Oxygen

The most important part
in Wastewater Treatment

View of DO Probe measuring Dissolved Oxygen by Ultraviolet Light

Dissolved Oxygen Probe

How it works: The TEII Fluoroprobe together with the Fluorometer (controller) is designed to provide long-term monitoring and control of appropriate devices based on the saturation level of oxygen in gaseous or aqueous solutions.

Dependable, Repeatable The TEII DO Meter can be used for long-term monitoring of oxygen levels without the necessity of changing the membrane or electrolyte fluids. These components are not used in this method.

Easy To Use Does not require repetitive calibration and/or compensation for membrane effects which are an extremely large source of error and drift for any probe using membrane/electrolyte and dissimilar metal anodes and cathodes. (galvanic and "Clark probe")

Reliable The maintenance requirement for continued long-term utilization is to wipe off the sensor. (if necessary)

Versatile Can be configured to control aeration of wastewater operations, aquaculture applications and process control.

What is Fluorescence? Fluorescence is the absorption of light at one wave length, which is changed to another wavelength.
The process in which a molecule emits a photon 10-8 to 10-4 s after absorbing a photon. It results from a transition between states of the same spin multiplicity.

How does it measure oxygen? The oxygen present in the silicone rubber sensor as a result of the oxygen from the water it is in, forces the patented sensor elements to glow orange/red when sensor is exposed to a blue light. (see photograph above)

Features, Benifits and Advantages

There are many advantages to using our optical method for the measurement of oxygen over the existing methods such as Galvanic and Clark probes.

1. Our sensor does not consume oxygen and is in a state of non-dynamic equilibrium, therefore, it does not require flow across the sensor in order to function. It is a requirement for the Clark and Galvanic probes that flow be present.

2. Our sensor does not require external air compressors, mechanical wipers, chlorine gas, or voodoo in order to operate. When coated with grease, slime, or any other substance, it works because it is in equilibrium with the oxygen in the water in a non-dynamic relationship.

3. Our sensor does not require maintenance such as re-filling of electrolyte, changing membranes or other nasty, time-consuming tasks.

4. Our sensor should last for years, as long as the environment surrounding it is compatible with silicone rubber.

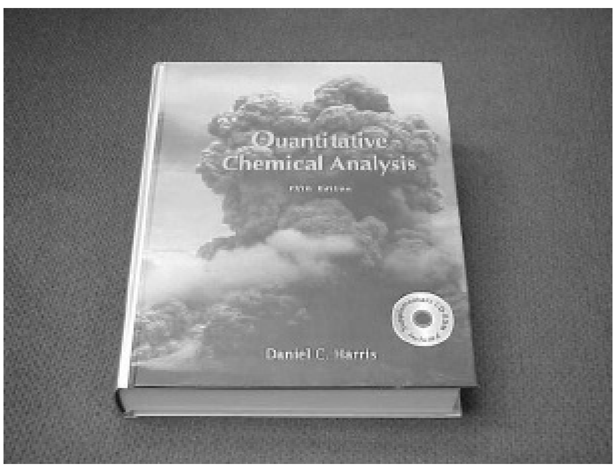
5. Our sensor does not get consumed or foul. Fouling, which is catastrophic for Galvanic and Clark probes and usually means total replacement of the probe. However, this does not affect our sensor whatsoever.

6. If our sensor has to be replaced at all, it will only be a very small part of the probe and can easily be replaced with a small screwdriver or a locking blade pocket knife. This cannot be said for the other probes mentioned above.

7. Our sensor, due to the advantages mentioned above, does not have the calibration or drift problem as the Galvanic or Clark probes do.

8. Clark and Galvanic based probes sensitivity and resolution set better as the oxygen increases. Our probe behaves in the opposite manner, working best below 8ppm.

Luminescence

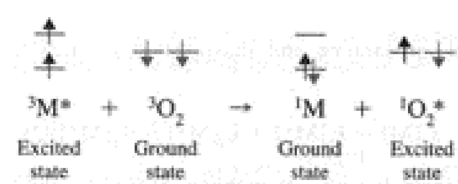


Many types of compounds produce analytically useful luminescence. We will restrict our discussion to Ru(II) complexes, which strongly absorb visible light, efficiently emit light at significantly longer wavelengths than they absorb, are stable for long periods, and have a relatively long-lived excited state whose emission is quenched by O_2.

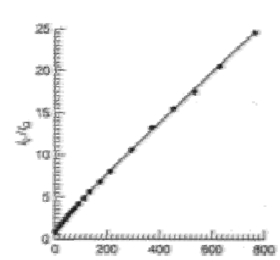
Because oxygen quenches luminescence from many compounds, it is often necessary to degas a solution or purge it with N_2 prior to emission measurements. The reason O_2 is such a good quencher is that its ground state has two unpaired electrons--it is a *triplet* state designated $^3O_2$*. Oxygen has a low-lying *singlet* state with no unpaired electrons.

The figure below shows that the lowest-lying excited state of many molecules is a triplet. This triplet excited state $^3M^*$ can transfer energy to $^3O_2$ to produce a ground-state singlet molecule and excited $^1O_2$.

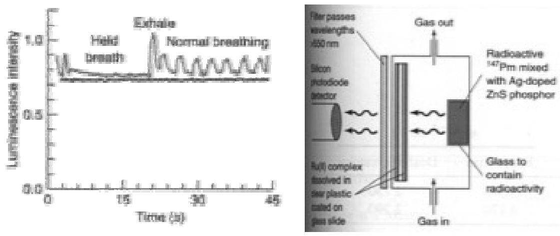
There are two electron spins up and two down in both the reactants and produce. This energy transfer therefore conserves the net spin and is more rapid than processes that change the spin.



The complex dissolves in silicone rubber (such as bathtub caulking compound), which is readily permeable to O_2. The figure below shows that luminescence of Ru(II) dissolved in rubber decreases by a factor of 25 when the O2 concentration increases from 0 to 1 atm.



The curve is not exactly linear because the Ru complex has multiple environments in the rubber matrix with somewhat different rate constants for absorption, emission, deactivation, and quenching at each site. The figure below demonstrates the response of a Ru(II) luminescence sensor to O_2 in a person's breath.



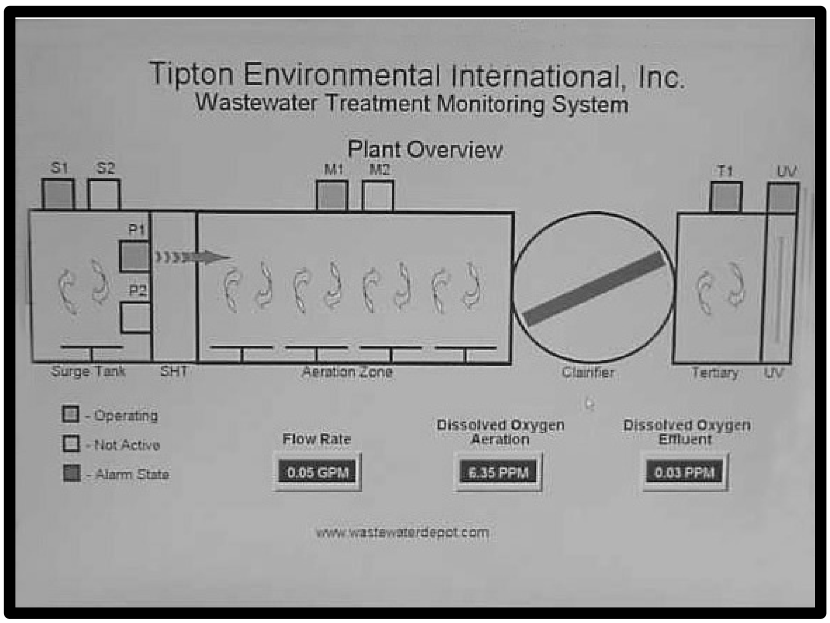
(a) Stern-Volmer plot for $(dpp)_3RuCl_2$ dissolved in a silicone rubber matrix. (b) Variation in luminescence intensity of the Ru(II) sensor exposed to a person's breath. [From J. N. Demas, B. A. DeGraff, J. Chem. Ed. 1997, 74, 690; E. R. Carraway, J. N. Demas, B. A. DeGraff, and J. R. Bacon, Anal. Chem. 1991, 63, 337; J. R. Bacon and J. N. Demas, Anal. Chem. 1987, 59, 2780.]

Works Cited

Harris, Daniel C. "Quantitative Chemical Analysis" New York: W. H. Freeman and Company, 1999

For a field-portable O2 sensor, it is desirable to reduce power requirements to a minimum. The figure below shows a clever approach to this problem.

The sensor is $(dpp)_3Ru(II)$ dissolved in transparent plastic coated on a microscope slide. To reduce the electrical requirement for the lamp down to 0, radioactive ^{147}Pm is mixed with a silver-doped zinc sulfide phosphor that emits visible light when irradiated by ß particles (high-energy electrons) from decay of the ^{147}Pm. The glass lamp housing prevents ß particles from exiting the lamp. Light from the lamp excites Ru(II), whose luminescence depends on the partial pressure of O_2 in the gas flowing through the sensor chamber. An optical filter that passes wavelengths > 550 nm rejects most of the light from the lamp but passes most of the light emitted by the Ru(II).



With this new technology of luminescence continuous monitoring of this wastewater treatment systems can be easily accomplished without continuous maintenance and re-calibration required.

T I P T O N
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