Looking Ahead: A Profiling Float Micro-Rosette

By Philip Bresnahan, Todd Martz, Joao de Almeida, Brian Ward, and Paul Maguire

We are developing the "Micro-Rosette," an instrument that will be deployed on an Argo-style profiling float. The Micro-Rosette is capable of capturing and storing a vertical profile of submilliliter seawater samples and then performing chemical analyses of the samples during a profiling float's park cycle. The prototype Micro-Rosette was designed to measure dissolved inorganic carbon (DIC) based on the method of Hall and Aller (1992) and refined by Sayles and Eck (2009). This technique involves placing an acidified seawater sample in a gas diffusion manifold where the CO_2 is quantitatively transferred to a receiving solution (NaOH). CO_2 reacts with OH^- to form carbonate and bicarbonate, thereby decreasing the solution's conductivity. The carbonate-loaded NaOH is eluted through a custom capacitively coupled contactless conductivity detector (C^4D), where the decrease in conductivity is quantified in order to determine the seawater's initial DIC content.

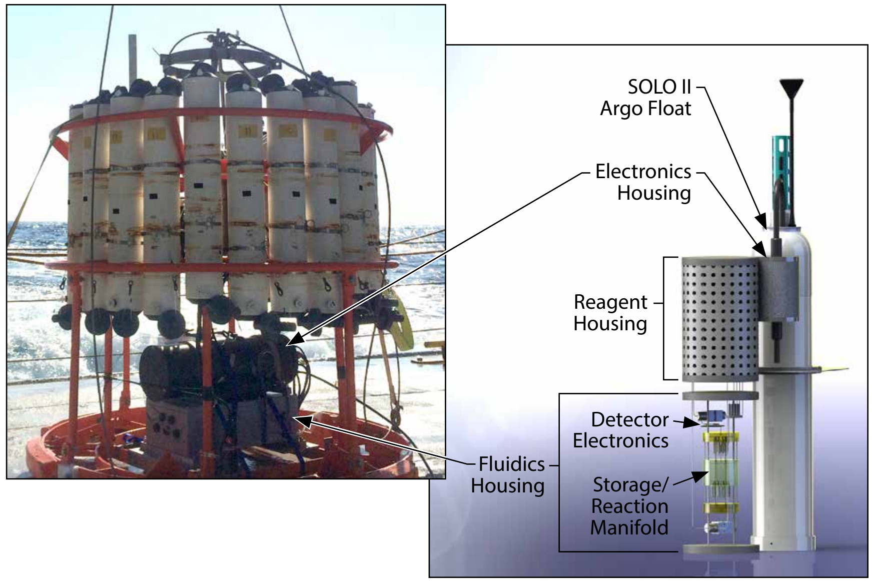

FIGURE 1. (left) Prototype Micro-Rosette fastened to bottom of R/V *Sproul's* rosette frame. (right) Conceptual schematic of the Micro-Rosette integrated into a profiling float. For scale, the SOLO-II float has an overall length of 1.3 m (4'4").

The Micro-Rosette has been evaluated on the bench top as well as in a 6,000 L test tank and at sea to a depth of 500 m while attached to a CTD/rosette winch onboard R/V *Sproul* (Bresnahan, 2015). Integration onto a profiling float is ongoing and supported by the National Science Foundation. The Micro-Rosette is designed to carry reagent volumes and has power sufficient for at least three years of operation onboard Argo floats at 10-day profile intervals. The initial design consists of 16 sample compartments, which translates into a reagent requirement of 3 L each of acid and base for 100 profiles and 50 kJ per profile. In later refinements, we aim to expand the number of sample compartments and measure additional chemical properties that do not lend themselves to simple solid-state sensors.

The system has three main states, each corresponding to a particular portion of the Argo float cycle: (1) ascent – sample collection, chemical reaction (in this case, acidification and gas diffusion); (2) descent – idle/pressure equilibration, continued reaction interval; (3) park – continued reaction interval, analysis, data processing, and transmission to profiling float controller. In practice, it is likely that the full sample cycle would be repeated one or more times during the park cycle in order to measure uniform deep water and/or onboard standards for data quality control. The design is composed of two main housings, one for electronics and the other for fluidics, that are connected by underwater communication and power cables. The principal rationale for utilizing separate housings is that the components within the fluidics housing must be held at ambient pressure.

Under strictly controlled laboratory conditions, we have achieved excellent precision in DIC (<0.2% RSD or ± 4 µmol·kg^{-1}) at sample volumes of <250 µL (Bresnahan, 2015). The prototype system has passed several proof-of-concept benchmark tests in our test tank and at sea, including many successful pressure tests as well as front-end sampling/storage of 16 seawater samples. The Micro-Rosette concept shows great promise for resolving event-scale phenomena (e.g., phytoplankton blooms), seasonal cycles, and upper ocean profiles, all of which regularly change DIC in excess of tens to hundreds of µmol·kg^{-1} over the respective temporal and spatial scales within which the Micro-Rosette is designed to operate. In the near term we aim to test a fully functional Micro-Rosette system on a profiling float by the end of the decade. Longer-term, we see applications that would extend chemical measurements in Biogeochemical-Argo beyond the CO_2 system.

REFERENCES

Bresnahan, P.J. 2015. Development and application of in situ marine inorganic carbon sensors: Quantifying change at high spatiotemporal resolution in the anthropocene. PhD thesis, University of California, San Diego.

Hall, P.J., and R.C. Aller. 1992. Rapid, small-volume, flow injection analysis for ΣCO_2, and NH_4^+ in marine and freshwaters. *Limnology and Oceanography* 37:1,113–1,119, https://doi.org/10.4319/lo.1992.37.5.1113.

Sayles, F.L., and C. Eck. 2009. An autonomous instrument for time series analysis of TCO_2 from oceanographic moorings. *Deep Sea Research Part I* 56:1,590–1,603, https://doi.org/10.1016/j.dsr.2009.04.006.

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