Advances in chemical sensor developments

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CONTROS® SENSORS
Products

**HydroC CH₄**
- Dissolved methane sensor
- 3000 meters
- High accuracy
- Long-term stability

**HydroC CO₂**
- Dissolved carbon dioxide sensor
- 6000 meters
- Fast response time
- High versatility

**HydroC CH₄ FT and CO₂ FT**
- Flow-through applications
- User-friendly
- Maintenance interval of 12 months

**HydroFlash O₂**
- Dissolved oxygen sensor
- 6000 meters
- High accuracy
- Very fast response time

**HydroFIA TA & pH**
- Total alkalinity and pH
- Autonomous analyzer
- Easy setup
- High accuracy
CONTROS® SENSORS
Add-ons

**Anti Fouling**
Enhanced anti fouling strategy for deployments in strongly growing areas e.g. coastal waters

**Pumps**
Pumped water flow for fast response time

**Cartridges**
Customer friendly handling of chemicals in plug-and-play cartridges

**Cross-Flow Filter**
Clean water supply for CONTROS HydroFIA

**Batteries**
Power solutions for applications up to 1000 m water depth

**Frames**
Mountings for the sensors on request

**Cables**
Custom cables for all CONTROS sensors
Pressure Tank

- Used for complete design test
- \( d = 350 \text{ mm}, h = 1000 \text{ mm}; \) approx. 95 ltr.
- Maximum pressure 1000 bar (800 bar currently realized)
- Fresh and seawater fillings possible
- Temperature stabilized (-3 °C to 30 °C)
- Tank fluid is physically separated from pressure generating liquid → no contamination → beneficial for gas sensor tests
- Option for controlled gas enrichment of the tank liquid
K-LANDER
- Stationary platform
- Long-term deployments 2+ years
- Open sensor integration policy
- Modular & scalable design
- 2000+ meters

MELDS
- Early leak detection system
- Measurement of CH₄, PAH, CTD
- Easy ROV/AUV integration
- 2000 meters

DPU
- Flexible and adaptable subsea data logger
- In-situ processing
- Optimized for low power consumption
- 2000 meters
CONTROS HydroC® CO₂
CONTROS HydroC® CO₂

Benefits

- High quality, versatile and robust
  - Can be used in water depths up to 6000 m and under harsh conditions
  - Easy integration with almost every oceanographic measurement system and platform

- Fast response time
  - First signal derived on a sub-minute scale
  - Capture even small signals in a short time

- Reliable technology
  - Proven track record in scientific publications
  - Robust and traceable data quality
Application
Shipborne Measurements at Gas Release Site (Scotland)
Application
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- CO$_2$-release experiment in Ardmucknish Bay, Scotland, 2012:
  - Release started with 90 kg CO$_2$/day
  - later 150 kg/day
  - two weeks in total

- Sensor used in a CTD frame from a boat

- Vertical profiling and horizontal towing at the release and at reference sites

Atamanchuk et al., 2014
Application

Shipborne Measurements at Gas Release Site (Scotland)

- Gas bubble detection
- Event detection on a sub-minute scale and profiling capability through response time correction

Atamanchuk et al., 2014
CONTROS HydroC® CO₂ / CH₄ TOUGH / Gen 3

Benefits

- Robust TOUGH membrane produced in-house
  - Withstands harsh conditions and mechanical stress
  - Easy handling of the membrane
  - Very low maintenance

- Enhanced gas-cycle management
  - Deep-sea and long-term applications
CONTROS HydroC® CO₂ FT COMPACT / Gen 2

Benefits

- Compact design
  - Even easier to integrate into flow trough systems

- Robust TOUGH membrane produced in-house
  - Long-term deployments over one year
  - Easy handling
  - Very low maintenance

- Temperature sensor in the flow head
  - Possibility to correct for warmed water when pumping to the sensor

- Reliable technology
  - Proven track-record in scientific publications
  - Robust and traceable data quality
CONTROS HydroC® CO₂
Summary

• **Continuous** and **direct measurements** of dissolved gas parameters.

• Small, individually **in-water calibrated**, **fast** and including drift correction means.

• **High quality production**, calibration and measurements incl. **peer-reviewed publications**.

• **User-friendly** through comprehensive, easy-to-use **software** as well as application-oriented features (logger, sleep-mode, etc.).

• **Strong customer support**.

• **Reliability** and ruggedness is proven during many missions and on various platforms.

• In the new compact FT version a **temperature measurement** in the equilibrator head is included as well as the new **TOUGH membrane**.
CONTROS HydroFIA® pH
**CONTROS HydroFIA® pH**

**Benefits**

- High quality continuous pH measurements
  - Carbonate chemistry applicable
  - Suitable for ocean acidification studies
  - Global change monitoring

- Easy setup for autonomous use
  - Deployment longer than one month possible
  - No more bottled samples
  - Save time and analyses cost
  - Replacing the sophisticated lab setup

- Low sample / reagent consumption
  - Decreased cost per measurement

- Calibration and drift free
  - Low maintenance efforts
Application
Spring Bloom Observation on a Ferry (Baltic Sea)
Application

Spring Bloom Observation on a Ferry (Baltic Sea)

- Measurements of $pCO_2$ (CONTROS HydroC CO$_2$) and pH (CONTROS HydroFIA pH prototype)
  - Low salinities of approx. 7 psu
  - Wide measuring range and high dynamics for pH and CO$_2$

12 April → 28 April

[Graph showing pH and $pCO_2$ measurements over time]
Researchers adapt optical pH measurement method for brackish waters

In the Baltic Sea an attempt to better observe possible acidification trends in brackish waters, into Daniel Müller, marine chemist at the Helmholtz Institute for Baltic Sea Research Warnemünde (IOW), Germany, together with several partners, evaluated the high-precision optical pH measurement technique, previously only applicable for the high salinity levels of the open ocean, for use in regions with low salinities. This has led to the development of a route to new devices from the sensor technology company Kongsberg Maritime, Germany. The newly adapted method is highly suitable for routine applications in the field, for instance as part of the Network Observatory of the ECSO in environmental monitoring of the Baltic Sea as well as for the pH monitoring of other coastal zones with low salinities. The work is a result of the EU and nationally co-funded project Environment.

Great advancement for pH monitoring in the Baltic Sea

The BRIESE Prize for Marine Research 2018 was awarded today at the IOW to Dr. Jens Daniel Müller (m.), Captain Klaus Küper (r.) from the BRIESE shipping company, IOW Director Ulrich Balthmann (l.). (Photo: IOW / K. Beck)
CONTROS HydroFIA® TA
CONTROS HydroFIA® TA

Benefits

• Worlds first commercially available autonomous TA analyzer
  ➔ Game changer in biogeochemical studies involving TA
  ➔ Carbonate chemistry applicable
  ➔ Suitable for ocean acidification studies
  ➔ Global change monitoring

• Easy setup for autonomous use
  ➔ Deployment longer than one month possible
  ➔ No more bottled samples
  ➔ Save time and analyses cost
  ➔ Replacing the sophisticated lab setup

• Low sample / chemicals consumption
  ➔ Decreased cost per measurement
Application

Monitoring coastal alkalinity in FerryBox (Wadden Sea)
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- FerryBox approach with broad sensor setup
  - Total Alkalinity (CONTORS HydroFIA TA)
  - Carbon Dioxide $\text{CO}_2$ (CONTROS HydroC $\text{CO}_2$ FT)
  - pH
  - Oxygen $\text{O}_2$
  - Salinity, Temperature
  - CDOM, Chlorophyll

- Installed on a Ferry sailing between Cuxhaven (GER) and Immingham (UK)

- First long-term (11 months) high resolution dataset for TA

- TA flux calculation from Wadden Sea into North Sea $\rightarrow$ Carbonate System

Voynova et al., 2018
Application

Monitoring Ocean Alkalinity – Southern Atlantic Ocean
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Monitoring Ocean Alkalinity – Southern Atlantic Ocean

- Using regular CRM measurements over the course of the cruise (standard deviation of 5 repetitive CRM measurements)

→ **Average field precision:** 1.1 µmol kg\(^{-1}\)

Seelmann et al., 2019 (submitted)
Application
Monitoring Ocean Alkalinity – Southern Atlantic Ocean

- Using regular CRM measurements (□) and discrete samples* (●)

- Raw data (drifted) can be corrected using CRM measurements or discrete sample measurements.

➔ Field accuracy: \((-0.3 \pm 2.8\) \(\mu\text{mol kg}^{-1}\)

Seelmann et al., 2019 (submitted)
- Chemicals are provided in cartridges
  - Separate indicator and acid

- User friendly and robust design.

- Usage of gas-tight bags to avoid the introduction of a head space during operation/consumption of the chemicals.

- No gas exchange with surrounding air.

- No degradation of the substances due to light.

- One cartridge set lasts for
  
  TA: 2500 measurements / pH: 16000 measurements
- Important for particle loaded waters to avoid clogging
- 0.2 µm pore size filter removes stray light particles in the visible light spectrum
- Reduction of bio-fouling
CONTROS HydroFIA®
Summary

- **Continuous** and **automated** measurement of pH and TA in seawater.
- **Calibration:**
  - pH → **calibration free** detection principle.
  - TA → **One-point calibration** doable by operator.
- Calibration and measurements tested and further developed in **R&D projects**.
- **High quality** systems: pH → precision ±0.001 pH units, accuracy ±0.003 pH units
  (overall uncertainty depends on indicator dye and pH reference)
  - TA → precision <±2 μmol kg\(^{-1}\), accuracy <±5 μmol kg\(^{-1}\)
- **User-friendly** through comprehensive, easy-to-use and continuously improved **firmware** as well as application-oriented features (e.g. addition of second inlet for regular standard measurements).
- Chemicals are provided in **cartridges** for easy operation and maintenance.
- **Low sample and reagent consumption** of approx. <20 mL (pH) and 50 mL (TA) per sample.
- **New laser detector** for CH$_4$ and CO$_2$ improving
  - Accuracy
  - Stability
  - Response time

- **Compact wet-chemical analyzers** for
  - Simplified integration into existing flow-through systems

- **Web interface** on upcoming product generations for
  - User-friendly sensor configuration
  - Live data monitoring
  - Remote operation of the instruments
Thank you

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