

BLUE GLOW vs ELECTROSPARK

Horace Heffner January, 2006

BACKGROUND

A blue-green glow has been observed on electrodes of high voltage electrolytic cells and electrolytic rectifiers. [1] [2] Electrodes to create the blue-green glow can be made from metals like Ni, Zn, Ti, Al or Zr that form insulating oxides. The glow has been created in cells containing a weak electrolyte like Pickling Lime (CaO), Baking soda, sodium metasilicate, or acetic acid, by gradually increasing the AC voltage through them typically to 200 - 400 V AC. Zn can only be conditioned to about 76 volts. As the electrodes are "conditioned" using high voltage AC they begin to act like opposed diodes and the cell then acts like a capacitor with a low current bypass resistor. That the electrodes act like diodes can be confirmed by replacing one of them with a fresh electrode of the same metal, or with electrodes made of materials which do not form the insulating layers, like Pb, Mg or C, and gradually increasing the voltage to avoid an unexpectedly large DC current.

When the electrode is "conditioned" and the glow is formed, the i vs V curve looks like Fig 1.

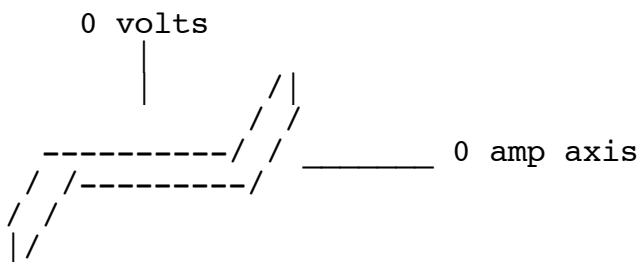


Fig 1. - i vs V curve

The i vs T curve looks like Fig. 2.

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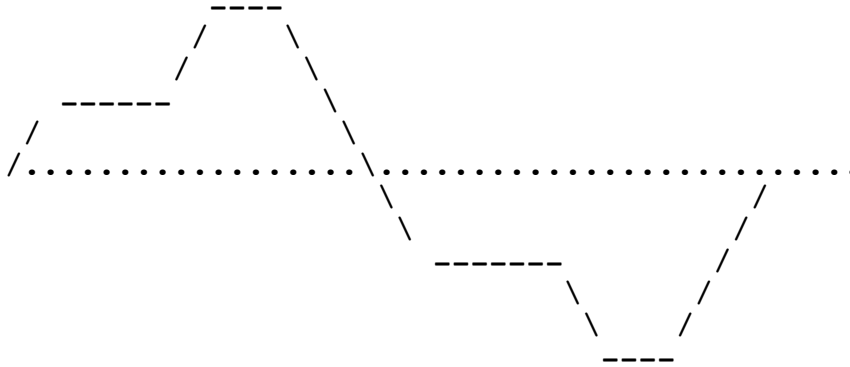


Fig. 2 - i vs T for blue glow.

These traces indicate there exists a voltage threshold at which conduction is suddenly increased. This threshold varies depending on the conditioning of the electrode and choice of metal, but is typically between 100 and 400 V. The above trace representations show operation at a peak voltage about twice the breakdown voltage.

THE ELECTROSPARK EFFECT

The electrospark effect, actual sparking or arcing through the oxide layer, can be brought about following conditioning by pushing the voltage way above the threshold value. This electrospark regime, described below, should not be confused with the glow regime, which operates in a more subtle way and is less obviously visible. The glow effect is often visible in the background even when a cell is operating in the electrospark regime.

THE DIODE EFFECT

The "diode effect" can be seen by replacing a conditioned electrode with a fresh electrode which is not yet conditioned, or a metal that does not form a similar layer, like lead, magnesium, or carbon. In one half of the trace there is close to an ordinary linear ohm's law relation, while in the other half the conditioned electrode's rectification and breakdown voltage remains evident. For example see traces at

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<http://home.earthlink.net/~lenyr/borax.htm>.

When operating above the breakdown threshold a blue glow can be seen in a dark room. If the cell current is DC, the blue glow is only about the anode. The blue glow intensity is proportional to current flowing above and beyond, i.e. incremental to, that current which sustains the threshold voltage.

HYPOTHESIS FOR THE GLOW CAUSE

A good working hypothesis for the observations is that during conditioning an insulating layer, probably primarily an oxide layer, grows on the surface of the electrodes to a thickness which prevents molecular ion flow to or from the electrode. This oxide layer passes electrons however, either through conduction or through tunneling, a fact which is easily tested by drying the electrodes and measuring conductivity through the electrodes. The effect of this molecule filtering yet conductive layer on an anode is to create an interphase zone in the electrolyte, bounded by the surface of the anode, across which a large potential drop occurs. This large potential drop across a short distance thus creates a colossal electrostatic field gradient at the surface of the anode. This powerful field gradient is sufficient, by means described below, to free and accelerate protons to sufficient energy to ionize the electrolyte in the interphase and cause recombination reactions that cause the glow.

PASSIVATION

This conducting oxide layer is well known, though the *reason* it conducts is not conclusive. [3] The process of forming this layer, earlier called “conditioning”, is formally called *passivation*. Passivation of an oxide forming electrode occurs when a sufficient current density is passed for a sufficient time through the electrode when it is used as an anode. Either DC or AC can be used, provided the necessary current density is achieved. If insufficient voltage is used, then no oxide layer forms, and ordinary anode corrosion results. After a sufficient passivation time interval and current density, the oxide layer, though initially insulating, begins to be conductive. As the layer becomes conductive it begins to absorb incident photons, i.e. becomes black as opposed to reflective, at least in the case of Ni anodes. [4] When the oxide

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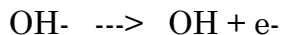
layer is conductive, the electrode is protected from corrosion, and is thus *passivated*. The oxide film which forms just prior to this is called a *precursor* or *prepassive film*. Passivation time is reduced by increasing the passivation voltage and thus current density.

THE CATHODE INTERFACE AND THE ANODE INTERPHASE

The anode interphase layer on a passivated anode creates the diode effect so clearly visible on i vs V traces. The diode effect comes from the difference in the high mobility of protons through the cathode (or anode) interphase layer vs the low mobility of the relatively big negative ions through the anode interphase layer.

The two molecule thick cathode interface is comparatively well understood and thoroughly described by Bockris. [5] Protons in the form of hydronium ions (H_3O^+) are very mobile in water, and easily electronated at the cathode interphase by electrons tunneling through the cathode interphase barrier when having a potential on the order of a few volts. The addition of a conductive oxide barrier at the cathode merely increases the potential required to achieve this tunneling by a few volts.

The anode interphase, however, is dramatically changed by a conductive oxide layer. Here, in order to sustain ordinary electrolysis reaction, an electron must be removed from an OH^- radical. However, a powerful gradient forms at the anode and may be sufficient to strip electrons from neutral molecules given a sufficient lack of availability of OH^- radicals in the vicinity of the anode. In ordinary electrolysis an OH^- radical must be adjacent to the anode surface in order to achieve an effective probability of electron removal. In fact the glow process can be expected with just such a reaction:



However, this reaction immediately removes charges from the electrolyte near the surface of the anode.

The low mobility of the negative molecular ions to the anode is in part due to the powerful polar nature of water, which forms a two molecule thick layer about the anode, the cathode, and also around any molecular ions themselves. This powerfully bound layer prevents molecular ions like OH^- from easily penetrating them.

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However, this layer can only account for a couple eV of the 100-400 volt diode effect breakdown voltage observed. Further the breakdown voltage does not act like an actual diode breakdown, except in spark mode, but rather as a range of quickly increasing current/voltage ratio.

What then can account for the large breakdown voltage? Electrons should be able to tunnel in either direction across the oxide barrier with the same probability. The answer may lie in part because the interphase layer on the anode is much thicker than the two molecule thick interface on the cathode, and thus the cell voltage is divided across more molecules. The OH⁻ radical is polarized. The O side is more negative than the H side. It can form chains at the anode. Fig. 3 is a representation of one example of such a weakly bound molecular chain.

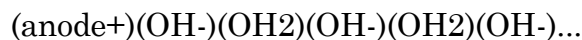
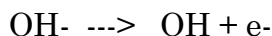


Fig. 3 Representation of anode interphase polar molecular chain

Multiple water molecules, OH, HOOH, and other polar molecules would be expected often in place of the OH₂ molecules shown in Fig. 3. Water is deliberately designated in Fig. 3 as OH₂ in that the negative O side of the water would be attracted to the hydrogen side of the OH⁻. When the potential drop across the first OH⁻ molecule is sufficient to strip an electron, we have:



In that the OH molecule is polar, we still have a chain as shown in Fig. 4

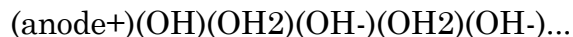


Fig. 4 Anode interphase polar molecular chain post-discharge

But the front molecule of the chain has to break free of the chain in order to have another electron exchange. The next OH⁻ radical, now at least two molecules away from the anode, must force its way to the anode for another reaction to occur. The diffusion rate for the big OH⁻ radical is much lower than for a much smaller proton tunneling its way through water molecules. The creation of the charge free gap

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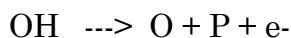
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places a large amount of the cell potential drop across that gap.

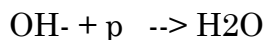
Given the high field gradient, we might at times see on the anode surface:



or possibly

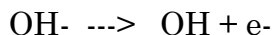


and the free proton, accelerated by the strong local anode field gradient, zips its way down the chain, causing ionization, some hydronium formation, but ultimately:



a recombination reaction.

In that the glow does not occur from normal low voltage cathode reactions, i.e.



it appears a substantial percentage of the anode reactions in the glow regime create free protons.

The diode forming zone in the electrolyte sustains the majority of the typical 200-400 V drop across a glowing anode cell. Assuming a 120 V drop across a 4 angstrom thick zone, the field strength is about 300 billion volts per meter.

The products of disruption caused by energetic protons, various forms of hydrogen and oxygen, then ultimately recombine to form water or oxygen, and in the process of recombination emit the characteristic blue-green glow of this recombination.

ELECTROSPARK REGIME OPERATION

If the voltage is pushed much beyond the breakdown threshold, bright spots form and in their early stages flash all over the electrode. The scope traces develop a hair like fringe that represents the sudden conductivity characteristic of sparks. This is

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called the electrospark regime. See:

<http://www.earthtech.org/experiments/sparkly/report.html>

Typically, the sparking sites erode, destroying the electrode, and sludge forms in the bottom of the cell. In addition, metal oxidation occurs which throws off calorimetry calculations significantly when not take into account. Microscopic examination of the electrospark hot spots show shiny metal interiors to the holes. The sparks must penetrate through the anode oxide layer. The initial sparkly effect, which gives the appearance of the motion of sparks around the electrode, must be due to the fast reformation of the oxide barrier after a spark. When the spark sites are deeply eroded, however, the appearance of motion of the sparks stops, and in the case of aluminum electrodes, leaves tiny static orange glowing hot spots.

If a DC cell is operated purely in the blue glow regime, it can operate indefinitely, or at least a very long time. Further, the current draw of the cell can be much less than an ordinary electrolytic cell, though the field strength and particle energies at the anode interphase are much higher than for ordinary electrolytic cells. The purely blue glow regime therefore is a much better regime to investigate for free energy creation than the electrospark regime.

Use of AC guarantees the essential anode coating stays in place. Use of square wave AC, though nonessential, would maximize the peak-to-peak voltage that can be used without entering the electrospark regime. Use of regulated DC is desirable if an anode material is used that forms an oxide that is not consumed by the process and does not become thick to enough to stop current flow.

POSSIBLE RELEVANCE TO COLD FUSION

In that free hydrogen nuclei and free electrons are undoubtedly created in the blue glow regime, it is a candidate for both vacuum energy creation via atomic expansion, and for cold fusion reactions via electron catalysis, and thus for tritium creation provided D2O electrolyte is used. Because the input power is low, an over unity coefficient of power should be much easier to spot as well. If any energy or nuclear effect is found, the regime can be made far more energetic by engineering conductive ceramic or semiconducting layers capable of avoiding the electrospark regime into very high voltages.

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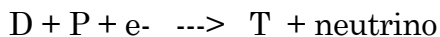
To maximize the energy gained from atomic expansion, the cell must be operated at as high a pressure as possible. Coincidentally, electrolysis provides an ideal means for maintaining cells with high internal pressure, by charging the cell interior pressure from the back side of a diffusing cathode made of Pd.

If testing for tritium is an objective, a cell design maximizing (electrode area)/(cell volume) is desirable, in order to maximize the final tritium concentration. Use of a closed cell would be desirable. The blue glow should be very effective at ensuring recombination. It may be possible to run a closed cell provided the anode is located in a horizontal manner at the top of the cell, having the back of the anode insulated from the electrolyte. The objective of this is to route any evolved gasses into the blue glow for recombination. To run a sealed cell, the cell power supply leads would have to be insulated. Any exposed electrode surface area would have to be located under the anode recombiner surface. It may be advantageous to have the anode shaped in a concave dome form, so as to create a gas trap.

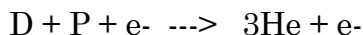
The pure blue glow regime might be investigated by amateurs without access to D2O by simply using very long run times. Ordinary water contains some deuterium. If tritium is produced, it should accumulate in the electrolyte. Electrolytes from very long runs, months or years, might be affordably tested by amateurs developing the right arrangements with labs having scintillation counters, or simply by the use of film.

Unfortunately, in ordinary water, almost no D2O exists. Almost all the deuterium is in HDO molecules. The probability of two deuterium atoms in the same close vicinity is unobservably small. If deuterium is required for a fusion reaction, we would then expect helium-3 to be the likely product, and there is no convenient test available to amateurs for helium-3.

The presence of tritium, if produced from ordinary water, would likely be due to



and this would be surprising indeed, because a weak reaction is required. The electron catalysis [6] for helium-3 would be:



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The electron catalysis of deuterium to produce tritium looks like:



while a dual electron catalysis[7] might look like:



where the He^{**} might end up in a heavy nucleus while in a de-energized state instead of forming helium.

In electron catalyzed fusion, the presence of electrons in the fused product creates the highly de-energized state. [6][7] The degree of de-energization at the moment of fusion depends on just how small the de-energized fused particle is upon initial waveform collapse. Given that it can be string sized, essentially all the energy of the reactants is then returned to the vacuum, followed by a permanent energy borrowing to "expand" the product quantum waveforms to normal size. We thus not only have zero point energy (ZPE) fueled atomic expansion, we have ZPE fueled nuclear expansion, followed by atomic expansion of any residual free leptons.

The key to anode fusion lies beyond merely creating the oxide film of a passivated anode, as described by Bockris. [J. O'M Bockris and A.K.N. Reddy, Modern Electrochemistry, Plenum Press, p.1319 ff.] The process of conditioning the anode must proceed to the point where an insulating barrier is created that permits an electrostatic field intensity sufficient to ionize an OH molecule. In other words, the surface barrier of the oxide film must be thick enough that electron tunneling to the anode only occurs at a voltage beyond the ionizing voltage of the OH molecule. When an electron is stripped from the neutral OH molecule (or possibly water for that matter) the proton of the OH molecule is freed, set loose within the high intensity electrostatic field required to create the electron catalyzed fusion generating cascade within the electrolyte.

Table 1 below shows that water requires about the same but less potential to ionize than OH.

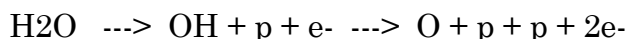
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Molecule	Energy (eV)
H	13.6
H2	15.4
OH	13.0
H2O	12.6
HO2	11.4
H2O2	10.5

Table 1 - Molecular Ionization Potentials in Gas

Given an H2O or OH molecule is about 1 angstrom in length, a field gradient of over 1.3×10^{11} V/m is sufficient to ionize OH to $O + p + e^-$. Thus in a two step process at the anode surface we have:



If this can happen in a single step, but producing a paired electron $2e^-$ boson, then this reaction is ideal for creating the dual electron catalysis ingredients. A single step reaction is energetically favored over a two step reaction because the spin opposed $2e^-$ boson is in a reduced energy state.

If we assume the potential drop at the cathode is about 2 volts, the drop through the electrolyte is 3 volts, and our cell operating voltage is 200 volts DC, the 195 volt anode potential drop can be spread over about 15 atomic layers. The anode interphase can be about 15 molecules thick and yet support the required free proton release at a diode layer breakdown voltage of 200 V, which is readily achievable. The anode phase then ideally consists of multiple levels of pairs of protons moving in a direction opposed to electron paired bosons. The formation of hydrogen peroxide should be suppressed at over 1.3×10^{11} V/m.

The dual electron boson, comprised of two electrons with opposed spin, has no magnetic field. Similarly, a dual proton boson, assuming such exists, has no magnetic field. The superposition of a dual electron boson and dual proton boson creates a boson with no magnetic field and no net charge. It is a tiny Bose-Einstein Condensate. Given that stimulation of the condensate by an intervening particle can cause waveform collapse, the formation of the de-energized He^* results, and the

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locus of that result may be inside a heavy nucleus.

In the high electrostatic field of the 10-15 molecule thick anode interphase taking a 200 V potential drop, we can expect powerful and rigid bonding of water into chains of stretched molecules. In this environment we can expect collective molecular actions, one of which is "Interatomic Coulombic Decay" as described in the Physics News Update quote below:

PHYSICS NEWS UPDATE

The American Institute of Physics Bulletin of Physics News
Number 705 October 20, 2004 by Phillip F. Schewe, Ben Stein

ATOMS CAN TRANSFER THEIR INTERNAL "STRESS" TO OTHER ATOMS, new experiments have revealed. Compared to atoms that are all by themselves, atoms with a close neighbor have a very efficient and surprising way to get rid of excess internal energy. An excited atom can hand over its energy to a neighbor, a research team led by the University of Frankfurt has demonstrated experimentally in a measurement carried out at the Berlin synchrotron facility BESSY II (R. Doerner, doerner@hsb.uni-frankfurt.de). Predicted in 1997 by a group at Heidelberg University (Cederbaum et al., Phys Rev. Lett, 15 Dec 1997), this decay mechanism occurs when atoms or molecules lump together. Once an excited particle is placed in an environment of other particles such as in clusters or fluids, the novel de-excitation mechanism, called "Interatomic Coulombic Decay," leads to the emission of very low-energy electrons from a particle that is neighboring the initially excited one (see figure at www.aip.org/png). The researchers demonstrated the effect in a pair of weakly bound neon atoms. The two neon atoms were separated by 3.4 Angstroms (about 6 times the radius of the neon atom) and held together by a weak "van der Waals" bond. Removing a tightly bound electron from one of the neon atoms allowed one of the less tightly bound atoms to jump down to the tightly bound spot and in the process gained energy. The extra energy was not sufficient to liberate any of the remaining electrons in the same neon atom, but it was sufficient to release an electron in the neighboring atom.

This newly verified effect may have a wide-ranging impact in chemistry and biology since it is predicted to happen frequently in most hydrogen-bonded systems, most prominently liquid water. Furthermore, it may be an important, and so far unknown, source of low-energy electrons, which have recently been shown to cause damage to

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DNA (see <http://www.aip.org/pnu/2003/split/636-1.html>). (Jahnke et al., Physical Review Letters, 15 October 2004; also see researchers' website at <http://hsb.uni-frankfurt.de/photoncluster/ICD.html>)

Such a process may well provide a mechanism for electron boson formation and for energy focusing phenomena in the anode interphase.

ENHANCING THE DC EFFECT

It may be possible to enhance the effects of the interphase by stimulating the water at natural resonant frequencies of water. The natural vibrational frequencies of water are shown in Table 2.

	bend	symmetrical stretch	antisymmetrical stretch
H2O	47.8	109.6	112.6
D2O	35.3	80.1	83.6

Table 2 - The vibrational frequencies of water molecule in THz.

Also of interest is that H2O absorbs energy at 190, 200, 250, 300, and 400 nm wavelengths.

Ed Storms' paper "Critical Review of the "Cold Fusion" Effect", March 1, 1996, page 42 mentions 82 MHz RF signals and high current micropulses (through the cathode) as being as heat enhancing stimuli. This frequency may only be lattice related, but if cold fusion is a surface effect then this frequency may also be related in some way to the effects of water molecules .

Puharich in US Patent 4,394,230 (1983), recommends some surprisingly low frequencies to reduce the energy requirements of water electrolysis, namely a fundamental carrier frequency: 3980 Hz, with strong harmonics at 7960 Hz, 15,920 Hz, 31,840 Hz, and 63,690 Hz.

In the interphase the bend and symmetrical stretch frequencies would be applied in a direction normal to the anode surface, and the antisymmetrical stretch would be

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applied parallel to the anode surface.

ELECTRON-HOLE ANNIHILATION HYPOTHESIS

The above conjectures are exciting, but not the simplest or most credible. A more credible hypothesis to explain the electrolytic anode glow comes from electron-hole annihilation at the interface between the electrolyte and the oxide coating of the anode.

The oxide layer that is effective in producing the glow becomes black, i.e. non-reflective, when it becomes effective [4]. A similar effect was noted by Steiner when making a negative resistance layer on zinc. [8] A reasonable hypothesis then is that the black semi conductive oxide layer forms the basis for both negative resistance, the diode effect, and when combined with a transparent cathode like an electrolyte, the glow effect. The oxide layer then, when in the glow regime, is acting like an N-type semiconductor conducting in reverse-bias, i.e. conducting with the minority charge carrier, conducting via holes. When an electron is stripped from an OH⁻ and then annihilates with a hole, a photon is produced. Possibly two photons are produced, with only one visible. The electrolyte is thus acting like a P-type semiconductor in reverse bias, i.e. conducting with the minority charge carrier, conducting via holes. The reverse bias operation of the electrolyte-oxide system is thus exactly the opposite of the forward current operation of a standard LED. The direction of the photon energy is reversed. Electrons from the transparent cathode (the electrolyte) annihilate with holes in the oxide anode. When electrons and positrons annihilate, in order to maintain conservation of momentum, two photons are created having exactly opposed moment, i.e. directions. Perhaps the same happens with electron-hole annihilation, and, given the electrolyte is the transparent electrode, we simply see the opposite photon from the one we see in an LED.

One problem with this hypothesis is that the glow color seems relatively constant, despite a range of electrode materials. The glow color should change, depending on the hole energy.

It is possible that both electron-hole annihilation and energetic free proton effects are happening in the blue-green glow creating interphase.

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SERENDIPITY

Of possible interest is the idea of using electrolytic passivation to create negative resistance solid state diodes from metals. Zinc can be passivated in a weak (tablespoon baking soda per 8 oz water) electrolyte by gradually increasing the AC voltage to about 76 volts. A much better passivation and higher final voltage would be expected using DC. Other metals require differing voltages, so can offer stronger negative resistance effects or effects at higher voltages and power density. Negative resistance devices are useful for creating oscillators, and may provide an economical way to oscillate very large amounts of power by use of large area negative resistance devices created by applying a conductive metal to the electrochemically passivated surface of an oxide forming metal.

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