Lithium as a fuel for LENR

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At first I was skeptical of the Fleischmann and Pons claim of excess power in an electrolysis experiment with a palladium cathode and a heavy water electrolyte. Then Richard Oriani [Oriani, R. A. et al., Fusion Tech. vol. 18, p.652, (1990)] reported excess power during cathodic charging of deuterium into palladium, and I changed my mind. I knew Oriani to be a careful and reliable experimentalist and when he found excess power I chose to believe it.

I suggested several theories for excess power. All but one were shot down by critics or abandoned by me. My polyneutron theory has survived. Polyneutron theory is based on the idea that the table of isotopes as recognized prior to Fleischmann and Pons is incomplete, and that the full table contains a hidden family of heavy isotopes of all the elements, including the element *neutrium*, symbol Nt, which has no proton in its nucleus. The isotopes of neutrium include the neutron ^{1}Nt and its isotopes ^{A}Nt that I have called polyneutrons in previous work.

Ordinary isotopes are represented by their chemical symbols H, He, Li, and so on. For the hidden family of isotopes I use the symbols in bold print **Nt**, **H**, **He**, **Li**, and so on. And for all isotopes I indicate the total number of nucleons (neutrons and protons together) by a superscript to the left of the chemical signal. In this notation a neutrium isotope composed of 100 neutrons is represented by $^{100}\mathbf{Nt}$, a hydrogen isotope with a nucleus that contains 100 nucleons including one proton is represented by $^{100}\mathbf{H}$, and a carbon isotope with a nucleus that contains 100 nucleons including 6 protons is represented by $^{100}\mathbf{C}$.

Deuterium (^{2}H) has played a key role as fuel in LENR theories. In polyneutron theory deuterium is responsible for the production of energy in reactions of the form

$$^{A}\mathbf{Nt} + {}^{2}\mathrm{H} \rightarrow {}^{A+1}\mathbf{Nt} + {}^{1}\mathrm{H} \qquad (1)$$

in which neutron isotopes grow larger. More energy is produced in beta decay reactions in which a neutron changes into a proton,

$$\begin{aligned} &^{A}\mathbf{Nt} \rightarrow {}^{A}\mathbf{H} \\ &^{A}\mathbf{H} \rightarrow {}^{A}\mathbf{He} \\ &^{A}\mathbf{He} \rightarrow {}^{A}\mathbf{Li} \end{aligned} \qquad (2)$$

and so on.

Still more energy is produced in alpha decay reactions in which an isotope emits a helium isotope and grows smaller,

$$\begin{aligned} &^{A}\mathbf{He} \rightarrow {}^{A}\mathbf{Nt} + {}^{4}\mathrm{He} \\ &^{A}\mathbf{Li} \rightarrow {}^{A}\mathbf{H} + {}^{4}\mathrm{He} \\ &^{A}\mathbf{Be} \rightarrow {}^{A}\mathbf{He} + {}^{4}\mathrm{He} \end{aligned} \qquad (3)$$

and so on.

Four instances of reaction (1) lead to

$$^{A}\mathbf{Nt} + 4({}^{2}\mathrm{H}) \rightarrow {}^{A+4}\mathbf{Nt} + 4({}^{1}\mathrm{H}), \qquad (4)$$

after which two instances of reaction (3) lead to

$$^{A+4}\mathbf{Nt} \rightarrow {}^{A}\mathbf{He} + {}^{4}\mathrm{He} \qquad (5)$$

In experiments for which ^{2}H is the fuel for excess power, neutron isotope theory requires that it be present in the electrolyte. This raises a question because in his later work Oriani obtained nuclear reactions by electrolysis of ordinary water. For years I did not worry about this, assuming that the concentration of ^{2}H in ordinary hydrogen (0.015%) would be enough to fuel the required nuclear reactions.

But now I question this assumption. Is the 0.015% deuterium in ordinary hydrogen actually enough to explain Oriani's energetic particle results? And if not, can polyneutron theory survive? Here I address these questions.

Oriani's recent electrolyte is lithium sulfate (Li_2SO_4) dissolved in ordinary water (H_2O), and his cathode is nickel. The potential fuels in this system are isotopes of hydrogen, lithium, oxygen, sulfur and nickel. Perhaps some of these isotopes could serve as fuels. Of these the lithium isotopes stand out as candidates. For investigating the reactions between polyneutrons and these isotopes, I need a table of the mass excesses of hydrogen, helium, lithium and neutrium. Following the format of the Nuclear Wallet Cards these are:

Nuclide	A	Δ(MeV)	Level Width, Lifetime, or Abundance	Decay mode	Comment
H	1	7.289	99.9885%		From Nuclear Wallet Cards
"	2	13,136	0.0115%		"
He	4	2.425	~100%		"
Li	5	11.68	1.5 MeV	α+p	"
"	6	14,087	7.6%		"
"	7	14.907	92.4%		"
"	8	20.945	938ms	β, β α	"
Nt	1	8.071	10m	β	^{1}**Nt** is the neutron.
"	A	$\Delta(^A\mathbf{Nt})$		β	$\Delta(^A\mathbf{Nt})$ is unknown.
"	A+1	$\Delta(^{A+1}\mathbf{Nt}) + \theta$		β	θ lies in the range
"	A+2	$\Delta(^{A+2}\mathbf{Nt}) + 2\theta$		β	1.95< θ <2.82,
"	A+3	$\Delta(^{A+3}\mathbf{Nt}) + 3\theta$		β	depending on the size of A.
	and so on.				

In this table the mass excesses $\Delta(^A\mathbf{Nt})$ for the ^{A}**Nt** isotopes have been approximated by a liquid drop model in which θ is the increment of Δ corresponding to an increase of one neutron in the size of the drop. Because θ is a slowly varying function of A, I treat it as a constant in reactions for which the value of A does not change significantly. Analysis of transmutation data has suggested that the value of θ lies in the range 1.95< θ <2.82 MeV depending on the size of the neutron isotope.

Calculation shows that there is only one type of exothermic neutron transfer reaction between ^{A}**Nt** and ^{7}Li,

$$^A\mathbf{Nt} + {}^7\mathrm{Li} \rightarrow {}^{A+2}\mathbf{Nt} + {}^4\mathrm{He} + {}^1\mathrm{H} + (5.193 - 2\theta)\ \mathrm{MeV}. \qquad (3)$$

This reaction is exothermic for θ in the range $1.95 < \theta < 2.596$ (about 3/4 of the full range of θ). Consider the series of such reactions generated by an initial isotope $^{A}\mathbf{Nt}$ in interaction with ^{7}Li:

$$^{A}\mathbf{Nt} + {}^{7}\mathrm{Li} \rightarrow {}^{A+2}\mathbf{Nt} + {}^{4}\mathrm{He} + {}^{1}\mathrm{H} \qquad (4)$$

$$^{A+2}\mathbf{Nt} + {}^{7}\mathrm{Li} \rightarrow {}^{A+4}\mathbf{Nt} + {}^{4}\mathrm{He} + {}^{1}\mathrm{H}, \qquad (5)$$

followed by two beta decays and an alpha decay which together give

$$^{A+4}\mathbf{Nt} \rightarrow {}^{A+4}\mathbf{H} \rightarrow {}^{A+4}\mathbf{He} \rightarrow {}^{A}\mathbf{Nt} + {}^{4}\mathrm{He}. \qquad (6)$$

The initial $^{A}\mathbf{Nt}$ in (4) is restored in (6) and the overall reaction is

$$2({}^{7}\mathrm{Li}) \rightarrow 2({}^{1}\mathrm{H}) + 3({}^{4}\mathrm{He}) + 5.19\ \mathrm{MeV}. \qquad (7)$$

In contrast, the isotope ^{6}Li is exothermic for neutron transfers in either direction,

$$^{A}\mathrm{Nt} + {}^{6}\mathrm{Li} \rightarrow {}^{A+1}\mathrm{Nt} + {}^{4}\mathrm{He} + {}^{1}\mathrm{H} + (4.373 - \theta)\ \mathrm{MeV} \qquad (8)$$

$$^{A}\mathrm{Nt} + {}^{6}\mathrm{Li} \rightarrow {}^{A-1}\mathrm{Nt} + {}^{7}\mathrm{Li} + (-0.820 + \theta)\ \mathrm{MeV}. \qquad (9)$$

Equation (8) increases the size of the neutron isotope and is exothermic for the full range of θ. Equation (9) decreases the size of the neutron isotope and is exothermic for about 1/4 of the full range of θ, reducing the net growth rate of ^{6}Li below the value given by equation (8). Natural lithium is composed of ^{7}Li (92.4%) and ^{6}Li (7.6%). Commercial lithium may contain an even smaller percentage of ^{6}Li because this isotope is often removed for use in nuclear applications.

Based on these considerations I now think that ^{7}Li is probably the principal fuel in Oriani's experiments that employed a light water electrolyte.