

Change of Isotopic Ratios in Transmutations

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Introduction

Looking at nature with open eyes, there are a number of examples for massive transmutations at all levels. They are always in the neglected “unsolved problem” corner of observations. Just a few examples follow.

Saturn’s tiny moon, Enceladus, is only 500 km in diameter; it is practically a “pebble in the sky.” Yet it has hot geysers, oozing through ice cover about 40 km thick. What is the mysterious energy source? Why does it have nitrogen in its atmosphere? Titan, Saturn’s big moon (bigger than Mercury), also has nitrogen in its atmosphere (~95%), yet no other planet or moon has it. The nitrogen must be reproduced all the time, as the planet does not have enough gravity to hold it!

Or what about the solar corona, which is several million degrees in temperature, yet the surface of our Sun is just about 7000°C. Ostensibly, transmutation-fusion is the cause of these anomalies.

The fundamental process of transmutation-fusion, and sometimes fission by spallation, is charge shielding. That is, strong electric fields may catalyze nuclear reactions, by reducing Coulomb repulsion of reacting nuclei. But this is not a static, rather a transient or usually oscillating, phenomena. This simple rule is the common feature behind transmutations, which appear under varied environments.

Intense, oscillating electric fields appear usually on sharp edges of electrodes, or on the surface of dust particles. In our solar system, transmutation appears where there is intensive dusty atmosphere: Enceladus is spitting out very fine silica particles in its geysers, Titan has a high density atmosphere full of dust due to storms.

The giant mass of our Sun is also collecting oscillating dust, from interstellar space. However, transmutation also appears in technical devices (and of course in biology as well).

Transmutation is a “bottleneck,” not a “disruptive” technology, considering the true and original meaning of the word.

Transmutation-fusion takes place, of course, in extreme high-energy environments, like inside stars, without the catalytic charge shielding field. Mainstream science is only aware of this matter building process in the depths of exploding supernova or colliding neutron stars. Even unstable, heavier than iron nuclei are assembled this way (via a series of slow and rapid neutron captures).

However, with the help of the catalysis effect of shielded electric fields (Coulomb shielding), even heavy elements, like lead or thorium, can be fused from lighter nuclei, as will be shown herein.

Colloids

Colloids—floating fine particles in plasma or liquid—are the most simple low-energy environment to achieve low-energy nuclear reactions (LENR). A typical, but heretic, example is traditional alchemy. Transmutation may take place here with two possible sources of dust (colloid) materials:

1. The wall of a glass vessel, in the form of silica particles.
2. Carbon soot from fire. The effect of these small, nano-sized particles made alchemy the first application of nanotechnology, during the Roman-Egyptian period.

The charge build-up on the surface of dust (colloid) particles, thus charge shielding, was enough to trigger transmutations. Lacking even the elements of quality control, in alchemy the outcome was always unpredictable, especially for carbon (soot) particles. In a way, the type of wood (charcoal) might have been an influential, but uncontrolled, important parameter.

Obviously, the secrecy of alchemists, including Newton, and their obscure language did not help progress at all.

A paper by Peter Grandics¹ details such an alchemical process, along with test results. Of course, the amount of external carbon particles were not monitored; that is an open parameter. But carbonates from ambient CO₂ do appear

floating in the fine colloid in the reagent water.



Photo 1a. Front view of the reactor. The quartz acoustic resonator is visible inside the metal EM resonator.

Dust Fusion Devices

Perhaps the simplest device for rapid transmutation is the dust fusion reactor (developed by George Egely). It is an acoustic plasma chamber, driven by a periodic microwave power supply. (See Photos 1a and 1b.) By varying the frequency and power level of the microwave power supply, acoustic resonance can be achieved within an acoustic



Photo 1b. Side view of the 100 Hz reactor. Note the cylindrical microwave resonator on the top.

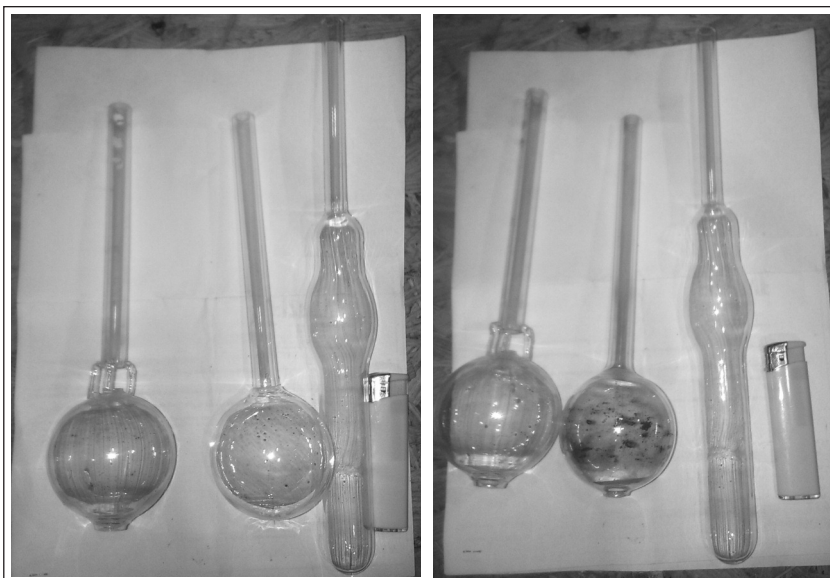


Photo 2. Acoustic resonators made of quartz.

(quartz) resonator. There are a wide variety of acoustic resonators for shape and geometry. Photo 2 shows some of the acoustic resonators. Obviously, many other forms of plasma generation methods are possible, like inductively or capacitively coupled plasma, or pulsed plasma between electrodes (the latter is the traditional form). Atmospheric plasma is the most convenient. In the case of a closed acoustic chamber, the composition and pressure can be varied along a wide range of parameters.

The dust (powder) is preferably electrically non-conducting, otherwise microwave will heat it directly, without the formation of plasma.

Fine *carbon dust* is ideal for this—especially if it was pre-baked, hardened, then milled into fine grains—as it has a high melting point.

There is another dust-based device developed by a Russian team led by Anatoly Klimov.² In this reactor a water-argon mixture is the base of the plasma, and Tesla coils are used to generate high-frequency, high-voltage plasma. Dust is generated by the ion bombardment of the electrodes, as cathode erosion is commonplace in high voltage electrodes. (See Figure 1.)

An unpublished dust fusion reactor was developed by Suhas Ralka, an inventor in Mumbai, India. It has hydrogen-based plasma, and nickel-tungsten dust. He claims COP around 6 to 10. There was significant transmutation on the electrodes of the discharge tubes. Bob Greenyer of Martin Fleischmann Memorial Project published the transmutation data.³

The dust may float as a colloid in liquid metal dense plasma as well. Mahadeva Srinivasan had a lecture at ICCF20 about a multi-ton transmutation result, in a Fe-Si plant in Coimbatore, India.⁴ This industrial oven used pulsed DC with graphite electrodes to generate molten Fe-Si liquid, with added charcoal particles.

Edward Esko⁵ developed a simple, elegant

arc discharge device, which is also inexpensive and easy to use.

The above examples are not the complete list of devices, as transmutation was observed in pulsed hydrogen plasma by Collie *et al.*⁶ as early as the 1910s.

Parameters Influencing Transmutation

The yield of transmutation varies by orders of magnitude. Transmutation may take place in the hot molten mix of minerals in the crust of Earth (and other planets and moons) as well.⁴ J.P. Wallace and co-authors prove that transmutation of elements is a continuous process, taking place even now.⁷

Mainstream science is of the opinion that heavy elements are “assembled” by a series of neutron absorptions (one by one) in stellar conditions, like supernovas and neutron star mergers. There is another, low energy method as well, via colloids.

The necessary conditions are unusual and sometimes counterintuitive, as parameters like dusty plasma frequency

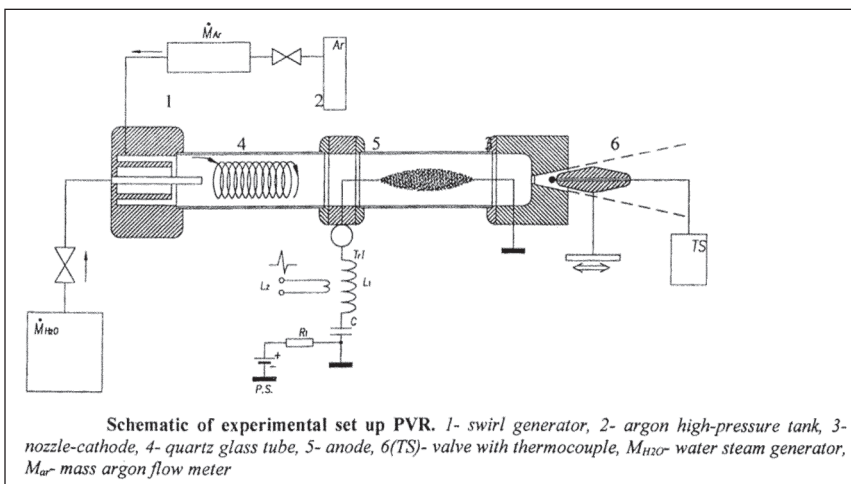


Figure 1. Klimov's dust fusion reactor.

seem to be an influencing factor.

In our experience, with dust fusion reactors the following major parameters were important:

- Plasma frequency
- Plasma temperature (temperature and pressure is tensor!)
- Grain quality (melting temperature), grain size distribution
- Plasma gas material
- Treatment time
- Input material mixture; chemical composition
- Electric/material properties of the input dust

Unfortunately, these parameters are interdependent, so they can't be tested independently from each other. For example, power input, temperature, frequency spectrum and treatment time are strongly coupled.

The shape of the acoustic resonators also has an important effect on the rate of transmutation—that is, on the yield. We usually used three different resonators:

1. A 60 mm sphere with two holes in it. The two holes (10 and 6 mm respectively) act with the sphere as Helmholtz resonators. The two holes tune the sphere at two different frequencies, but in the oscillating plasma the sum and the difference of their frequencies appear also. Plasma usually fills the upper part of the sphere at 1 KW input power. The oscillating system consists of the dusty plasma above and the hot gas below it.

By changing the input power, the volumetric ratio is tuned, thus there is a slight effect of base power on the fundamental plasma/gas oscillation frequency.

2. The “trumpet” is a tube about 100 mm long, with two trumpet-shaped ends, of the same geometry. Again, there are two fundamental frequencies—one along the tube, which is lower, and across the tube, which is higher. This irregular shape doesn't allow sharp eigen frequencies, as the system is noisy. Further, during the tests only the surface of the treated dust is affected by transmutation; below the surface there is no effect.

3. Sphere with “handle.” (This is a 60 mm diameter quartz sphere with a 20 cm long, 10 mm inner diameter tube.) The tube has two purposes: it can be grabbed, so that the sphere can be rotated, and it tunes the base frequency of the dusty plasma/hot gas oscillator. This system is poorer in sharp acoustic oscillations, as the “handle” is dampening the peak amplitude. (See Photo 2.)

There are a number of other possible shapes for acoustic oscillators, but financial restrictions forbade extensive explorations, and we had to restrict research in order to explore the effects of other parameters as well.

Variable Power Supply

Commercial household microwave ovens have single pulse operation, with a 50% duty cycle. Our first devices operated in a double pulse mode, at fixed 100 Hz frequency. Later we developed a tunable frequency power supply in order to increase acoustic amplitude. It yielded higher transmutation rates (but the device was stolen from us, so our recent results are made with 100 Hz).

Transmutation Results

Several tests were carried out, usually with 99.99% pure graphite (reactor grade). It is pre-baked, and its dust is barely conducting, though before rasping it is electrically conducting as any other graphite. Soft graphite is conducting even in fine dust form, thus it absorbs microwaves; consequently, plasma generation is poor.

Charcoal is also fine, but it contains several trace materials, like Fe, Ni, Ca, Mg, P, S, etc. Transmutation may take place between several elements, but is harder to control. Both materials were used, and the test results are shown in the tables.

In our test an Agilent triple quadruple magnet device was used, which yields a medium resolution of isotopic distributions. Not all the isotopes are shown, because of interferences (like Ca^{20}_{40}). Those test results are simply omitted. A reactor grade graphite was used in atmospheric air, so most reactions take place between carbon, oxygen and nitrogen, the usual George Ohsawa reactions. See Table 1a. All samples were treated at 1500 W input power, usually for 8 minutes.

Anyone with moderate skepticism may doubt the data presented in Table 1a, for several reasons. First of all, as carbon dust is heated in air, it will turn eventually into CO_2 , leaving the quartz resonator via the holes. Thus it might seem like a mere “distillation,” leaving the non-combustible elements (and its oxides) behind, in the leftover. Further, there is evaporation of low melting point materials, like oxides of alkali metals and alkaline earth metals, and PO_2 , etc. No doubt, this process is also present, and transmutation competes with “distillation” and evaporation.

Indeed, if the treatment time is about 3 minutes, all metals (their oxides) are getting more dense with the *same ratio*, which is really distillation or densification. After about 4-5 minutes of treatment this is no longer true. This uniform ratio of “densification” falls apart. The appearance of phosphorus and sulphur with their low melting/disassociation temperatures proves this.

Phosphorus is generated from ${}^7\text{N} + {}^8\text{O} \rightarrow {}^{15}\text{P}$ reactions. Sulphur is generated from ${}^8\text{O} + {}^8\text{O} \rightarrow {}^{16}\text{S}$ reactions. In Table 1a there is no sulphur left in the spherical resonator after 10 min of treatment; only phosphorus is left, in increased density.

New elements are also synthesized, as a sign of transmutation-fusion.

Lithium and boron were barely present in the original untreated sample, or at least their initial quantity was within the limit of test error.

There are some heavier elements, where the test error was zero, the original quantity in the sample zero, yet they have appeared in the treated sample. They are shown in Table 1b. Some other elements with very low melting/evaporation, like rubidium, are also on this list, because their initial amount is within the test error (that is, their initial presence is doubtful).

In the chain of fusion reactions involving carbon, oxygen and nitrogen (Ohsawa chain), there is no path leading to Ni, only iron. Indeed, the initial amount of Ni is barely changing (60 Ni from 15.5 to 26.3, 61 Ni from 15.8 to 27.3, 62 Ni from 16.5 to 27.18), roughly doubling, which may really be a “distillation” effect. But iron, with a similar melting/disassociation temperature, is significantly enriched, about six-fold (54 Fe from 370 ppm to 2234 ppm, 56 Fe from 805 ppm to 5152 ppm, 57 Fe from 656 ppm to 4017 ppm in the spherical resonator).

It is also noteworthy that the concentration of low melting point of lead is doubled, while the concentration of tungsten increased by a factor of 20. Yet at the same time, all isotopes of Zn remained the same after treatment than before treatment (64 Zn 28.87 before treatment, 28.98 after treatment; 66 Zn 31.43 before, 30.48 after; 67 Zn before,

29.68 after; 68 Zn 30.3 before, 31.27 after).

While reactor grade pre-baked graphite contained only a small amount of trace elements, thus a part of the Oshawa chain of reactions, little other reactions took place. Charcoal is a better starting material. It contains many trace elements, thus allowing a wider range of reactions.

Table 1a. Transmutations for reactor grade graphite (Test #2).

| Element and Its Isotopes (All results are in mg/kg, that is ppm) | Test Error | Untreated Sample | Treated Sample Sphere | Treated Sample Sphere with Handle | Treated Sample Trumpet |
|--|------------|---------------------|--------------------------|---|---------------------------|
| ⁶ Li | 0.96 | 0.93 | 11.03 | 1.52 | 2.75 |
| ⁷ Li | 0.66 | 0.64 | 7.36 | 1.05 | 1.94 |
| ¹⁰ B | 349 | 322 | 1091 | 358 | 1340 |
| ¹¹ B | 378 | 342 | 1140 | 395 | 1365 |
| ⁴⁰ Ca | 0.84 | 0.79 | 3.74 | 0.69 | 3.22 |
| ⁴² Ca | 0.59 | 0.73 | 2.43 | 0.8 | 2.04 |
| ⁴³ Ca | 0.76 | 0.78 | 3.48 | 1.14 | 3.44 |
| ⁴⁴ Ca | 0.92 | 0.88 | 4.08 | 1.13 | 3.77 |
| ⁴⁶ Ti | 2.16 | 6.12 | 34.11 | 10.3 | 13.29 |
| ⁴⁷ Ti | 1.39 | 5.451 | 32.18 | 9.01 | 10.92 |
| ⁵⁰ Ti | 0.88 | 12.41 | 39.57 | 11.7 | 11.43 |
| ³¹ P | 0 | 3.43 | 14.13 | 3.2 | 5.01 |
| ³² S | 0 | 66.99 | 0.0 | 77.62 | 4.16 |
| ³³ S | 0 | 53.84 | 0 | 67.8 | 0 |
| ³⁴ S | 0 | 66.94 | 0 | 77.7 | 5.8 |
| ⁵⁴ Fe | 7.81 | 770 | 2234 | 649 | 780 |
| ⁵⁶ Fe | 16.9 | 805 | 5152 | | |
| ⁶⁰ Ni | 0.21 | 15.5 | 2.6.29 | 19.27 | 7.67 |
| ⁶¹ Ni | 0.23 | 15.8 | 27.32 | 19.93 | 8.25 |
| ⁶² Ni | 0.2 | 16.57 | 27.18 | 20.08 | 7.84 |
| ⁶⁶ Zu | 5.8 | 31.43 | 30.48 | 10.12 | 28.8 |
| ⁶⁷ Zu | 5.8 | 28.7 | 29.68 | 9.22 | 28.85 |
| ⁶⁸ Zu | 5.99 | 30.34 | 31.27 | 10.46 | 28.0 |
| ⁷⁹ Br | 3.84 | 2.69 | 9.78 | 2.49 | 6.26 |
| ⁸¹ Br | 5.65 | 4.46 | 10.59 | 3.76 | 6.87 |
| ¹³² Ba | 1.32 | 6.63 | 18.72 | 5.65 | 13.62 |
| ¹³⁴ Ba | 2.11 | 5.65 | 17.49 | 5.1 | 11.93 |
| ¹³⁵ Ba | 2.17 | 5.44 | 16.94 | 4.89 | 11.97 |
| ¹³⁶ Ba | 2.11 | 5.49 | 17.36 | 4.94 | 11.98 |
| ¹³⁷ Ba | 2.16 | 5.59 | 17.45 | 4.97 | 12.0 |
| ¹³⁸ Ba | 21.2 | 5.4 | 17.05 | 4.91 | 11.86 |
| ¹⁸² W | 0.0 | 0.42 | 12.05 | 1.5 | 0.65 |
| ¹⁸³ W | 0.0 | 0.44 | 12.26 | 1.53 | 0.64 |
| ¹⁸⁴ W | 0.0 | 0.42 | 11.66 | 1.45 | 0.63 |
| ¹⁸⁶ W | 0.0 | 0.43 | 11.88 | 1.49 | 0.64 |
| ²⁰⁴ Pb | 0.88 | 4.39 | 7.25 | 1.92 | 2.13 |
| ²⁰⁶ Pb | 0.88 | 4.18 | 7.35 | 2.01 | 2.28 |
| ²⁰⁷ Pb | 0.92 | 4.29 | 7.68 | 2.11 | 2.33 |
| ²⁰⁸ Pb | 0.9 | 4.26 | 7.51 | 2.04 | 2.31 |
| ²⁰⁹ Bi | 0.01 | 0.09 | 0.01 | 0.0 | 0.0 |
| ²³² Th | 0.02 | 0.02 | 0.15 | 0.04 | 0.25 |
| ²³⁴ U | 0.15 | 0.11 | 0.56 | 0.11 | 0.88 |

On the negative side, charcoal's composition is uneven, as it varies from wood to wood. So a large batch is necessary, but within a well ground batch this is not a problem. Here the Oshawa chain is also dominant. In Table 2, several interesting results are shown. Note the widely different yields of different acoustic resonators. The difference from the previous reactor graphite tests is that the spherical quartz (with two holes) was rotated during the tests with a device. Thus the charcoal was inside of the dusty plasma most of the time. This is most apparent for copper, but iron also dominates, as well as the presence of volatile materials like sulphur and phosphorous. Mercury also appears, but in the untreated charcoal its quantity is within the test error. (Test results are not shown when the results were within error margin and around 0 ppm.)

The double hole sphere was used for 10 and 15 min of treatment time as well; note the difference, most probably due to evaporation/distillation as well.

In Table 2, some materials with low melting/evaporation temperature were increased in time, like P, Sn, Pb and Rb, and P, S were still present after 15 min of treatment. Zn, Ni and some end products increased in concentration, while most materials decreased, probably due to evaporation.

There is a marked difference between the test results of reactor grade (99.99% graphite) and charcoal (98% carbon). There are few reaction paths in the former (Oshawa chains) and several in the latter.

The changes of heavier than iron-nickel elements are especially marked, more pronounced for the charcoal. For reactor graphite, nickel is increasing ostensibly due to "distillation," from 15 ppm to 26 ppm. For charcoal, it is from 11 ppm to 101 for 10 min, and 318 for 15 min.

The clearest indicator for transmutation is the presence of low melting temperature materials, like P, S, K, Na, Sn and Pb, and rubidium. Rubidium is 5.7 ppm in the original sample, 25.4 after 10 min treatment, and still 13 ppm after 15

min treatment. ⁸⁵Rb mass is way above the ⁵⁶Fe mass and ²⁰⁶⁻²⁰⁸Pb is obviously higher mass than iron. The same is true for Sn, where the concentration is increasing in time, but its oxide has a low disassociation/evaporation temperature.

Bob Greenyer also found copious amounts of lead in his (unpublished) study of Ralka's transmutation tests, done by high-energy, cavitating tungsten-water mixture. That study was carefully done at several sample sites, and the results are not likely to be a test error, since several sites were used.

Open Questions

There are more questions than answers. The questions are related partly to the technology (there is much room to develop) and the physics behind test results as well. There is an obstacle concerning the technology: the acoustic resonator ought to have openings, to have high amplitude oscillations. When the openings are closed, or connected to a tube (handle), the oscillations are damped, and the yield is lower.

The output of volatile materials, like P, S, Pb, Sn, Sb, Rb, Cs, K, Na and Hg is probably *much higher than measured*, as they may leave the acoustic resonator continuously due to heating. In principle it is possible to trap and measure them, but at an extra cost and sophistication.

The mechanism of transmutation of heavier than iron materials is not known. This concerns possible fusion or fission/spallation as well. It would be useful to test the process in several other gases than air. We built such an air tight cylindrical type electromagnetic cavity resonator, with a spy-window on its side, and it worked well. (All such devices and the test results were stolen by investors.)

When only nitrogen, helium or argon were used, there was little or any transmutation. Pure oxygen was never used, in fear of a chemical explosion.

No alpha, beta or gamma radiation has been detected by our simple Geiger tube and semiconducting devices.

Table 1b. Treatment of nuclear grade graphite in air. Continuation of Test #2. (Boldface denotes a large change.)

| Element/Isotope | Error | Original | Spherical Resonator | Sphere with Handle | Trumpet Shaped |
|--|-------|----------|---------------------|--------------------|----------------|
| ¹⁰⁷ Ag | 0.0 | 0.0 | 0.0 | 0.0 | 1.35 |
| ¹⁵¹ Eu | 0.0 | 0.0 | 0.02 | 0.0 | 0.01 |
| ¹⁵³ Eu | 0.0 | 0.0 | 0.02 | 0.0 | 0.01 |
| ¹⁵⁵ Gd | 0.01 | 0.03 | 0.17 | 0.04 | 0.05 |
| ¹⁵⁶ Gd | 0.01 | 0.01 | 0.12 | 0.02 | 0.06 |
| ⁸⁵ Rb | 0.26 | 0.29 | 0.94 | 0.33 | 1.04 |
| ⁸⁷ Rb | 0.4 | 0.42 | 1.61 | 0.47 | 1.54 |
| ⁸⁸ Sr | 2.65 | 2.73 | 11.01 | 2.9 | 9.97 |
| ¹⁴⁷ Sm | 0.0 | 0.01 | 0.08 | 0.04 | 0.03 |
| ¹⁴⁸ Sm | 0.01 | 0.02 | 0.23 | 0.05 | 0.08 |
| ¹⁴⁹ Sm | 0.00 | 0.01 | 0.07 | 0.04 | 0.03 |
| ¹⁵⁰ Sm | 0.01 | 0.02 | 0.29 | 0.06 | 0.09 |
| ²³ Na | 1.08 | 1.05 | 3.86 | 1.37 | 4.46 |
| ³⁹ K | 0.25 | 0.24 | 0.81 | 0.32 | 1.66 |
| ⁴¹ K | 0.28 | 0.27 | 0.99 | 0.38 | 2.04 |
| ¹⁹⁰ Pt | 0.00 | 0.00 | 0.16 | 0.16 | 0.15 |
| 192,194,195,198Pt isotopes are complete 0. | | | | | |

The transmutation yield increased with the pressure, up to about 1.5 bar, but decreased above it, as the volume of the plasma decreased at the same maximum power input (1.5 KW).

A number of tests were carried out with a portable, handheld X-ray dispersion device, in a nearly closed spherical acoustic resonator with a handle. It was less reliable than ICP-MS, therefore only some broad, preliminary conclusions were drawn. One curious observation has been that the *distribution of acoustic spectra had an influence upon the quality of the element distribution*, given all other parameters were kept the same. This observation deserves further investigation before any conclusion is drawn. This test series was done on zeolite samples

only, with dominant Al, Mg, Si content, in air atmosphere.

Changes in the Isotopic Ratios

The triple quadrupole Agilent device is not accurate enough to give the mass and isotope ratio at the same time. Isotope ratios are to be determined from raw input data (count per seconds) after a careful calibration.

A long cherished notion of nuclear physics is that isotope ratios are the same on Earth for each element. This has turned out to be only a partial truth, as materials like Pb and Sr may differ in their isotope ratios depending on their site

Table 2. Charcoal and air [mg/kg]. (Boldface denotes a large change.)

| Element/Isotope | Test Error | Untreated | Sphere 10 Minutes | Trumpet 10 Minutes | Sphere 15 Minutes |
|---|------------|-----------|-------------------|--------------------|-------------------|
| ²⁷ Al | 3008 | 2048 | 19027 | 9134 | 7942 |
| ⁴² Ca | 9125 | 18083 | 192729 | 82765 | 83245 |
| ⁴³ Ca | 10441 | 18039 | 199349 | 86077 | 85103 |
| ⁷⁴ Ca | 9789 | 18565 | 200634 | 86495 | 87331 |
| ²³ Na | 10813 | 3960 | 12085 | 8600 | 12108 |
| ⁵⁹ Co | 0.03 | 9.66 | 114 | 55.8 | 49.1 |
| ⁶³ Cu | 20.5 | 71.2 | 31177 | 306 | 468 |
| ⁶⁵ Cu | 20.5 | 71.8 | 32355 | 305 | 457 |
| ⁵⁶ Fe | 72.4 | 2625 | 56352 | 30683 | 21282 |
| ⁵⁷ Fe | 59.1 | 2178 | 53935 | 25933 | 17728 |
| ¹⁹⁸ Hg | 0.69 | 0.42 | 0.68 | 0.8 | 0.97 |
| Other isotopes are similar. | | | | | |
| ³⁹ K | 2627 | 7043 | 38177 | 21837 | 18723 |
| ²⁴ Mg | 2079 | 3475 | 34300 | 16795 | 18405 |
| ¹⁴³ Nd | 0.13 | 1.0 | 13.73 | 5.75 | 4.05 |
| ⁸⁵ Rb | 2.58 | 5.7 | 25.3 | 22.9 | 13.6 |
| ⁶⁰ Ni | 1.83 | 11.16 | 101.3 | 50.4 | 318.7 |
| Note the enrichment after 15 minutes. | | | | | |
| ³¹ P | 11.2 | 625 | 8988 | 3795 | 3900 |
| Note that after 15 minutes the concentration is still high. | | | | | |
| ³² S | 135 | 574 | 7116 | 3514 | 2697 |
| ¹¹⁶ Sn | 0.48 | 2.63 | 33.48 | 14.8 | 35.7 |
| ¹¹⁷ Sn | 0.83 | 4.38 | 57.9 | 25.2 | 66 |
| Note the increasing concentration with time. | | | | | |
| ⁴⁷ Ti | 21.4 | 235 | 3174 | 1818 | 1607 |
| ¹⁸² W | 0.08 | 1.45 | 9.46 | 5.82 | 3.77 |
| ¹³³ Cs | 0.13 | 0.22 | 0.58 | 1.08 | 0.36 |
| ⁵¹ V | 1.97 | 17.2 | 153 | 73 | 50.2 |
| ¹²³ Sb | 0.06 | 0.93 | 7.49 | 4.81 | 3.59 |
| ²⁰⁶ Pb | 2.95 | 64.3 | 127 | 21 | 231 |
| Note the increasing concentration with time. | | | | | |
| ⁸⁴ Sr | 25.4 | 67.3 | 958 | 463 | 360 |
| ⁶⁶ Zn | 79 | 224 | 577 | 121 | 737 |
| Note the increasing concentration with time. | | | | | |

Table 3. Changes in isotope ratios in graphite.

| Material Abundance in References | | Material in Untreated Graphite | Material in Treated Graphite Sample 1 | Material in Treated Graphite Sample 2 |
|----------------------------------|--------|--------------------------------|---------------------------------------|---------------------------------------|
| ⁶⁵ Cu | 30.9% | 34.2% | 33.97% | 33.05% |
| ⁴⁷ Ti | 7.28% | 45.52% | 46% | 51.25% |
| ⁴⁹ Ti | 5.51% | 54.48% | 54% | 48.75 |
| ⁶⁹ Ga | 60.4% | 94.61% | 94.93% | 96.43 |
| ⁷¹ Ga | 39.6% | 5.39% | 5.07% | 3.57 |
| ⁷² Ge | 27% | 72.6% | 64.58% | 64.08% |
| ⁷³ Ge | 7.76% | 8.38% | 8.33 | 17.48% |
| ⁷⁴ Ge | 36.5% | 18.99% | 27.08% | 18.45% |
| ⁷⁷ Se | 7.58% | 25.78 | 15% | 16.34% |
| ⁷⁸ Se | 23.5% | 16.41% | 19% | 15.84% |
| ¹¹⁰ Cd | 12.39% | 11.81% | 8.18% | 11.8% |
| ¹¹¹ Cd | 12.75% | 12.65% | 6.96% | 11.77% |
| ¹¹² Cd | 24 % | 27.9% | 39.89% | 28.44% |
| ¹¹³ Cd | 12.26 | 12.9% | 8.48% | 12.72% |

of mining.

We found some changes in the isotope ratio as well due to plasma treatment. Some of these were minor and just due to test error, but in other cases they might be significant. In Table 3 some of the significant changes are shown, but most materials do not deviate significantly.

There were further deviations in the case of tellur, samarium, europium, gadolinium, etc. as well. However, these were just preliminary tests. Much is to be done to improve the amount and reliability of isotope data.

Energy Balance

Transmutation requires energy to initiate, but fusion yields energy, until the iron-cobalt-nickel nuclei binding energy maximum. The synthesis of heavier than nickel elements requires net energy input, but in all of our transmutation tests we found such heavier elements.

Unfortunately with our simple, open cavity method we are not yet capable of measuring mass balance; that is, most materials evaporate, like P, S, halogens, etc.

But we never encountered sudden energy release, while working with ambient air as a background gas.

Three mechanisms are involved with energy release:

1. Fusion of lighter elements, like H₂, O, N, C (maybe Li, B) into Al, Mg, S, P and eventually Fe. These processes yield some energy.
2. Synthesis of neutrons, from the protons of ambient air water vapor. This requires energy investment. Their capture into nuclei yields shift in isotope distribution.
3. Synthesis of heavy elements, like Pb, Th. This very strange process was observed in dust fusion experiments, in experiments by us, Greenyer and Quantum Rabbit (Esko).

All in all, the net energy release can be near zero. Early electrochemical LENR tests with light water (H₂O) yielded no net energy release—or just a small amount—but transmutations were present on the surface of electrodes.

The initial composition, and the choice of initial materials (and ignored impurities), do influence the net energy output. When there are predominantly protons (hydrogen) in the system, neutron synthesis and transmutation is dominant. When heavy protons (deuterium) are present initially, and there are no heavy elements in the bulk of materials, energy release can be dominant.

Quality control is essential, but it easier to talk about it than to realize it in practice.

Conclusions

There were four groups of events pointing towards nuclear transmutation in our tests.

1. Appearance (synthesis) of new elements shown in Table 1b, like Ag, Eu, Gd, Rb, Sr, Sm, Na, K, ¹⁹⁰Pt.
2. Persistent presence of low melting point materials, like P, S, Sb, Sn, Ag, K, Rb, Cs even after continuous heating above 1200-1500°C, up to 10 min.
3. Persistent presence of heavy mass materials like Pb, despite their low melting/evaporation point. Charcoal-based carbon is going to initiate this effect, but the presence of tungsten is also triggering this process, as was found in Ralka's device by Greenyer.
4. Shifts in isotope distribution, as found in our tests, in Table 3.

The paths leading to these chains of transmutation events are not yet firmly established. But these tests give food for thought for theoreticians.

There are some probable predictions, but not firmly established ones:

- a) Charge shielding is effective for highly divergent electric fields around electrode tips, dust particles (divE >>0).
- b) Fusion is most likely between a neutral and an ionized atom. There is no need for full ionization, as no hard X-rays are observed.

c) There are several possible fusion paths. The simplest is the step-by-step process of adding a synthesized neutron, or a single proton. But heavier nuclei may fuse with each other, like $2\text{O}^{16}_{16} \rightarrow \text{S}^{32}_{16}$ without having ion accelerators.

d) There is no way to understand and thus to design fusion paths as long as there is no correct model for all nuclei. Models of nuclei, like shell or droplet, are clearly not adequate to describe the observed transmutations.

Transmutation requires more sophisticated models capable of describing dynamic processes involving nuclei and their electron cloud. The solid, crystal-like symmetric models of Norman Cook⁸ and Laszlo Sindely⁹ seem more appropriate for this task.

All in all, transmutation is fundamental for any practical LENR applications, like heat generation or direct electric energy production. It can lead, for example, to $p + B \rightarrow 3\alpha$ reaction, which is a holy grail for hot fusion researchers, as it is a neutron-less reaction. But LENR seems to be more conducive to the proton-boron reaction, which is difficult in a hot fusion environment.

Paths of LENR

There are maybe five distinct type of reactions in LENR:

- Perhaps the simplest is to create neutrons via $e + p \rightarrow n^0_1$ reaction, and the ultracold, slow neutron will react with any neighboring nuclei. Though synthesis of a neutron is endothermic, consequent reactions can be exothermic, thus a small excess energy can be generated.
- Spallation (removing a small part of the nuclei by an incoming small particle). In this way a proton is removed, or at most an α particle. This is a kind of induced fission, and can be favorable in terms of energy. A large nuclei, heavier than iron, may participate in this reaction. It requires hydrogen or helium plasma, otherwise it is improbable.
- Electron capture. (K-capture or positron emission.) It takes place only if a nuclei is neutron rich, and adding one more proton makes the nuclei more stable. There were "rumors" of extreme high mass neutron rich carbon isotopes by Oriani, but that was not verified independently.
- Multibody fusion of several light nuclei. This mechanism "sweeps the nuclei debris." Some of the puzzling LENR transmutation points towards this possibility.
- Algebraic sum of light nuclei. This is a step by step process. The Oshawa chain of reactions between C, O, N is a typical example, and dusty plasma in transient conditions is a favorable technical environment. It is an open question whether this process may take place above lanthanum, as heavy nuclei are "neutron hungry." Above lanthanum the ratio of the neutron/proton is exceedingly high, especially when the number of protons is odd.

Empirical Observations

The observations below are rather speculative. More empirical evidence is needed, but it is worth keeping them in mind.

"Seed material"

Transmutation is more likely to happen if there is some seed material from the nuclei to be synthesized. So if, say, calcium is the target material, carbon + 2 nitrogen will do it. But

the reaction is more likely to happen if there is a tiny amount of calcium already present among the ingredients. Wild speculation is the presence of a "morphogenetic field." The jury is out and will be for awhile. There were some occasional remarks about it by Esko, Greenyer, J.P. Biberian, etc.

Similar materials

It is not pure coincidence that some minerals are found more frequently around some specific "company." They are just under each other in the periodic table, like Cr, Mo, W; Ni, Pd, Pt; Mg, Ca, Sr, Ba; or Si, Ge, Sn, Pb, etc. That is, if we are to make Mo, a little Cr or W will help.

Szumski's principle prevails¹⁰

There is not much energy release in transmutations above, say, carbon, because heavier isotopes prevail in these reactions. That is, excess energy is immediately turned into making additional neutrons, thus heavier isotopes. Only detailed tests of isotopes can prove or deny this rule. High resolution ICP-MS tests are the only means to decide this problem.

The fusion device described herein was designed by the first author (Egely), the tests were carried out by the second author (Balint), and the transmutation experiments and power supply were done by the third author (Rosko). The mechanical parts were designed by Csaba Csokör. Laszlo Sindely made the isotope ratio calculations.

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