Summary of the Transmutation Workshop Held in Association with ICCF-14

George H. Miley
Dept. of Nuclear, Plasma and Radiological Engineering University of Illinois, Urbana, Il
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Abstract

The purpose of this workshop was to exchange technical information and insights on the emerging field of nuclear transmutations associated with LENRs. Transmutations have been observed under a variety of conditions (various electrode designs and a range of loading techniques, including electrolytic, gas loading, laser excitation, electric arcs and biological media, among others.). Discussions covered most of these situations, with the goal of identifying unifying aspects the fundamental reaction mechanism.

The workshop was held Friday afternoon following the closing of the main ICCF-14 Conference. It was conducted in the Gordon Research Conference style with short presentations, plus panel and participant discussions. Over 35 persons participated while another dozen indicated interest but had to leave due to flight times. George H. Miley, University of Illinois, served as the organizer with assistance from panel chairs Xing Zhong Li, Akito Takahashi, and Ed Storms. The schedule for the half day workshop (Friday, August 15, 2008) was as follows:

- 1:30 – 1:50pm Introduction and Brief Overview of the Field – George H. Miley
- 1:50 – 2:30pm Short Presentations and Panel Discussion of Prior Experiments - Xing Zhong Li Panel chair
- 2:30 – 2:45pm Break
- 2:45 – 3:25pm Short Presentations and Panel Discussion of Theory – A. Takahashi, Panel Chair
- 3:25 – 4:05pm Panel Discussion of Key Issues for Experiments and Theory, and Future Directions – all panel chairs plus participants.
- 4:05 – 4:45pm Panel Discussion of Scientific Implications and Potential Commercial Applications – Ed Storms, panel chair
- 4:45 – 5:00pm Discussion and Summary Remarks. – George H. Miley

In the spirit of the Gordon Conferences, specific discussion and presentations from the workshop are not published. This provides participants with more freedom to discuss recent results. In this spirit, the present summary is intentionally quite general but hopefully provides the reader with a broad view of the discussion and general conclusions coming out of the workshop.

Comments About Discussion

Brief presentations (~ 3 min each) were volunteered by 6-10 participants prior to each panel discussion. These presentations, combined with remarks by the panel chair, provided background for the following panel discussion. Panel members stated some points and then the discussion was open to the floor. The questions posed to the panel were; Is the transmutation phenomenon real? What reactions occur? How can they occur in view of the high-Z columbic barrier involved? Is heat produced? What elements undergo transmutation and can these be identified in advance through the experiment design? What are the potential applications?

Participants were referred back to the ICCF-10 paper by Miley and Shrestha titled: "Overview of transmutation reactions" which documents literature where such reactions have been reported by a number of research groups worldwide. Indeed, when asked for a show of hands, over 20 participants at the workshop said they had personally observed various transmutation reactions in experiments. The scientific characteristics of LENR open a whole new interdisciplinary field of nuclear physics. Potential applications such as unique power sources, transmutations, isotope production, and waste management were discussed. A general view, however, was that such applications represent great potential. However, much more research and development is needed to get transmutation type cells to a state where therein practicality can be fully evaluated. Some points from the Miley-Shrestha review paper were presented at the opening of the workshop and are briefly summarized here.

Transmutations reactions observed to date can be divided into two different types. The first type is direct reaction to single products. Early electrolysis based transmutation experiments frequently reported one or more isolated products, i.e. "direct transmutations" vs. product arrays. In several cases radioactive products were observed. Most recently Mitsubishi Corp. researchers reported a precision real-time measurement using built-in XPS diagnostics. An atomic layer of Sr-88 coated on a thin-film Pd substrate was transmuted into Mo-96 over 200 hours.

The experiment used 1 atm of deuterium on one side of the thin film to force deuterium diffusion through a multi-layer thin-film Pd/CaO substrate. Cs-133 was also transmuted into Pr-141 in a similar experiment. The second type is product array, illustrated from early studies by Miley, Mizuno, Bockris, and others. Such a result is illustrated from Miley's work in the following figures.

These figures illustrate some common features observed in these types of reactions. Large reaction rates occur for key products lying in 4 mass zones, the lack of energetic gamma or neutron emission but low level emission of low energy x-ray or beta radiation production and MeV protons and alphas. The reaction leads to productions of nearly stable elements. Non-natural isotopic ratios for many products were observed (Fig. 2), as might be expected, and gives further evidence against mistaking transmutation products with impurities. Such features need further experimental definition since they should provide key signatures that theory must explain. Indeed several theorists (e.g. A. Takahashi, L. Larson, X.Z. Li, and Widon) have already used data from the experiments noted here as a test of their models. Indeed, they have achieved some degree of success in reproducing major trends.

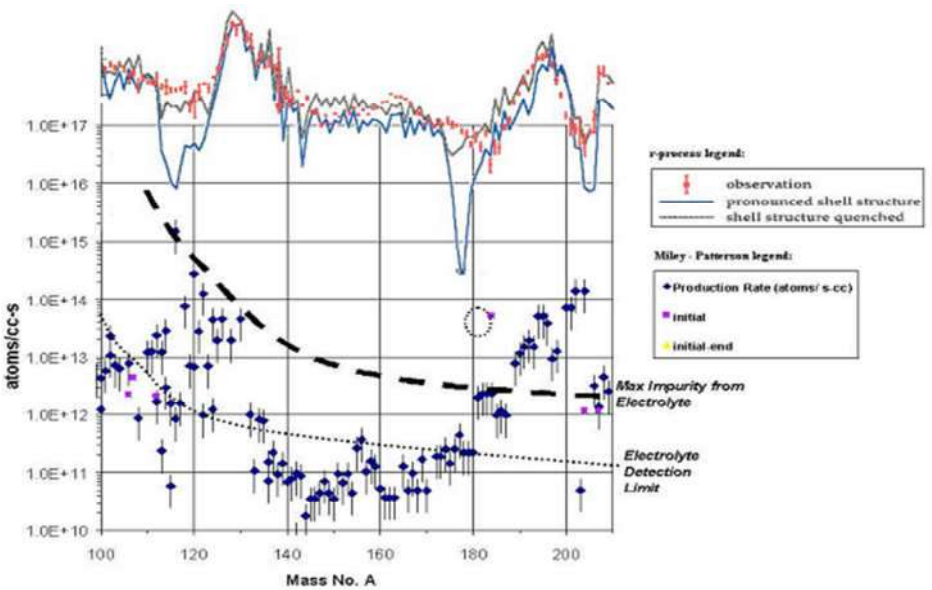

Figure 1. Comparison of mass number abundance in Miley-Patterson & r-process results. Extreme care was taken to rule out potential impurities from the electrolyte and cell components.

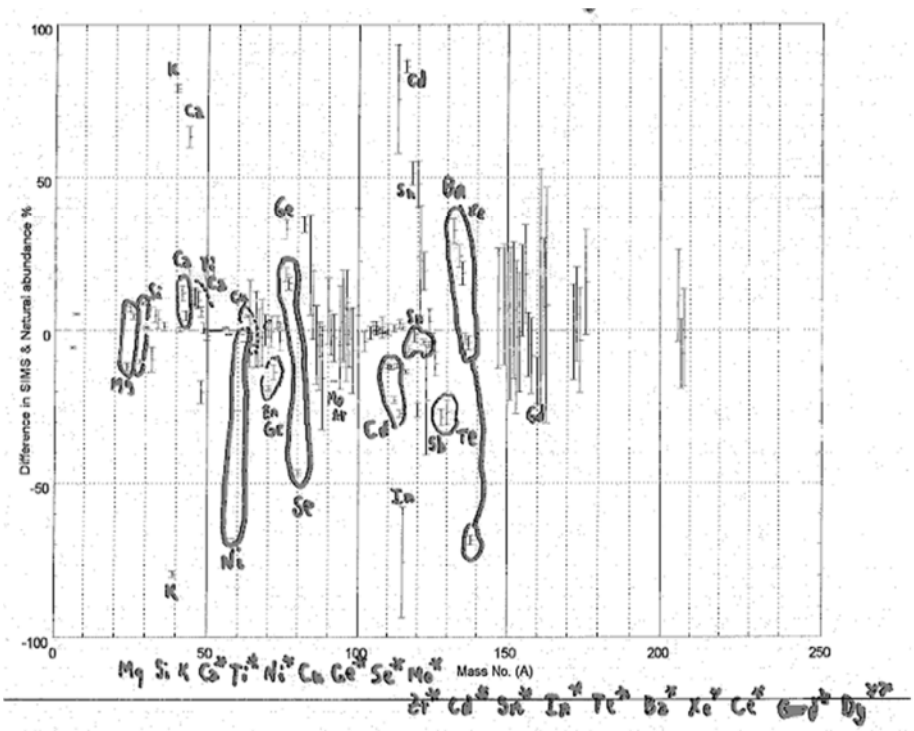

Figure 2. Many transmutation products have isotope densities that show distinct deviations from natural elements. The differences were found to be larger for some rare elements as opposed to larger yield common elements. Detailed study of Ag and Cu using neutron activation analysis confirms the SIMS results shown here.

Ed Esko, Quantum Rabbit LLC provided new information about carbon arc and also biological transmutation studies, video, and points. Following this brief review, the panels' convened to discuss issues related to experiment, theory, and science/applications.

Workshop discussions of experiments covered various topics including: What are the key experiments to date that have the most decisive evidence of transmutation products? Which have been reproduced? What key features/signatures come from these that theory must benchmark against? What is the most urgent next step in experiments? What diagnostics have provided the best analysis, and what new diagnostics should be brought in? Ed Storms summarized the theory discussion by citing physics issues that must be explained in a comprehensive theory. These were summarized, including Columbic barrier penetration - rates, Z-dependence, H vs D, "agent" involved reactions following penetration - unique stable products, lack of high energy radiation, non-natural isotope ratios, Energy and mass balances, fuel and ash, role of solid-state lattice, loading effects, coherent QED effects, irreproducibility, trigger, non-equilibrium effects. With the limited time available, the general consensus was not reached, but the feeling frequently expressed was that the experiments highlighted here represent a strong start towards addressing these questions. One added comment was that a reviewed effort should be made to find transmutations that lead to easily detected radioactive products. While reported by some workers, e.g. R. Bush, Cal Poly, this has not been achieved in recent experiments. Another possible experiment proposed by X.Z. Li and others (e.g. Stoppimi, U. Pisa) would be to attempt measure of neutrons from transmutation cells. Several prominent theories suggest neutrino emission. However, some participants charged that leading current underground neutrino detector facilities do not have the required sensitivity to undertake such measurements until a high reaction rate cell is developed. Several participants discussed potential triggers with lasers, ultrasound, and "super wave" input.

Some issues concerning theory were then discussed: What are the key theories now, and which have been successfully benchmarked against experiment? Is there any consensus about how the high Z barrier is overcome and how multi-body reactions occur to form heavy products? Are there theoretical predictions about reactions/experiments that should be pursued?

Questions mentioned about science/applications were: What new science is brought out by LENR transmutations and can this work contribute to advancing basic science? Are there potential practical applications, or is this premature to decide? Do any applications appear to be competitive cost-wise with other approaches, for example neutron irradiation transmutations?

Unknown factors were also emphasized by several speakers during the discussion. A Benchmarked theory is not available. Range of experimental conditions and possible reactions possible is not yet clear. The character of the nuclear-active-state for transmutations (otr for cold-fusion in general) is not well defined. Initiation methods; the role of non-equilibrium flows, the dependence on temperature and limiting conditions were discussed, but no conclusions reached. Cell operational lifetime considering fueling requirements and ash buildup need attention. The question of how to benchmark theory to experiments in view of the variety of reaction conditions and irreproducibility encounter in work to date was discussed, and viewed a key goal needed to advance this field forward.

Conclusion and Future Plans

Overwhelmingly participants reported that they felt the workshop was very successful and long overdue in view of the world-wide work in the field. At the close of the meeting there was a brief discussion of the need for and possible organization of future meetings or workshops devoted to this topic. The present workshop served the purpose of bringing the community together and opening a dialogue on issues plus identifying key issues for future study. But the time was too short to explore topics in any detail, so the participants overwhelmingly agreed that a longer follow-up meeting is desirable. One possibility is a meeting dedicated to John Bockris who started the well received series on this topic while at Texas A&M. The series ended with his retirement, but could now be revived. Several locations in the US were mentioned as possible as well as a site in India. Alternately many participates thought the formation of a Gordon Conference series would greatly help to move the field forward. However, these meetings are costly for participants, so they may not be practical until more funding enters the area. Several stated that in the interim, holding another workshop as a satellite meeting to ICCF meeting may be most attractive. It was agreed that this discussion would continue among participants via e-mail in an effort to formalize a next meeting or workshop.