External Radiation Produced by Electrolysis — A Work in Progress

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Abstract

Oriani has shown that electrolysis of ordinary water generates showers of energetic charged particles that can be detected outside the electrolysis cell. Here I attempt to confirm external radiation and to explore some of its properties. Possible sources of error are investigated. Preliminary experiments have not revealed showers, but they suggest that a flux of radiation may be emitted from the cell with an intensity that declines with distance from the cell. Further work with better control of environmental factors is required before a definitive statement can be made. Nuclear reactions and decay products that may be responsible for the radiation remain to be identified.

Prompted by the initial report by Fleischmann, Pons and Hawkins [1] of nuclear reactions accompanying electrolysis, hundreds of other investigators have reported various nuclear phenomena including energy production, generation of helium and tritium, nuclear transmutations, and emission of energetic charged particles. A comprehensive bibliography of this work can be found in the review by Storms [2].

Many experiments have employed an electrolysis system consisting of a glass cell with an electrolyte of a lithium salt in water or heavy water as electrolyte, a platinum anode, and a nickel or palladium cathode. Energetic charged particles associated with electrolysis can be recorded in CR39 plastic detectors and can be revealed by chemical etching. The present work employs a system with an electrolyte of Li_2SO_4 in ordinary water (sometimes slightly enriched with D_2O) and a nickel cathode, and is addressed to the investigation of energetic charged particles in the air outside the electrolysis cell.

The detector chips employed contained many latent tracks as received from the manufacturer, apparently alpha particles from decay of airborne radon and from radon that had diffused into the surface layers of the chips and decayed there. ^{222}Rn has a half life of 3.8 days which is long enough for it to diffuse a short distance into the plastic detector. Within a few hours after decay it emits three alpha particles in a series of reactions ending with ^{210}Pb. The ^{210}Pb has a half life of 22 years and emits a fourth alpha particle in reaching stable ^{206}Pb. Fewer than 10% of the ^{210}Pb atoms will have decayed during the two or three years between manufacture and use of the detector material. Hence most embedded radon atoms generate tracks for three alpha particles. With sufficient etching to reach beyond the maximum penetration depth of radon, tracks with favorable orientations (i.e. near enough to perpendicular to the detector surface) can be revealed by etching and many of these can be resolved.

The density of etch pits developed on a detector chip depends on the duration of the etching process. Figure 1 shows etch pit densities for as-received detector chips as a function of etching time at 80°C in 6.5 N KOH. For times of 1 and 2 hours no pits at all were observed. For 3 or more hours etch pits were observed, at first increasing in numbers and then leveling off after 6 or 7 hours. The upper curve shows total etch pits per chip and the lower curve shows the numbers of pits that occurred in multiplets for which two or three distinct tracks from decay of a single

radon nucleus could be resolved. Based on this study an etching time of 7 hours was employed in subsequent research.

As-received detector chips showed wide variation in latent track density, which is largely responsible for the fluctuations in etch pit numbers in Fig. 1. This variation was examined in a series of 23 chips with the result shown in Fig. 2. The mean track density was 314 etch pits per 1.5 cm^2 counted area per detector chip. The large dispersion suggests that chips should be pre-etched before undertaking an experiment to reveal pre-existing tracks, then etched again after the experiment to reveal the desired incremental tracks. However, double etching was not employed in the present work.

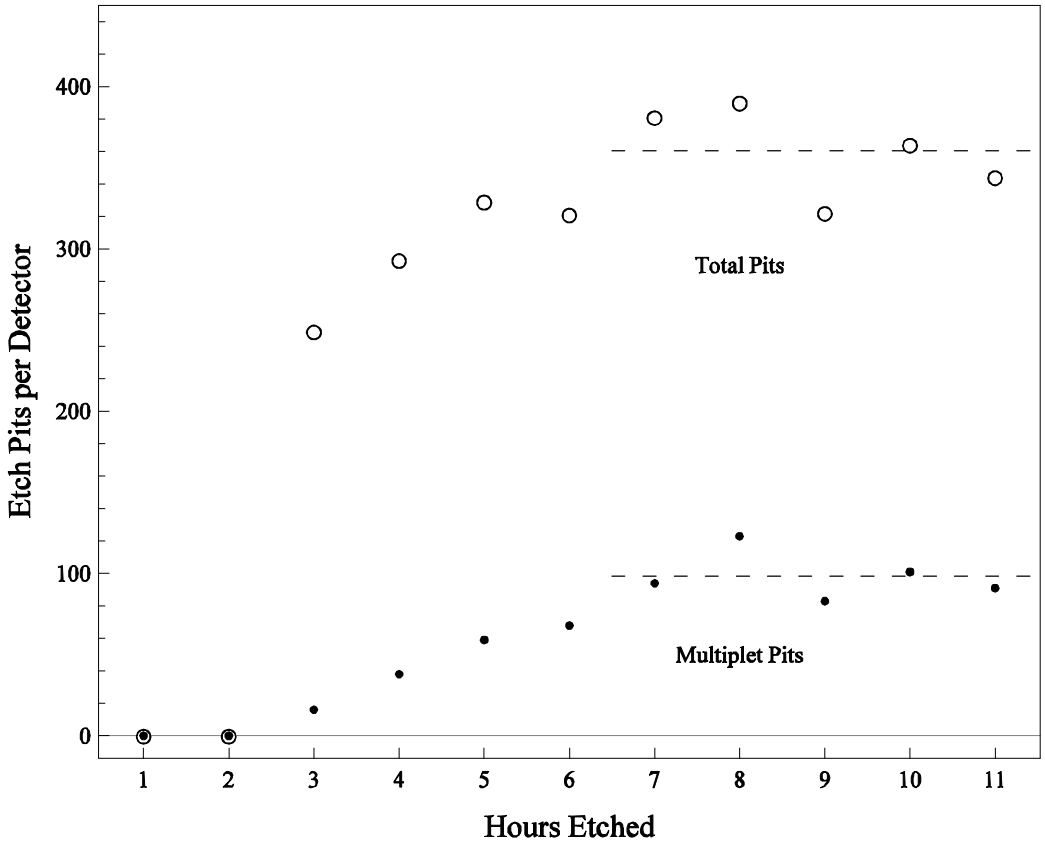

FIGURE 1. Etch pit density as a function of etching time in 6.5N KOH at 80C. Density is measured in etch pits per 1.5 cm^2 detector area. Total pits include those that occur in multiplets of 2 or 3 from decay of embedded radon. No pits are formed for etching times of 1 or 2 hours, after which the density of pits rises and levels off after about 7 hours.

Oriani [3] observed external particles utilizing an electrolysis cell whose cathode was a sheet of nickel that capped and closed the otherwise open bottom of a cylindrical glass cell. The electrolyte was a solution of Li_2SO_4 in ordinary water. A large particle shower containing about 150,000 energetic particles was detected in the $H_2 + O_2$ vapor above the electrolyte. Below the cathode was clamped a second length of glass cylinder containing a mixture of air and such quantity of hydrogen as may have diffused through the nickel cathode. In a second experiment [4] Oriani placed a detector in the vapor below the cathode. During electrolysis the detector

recorded tracks from a shower of about 150 energetic particles that emanated from a point in the gas below the cathode and above the surface of the detector.

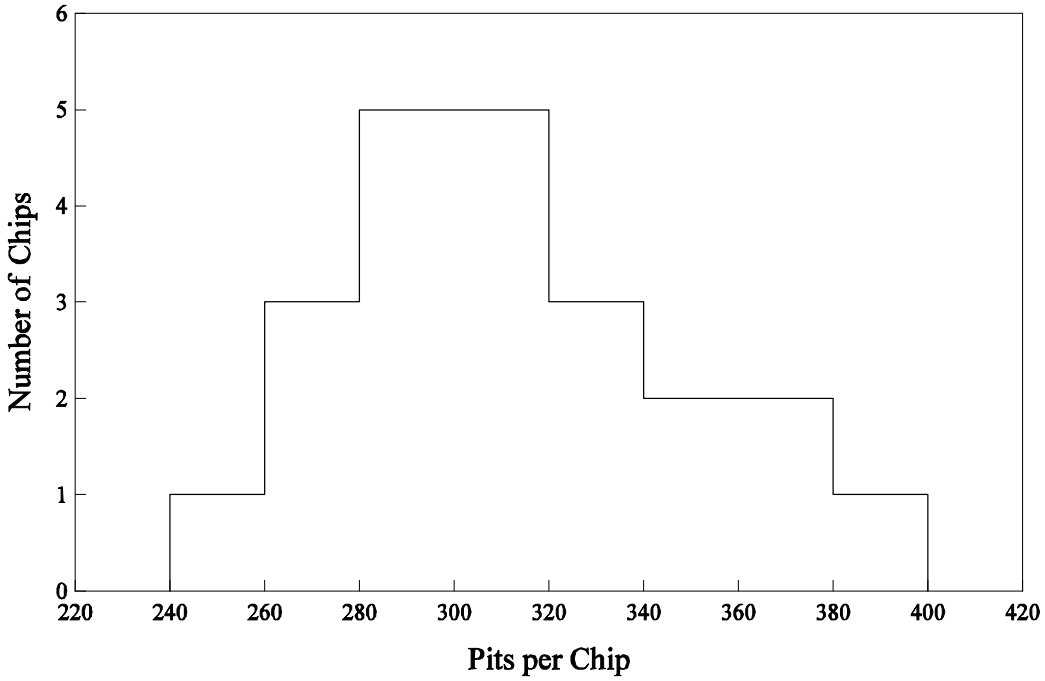

FIGURE 2. Latent tracks in detector chips as received from the manufacturer. The histogram shows the numbers of detector chips having counts in 20-pit intervals from 240 to 400 pits per chip. The mean number of pits per chip is 314.

The present experiments employ a modified cell that is closed at the bottom by a glass microscope slide. The cathode is a nickel wire whose lower end is shaped like the letter W that rests on the glass closure. The electrolyte was a solution of 2.2 g Li_2SO_4 in 100 ml ordinary water, sometimes enriched with D_2O. It was in contact with the glass cell wall, the glass bottom closure, and a Viton rubber O-ring that lies between the cell and the closure to prevent leakage of electrolyte. The upper end of the cell remains open to permit the escape of hydrogen and oxygen electrolysis products. All system components with the exception of the O-ring were made of commercial materials that had not previously been associated with electrolysis. The O-ring had been used by Oriani in his experimental work. Any nuclear particles that reach the outside air during electrolysis must pass through the glass cell wall, the glass closure, or the Viton O-ring; or must have exited the open end of the cell along with the effluent gases.

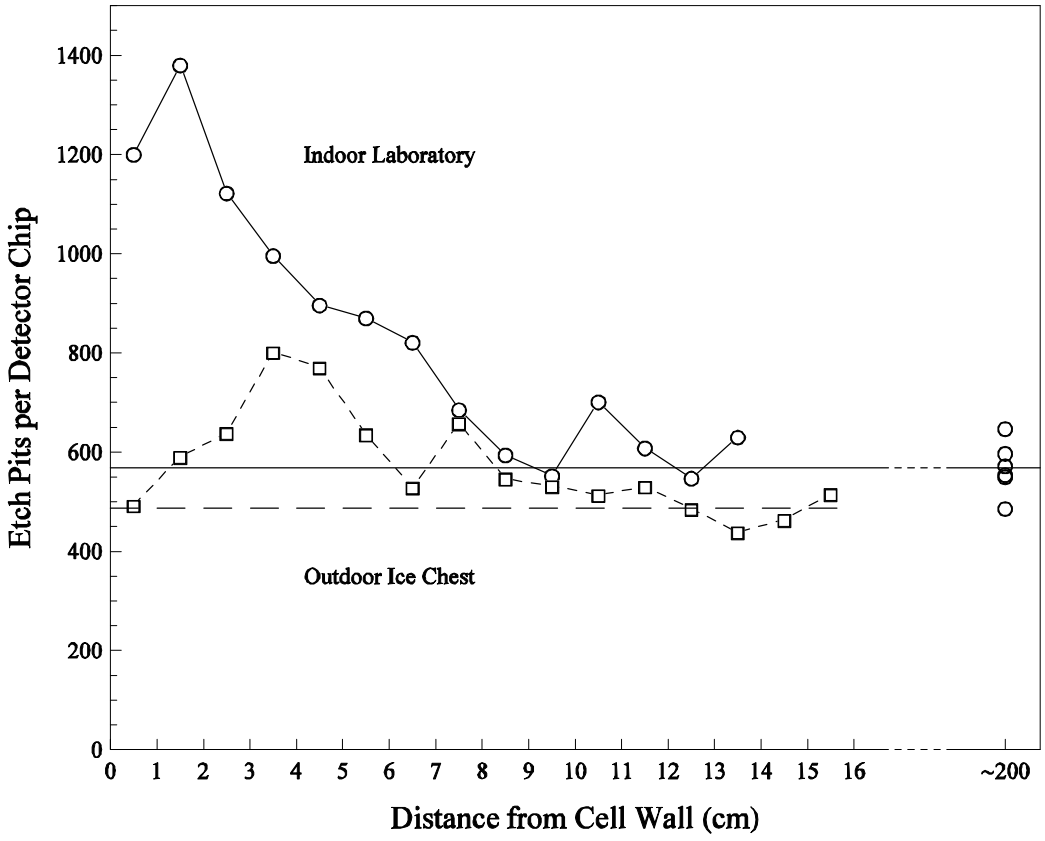

FIGURE 3. Density of etch pits as a function of distance from the cell. Chips measuring 1 cm × 2 cm were placed with long edges in contact on a horizontal surface about 1 cm below the level of the O-ring. Exposures of 4 days were made in an indoor laboratory and in an outdoor ice chest. The indoor exposure suggests that energetic particles may reach out to a distance of about 8 cm from the cell (the solid horizontal line is a background level determined from 6 remote detectors at a distance of about 200 cm). The ice chest exposure suggests a weakened or dead cell as discussed in the text.

An experiment was designed to detect energetic particles in the air surrounding the cell. Ordinary water was used in the electrolyte. Sixteen CR39 detectors (approximately 2 cm × 1 cm) were aligned lengthwise face-up with long edges in contact, on a flat surface extending out about 16 cm from the glass wall of the cell. This surface was about 1 cm below the bottom level of the electrolyte. Electric power was supplied by a low-capacity 6 volt battery. The apparatus was assembled in a closed ice chest that was placed outdoors to avoid the possibly higher level of radon in laboratory air. Exposure time was 96 hours. The system was unattended except for occasional brief opening of the chest for addition of distilled water to maintain the level of electrolyte. During the experiment the battery voltage dropped from 6 V to 3.5 V. The variation of etch pit density with distance from the cell is shown in the dashed curve in Fig. 3. The number of etch pits per 1.5 cm^2 of measured detector chip area rose from about 500 pits/chip at a distance of 0.5 cm from the cell to a maximum of about 800 pits/chip at a distance of 3.5 cm, then fell to a background level of about 500 pits/chip at a distance of 6–8 cm.

The level of cell activity appeared to be significantly reduced after the ice chest experiment, or perhaps even to have disappeared before or during the experiment. In an attempt to bring the cell back to health the cathode was sanded to disturb the surface layers and a small amount of D_2O was added to the electrolyte, increasing the D_2O concentration to perhaps 5% of the fluid (I did not keep an accurate record).

Cell activity appeared to have been restored, and a distance experiment was conducted indoors. This experiment exposed 14 chips in line extending out from the cell as in the ice chest experiment, plus six chips at a distance of about 200 cm to serve as controls. The variation of etch pit density with distance from the cell is shown in the upper curve in Fig. 3. The pits/chip ratio rose from about 1200 at a distance of 0.5 cm to about 1400 at 1.5 cm, then declined to the level of the controls at about 8−11 cm. The indoor experiment suggests that charged particle tracks in excess of background level can be observed out to a distance of about 8 cm from the cell wall. The ice chest result is puzzling because the concentration of pits is at background level near the cell, passing through a maximum about 2 cm from the cell.

In addition to reducing the background from airborne radon relative to the indoor level, the ice chest protects the system from laboratory air currents while subjecting it to the currents associated with convection flow powered by about 1 watt of electrolysis power. An air flow experiment was conducted to explore the possibility that air currents may influence the particle flux. The electrolyte was ordinary water with addition of approximately 5% D_2O, the same electrolyte as used in the indoor distance experiment. The D_2O concentration declined throughout the experiment owing to the periodic addition of distilled water to maintain the level of electrolyte in the cell. A fresh nickel cathode was employed.

In the indoor air flow experiment 2 or 3 detector chips were placed face up on a surface near the cell about 1cm below the bottom level of the electrolyte. The centroid of their combined areas was about 3 cm from the cell wall. An electric fan was placed about 25 cm from the detectors, set on “low", blowing air across the detectors toward the cell. After 2 days the fan was turned off and the chips were etched and counted. These chips then were replaced by a second set and the experiment was continued with the fan off for another 2 days after which the second set of chips was etched and counted. Two additional alternating 2-day fan-on and fan-off runs were made. Finally a fan-on run was made with the detector chips separated by a distance of 80 cm from the cell while maintaining the 25 cm spacing between fan and chips.

The results of this experiment are plotted in Fig. 4. When the fan is on the flux of particles in excess of preexisting background increases by a factor of about 7 compared with when the fan is off. Furthermore, when the fan is on its influence overwhelms and masks that of electrolysis. It is clear that flow velocity is a major contributing factor to the density of tracks that form in CR39 detectors exposed to air. This confirms the observation of R. R. Engel [5] of an order of magnitude increase in recorded tracks in a CR39 detector chip mounted on the end of a ceiling fan blade.

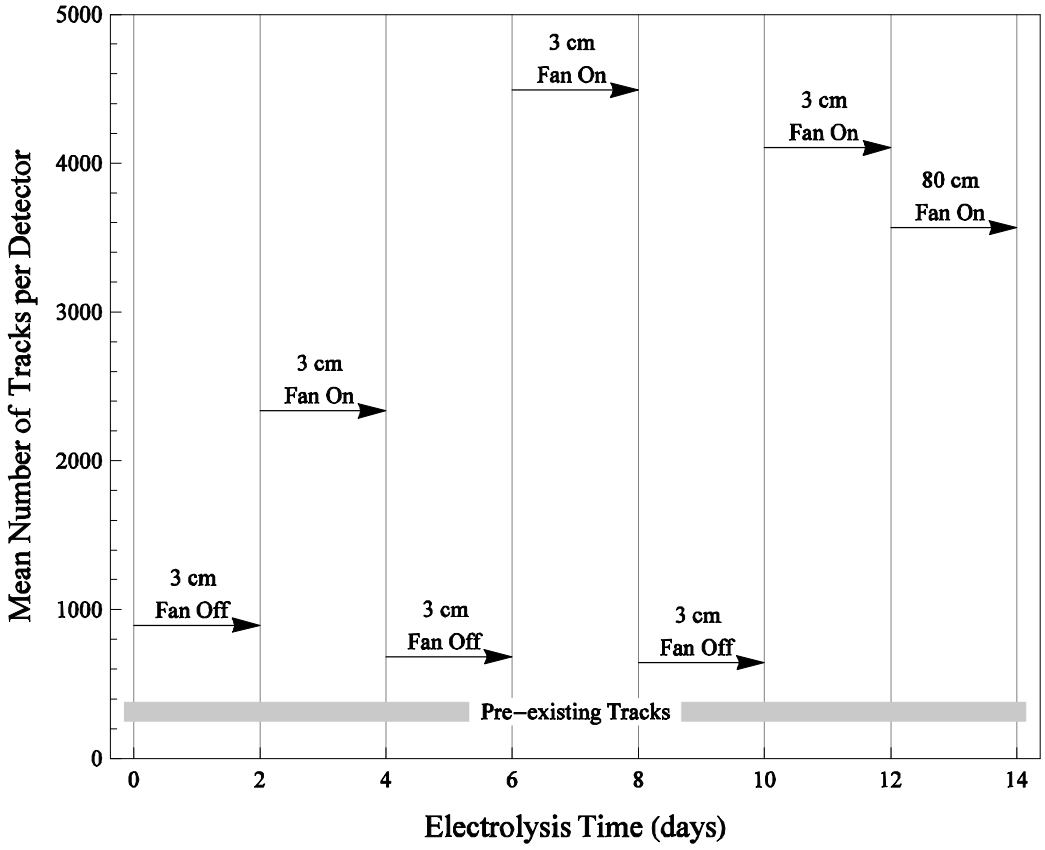

FIGURE 4. Influence of air flow on track density. The experiment consisted of 7 consecutive 2-day runs during which the electrolysis cell remained on. In each run 2 or 3 chips were placed either 3 or 80 cm from the cell, and a fan directed at the chips was either on or off. Track density in excess of background is an order of magnitude greater when the fan is on compared with when it is off, independent of the separation of the chips and the cell.

Although the current of air from the fan exceeds that from various currents of room air and of convection currents from the warm cell in a closed ice chest, it is necessary to consider the influences of these smaller currents. They may be sufficiently large that if unrecognized and uncontrolled they could mask the experimental signals being sought. In the ice chest a stable circulating flow of air can be maintained by the ~1 W power of the electrolysis cell. Air warmed by the cell will rise, spread laterally, cool, descend, and flow back toward the cell where it again becomes heated. There will be a region of stagnation close to the cell below the bottom of the column of warm electrolyte, in which the air velocity will be small and in consequence the density of new tracks will be small. The velocity will be a maximum at a distance from the cell comparable with the dimensions of the column of electrolyte, at which distance the density of new tracks will also be a maximum. Beyond this distance air velocity and track density will decline to a background level. For a weak or dead cell this may provide an interpretation of the dashed curve in Fig. 3.

In the indoor experiment the pattern of air flow is complex and uncontrolled. To the convective current associated with the warm cell must be added currents from the circulation system that warms the laboratory, to currents from opening and closing doors, from personnel walking close to the equipment, and from convection currents from a nearby hotplate

intermittently used for heating the etchant. In aggregate these currents may be roughly independent of distance from the cell. For this reason the solid curve in Fig. 3 may provide a fair approximation to a flux of particles from the cell. This is not strong evidence but it is the best presently available from these experiments. It suggests that a flux of radiation may extend outward from an active cell and weaken with distance.

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References

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[4] R. A. Oriani and J. C. Fisher, *Proc. 11th International Conference on Cold Fusion*, Marseilles, France, 31 Oct.−5 Nov., 295 (2004).
[5] R. R. Engel, private communication.