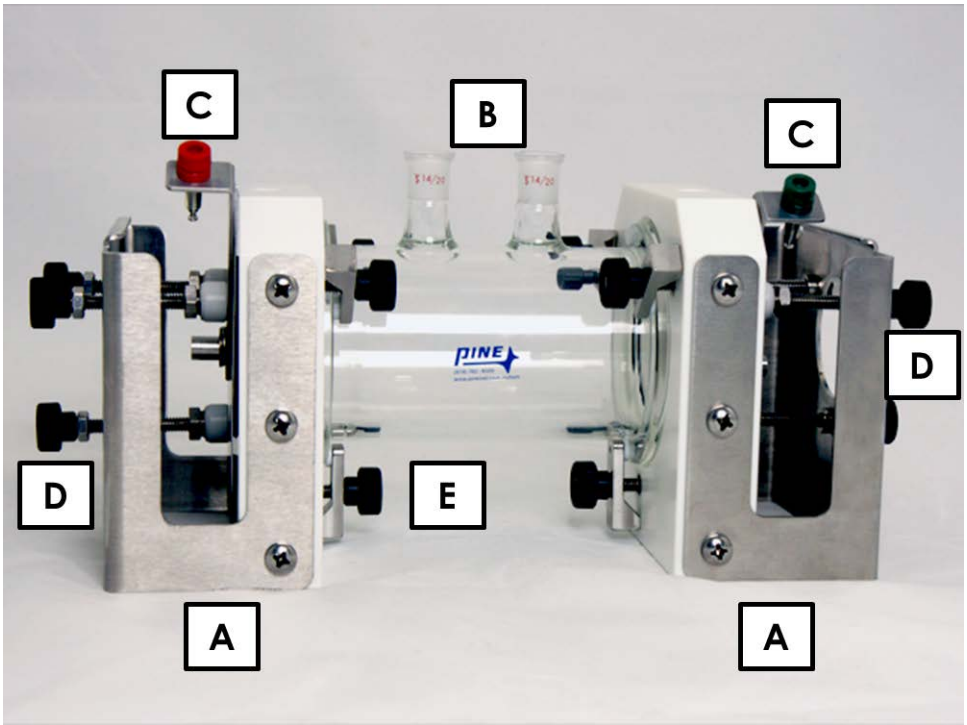
On the other end of the cell, users can install the photoanode, in the same way a flat metal sample fits into the end assembly. The inner-facing aspect of the photoanode (Si wafer, flat metal, often coated with catalyst) is place facing the opposite side of the cell. The additional four 14/20 ports can hold counter and reference electrodes.

5. Major Components

There are seven major components of the Proteus Alpha Cell. Individual parts and assemblies are available from Pine Research at any time. The major components of the Proteus Alpha Cell are:

- Two end assemblies
- Two electrode connection assemblies (one red banana jack and one green banana jack)
- One glass cell (either standard or jacketed versions available)
- One package of five #333 Viton O-Rings
- One package of five #338 Viton O-Rings

A fully assembled Proteus Alpha Cell is shown with these major components labeled (see: Figure 3).



A	**End Assembly**	Contains the necessary clamps and O-Rings to seal the sample to the removable Glass Body Cell
B	**Glass Body Cell**	Holds the sample solution; provides 14/20 port access to the sample solution (standard glass shown)
C	**Electrode Connection Assembly**	Makes connection between flat samples and terminate with a $4\ mm$ banana jack
D	**Radial Seal Clamps**	Adjust to fit and seal curved samples in place
E	**Cell Body Seal Clamps**	Tighten to seal the Glass body Cell in place

Figure 3. Major Components of the Proteus Alpha Cell

5.1 End Assembly

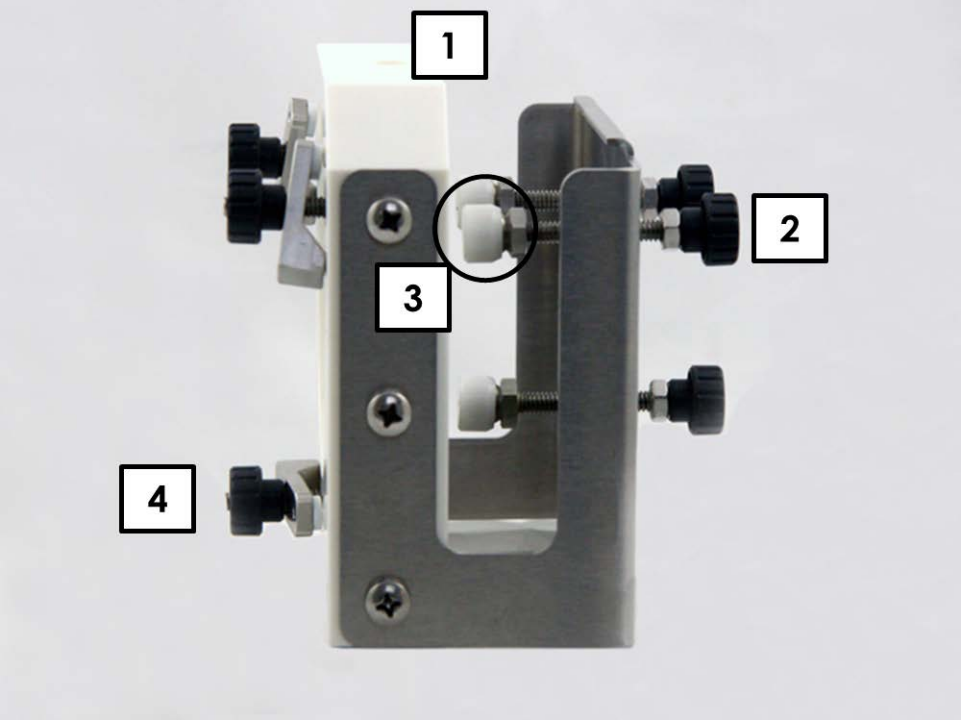
Each End Assembly is made with rigid plastic and metal components (see: Figure 4). At the heart of the End Assembly is the Plastic Base. The plastic base contains an inlaid gap on either side. On the inward facing side of the end assembly is a #338 O-ring (larger of the two), which seals against glass flange (see: Figure 5a). The outward

facing side of the end assembly is a #333 O-ring (smaller of the two), which seals against the sample (see: Figure 5b).

The End Assembly also contains three threaded screws (Threaded Sample Seal Clamps, see: Figure 4). These screws run through the stainless steel support frame in a radial fashion. Each screw is fitted with a plastic pivoting foot. As the screws are tightened onto a sample (or window) that is placed between the pivoting feet and the O-Ring, a pressure force is created. When tight enough, the pressure from the feet seal the sample or window in place. The pivoting feet adjust around samples with some degree of curvature; therefore, the Proteus Alpha Cell accepts samples that are not perfectly flat.

Finally, the Cell Body Seal Clamps of the End Assembly are designed to seal the Glass Body Cell against the #338 O-Ring (see: Figure 4). Thus, when a sample is installed on both ends of the assembly, it creates a leak-proof seal such that the glass cell (installed between the end assemblies) holds solution.

The design of the Proteus Alpha Cell allows for nearly unlimited sample dimensions. As shown, samples are created with a tight seal against O-rings and ample vertical and horizontal space to accommodate samples of any size (see: Figure 6). This advantageous design reduces mechanical stress on the sample, thereby minimizing stress corrosion at the point of clamp-to-sample contact. The radial arrangement also improves the seal between sample and end assembly.



1	**Plastic Base**	Contains a 14/20 Port and O-Ring inlays; the O-Rings are used to seal to the glass cell body and electrode sample
2	**Threaded Sample Seal Clamps**	Tighten to seal the sample in place
3	**Sample Seal Clamp Pivot Foot**	Adjust to fit curved samples; composed of plastic
4	**Cell Body Seal Clamps**	Tighten to seal the glass cell body in place

Figure 4. Proteus Alpha Cell End Assembly Components (side view)

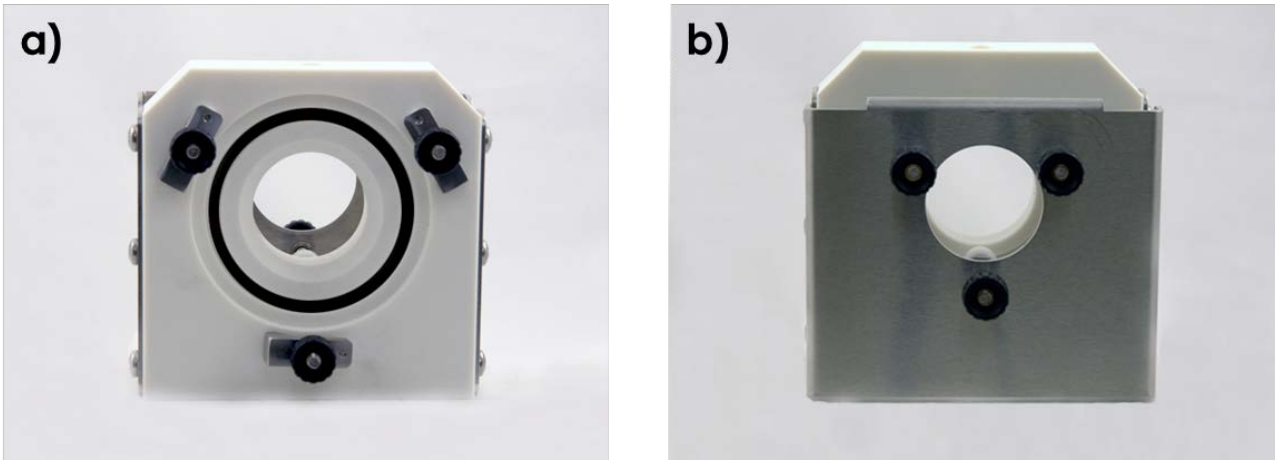


Figure 5. Internal (a) and External (b) Sides of the End Assembly

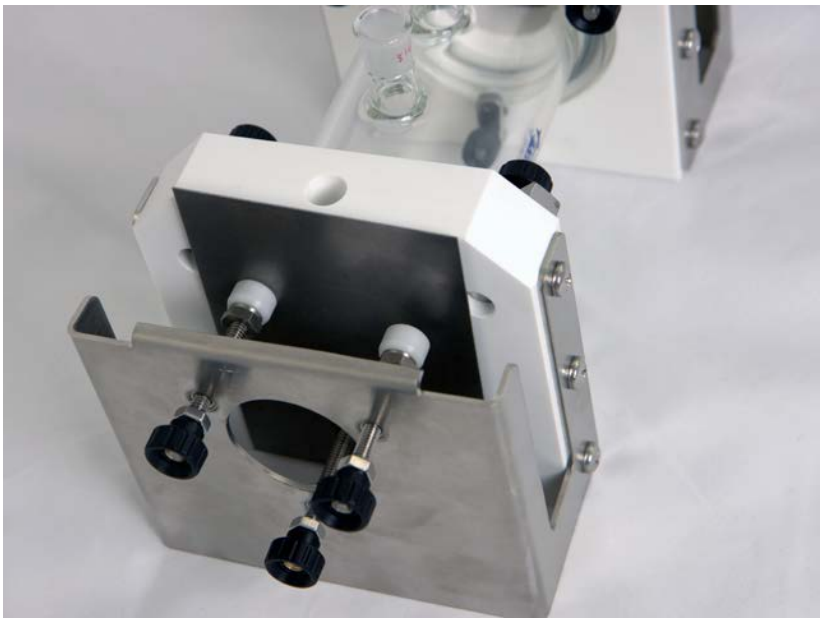


Figure 6. Installation of Metal Sample into the Proteus Alpha Cell

5.2 Glass Cell

5.2.1 Standard Glass Cell

The glass cell included in the Proteus Alpha Cell has a $\sim 150\ mm$ ($6\ in.$) long borosilicate body, with flanges on both open ends (see: Figure 7). There are two 14/20 ground glass joints on the top surface of the glass cell. The large flanges have sufficient surface area to make a tight seal against the O-Rings seated in the inner side of the plastic base.

Cell customization options include adjustments to the overall length, number and position of ports, etc. Inquire with Pine Research to discuss your specific cell body needs. We are happy to work with you for a custom cell (yes, even for a quantity of one cell).

Figure 7. Proteus Alpha Cell Glass

5.2.2 Jacketed Glass Cell

The jacketed glass cell included in the Proteus Alpha Jacketed Cell bundle has a $\sim 150 mm$ ($6\ in.$) long borosilicate body, with flanges on both open ends (see: Figure 7). There are two $14/20$ ground glass joints on the top surface of the glass cell. The large flanges have sufficient surface area to make a tight seal against the O-Rings seated in the inner side of the plastic base. Surrounding the central portion of the cell is a glass water jacket and two hose barbs for water inlet and outlet. The Proteus Alpha Cell design provides easy access to the hose barbs, located on the side of the cell.

Cell customization options include adjustments to the overall length, number and position of ports, etc. Inquire with Pine Research to discuss your specific cell body needs. We are happy to work with you for a custom cell (yes, even for a quantity of one cell).

Figure 8. Proteus Alpha Jacketed Cell

5.3 Electrode Connection Assembly

The electrode connection assemblies are color coded based on the Pine Research color standard for electrodes (red = working electrode; green = counter electrode) (see: Figure 8). There is no difference between the green and red electrode connection assembly other than the color of the banana jack connector. The flexibility in the design allows the user to orient the assembly in the most ideal position for the samples used. A spring loaded pogo pin connector is sharp enough to pierce through any metal oxide film that may have formed on the contact side of the sample. The electrode connection assembly is held in place by one of the same seal clamps that seals the sample to the end assembly; installation details are provided below (see: Section 7.5).

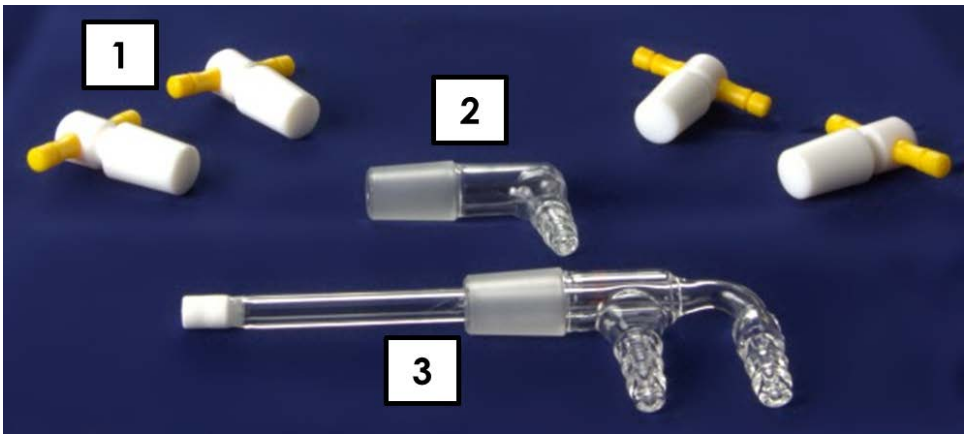
Figure 9. Electrode Connection Assemblies for the Proteus Alpha Cell

5.4 O-Rings

Included with the Proteus Alpha Cell are packages of five #333 O-Rings and five #338 O-Rings. Organic solvents can cause fluoroelastomer O-Rings to swell; therefore, extended use in organic solvents will warrant an O-Ring change. Purchase additional packs of five O-Rings from Pine Research as needed.

6. Included Accessories

The accessories selected for inclusion in the Proteus Alpha Cell Kit will aid the filling, draining, and gas purging/blanketing needs for most users (see: Figure 10). The PTFE stoppers (part #: RRPG085K2) function to seal any unused ports. The two deaeration accessories (*i.e.*, the Single Port Gas Outlet and the Dual Port Gas Inlet) are designed to mount a $14/20$ port and accept tubing with a $1/4''$ or $6.5\ mm$ inner diameter. The Dual Port Gas Inlet (part #: RRPG086) has a top hose barb that functions to bubble gas directly through the electrochemical system while the bottom hose barb blankets the solution with gas. The Single Port Gas Outlet (part #: RRPG095K1) serves as an escape for gases introduced through the Dual Port Gas Inlet or produced by the electrochemical reaction. Each of these accessories can be used with many other cells where $14/20$ ports are used. Replacement parts are available from Pine Research.



1	**PTFE Stoppers**	Seal the cell; four 14/20 stoppers are included
2	**Single Port Gas Outlet**	Serves as the outlet for degassing or gas collection experiments; mounts any 14/20 port
3	**Dual Port Gas Inlet**	Bubbles gas through/deaerates the cell solution; mounts any 14/20 port

Figure 10. Accessories Included with the Proteus Alpha Cell

7. Assembly

The Proteus Alpha Cell is very easy to assemble, disassemble, use, and clean. As described (see: Section 5), the Proteus Alpha Cell is ships with all necessary components.

When unpacking the contents of the Proteus Alpha Cell, verify the components were not damaged during shipping. Pine Research takes great care to pack products with industry standard methods, however sometimes packages are mishandled in shipping. Do not use the product if you suspect an item has been damaged in transit. Immediately contact Pine Research to discuss the product and suspected damage before attempting to use the Proteus Alpha Cell.

The details on how to assemble the Proteus Alpha Cell are provided chronologically in the remainder of this section.

7.1 Install Viton O-Rings

Install one #333 Viton O-Ring into the recess in the plastic base on the outside (sample) side. The O-Ring will seat snugly into the recess (see: Figure 11). Similarly, install one #338 Viton O-Ring into the recess in the plastic base on the inside (glass) side. The O-Ring will seat snugly into the recess (see: Figure 12).

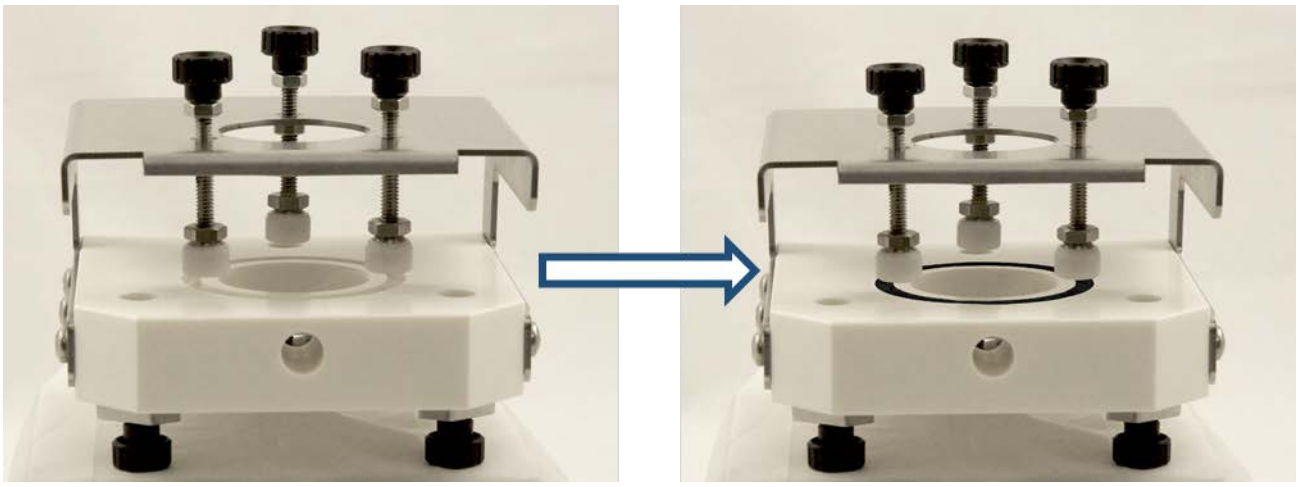


Figure 11. Installation of an O-Ring into the External Side of the Plastic Base

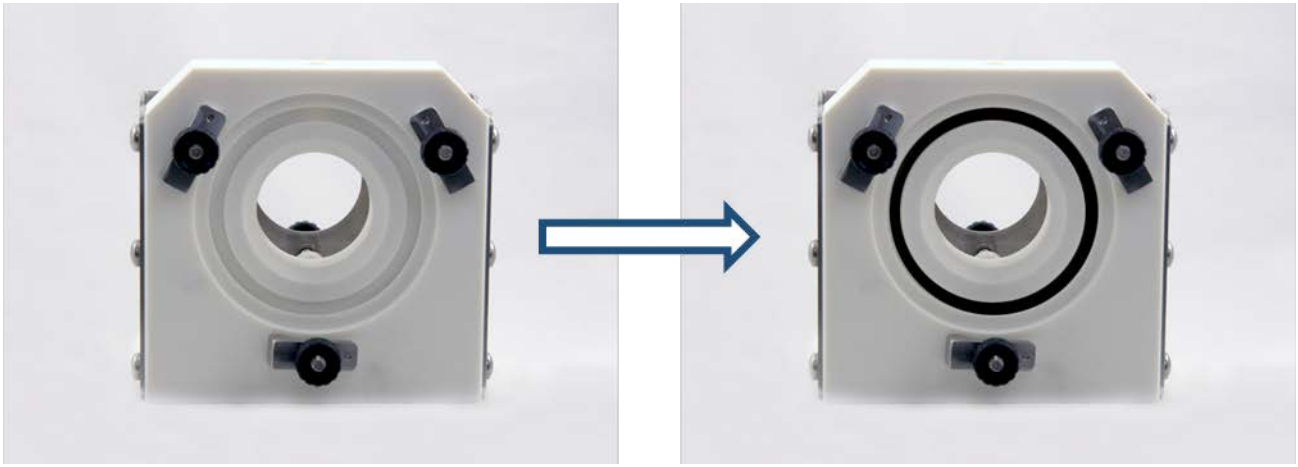


Figure 12. Installation of an O-Ring into the Internal Side of the Plastic Base

7.2 Connect First End Assembly to the Glass Cell Body

For initial assembly, no tools are necessary. We recommend connecting the first End Assembly to the Glass Cell in a vertical orientation (see: Figure 13). Adjust each seal clamp by turning the black knob. Ensure each seal clamp knob is threaded to the same position. Place one End Assembly on a flat surface with the seal clamp knobs seated flush to a flat surface. With the 14/20 ports oriented up, place the Glass Cell Body onto the plastic End Assembly Base. Center the cell so that it fits evenly within the plastic notch in the end assembly (see: Figure 14). Loosen the Cell Body Seal Clamps so the metal arm (fitted with a plastic ring) swivels to fit over the glass flange. Finger tighten this knob on the Cell Body Seal Clamp. Move on to the next clamp and repeat until each of the three clamps are lightly tightened. Then, tighten each knob again ensuring an even seal against the O-Ring.

CAUTION:

Do not over tighten the Glass Body seal knobs. The knobs only need to be tightened sufficiently to make a seal against the O-Ring, visible through the flange during tightening.

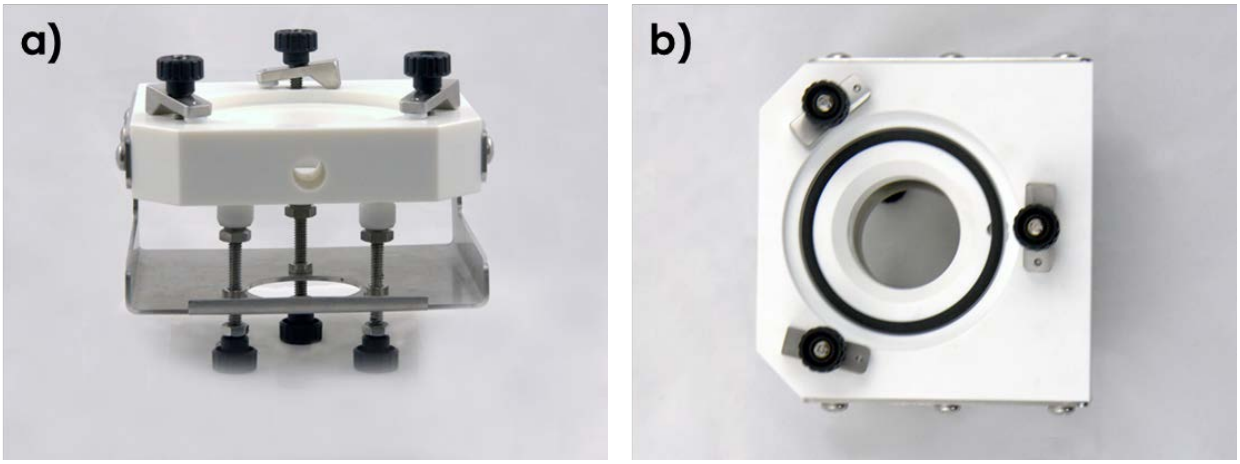


Figure 13. End Panel Views of the a) Appropriate Orientation to Install the Glass Body and b) Top of the End Panel with Seal Clamp Screw Knobs Prior to Installing Glass Body

Figure 14. Attachment of the Cell Body to the First End Assembly (Vertically Oriented)

After the first End Assembly has been securely attached to the glass cell, it is easier to rotate the cell into the horizontal position for the second End Assembly attachment (see: Figure 15).

Figure 15. Horizontally Oriented Cell Setup

7.3 Connect the Second End Assembly to the Glass Cell Body

Raise the Proteus Alpha Cell such that the Glass Body Flange on the unconnected side is at the correct height to mate with the second End Assembly. In a similar fashion to the installation of the first End Assembly, center the cell so that it fits evenly within the plastic notch in the second end assembly. Loosen the Cell Body Seal Clamps so the metal arm (fitted with a plastic ring) swivels to fit over the glass flange. Finger tighten this knob on the Cell Body Seal Clamp. Move on to the next clamp and repeat until each of the three clamps are lightly tightened. Then, tighten each knob again ensuring an even seal against the O-Ring. Make any minor adjustments so the cell is planar with a flat surface (see: Figure 16).

Figure 16. Proteus Alpha Cell End Assemblies Connected to Glass Cell Body

7.4 Install Samples into the End Assemblies

The samples (or quartz disks) placed in the End Assemblies become the electrodes (or windows) (see: Figure 6). To install the sample, slide the sample between the End Assembly outer O-Ring and the Radial Seal Clamps. In alternating fashion, finger tighten the radial seal clamps using the black knobs on the end of the stainless steel support. The pivoting feet will adjust to the ideal angle and create a tight seal between sample and O-Ring.

Leave one of the Radial Seal Clamps loose to later insert the Electrode Contact Assembly. As before, the clamps need only be tightened enough to create a seal. Do not over tighten.

CAUTION:

Do not over tighten the Radial Seal Clamps. The clamps need only be tightened enough to make a seal against the O-Ring. Over-tightening the clamps may damage the cell or the sample.

7.5 Install Electrode Connection Assemblies

With the appropriate (or preferred) colored Electrode Connection Assembly, identify the spring loaded pogo pin on the underside of the Electrode Connection Assembly (see: Figure 17a). The pogo pin should strike the rear of your sample for optimal electrical contact. Slide the Electrode Connection assembly to the desired position, beneath one of the pivoting plastic feet of the Radial Seal Clamp (see: Figure 17b). Slowly tighten the knob for the Radial Seal Clamp holding the Electrode Connection Assembly until tight (see: Figure 17c). Repeat this step for the opposite End Assembly.

At this point, the Proteus Alpha Cell major components are assembled. Accessories can be used at any time as appropriate.

Check all Radial Seal Clamps again before filling the Glass Body with solution. Solution can then be added to the Glass Body through one of the 14/20 ports at the top of the cell. Use caution, standard safety practices, and appropriate personal protective equipment when filling the cell with solution as to prevent injury.

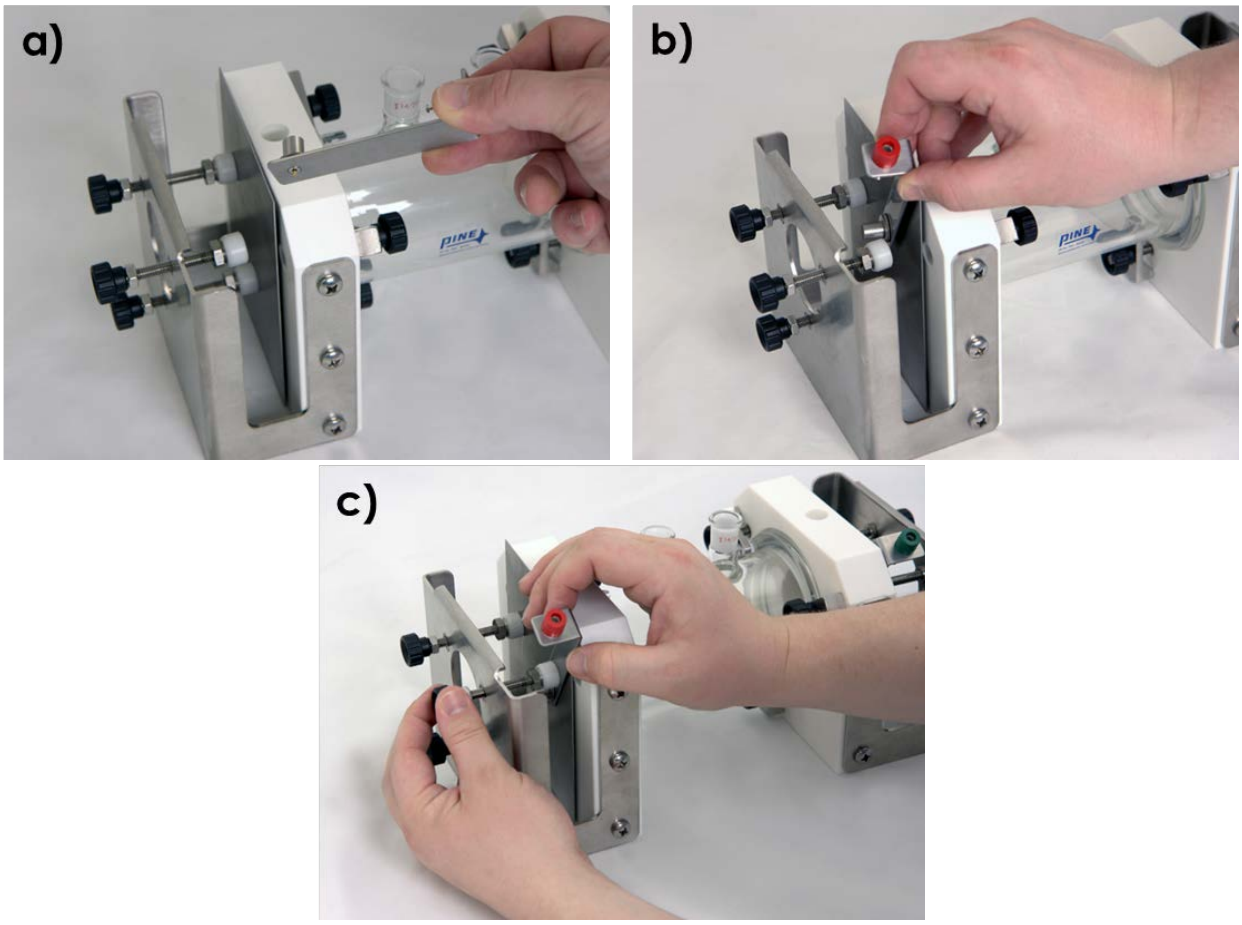


Figure 17. Stages of the Electrode Contact Assembly Installation

8. General Usage Comments

Each user will identify his/her own preferred practices in using the cell. Some may purge solution with a stream of insert gas (such as N_2 or Ar). Others will install only one flat sample in the Proteus Alpha Cell and install a counter electrode material (graphite, platinum foil, etc.) on the adjacent side of the cell. Others will install a photoanode and quartz window for photoelectrochemical experiments. The following are general commentary about using the Pine Research Proteus Alpha Cell.

- It is suggested to have the reference electrode as close to the working electrode as possible. Each of the plastic bases of the End Assemblies has a central $14/20$ port. With a Pine Research $9.5\ mm\ OD$ reference electrode installed (comes with a $14/20$ Teflon adapter), the horizontal distance between working electrode and reference electrode is $1.29\ cm$.
- The Dual Port Gas Inlet Tube is a convenient way to both purge and blanket solution. The top port connects to the ceramic gas diffuser at the base of the tube, which sits in solution in the cell. Pass insert gas through this port to displace dissolved oxygen from the electrolyte. Since the convection from bubbling gas can cause electrochemical noise and errors in measurement, switch the stream of inert gas to the lower barb on the Dual Port Gas Inlet Tube to blanket (or fill the headspace of the cell) with inert gas. Blanketing the atmosphere above the electrolyte level decreases diffusion of unwanted gases (such as oxygen and carbon dioxide) into solution. Consider the Three-Way Valve Purge Kit (part #: AKPURGE1) as an optional accessory to link the gas supply to the gas accessories included with the Proteus Alpha Cell.
- The Glass Body cell is not a pressure vessel. It was not designed to withstand added pressure. If gases are sent into the cell, a vent must be open to properly balance the internal pressure of the cell. The Single Port Gas Outlet, an included accessory, has a $14/20$ joint and can serve as the outlet.
- After all Proteus Alpha Cell assembly steps are complete, fill the cell with solution above the O-Rings and verify that cell is not leaking. If solution leaks outside the cell toward the stainless steel portion of the End

Assembly, tighten the Radial Seal Clamps. If solution leaks inside at the flange-to-plastic connection of the Glass Body, carefully tighten the Cell Body Seal Clamps. Do not use the Proteus Alpha Cell until the leak has been resolved.

- The design of the cell allows for use in the vertical orientation. Ensure that any open 14/20 port (there are four total) is properly sealed before inverting the cell.
- Prevent solvent evaporation during experiments by plugging ports not in use by a probe.
- To easily drain the cell, plug all but one of the 14/20 ports (one of the Glass Body ports is optimal) and carefully pour used electrolyte into the appropriate waste container. Drain solution before removing the flat electrodes.
- After experimentation is complete and the cell has been drained, remove the metal samples from the end assemblies, remove the glass cell, rinse all parts free of any corrosive solution, and store the Proteus Alpha Cell safely.
- When finished using the cell, it is important to disassemble the Glass Body from the End Assemblies and thoroughly rinse with solvent (most likely deionized water for aqueous use). Minimize solution contact with any metal part of the cell to extend the lifetime of metallic parts. The End Assemblies are shipped fully assembled. Each component of the assembly can be replaced. Over time, corrosive vapor and solutions dropped on metal portions of the end assembly have the propensity to corrode. Therefore, a user with simple tools such as a screwdriver can replace any part of the Proteus Alpha Cell.
- To use the Proteus Alpha Cell as a photoelectrochemical cell, install quartz windows (sold separately) into each End Assembly. The hole in the plastic body is aligned with the hole in the stainless steel frame. A large surface area window of UV transparent quartz makes for an attractive photoelectrochemical cell.

9. Optional Accessories

Review the Proteus Alpha Cell website on the Pine Research Instrumentation website for a list of optional accessories. In addition, a reference electrode is not included with the Proteus Alpha Cell and must be purchased separately. See the Pine Research Instrumentation website for a list of available $9.5mm\ OD$ reference electrodes.

INFO:

Optional Accessories can be found on our website:

https://www.pineresearch.com/shop/

10. Contact Us/Support

Pine Research is happy to work with you to design and customize any of our products to suit your needs. Give us a call or drop us an email so we can better understand your needs. We will bring our expertise to see if we already have a solution. If not, we can provide custom products to fulfil your needs.

10.1 Email

Reach us by emailing the entire sales department: pinewire@pineresearch.com.

10.2 Website

There is a contact us form on our website. There may also be additional resources (such as YouTube videos) for some of the products mentioned here: http://www.pineresearch.com/.