Electrochemical Phosphate Sensor

(OTT ID 1513)

Inventor: Dr. Woo-jin Chang, Department of Mechanical Engineering and School of Freshwater Science

UW-Milwaukee

For further information please contact:

Jessica Silvaggi, PhD, CLP

Senior Licensing Manager

1440 East North Ave.

Milwaukee, WI 53202

Tel: 414-906-4654

Jessica@uwmrf.org

Why are Phosphates a Problem?

Increased levels of phosphates can lead to:

- Eutrophication (excessive plant growth such as algal blooms)
- At first plant growth may be stimulated, but over time excessive plant growth can choke the water way, and lead to death of the plants
- Low oxygen in waterways can occur and death of aquatic organisms
- Some algal blooms are toxic to humans

Sources of increased phosphates in the environment include:

- Fertilizers and farm water run-off (and manufacturing of fertilizers)
- Sewage
- Pulp and paper industry
- Detergents
- Vegetable and fruit processing

Current Problems Phosphate Detection

- The EPA notes that “Monitoring phosphorus is challenging because it involves measuring very low concentrations down to 0.01 milligram per liter (mg/L) or even lower….”

- Even such very low concentrations of phosphorus can have a dramatic impact on streams. Less sensitive methods should be used only to identify serious problem areas.

- The EPA approved method for measuring phosphates involves the use of chemical reagents

- In some cases samples must be brought back to the lab for analysis

Low-Cost Electrochemical Solution

Our inventors developed a disposable low-cost SPE phosphate sensor using Graphene Oxide, Pyrrole, Ammonium molybdate and Cobalt Oxide

- **Sensitive** – Detects as low as 10^{-10} M (mol/L), several orders of magnitude lower than other devices
- **Inexpensive** – Only a voltmeter is needed for detection and the materials used are readily available
- **Disposable** – Sensors can be fabricated for one time use for quick and easy set-up
- **Pre-Calibrated** – Sensors can be supplied pre-calibrated and are easy to use
- **Multiple Applications** – Residential, industrial, environmental, governmental and research use

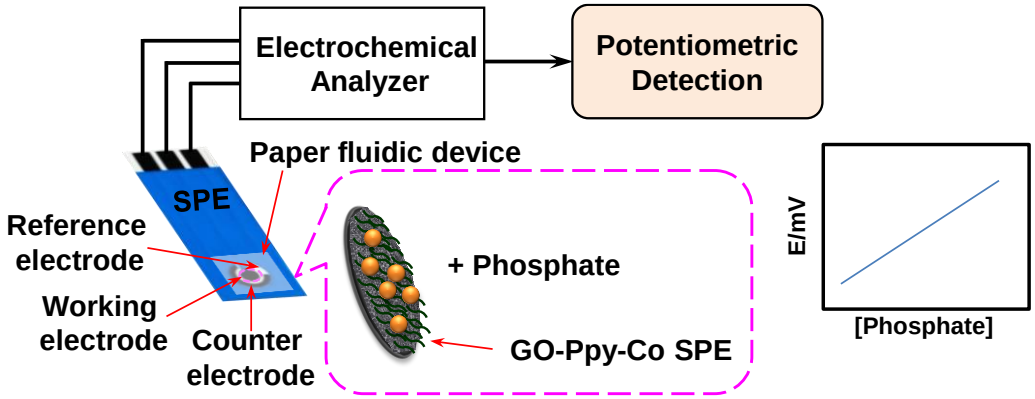
Intellectual Property and Licensing

- **U.S. Provisional Patent Application filed August 2017**

- **Looking for a development partner to:**
  - Aid in development of the final end user prototype
  - Determine the proper manufacturing pathway
  - Aid in funding further evaluation of the sensors for long term use versus disposable
  - Bring the products to market
- **Market**
  - The global market for water analysis instrumentation is projected to reach $3.6 billion by 2020
  - Water analysis is critical in residential, commercial, and industrial sectors

Novel Disposable Phosphate Sensor

Schematic diagram of the setup



Chemical reaction using Cobalt (example)

$$3CoO + 2H_2PO_4^- + 2H^+ \rightleftharpoons Co_3(PO_4)_2 + 3H_2O \text{ at pH } 4.0$$

$$3CoO + 2HPO_4^{2-} + H_2O \rightleftharpoons Co_3(PO_4)_2 + 4OH^- \text{ at pH } 8.0$$

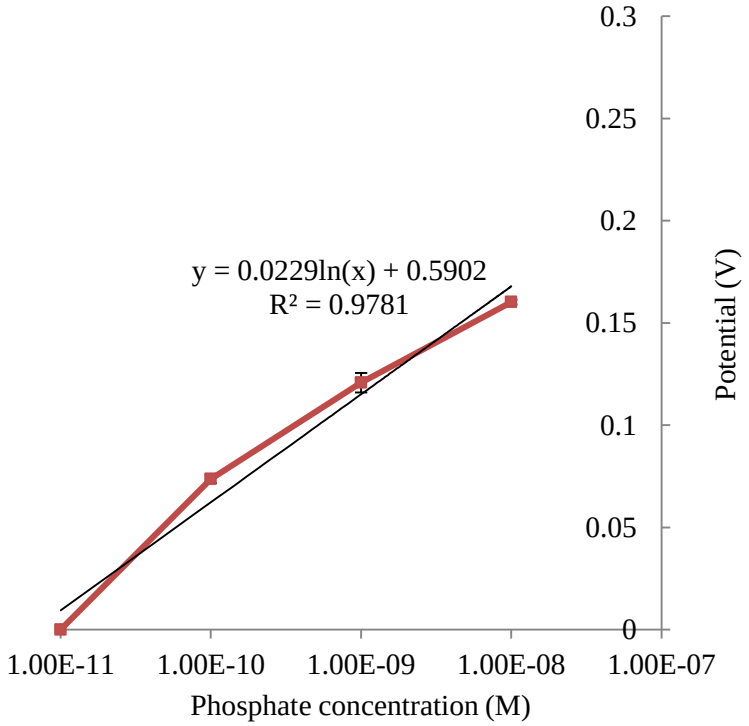
$$3CoO + 2PO_4^{3-} + 3H_2O \rightleftharpoons Co_3(PO_4)_2 + 6OH^- \text{ at pH } 11.0$$

- Carbon working electrode surface of Screen Printed Electrode (SPE) modified by selective combinations of Graphene Oxide, Pyrrole, Cobalt Oxide nanoparticles, Tin (IV) Chloride, Diphenyltin Dichloride, or Ammonium Molybdate by drop-casting method

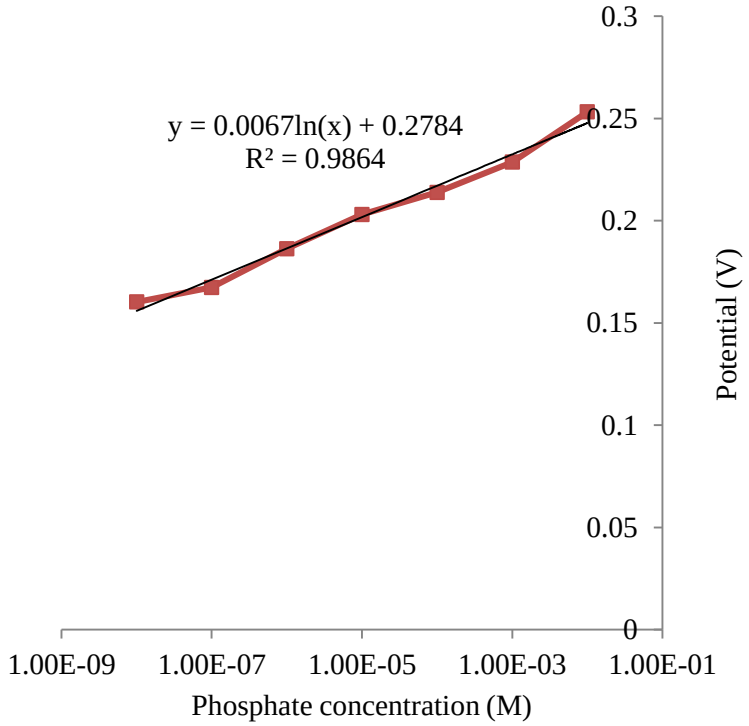
- Different concentrations of KH_2PO_4 aqueous solution used to determine the sensitivity and lower detection limit (LOD) of phosphate ion ($\boldsymbol{PO_4^{3-}}$)of the developed sensor using open circuit voltammetry

Phosphate is Detected in Several Ranges

Low concentration range



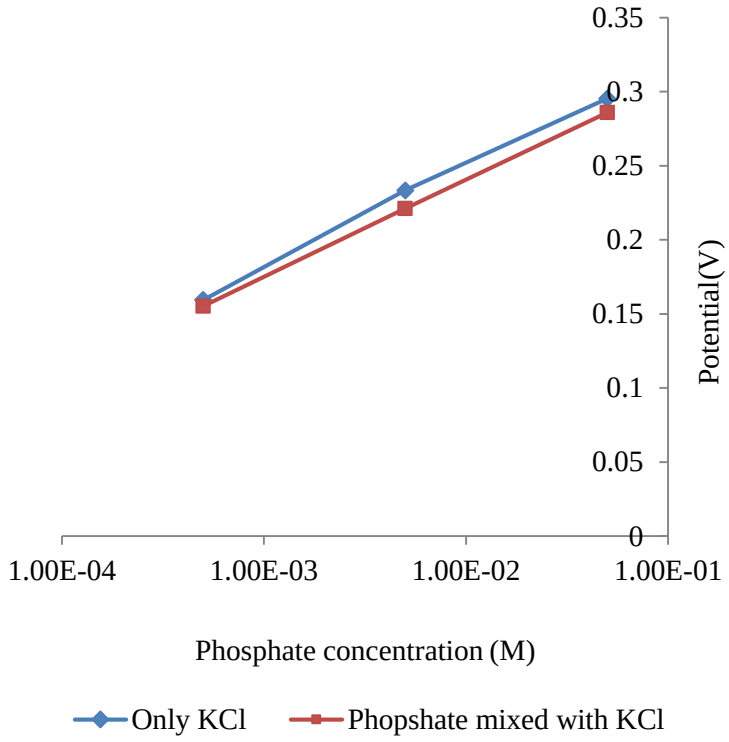
High concentration range



Phosphate detection using mixture of Pyrrole and Ammonium molybdate modified SPE in KH_2PO_4 aqueous solution at pH 4.5 (left)

Linear Measurement of Phosphate

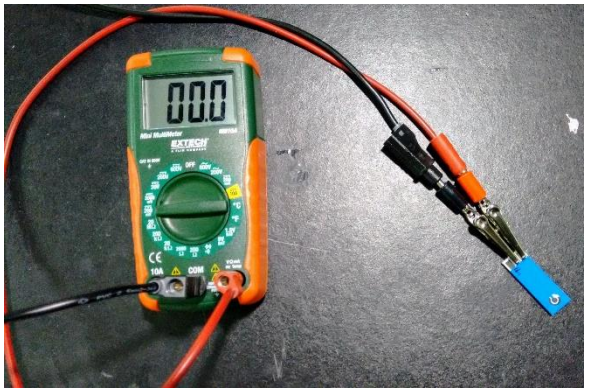
Insignificant interference by KCl

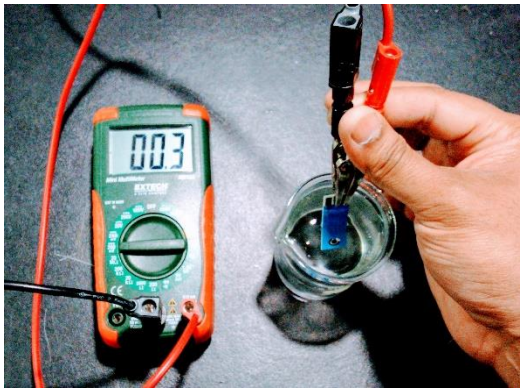


Interference test of Phosphate ions in presence of Cl^- ions using mixture of Pyrrole and Ammonium molybdate modified SPE in KCl solution and KCl in KH_2PO_4 aqueous solution at pH 4.5

In Summary

- Our team has demonstrated a highly sensitive phosphate sensor that can be used as a simple hand-held device
- The materials for manufacture are inexpensive and easy to obtain
- Extensive training will not be necessary to use the device
- Licensees can derive further profit from the use of one time disposable sensors





Next Steps

- Determine whether sensors can be used in longer term applications or continuous use:
  - Sensor will be submerged in standard solution for certain period of time, and then use it for the measurements to characterize the sensitivity change over time and robustness
- Test sensors further to characterize effect of temperature (5°C-50° C) on detection, as well as appropriate temperature range for the detection
  - The sensor will be tested in pressure chamber with pressure up to 80 psi (the pressure regulator in residential use is set between 40-50 psi)
- Find partner to manufacture and develop the final prototypes

Electrochemical Phosphate Sensor

(OTT ID 1513)

For further information please contact:

Jessica Silvaggi, PhD, CLP
Senior Licensing Manager
1440 East North Ave.
Milwaukee, WI 53202
Tel: 414-906-4654
Jessica@uwmrf.org