# POLYNEUTRON THEORY 1

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I report results from an experiment that I have done in collaboration with Richard Oriani, suggesting that LENR reactions can take place within solid CR39 plastic detector material, and suggesting that these reactions are accomplished by mobile neutral particles that interact with immobile hydrogen and possibly oxygen nuclei in the plastic. This experimental evidence for polyneutrons is presented, and new experimental opportunities are suggested. In this note I review some history of our experiment, to provide an opportunity for critical discussion prior to preparing a technical paper for publication.

For many years my friend and colleague Richard Oriani used CR39 plastic detector chips to record energetic particle emission from his electrolytic LENR experiments. These chips are about 1 cm by ½ cm in area, and are about 1 mm thick. They are manufactured primarily for use in radon detectors where they record energetic alpha particles emitted by decay of radon and radon daughters.

Alpha particles and other charged energetic particles in the air within a few cm of a detector chip and moving toward it can reach the plastic surface with sufficient energy to penetrate the plastic and disrupt its molecular structure for a short distance before coming to rest. The disruption is caused by electrostatic forces between the alpha particles and the charged atoms of which the plastic is composed. Subsequent etching with NaOH produces sharp conical pits, pointed into the chip along each such damage track where the plastic has been etched away more rapidly than the surrounding undamaged plastic. When the chip is viewed with a microscope the sizes, shapes, and orientations of the etch pits provide information about the nature of the responsible energetic particles. This technique has been employed to investigate the production of energetic particles in LENR experiments. But radon alpha tracks can introduce a substantial background, so it is difficult to be sure if an etch pit was from a LENR reaction or from radon decay in the surrounding air.

Oriani and I often worked together, and we decided to do an experiment designed to rule out radon contamination. I ordered a special sheet of CR39 that was in an early stage of manufacture, before it had been cut into chips for radon detectors. Then I cut it into larger chips, about 4 cm on a side. Oriani's electrolysis cell was contained in a vertical open tube about 3 cm in diameter, and a 4 cm wide chip could completely close the lower end of the cell. Here in California (Oriani was in Minnesota) I placed a pair of these big chips in face-to-face contact, and Scotch taped them around the four edges to hold them in intimate contact. Then I mailed the pair (we called it a sandwich, although it had no filling) to Oriani. He put a very thin sheet of Mylar over one exposed surface of the sandwich, and clamped that surface over the open lower end of his electrolysis cell. Then for the cathode he shaped the end of a nickel wire like the letter **W**, and placed the **W** flat on the electrolyte side of the Mylar sheet. The Mylar improves the seal of the sandwich to the electrolysis cell, and gives partial protection of the CR39 from chemical attack during electrolysis.

Then the current was turned on and electrolysis continued for three days. After electrolysis Oriani washed the sandwich and mailed it back to me. A few days later I opened the sandwich, put the separated chips into hot, stirred NaOH, and etched them for about 10 hours. After letting the chips cool overnight in the etchant I washed and dried them and examined them microscopically for evidence of particle tracks. The surfaces were cloudy, indicating that the Mylar may not have completely protected against chemical attack. Oriani was familiar with this problem, and suggested that a second etch would clear away the cloudy surface and reveal etch pits. So I etched the separated chips again in hot stirred NaOH for about 10 hours, then cooled overnight in the etching bath. This time, when the chips were examined with the microscope, the cloudiness was gone and the plastic was clear, except for several circular areas that were dotted with hundreds of small pits that could only have been caused by energetic particles.

Each pitted area appeared to be a cross section of a three-dimensional cloud of randomly oriented particle tracks that had formed and grown within the sandwich. The largest cloud appeared to have started near the bottom of the bottom chip and grown up and out from there until it reached the upper face between the two chips. The direction of growth of the track cloud, from bottom to top of the lower chip, could be established by the diminished density of etch pits in the upper face compared with that in the lower face of the lower chip. Oriani and I had expected to find a pattern of etch pits on the bottom of the upper chip that matched the pattern on the top of the bottom chip. This is expected for chips in intimate contact, where there is nothing to impede polyneutron migration and track formation from crossing freely from one chip to the other. The fact that the big shower did not cross from the lower to the upper chip indicates to me that the two chips were not in contact when the shower grew. It is now my opinion that shower growth took place primarily during the two hot etches I performed on separated chips after Oriani returned them to me.

The etched tracks are small and well-defined. I estimated their lengths from the lengths of tracks that were nearly parallel to the chip surfaces, and found them to be only a few percent of the chip thickness. Because damage tracks are so short, few if any of them can have crossed trough a chip. They must have come from decays or reactions within the plastic material close to the surfaces under examination. The pit density was greatest at the center of each cross section, which suggests that the presence of one nuclear reaction increased the probability of another reaction nearby in a random direction as the shower grew; yet there was no charged particle track that connected any two events. Hence if, as it appears, shower particles are related by connecting particles, the connecting particles must have been neutral, because they left no tracks. And the neutral particles would diffuse away because they carry no electric charge that could disrupt their surroundings. The two surface clouds on the lower chip had sizes and alignment that indicate they are cross sections of a single three-dimensional cloud of tracks within the lower chip. They provide evidence of nuclear activity inside the CR39 plastic material.

So I assume that the connecting particle is a polyneutron (a nuclide composed entirely of neutrons) that picks up one or more neutrons from a CR39 nucleus, and departs carrying substantial kinetic energy. After the interaction the CR39 nucleus also carries away kinetic energy, but because it is charged it slows rapidly to a stop as it loses energy by disrupting the structure of the plastic: this is the origin of a damage track and leaves a damage track that can be revealed by etching. The polyneutron is electrically neutral and leaves no damage track, but it gradually slows by elastic interactions, then diffuses around thermally until it makes a close encounter with another CR39 nucleus. Then it repeats its strong interaction, inducing track generation by the participating CR39 nucleus, and it repeats its neutral escape via further elastic diffusion. In other words, a shower is caused by one or more itinerant polyneutrons, each of which continues to diffuse in random directions from one track-producing interaction to another.

A polyneutron may grow ever larger by repeated interaction with CR39 atom nuclei as described, or it may shrink to oblivion if its radioactive decay is faster than its growth. However I think it probable that polyneutrons undergo fission from time to time, which can on average put a cap on their sizes. Then a shower of (say) 1000 tracks, of which perhaps 100 can be revealed by etching a cross section of the shower, could have been caused by several polyneutrons, each of which grew to perhaps 100-neutron size, then fissioned to a pair of about 50-neutron size, each then growing back by repeated interactions with CR39 nuclei to 100-neutron size, and so on.

Now I turn to consideration of the composition of CR39 plastic, and the way in which its chemical elements can serve as fuel for the polyneutron growth required for a chain reaction. In polyneutron theory, the polyneutron growth reaction is

$$ {}^{A}n + {}^{B}Z \rightarrow {}^{A+C}n + {}^{B-C}Z, \qquad (1) $$

provided that angular momentum and parity are conserved.

In this reaction a polyneutron with A neutrons picks up C neutrons from a fuel nucleus ${}^{B}Z$. The reaction produces an enlarged polyneutron with A+C neutrons, and a smaller isotope of the fuel nucleus with B−C neutrons. CR39 plastic is composed of three chemical elements: hydrogen, carbon, and oxygen, at least one of which must have a stable isotope for which equation (1) is exothermic. The isotopes passing this test are ${}^{2}H$ and ${}^{18}O$, revealing them as the only potential fuels in the sandwich experiment. Oriani and I did not expect to find evidence for a polyneutron chain reaction within the CR39 plastic. And we did not immediately understand the significance of the experiment. Now, however, I believe that CR39 can support polyneutron chain reactions, and that the sandwich experiment did support several such chain reactions with ${}^{2}H$ and possibly ${}^{18}O$ fuels at various locations in the two chips.

Yet I believe it is an open question whether these chain reactions began anywhere in Oriani's apparatus or electrolyte. Perhaps small chain reactions were present in the CR39 sheet as received from the manufacturer, and developed only slowly until I gave the sandwich chips long hot etches after Oriani sent them back to me. The high temperature would increase the diffusion rate, which would cause rapid development of such reactions and growth of damage track showers, leading to what was found by subsequent microscopic examination.

Is it really possible that the CR39 sheet was activated by polyneutrons before we received it from the manufacturer? We could have checked this by exposing test portions of the as-received sheet to a high temperature for a day or two, then etching them. We might then have noticed the patches of chain reactivity. But we did not do this, as we did not anticipate the possibility that it could be important. Overall I think it quite possible that we were dealing with a sheet of CR39 that had become activated for chain reactions before we received it. This possibility can be tested with another sheet, but that will have to await a new sheet, the original one having been used up. And unfortunately the supplier will not now sell me a plain sheet. They will sell only a sheet that has been cut into hundreds of small numbered chips suitable for use in a radon detector.

I wondered about this, and searched the internet for other suppliers. I discovered that some suppliers keep their freshly manufactured CR39 refrigerated, which they claim extends the shelf-life of the material. Why would it have a shelf-life, and why would refrigeration extend it? This looks to me like polyneutron contamination in the factory. One supplier offered for sale some scrap sheet that had overstayed its shelf life and was no longer acceptable for all applications. Unfortunately it took me too long to appreciate the value of this material; and when I realized that it was just what I needed in order to investigate factory contamination, I could no longer find it on the internet. And I had forgotten the supplier's name.

Now I am hoping that a few of the hundreds of little chips I do have may have been contaminated; and I will use heat treatment and etching in an attempt to find one. If I do find one, I can heat it long enough to grow its chain reaction to large size and can use it to activate other chips by heating together, in close contact, the active chip and a chip to be activated. This will allow the chain reaction to cross into the virgin chip, and I can prepare all the active chips I want as long as the $^{2}$H and possibly $^{18}$O fuels hold out (after the fuel is used up I will have to replace the previously active chip by one of its active descendants). (This is essentially the same as an experiment I have previously suggested, except that I now suggest doing it with CR39 chips instead of palladium cathodes. And since a dead sample of Pd could be activated by an active CR39 chip as well as by an active Pd cathode, I now suggest this be tried. It appears to me that the problem of activating a dead Pd cathode may be solved in this way.)

The sandwich experiment has proved to be of considerable value. As of now:

I believe that LENR can occur within solid CR39.

I believe that neutral nuclei are active there, suggesting chain reactions.

I believe that a chain reaction can cross from one detector chip to another.

I believe that $^{2}$H and possibly $^{18}$O are fuels.

Polyneutron theory has been useful for understanding the above phenomena.

I will close this discussion now, and will resume it in the near future with another installment.