Electrochemical Phosphate Sensor
(OTT ID 1513)

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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
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
• 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
• 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$_2$PO$_4$ aqueous solution used to determine the sensitivity and lower detection limit (LOD) of phosphate ion ($PO_4^{3-}$) of the developed sensor using open circuit voltammetry
Phosphate detection using mixture of Pyrrole and Ammonium molybdate modified SPE in $\text{KH}_2\text{PO}_4$ aqueous solution at pH 4.5 (left)
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 KH₂PO₄ aqueous solution at pH 4.5
• 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
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