# Inactivation of *Cryptosporidium paruvm* using Photoelectrocatalytic Oxidation

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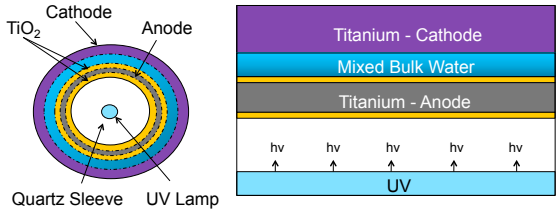
## Photoelectrocatalytic Oxidation

•An advanced oxidation technology that uses UV radiation to activate a $TiO_2$ based photoactive electrode, that can produce free chlorine species (HOCl, $OCl^-$ and $Cl_2$) by oxidizing dissolved chloride ions in water.

•Photoelectrocatalytic oxidation (PECO) uses chlorination, UV, and hydroxyl radical oxidation to disinfect water, during the point-of-use drinking water purification application.




END VIEW - PECO PLAN VIEW - PECO

**Figure 1**: A UV lamp of housed within a quartz sleeve. Titanium Dioxide ($TiO_2$) semi-conductor encompasses the titanium anode. The bulk water interface is where the advanced oxidation process take place, with an abundance of free electrons on the surface of the titanium cathode.

## *Cryptosporidium parvum*

•A waterborne pathogenic organism known to infect humans through ingestion of water (fecal-oral route)

•Accountable for 42% of all US waterborne outbreaks (total of 87), 1991-2002 (Craun, 2006)

•Increased regulations have decreased outbreaks significantly
-Long Term 1,2 Surface Water Enhanced Treatment Rule

•Very resistant to inactivation via chlorination; susceptible to UV irradiation

## Hypothesis

•Due to the three germicidal approaches (UV, $Cl_2$, and $^{\bullet}OH$), I expect a strong correlation between inactivation of *Cryptosporidium* and the use of PECO, compared with no treatment, UV only treatment, and photocatalysis treatment.

•Inactivation of *Cryptosporidium* should follow first order reaction kinetics, the Chick-Watson model

## Research Question

How effective is the photoelectrocatalytic oxidation device in inactivating *Cryptosporidium parvum*?

## Methods

•A 7L tank filled with 4L of tap water, acts as a re-circulating batch system. A PECO unit is connected to a submerged pump.

•One mL of 2 x $10^7$ oocysts is inoculated into each tank, and allowed to re-circulate throughout the system, sans treatment, before the first sample is taken at time = 0.

•Three tanks, with a respective PECO device (One control = No treatment)

•Sampling Technique
0, 15, 30, 45, and 60 minutes
1 mL [IFA], 300 µL [Flow Cytometer] (triplicates)
Positive and Negative controls (duplicate):
Positive: Enumerated oocysts at 1000, 750, 500, 250, 100, 10
Negative: Heat Inactivated oocysts

•Samples are then prepared for inoculation on to the established HCT-8 cell monolayer, on a 8-well chamber slide. After well inoculation, sample is then processed using an immunofluorescent assay.

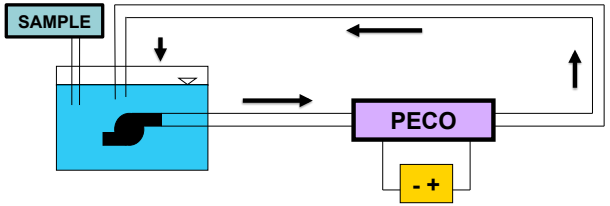



**Figure 2**: Schematic of one PECO unit; a 7L tank, 12V Power Supply, 2-½" ID x ¾" OD Vinyl Connector Tubes, PECO device, Pump (Max Q = 5.4 L/min)

## References

• CH Diagnostics and Consulting Service. (2011). Product Information.

• Craun, M. (2006). Waterborne Outbreaks Reported in the United States.

• Lucido, J. (2010). In-Situ Chlorine Generation and Microbial Inactivation by Photoelectrocatalytic Oxidation.

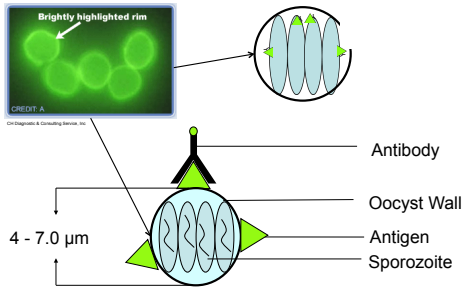
• Masters, G., Ela, W. (2008), Introduction to Environmental Engineering and Science. Third Edition. 300-301.

## Immunofluorescent Assay (IFA)

•Developed to detect ACTIVE *Cryptosporidium* oocysts in human, animal, and fecal smears

•Use of dyes to stain oocysts, that are viewed using microscopy
-Rat anti-sporozoite antibody, Goat anti-rat IgG FITC labeled anti-body

•Infection detected as a monolayer containing at least one focus of life stages



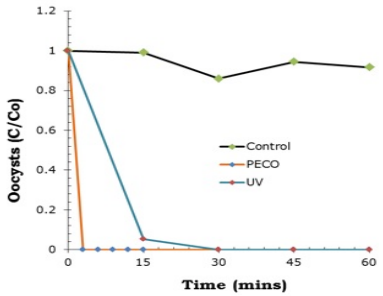




**Figure 3**: PECO achieved complete inactivation by the 3 minute sampling point. Operational parameters: flowrate, applied voltage (9Volts), seeded oocysts concentration (2x$10^7$ oocysts/mL). Tank 1 served as the control (no treatment), with the identical operational parameters as tanks 2 and 3.

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