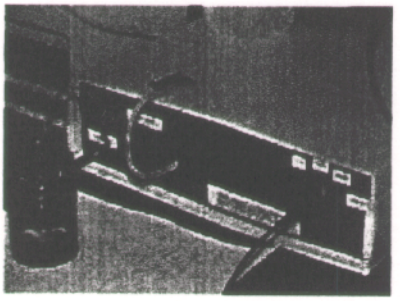
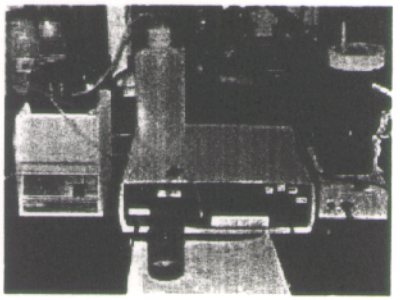
NASA Office of Technology Transfer

John C. Stennis Space Center

Dual-Use Activities Bring Results

A Portable Instrument to Measure CDOM Light Absorption in Aquatic Systems





World Precision Instruments, Inc., of Sarasota, Fl, has developed an innovative instrument to accurately measure CDOM absorption in the field.

World Precision Instruments, Inc. (WPI), of Sarasota, Fl, in collaboration with NASA's John C. Stennis Space Center, has developed an innovative instrument to accurately measure Colored Dissolved Organic Matter (CDOM) absorption in the field. This successful collaboration has culminated in an exciting new device, called the UltraPath, now commercially available thru WPI. Traditional methods of measuring absorption of dissolved materials require special handling and storage prior to measurement. Use of laboratory spectrophotometers as the measuring devices have proven time consuming, cumbersome and delicate to handle. The UltraPath provides a low-cost, highly sensitive, rugged, portable system that is capable of high sensitivity measurements in widely divergent waters.

UltraPath

Scientists are examining the role that coastal ocean environments play in the global carbon cycle. Using Ocean Color data from satellite-based instruments, scientists are working to understand the processes that govern the high productivity of coastal systems. To interpret Ocean Color data in these optically complex environments, there is a strong need to quantify the absorption of blue light by Colored Dissolved Organic Matter (CDOM). Working through the Office of Technology Transfer's Dual-Use Development Program at John C. Stennis Space Center World Precision Instruments (WPI) has developed a new device, called UltraPath. The device combines high sensitivity in a low-cost portable system.

HOT Points

- **Reduces cost and expense**
- **Durable and rugged**
- **Highly Sensitive**
- **Portable measuring system**
- **Easy to use**
- **Provides user selected optical path lengths**
- **Proven to work in divergent environments**

Traditional methods of measuring absorption of dissolved materials require special handling and storage prior to measurement. Use of laboratory spectrophotometers as the measuring devices have proven time consuming, cumbersome and delicate to handle. CDOM absorption can be measured with reasonable accuracy using a 10 cm path cell in most inland and near shore environments. However the combination of low concentration and short path lengths makes the use of a traditional spectrophotometer impractical in many offshore and shelf waters. Alternative methods include sample concentration and longer path length cells. Although these techniques extend the use of the spectrophotometric method to a wider range of water types, sample handling and storage (4 degrees C) requirements often prevent the collection and analysis of CDOM samples from isolated or distant waters.

Dr. Richard Miller teamed with WPI scientists, Dr. Mathias Belz and Dr. Suyi Liu, to develop an instrument that would meet the needs of both NASA and the general scientific community. The Ultra Path system is designed for user-selectable optical path lengths, very high sensitivity and an extended dynamic range for VIS (visible) absorbance measurements. The unit has the capability to measure at four optical paths (2 cm, 10 cm, 50 cm, 200 cm) within a single sample. An operator-controlled switch changes the optical path of the sample, allowing absorbance measurements over a broad range. The fluid path of the sample cell is optimized to produce a laminar flow that is virtually free of interference from trapped air bubbles and adherence of dissolved substances to the inner flow cell wall. In particular, the design greatly minimizes the problems commonly found with flow cells of long optical path lengths; such as trapping dust particles and fibers or particular matter inside the cells.

UltraPath's unique design solves measurement problems in both fresh and saltwater environments and has proven to work in widely divergent water types ranging from the lab to the field. **"The UltraPath is providing measurements of CDOM absorption comparable to expensive, delicate spectrophotometric systems in a reasonable low-cost portable system" Miller said. "Moreover, the precision of the longer path lengths greatly enhances our ability to make absorption measurements, at sea, over a much broader range of CDOM concentration."**

The Ultrapath system includes a photodiode array-based spectrometer to measure the absorbance of the selected path length. Light from a newly developed tungsten source (with an effective color temperature of approx. 6000K) is transmitted to the UltraPath sample cell and from the cell to the spectrometer via optical fibers. A peristaltic pump is used to evenly draw and /or circulate sample through the UltraPath sample cell.

A key design feature of the UltraPath is its tubular sample cell, the outer-wall being comprised of a material having unique optical properties that result in total internal reflection and refraction of light at the core/wall interface. The result is that light directed into the liquid-filled core of the cell will propagate along the cell as if it were an optical fiber. This enables a light path length of 200cm and more. UltraPath is designed for convenient mobility making it suitable for a broad range of laboratory and field environments. **"Although UltraPath was originally designed for determination of CDOM, it is an ideal instrument for any study requiring precise and highly sensitive spectroscopic determination of analytes, either in the laboratory or in the field. The dual use program has provided both partners with the opportunity to combine NASA's vast knowledge of Oceanology with WPI's expertise in optical instrumentation resulting in the successful design of UltraPath" said Belz.**

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NASA Partners with Commercial Company to develop a Portable Instrument to Measure CDOM Light Absorption in Aquatic Systems

Hancock County, Miss.-NASA scientists are examining the role that coastal ocean environments play in the global carbon cycle. Using Ocean Color data from satellite-based instruments, scientists are working to understand the processes that govern the high productivity of coastal systems, particularly in ocean margins influenced by rivers. To interpret Ocean Color data in these optically complex environments, there is a strong need to quantify the absorption of blue light by Colored Dissolved Organic Matter (CDOM), a dominant absorber of light in coastal regions.

World Precision Instruments, Inc. (WPI), of Sarasota, FL, in collaboration with NASA's John C. Stennis Space Center, has developed an innovative instrument to accurately measure CDOM absorption in the field. NASA's Dr. Richard Miller of the Earth Science Applications Directorate teamed with WPI scientists Dr. Mathias Belz, Dr. Suyi Liu and other staff members to develop an instrument that would meet the needs of both NASA and the general scientific community. This successful collaboration has culminated in an exciting new device, UltraPath, now commercially available from WPI.

Supported, in part, by the NASA Office of Technology Transfer (OTT) through the NASA Dual-Use Technology Development Program, the device is a low-cost, highly sensitive, rugged, portable measurement system comparable to advanced spectrophotometric systems that are capable of high sensitivity measurements in widely divergent waters.

A major goal of ocean optics is to determine the role that water components play in the spectral absorption of light. CDOM strongly absorbs light in the UV and blue regions of the spectrum. In productive waters, light is primarily absorbed by a combination of CDOM and phytoplankton pigments in the blue regions of the spectrum. This variability of CDOM properties can cause errors in both semi-analytical and empirical algorithms used in the analysis of satellite imagery, particularly algorithms on 412 and 443 nm bands.

Although CDOM can be the dominant absorber in coastal and river-dominated shelf environments, CDOM can also be an important optical component in offshore waters. CDOM concentrations vary significantly between open ocean waters with low

CDOM (0.007 AU/m at 380 nm) and freshwaters that are turbid and have high CDOM levels (10-20 AU/m at 380 nm). Therefore, there is a strong need to measure CDOM spectral characteristics over a wide range of concentration

The availability of CDOM absorption measurements is often limited, particularly in the optically complex and CDOM-rich environment of river dominated coastal margins. The lack of CDOM measurements can affect the development of regional-to-global scale ocean color models of chlorophyll pigments and primary productivity.

Traditional methods of measuring absorption of dissolved materials require special handling and storage prior to measurement. Use of laboratory spectrophotometers as the measuring devices have proven time consuming, cumbersome and delicate to handle. CDOM absorption can be measured with reasonable accuracy using a 10 cm path cell in most inland and near shore environments. However the combination of low concentration and short optical path length often makes the use of a traditional spectrophotometer impractical in many offshore and shelf waters.

Alternative methods include sample concentration and longer path length cells. Although these techniques extend the use of the spectrophotometric method to a wider range of water types, sample handling and storage (4 degrees C) requirements often prevent the collection and analysis of CDOM samples from isolated or distant waters.

The UltraPath™ system is designed for user-selectable optical path lengths, very high sensitivity and an extended dynamic range for VIS (visible) absorbance measurements. The unit has the capability to measure at four optical paths (2cm, 10cm, 50 cm and 200cm) within a single sample. An operator-controlled switch changes the optical path of the sample, allowing absorbance measurements over a broad range. The fluid path of the sample cell is optimized to produce a laminar flow that is virtually free of interference from trapped air bubbles and adherence of dissolved substances to the inner flow cell wall. In particular, the design greatly minimizes the problems commonly found with flow cells of long optical path lengths: such as trapping dust particles and fibers or particulate matter inside the cell.

UltraPath's unique design solves measurement problems in both fresh and saltwater environments as it has proven to work in widely divergent water types with samples ranging from the lab to in the field. **"The Ultrapath is providing**

measurements of CDOM absorption comparable to expensive, delicate, spectrophotrometric systems in a reasonably low-cost portable system" Miller said. "Moreover, the high precision of the longer path lengths greatly enhances our ability to make absorption measurements, at sea, over a much broader range of CDOM concentration" he added.

The UltraPath system includes a photodiode array-based spectrometer to measure the absorbance of the selected path length. Light from a newly developed tungsten source (with an effective color temperature of approx. 6000K) is transmitted to the UltraPath sample cell and from the cell to the spectrometer via optical fibers. A peristaltic pump is used to evenly draw and/or circulate sample through the UltraPath sample cell. A key design feature of the UltraPath is its tubular sample cell, the outer-wall being comprised of a material having unique optical properties that result in total internal reflection and refraction of light at the core/wall interface. The result is that light directed into the liquid-filled core of the cell will propagate along the cell as if it were an optical fiber. This enables a light path length of 200cm and more. UltraPath is designed for convenient mobility making is suitable for a broad range of laboratory and field environments.

"Although UltraPath was originally designed for determination of CDOM, it is an ideal instrument for any study requiring precise and highly sensitive spectroscopic determination of analytes, either in the lab or in the field. The dual use program has provided both partners with the opportunity to combine NASA's vast knowledge of Oceanology with WPI's expertise in optical instrumentation resulting in the successful design of UltraPath" said Belz.

The dual-use concept of product development is based on the sharing of costs, risks and successes between the government and a commercial partner. In these projects, NASA can contribute technology development, unique facilities and know how, engineering resources, and potentially some part of the funding. In turn, the commercial partner contributes its unique resources, facilities, manufacturing, and marketing capabilities. The result is an approach that provides considerable flexibility, and draws upon the capabilities of both parties.

For more information on the NASA Dual-Use Technology Development Program at Stennis, call (228) 688-1929, or access the web site at http://technology.ssc.nasa.gov.

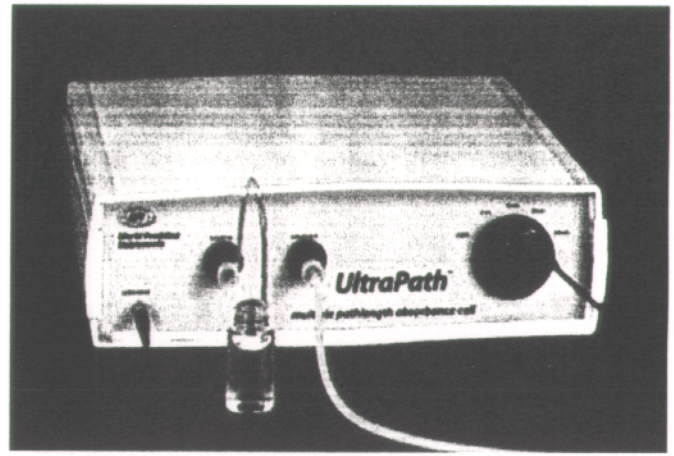
For more information on the UltraPath spectrographic instrument, contact World Precision Instruments at (941) 371-1003, or visit their website at http://www.wpiinc.com.

Portable CDOM Measurement Instrument

World Precision Instruments, Inc. (WPI)

UltraPath™ system

An innovative instrument to accurately measure Colored Dissolved Organic Matter (CDOM) absorption in the field.



UltraPath™ system

Accomplishments

- Designed for user-selectable optical path lengths over an extended dynamic range for VIS (visible) absorbance measurements
- Operator-controlled switch changes the optical path, allowing absorbance measurements over a broad range
- Capacity to measure at four optical paths (2cm, 10cm, 50 cm and 200cm) within a single sample
- Designed for convenient mobility suitable for a broad range of laboratory and field environments

Commercialization

- Device is a low-cost, highly sensitive, rugged, portable measurement system comparable to advanced spectrophotometric systems.
- Capable of measurement in both fresh and saltwater environments and in widely divergent water types with samples ranging from the lab to in the field.
- Provides measurements of CDOM absorption comparable to expensive, delicate, spectrophotrometric systems in a reasonably low-cost portable system

Government/Science Applications

- Ideal for any study requiring precise and highly sensitive spectroscopic determination of analytes, either in the lab or in the field.
- Tool to quantify the absorption of blue light by Colored Dissolved Organic Matter (CDOM) for correlation with Ocean Color data from satellite-based instruments used to understand the processes that govern the high productivity of coastal systems, particularly in ocean margins influenced by rivers

Stennis Space Center
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