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Research Article

Evidence for Nuclear Transmutations in Ni–H Electrolysis

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Abstract

We report an easily reproducible Low Energy Nuclear Reactions (LENR) electrolysis experiment on an Ni–H system. An electrolytic cell with a Ni cathode and a Pt anode with an aqueous (H_2O *not* D_2O) solution of K_2CO_3 as electrolyte was used for the experiment. A dc-power supply capable of supplying up to 5 A current was used to drive the electrolysis with the typical current being around 4 A and the applied voltage about 100 V. After running the electrolysis for about two weeks with a daily run time of 8 h on an average, a part of the nickel electrode, which by this time had become black, was taken for elemental analysis using Energy Dispersive Spectroscopy (EDS). The EDS analysis showed that a whole host of new elements had appeared on the cathode such as: K, Fe, Cu, O, Rh, Zr and Pb. The apparent concentration of the elements varied from just over a percent for K and Pb to about 10% for Rh and 20% for Cu. The sample was then taken to a Time of Flight Secondary Ion Mass Spectrometer (ToF-SIMS) for isotopic analysis. This analysis also showed that a set of new elements had appeared on the nickel wire which were: K, Si, Mg, Mn, Zn, O & Rh. The Ni itself was found to have the following isotopes: ^{58}Ni, ^{60}Ni and ^{62}Ni with isotope concentration ratios differing significantly from the ratio found in naturally occurring Ni. It was clear that in the electrolyzed Ni the concentrations of ^{60}Ni and ^{62}Ni had gone down compared to the concentration of ^{58}Ni. This is a clear indication that nuclear reactions had taken place during electrolysis.

Keywords: Electrolysis, LENR, Ni–H systems, Transmutation

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1. Introduction

Since the announcement of the discovery of low energy nuclear reactions (LENR) by Fleischmann and Pons in 1989, there has been a large number of attempts to replicate their results [1]. There have been many successful replications of excess heat in palladium–heavy water systems (Pd–D_2O or Pd–D) even though the detection of excess heat is not always easy, especially if the effect is small [2]. On the other hand, finding transmutation products provide undeniable evidence of nuclear reactions and there has been large number of instances of this in the Pd–D and other systems [3]. In the light of this it would be useful to find an easily reproducible experiment to convince any interested researcher of the truth of the LENR phenomena. The Ni–H_2O (or Ni–H) system fits the bill, being very easy to set up and run and seems to work the first time unlike the Pd–D system which seems to require considerable coaxing before it will reveal

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the LENR phenomenon. There have been many reported studies on the Ni–H system that have reported excess heat as well as transmutation products [3].

2. Experiment

2.1. Experimental apparatus

A schematic of the electrolytic cell used is shown in Fig. 1. The experiments were done with a Ni (99.99%) cathode and a Pt (99.999%) anode in a 1 l glass beaker with the electrode diameters being 0.75 mm (Ni) and 0.5 mm (Pt). The electrolyte was K_2CO_3 (minimum purity 99%; the maximum limits of impurities were: iron: 0.001%, sodium: 0.1%, chloride: 0.03%, nitrate: 0.01% and sulphate: 0.02%, the remaining being moisture) dissolved in about one liter of distilled water with an approximate 1/2 molar concentration to begin with. The molarity of the solution was maintained between 1/2 and 1 by adding distilled water to the beaker as needed. Metallic impurities in K_2CO_3 were less than 0.1%. To prevent accidental combustion within the electrolytic cell the evolving hydrogen and oxygen gases were allowed to escape from the cell through different vents.

2.2. Experimental procedure

A dc current less than 5 A at voltages up to 100 V was used to drive the electrolysis. Because of the relatively large power dissipated in the electrolyte it would be boiling vigorously and losing water which was replenished by adding distilled water as required.

A single Ni electrode was used for the electrolysis experiments. The tip of the electrode about 3–4 mm in length was cut-off at various stages of the experiment for EDS analysis to monitor the progress of the nuclear reactions. The duration of electrolysis was 100 h. Detailed analysis including both EDS and SIMS were done only on a piece of the Ni electrode subjected to the full 100 h of electrolysis and is reported here. EDS analyses were done on the pieces Ni electrode cut off at earlier stages to check whether LENR process had started and, if so, how it was progressing.

We were unable to carry out a detailed elemental analysis of the electrolyte before and after the experiment for lack of suitable facilities.

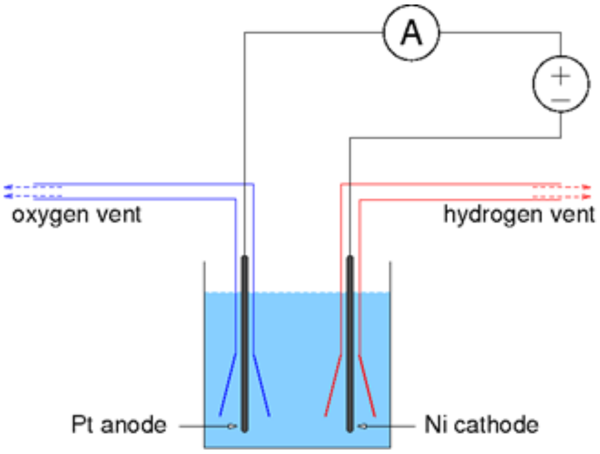


Figure 1. Schematic of the electrolytic cell used for the experiment. The electrolyte was K_2CO_3 dissolved in distilled water.

3. Analysis technique: EDS

Energy Dispersive Spectroscopy (EDS) is a surface spectroscopic technique [4]. It is usually associated with electron microscopy. Some of the electrons used for imaging knock out core electrons from the surface atoms giving rise to characteristic X-ray emissions from the excited atoms. The X-rays are analyzed to determine the elements and their concentration.

3.1. Analysis technique: ToF-SIMS

Secondary ion mass spectrometry (SIMS) is a technique used to analyze the composition of solid surfaces and thin films by sputtering the surface of a specimen with a focused primary ion beam and collecting and analyzing the ejected secondary ions [5]. The mass/charge ratios of these secondary ions are measured with a mass spectrometer to determine the elemental, isotopic, or molecular composition of the surface to a depth of, typically, a few nanometers.

For the determination of concentration of isotopes in a sample “multiple collector inductively coupled plasma spectrometry (MC-ICP-MS)” is a far more accurate technique than SIMS [6]. But SIMS has an advantage over MC-ICP-MS in that it determines the isotope ratios at the surface of a solid sample down to a few nanometers while MC-ICP-MS can only determine isotope ratios in a sample which is dissolved in some solvent. But of late spectrometers have started becoming popular which uses laser ablation (LA) to dislodge ions from the surface to be analyzed and thus can analyze isotopic concentration of surfaces very well. For lack of easy access to such an LA-MC-ICP-MS machine we decided to do our analysis on a SIMS machine.

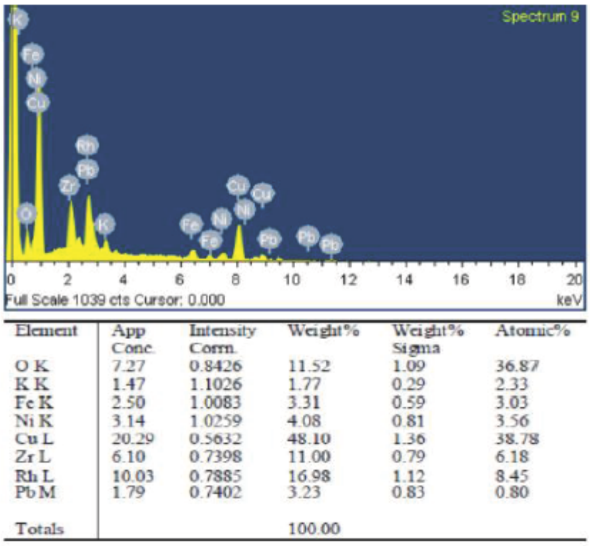
Time of Flight (ToF)-SIMS is a particular type of SIMS where the isotope determinations are done by measuring the transit time of ions which are accelerated according to their charge to mass ratio through a certain region of space [5].

4. Results and Discussion

After a run of a total of about 100 h the Ni electrode was analyzed for new elements using EDS. See Fig. 2 for a typical spectrum. Evidence for a whole host of new elements can be seen with substantial amounts of new metals such as copper (20%), rhodium (10%) and zirconium (6%) and iron (2.5%). Interestingly Ni concentration is only 3.1% in this particular spectrum! It is to be pointed out that the spectra obtained from different regions of the sample differ in the observed elements and their concentrations. EDS data show that new elements have appeared on the cathode. To confirm that nuclear transmutations have taken place in the Ni wire we carried out mass spectrometry on the Ni wire using a ToF-SIMS. Even though, inadvertently, the sample was cleaned lightly with an emery paper to expose the shining nickel metal underneath before being analyzed in the ToF-SIMS machine, the results turned out to be very significant.

The SIMS analysis found various elements on the wire surface as expected such as K, Si, Ca, Zn, Mg, Mn, Rh, Zr and Pb. We confined our isotopic analysis to nickel for which we had a standard available as a piece of unused Ni wire. The isotopic concentrations of nickel found in its natural state are: ^{58}Ni: 68%, ^{60}Ni: 26%, ^{61}Ni: 1.1%, ^{62}Ni: 3.6% and ^{64}Ni: 0.9% [7]. For the electrolyzed Ni the isotope analysis was done only for ^{58}Ni, ^{60}Ni and ^{62}Ni because we got clear signals from these isotopes only.

The SIMS analysis was done on two regions (each 10 μm diameter) of the Ni sample. Figure 3 shows the SIMS signals from Ni isotopes from region I of the sample. In Table 1, we have shown the isotope ratios of Ni observed in nature as well as what we observed in our electrolyzed samples. It is clear that the isotopic ratio in the electrolyzed Ni is not what is found in the natural state of Ni. This fact strongly suggests that nuclear transmutation does take place during electrolysis. Isotopic ratio of Ni is modified by the electrolysis process with ^{60}Ni and ^{62}Ni being significantly depleted with respect to the more abundant ^{58}Ni.



Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	7.27	0.8426	11.52	1.09	36.87
K K	1.47	1.1026	1.77	0.29	2.33
Fe K	2.50	1.0083	3.31	0.59	3.03
Ni K	3.14	1.0259	4.08	0.81	3.56
Cu L	20.29	0.5632	48.10	1.36	38.78
Zr L	6.10	0.7398	11.00	0.79	6.18
Rh L	10.03	0.7885	16.98	1.12	8.45
Pb M	1.79	0.7402	3.23	0.83	0.80
Totals			100.00		

Figure 2. EDS spectrum of a certain region of a Ni cathode after about 100 h of electrolysis.

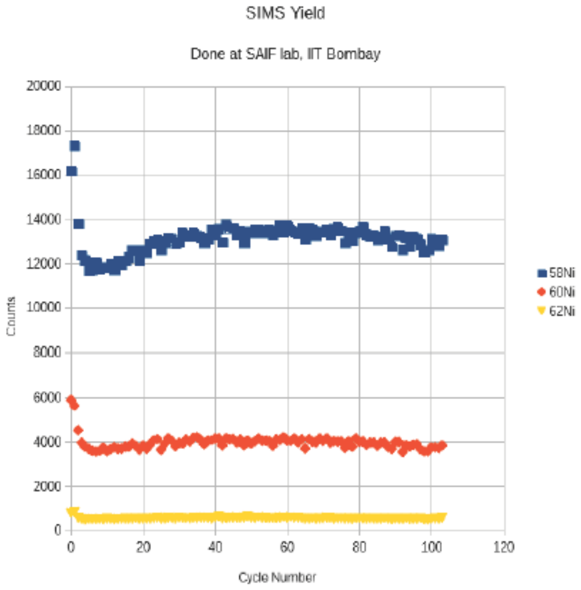


Figure 3. SIMS Yield from Region 1. Each cycle lasts 20 s. Total data acquisition time is about 0.5 h.

Table 1. Comparison of isotope ratios of natural and electrolyzed nickel.

Isotope ratios	Natural nickel	Electrolyzed nickel	
		Region I	Region II
^{58}Ni/^{60}Ni	2.596(1)	3.3(1)	3.5(1)
^{58}Ni/^{62}Ni	18.73(1)	24(1)	27(2)

More work needs to be done to systematize the findings such as:

(1) What happens if the electrolysis process is carried out at a different voltage? Is there a threshold voltage? Please note that this work was done at around 100 V.
(2) What are the isotope numbers of the other elements found on the Ni cathode? Are they all stable nuclides? Are some of them radioactive?
(3) How do the isotope ratios evolve with the duration of electrolysis?
(4) Does the electrolyte have any effect on the transmutation process? Will the use of a different electrolyte result in different isotope ratios for Ni?
(5) Would an external applied magnetic field have any effect on the outcome?
(6) Are there any hazardous neutron or γ-ray emissions during the process? No monitoring for such radiation was done during the experiments reported here as it is believed generally that LENR reactions do not produce any hazardous radiations. But still, this is a very important safety consideration and monitoring for such radiations should be done in LENR experiments as a matter of routine.

One of the observations made during the course of this work was that Ni–H electrolysis always seem to produce new elements at the cathode. The transmutation process seems to start right away, without delay, once the electrolysis is started. We could see this from the EDS analysis of a piece of the Ni wire subjected to only a few hours of electrolysis, but not reported here. Thus Ni–H systems seem friendlier than the Pd–D systems in which the LENR processes start with a large time delay, if at all.

Another strange observation is that the isotope ^{62}Ni which has the highest binding energy per nucleon of all the nuclides got depleted during our experiment! This raises the question of whether we are dealing with an endothermic process here.

5. Conclusion

It is easy to reproducibly induce nuclear transmutations in Ni–H systems and a large number of transmutation products are seen on the cathode on elemental analysis. Mass spectrometric analysis shows that isotope ratios of Ni are modified in the Ni cathode which is an undeniable indication that nuclear transmutations can be induced by low energy electrolytic processes.

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