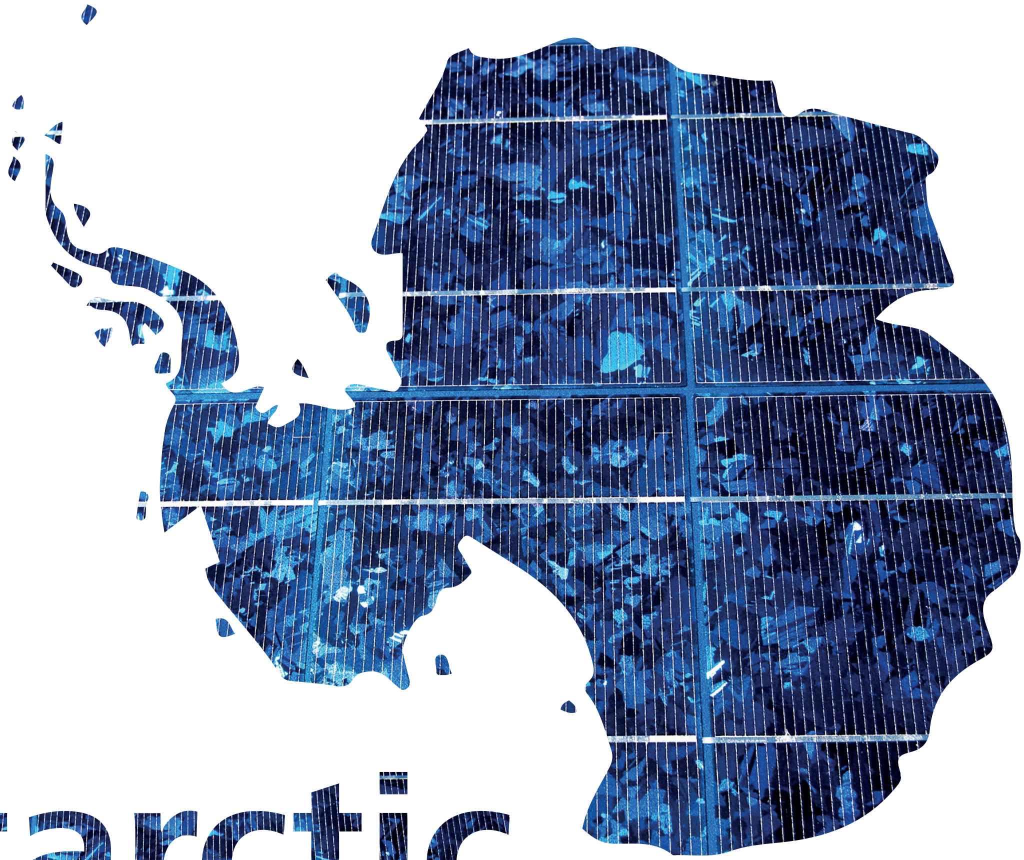


Antarctic solar cells

or A step-by-step guide to being a researcher at the end of the world

Traveling to Antarctica might sound like traveling to the very end of the world for many – even more so when you come from a small country, for instance, Uruguay, where the longest distance between two points does not exceed 1000 kilometers. Still, scientists from the University of the Republic in Uruguay take this trip upon them to do research at the country's Scientific Antarctic Base «Artigas» (BCAA in Spanish), situated at 3012 kilometers from the Uruguayan capital Montevideo. Among them is our guest author, María Fernanda Cerdá. Here she is on the joys and strains of being a researcher in Antarctica.

The rough climate at Antarctica requires special adaptation. This includes the means of transportation – here's our track vehicle.

Step 1: Know what you're getting yourself into

The BCAA (figure 1) is located at Collins Bay on King George Island, roughly 1000 kilometers south of Cape Horn (figure 2). Traveling there is not without its complications, and traveling there to do science is again a completely different story. As a researcher, there is only one person responsible for transporting all necessary materials for your work to the Antarctic Base: you. This means that you have to take with you absolutely everything that you might need – and might not need, too, just in case. Anything that you forget stays at home.

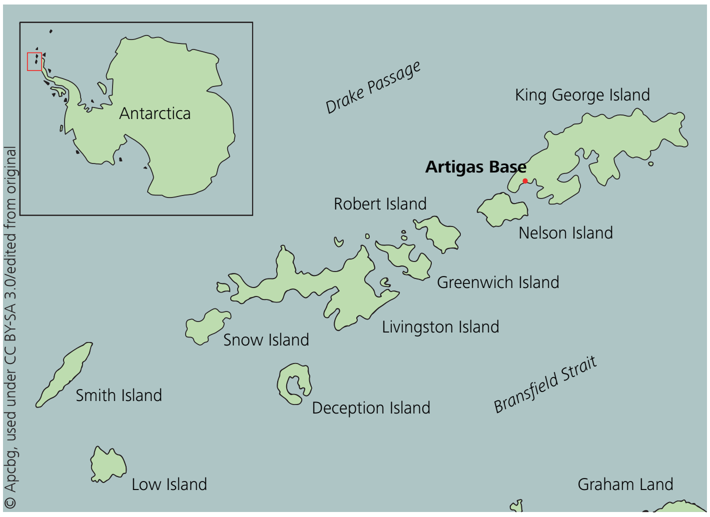


Figure 2. The Uruguayan Antarctic base «Artigas» is on King George Island, the largest of the South Shetland Islands. It is situated roughly 1000 kilometers south of Cape Horn, the southernmost point of South America.

Step 2: Plan around uncertainties

So far, so good. But keep in mind that a research trip to Antarctica takes luggage planning to a whole new level, because you never know exactly how long you are going to stay. Crossing from the South American continent to King George Island and back is only possible when climatic conditions are good. This means that maybe you'll only spend 10 days at the base, but you might have to stay for 3 months until our plane can return to pick you up. In Antarctica, weather and nature dictate the lives and activities of all.

If you look for a «real» laboratory at the BCAA, you will look in vain. A small room with a table is all we have (figure 3)! There is no access to the instrumental equipment that is necessary for many analytical purposes. Moreover, you cannot carry with you all the equipment you have at the university, as the plane is needed to transport many things to the base, e.g., supplies for those who are going to spend the worst part of the year isolated in Antarctica. So, if you're lucky enough to get the opportunity to travel to the BCAA, you will need foresight and good planning to pack your «scientific luggage».

Figure 1. Panoramic view of the Scientific Antarctic Base on King George Island. *Picture by Gabriela Rufener*

Figure 3. The «lab» at the BCAA is nothing more than a small room with a table.

Step 3: Get to work

So, you have arrived at the BCAA. What now? If you're a chemist and you work with dye-sensitized solar cells, your first task may be quite simple: walk across the island and collect samples of algae (figure 4).

My project at the Antarctic base was to collect red algae on King George Island, extract the dyes responsible for their color, and select those with the proper characteristics to assemble a dye-sensitized solar cell, which I was going to do after returning to Montevideo. The first part of the work can be done without any special equipment: all you need to do is compare the color of the extracts obtained with different solvents and select those with the deepest red. To be suitable for solar cells, however, the dyes have to combine two properties: in addition to high extinction coefficients at suitable wavelengths, high oxidation potentials are required. Only a dye exhibiting both properties can transfer the electrons to the semiconductor of the cell, and thereby make it possible to harvest electricity from the cell.

Step 4: Use the instrument that suits your application

Unlike the extinction coefficients which can be estimated by an experienced eye, you will need the help of an instrument to measure the oxidation potentials of your dyes – preferably a small instrument that is light and easy to use, such as the ones from DropSens. Weighing less than half a kilogram, the

Figure 4. Red algae can be found in abundance on King George Island. Here I am collecting some samples. *Picture by Patricia Valdespino*

portable potentiostat «μStat 400» is well within your luggage restrictions and solves your problem (figures 5 and 6)! The device works with screen-printed electrodes that combine the working electrode, reference electrode, and counter electrode in one handy sensor and require only a drop of solution. This means that only small quantities of sample and of electrolyte solution are required for the measurements. This again comes in handy when packing: you won't need to bring more than 20 milliliters of electrolyte solution to the Antarctic base.

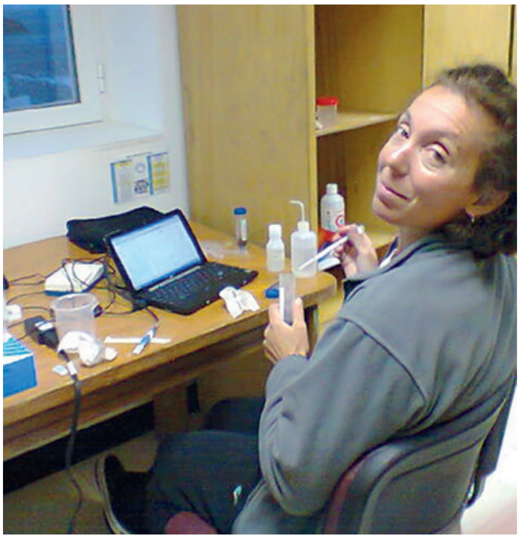


Figure 5 (top). To determine the oxidation potentials of the dyes I had extracted, I used an experimental setup that consisted only of the 400 μStat potentiostat and a laptop. **Figure 6 (left).** Here I am measuring the oxidation potential of a dye using the μStat 400 from DropSens.

Step 5: Evaluate your data

When you analyze a dye, you will obtain a curve similar to the one in figure 7: a cyclic voltammogram. To produce this, the potentiostat performs a potential sweep on the working electrode and measures the current that results in the electrolytic cell. The electrolytic cell is made up of the sensor with its three electrodes and the sample solution containing dye extract and electrolyte solution. The sweep starts at a small potential that increases to the point at which the analyte – your dye – has been oxidized. Afterwards, a backward scan is performed during which the dye is reduced. The voltammogram plots the current in the electrolytic cell against the applied potential.

The voltammogram in figure 7 unveils that the dye in question has a promising oxidation behavior: there is a strong peak at 1.0 V at positive current values, i.e, in the oxidation quadrant (upper right) of the graph. This means that the oxidation potential is high. Other samples that I've analyzed didn't show such a peak, or exhibited contributions at a lower potential (around 0.6 V) and therefore weren't good candidates for a dye-sensitized solar cell.

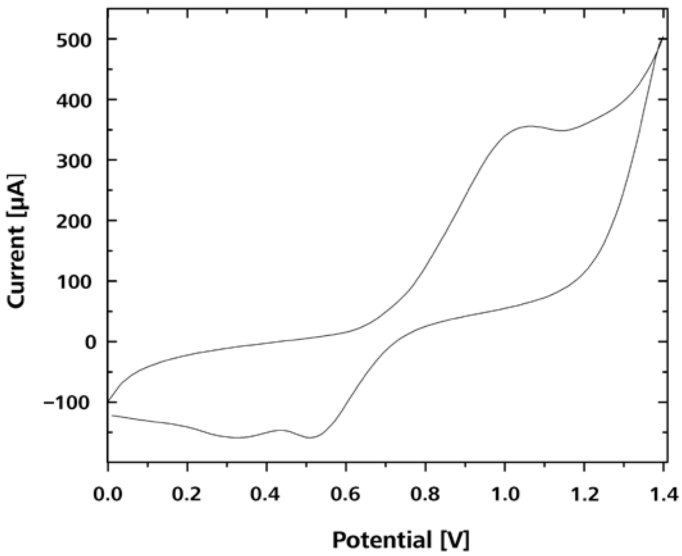


Figure 7. A dye-extract from red algae was analyzed by cyclic voltammetry at a potential sweep rate of 0.1 V/s. The strong peak at 1.0 V in the oxidation quadrant (upper right) of the graph reveals a high oxidation potential.

My tiny helper

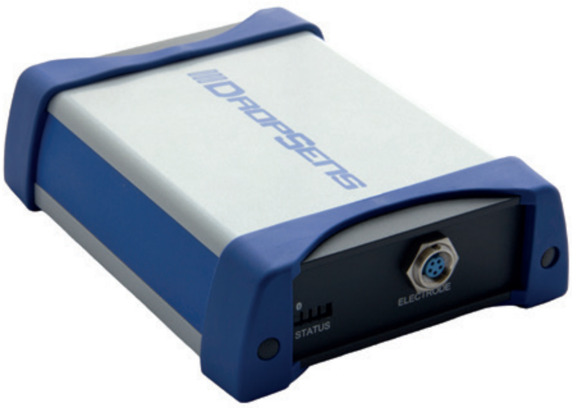
The µStat 400 helped me identify potentially suitable dyes for solar cells by shedding light on their oxidation behavior. In addition to that, there are three main reasons to choose this potentiostat – especially when working at a place like the BCAA: its small size, its light weight, and the fact that measurements don't generate waste that has to be flown back to the continent.

My colleagues at the BCAA. *Picture by Cap. (Nav.) Esteban Carrero*

About the author

María Fernanda Cerdá graduated with a PhD from the Faculty of Chemistry of the University of the Republic (Udelar) in Montevideo, Uruguay. Today, she is Associated Professor at the Faculty of Sciences of her alma mater. Fernanda has been working on the topic of dye-sensitized solar cells for 4 years, in which she has evaluated the suitability of dyes coming from flowers and fruits native to Uruguay for use in solar cells.

In hopes of extending her research to dyes from Antarctic red algae, she presented her project at the Uruguayan Antarctic Institute (IAU) in 2013. In the end of 2014, she finally got the news that her project was selected, but wasn't able to travel on the fixed dates. After signing up again, she waited all summer for news from the IAU. «I was looking at the stars, wondering what the Southern Cross constellation looks like from Antarctica» says Fernanda. «I felt like haunted by Antarctica. I took my youngest daughter to two movies, and both were full of references to Antarctica. And then I finally got the invitation to travel on the last flight»! And after a week of cloudy skies, just some nights before returning home, she could finally see the Southern Cross, this time from the furthest south she had ever been.



The µStat 400 from DropSens weighs only 480 g and measures 13.2 cm × 10.0 cm × 3.6 cm.

DropSens

DropSens is specialized in the design and manufacture of instruments for electrochemistry research and is based in Oviedo, Spain. The product range includes, among others, potentiostats, screen-printed electrodes, and accessories for screen-printed electrodes. Metrohm recently added DropSens to the portfolio of instruments and accessories to provide an even wider range of low-cost to high-end solutions for electrochemical research.