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**UNDERSTANDING REPRODUCIBILITY: TOPOLOGY IS THE KEY.**
by Dr. Peter Glück

*Profoundness has to be concealed. Where? At the surface!* (Hugo von Hoffmannstahl)

*The surface was created by the devil.* (Wolfgang Pauli)

Lack of reproducibility was a kind of original sin and a rich source of troubles, despair and skeptics from the start of the cold fusion story. Now the situation is much improved, but the progress has resulted mainly from trial and error experiments and not from cause-effect considerations, principles, models or theories. This statement is valid even for the newly born light-water excess energy experiments [1]. The most developed theories, e.g. the T.R.M. model of Bush [2] must be combined with purely empirical descriptions of know-how and engineering data as those of Cravens [3] for electrochemical cells. Scaramuzzi [4] for gas-metal systems, Mills [5] (the experimental part) and Mallove [1] for light water experiments. An example of spectacular irreproducibility was obtained by the scientists of the Bhabha Atomic Research Center [6,7]: "not only are the anomalous fusion reactions found to take place in only a very few chips (obtained from the same piece of titanium) but even in those chips, tritium production is restricted to a small number of selected localized 'hot spots' only..."

Theory or analysis can do only a little for solving such practical problems like the choice of a working electrode [3]. The situation reminds me of a saying of the famous Spanish painter Salvador Dali: "The only difference between a madman and me is that I am not mad." A statement like, "a good electrode is an electrode which is good" is not a tautology but a research report.

In my opinion, this "lack of reproducibility" is actually nothing else than an extremely high, mimosaceous SENSITIVITY of the cold fusion phenomena, which can be triggered, delayed, perturbed or stopped by some hyperfine, immeasurably small causes such as sub-parts-per-billion level impurities or "esoteric" metallurgical factors. This sensitivity is intrinsic to these phenomena and for this reason it seems inappropriate to correlate cold fusion to some ordered features of the systems like electron screening, crystal or lattice structure, even defects of these or to any other easily controllable factor.

In the following, I intend to prove my belief that the experimental facts and ideas generated by the scientists working in this emergent scientific field have attained such a "density" that a global vision and a continuous logical network of certitudes can be created and these can be used to solve the central puzzle of the field.

**DEFINING COLD FUSION PHENOMENA**

Cold fusion phenomena are extremely sensitive and much varied nuclear processes appear to take place at localized areas on the surface of some metallic hydrides. The phenomena are generated and stimulated by dynamic factors. Due to their <u>common topology</u> which is not sufficiently controlled at the present, all the phenomena having <u>different mechanisms</u>, appear as chaotic, non-linear, non-predictable.

Cold fusion phenomena must be considered as sui-generis heterogeneous catalytic processes and the modern concepts regarding active sites have to be applied in order to understand and direct the reactions.

**MORE ABOUT SENSITIVITY**

* Monomolecular layers of heavy metals change the surface/interface properties of electrodes considerably.
On this basis, Schlapbach et al [8] have developed an analytical method with sensitivity better than 1 part-per-trillion.

* A remnant soap film can inhibit the light water process, wherein the electropolishing of the nickel cathodes is also a condition of success [1].

* Both the outer and inner impurities have to be considered; it has been shown that some impurities (Rh, Ag) are migrating toward the surface of the palladium electrodes [9].

* The usual construction materials of the electrochemical cells - i.e. glass and platinum - seem to be good reservoirs of impurities when exposed to long term corrosion. Perhaps it is not accidental that one of the best cells, that of Takahashi [10] is made of polyacrylate plastic.

**THE VARIETY OF COLD FUSION PHENOMENA**

The data presented in the two excellent, complementary surveys published in 1991 [7, 11] is impressive. More information was published later on light water excess heat reactions [5] considered to be actually alkali-hydrogen fusion [12], multi-body fusion [10] as well as on a newly discovered low energy intensity emission characteristic for palladium loaded with hydrogen or deuterium [13].

The similarities and differences between the processes carried out in the three main systems: palladium, titanium and nickel (as well as their alloys) are not clear at the moment.

**THE SURFACE IS THE LOCUS FOR THE COLD FUSION REACTIONS...**

* Newly created surfaces can trigger nuclear reactions - see fractofusion and the co-deposition procedure of Szpak [14].

* The light water excess heat process is clearly localized on the very surface of the nickel cathode, impenetrable for the alkaline metal participant/component [5,12].

* Cold fusion in thin films works well [15].

* Implantation, even at high density seems to have a moderate efficiency.

* Tritium formed in the electrolytical experiments goes into the electrolyte [11], only a very small fraction of helium remains in the electrode [11].

**BUT ONLY IN RESTRICTED AREAS -- ACTIVE SITES!**

* Neutrons and tritium are released in bursts; bursts are temporal just because they are local, suggesting some sort of "cascade reaction or micronuclear explosion" [7].

* The point effect (the fusion reactions occur on the isolated tiny areas of the surface, due to the directed moving deuteron flux) was postulated by Jiang et al [16].

* There are many data regarding nonuniform distribution of tritium in the electrodes.

* Hot spots on electrodes can be visualized by infrared techniques [3].

* Post-electrolysis cathodes present tiny spot defects suggesting cold fusion in grain boundaries.

## COLD FUSION IS STIMULATED BY DYNAMIC EFFECTS

* It is interesting to remark that different D/Pd ratios are necessary in order to trigger the emissions of neutrons, tritium or heat. But in all these cases a long and rather unpredictable induction period is required suggesting "a waiting time for removing an obstacle," not just "swelling of a network." Some abundant emissions of neutrons result from a barrier-breaking process, see e.g. the work performed at NTT-Tokyo [18] and our study [19].

* Many researchers consider pulsing current a critical factor.

* High temperature (i.e. high mobility) like in molten salt experiments [10] is advantageous for the heat release.

* The same effect is obtained by high voltage discharges.

* The ever growing patent literature presents many dynamic methods for the enhancement of cold fusion: different forms of excitation energy-mechanical (i.e. vibration), electrical, magnetic, supersonic, optical irradiation, heating, pressure waves, etc.

* In spite of the expectations, very high pressure is <u>not</u> a stimulating factor [21].

* Cluster impact fusion - the nearest neighbor of cold fusion is obviously also based on dynamic effects (and is a surface process too). [See new evidence, page 14.]

## SURFACE MOBILITY OF METAL ATOMS IS KEY

Surface mobility of metal atoms is the key both for heterogeneous catalysis and for cold fusion.

One of the modern and successful Russian schools in the field of heterogeneous catalysis [22] considers that surface dynamics is the determining factor for the existence of active centers. Motion of both isolated atoms and clusters of noble metal atoms have to be considered. Chaotic motions of surface atoms can be now directly observed. Surface dynamics and especially the rapid gas-surface energy transfer are emphasized as important factors for catalysis in the review of Somorjai [23]. Actually, the study of catalytic surface phenomena in operating conditions is very difficult, given that the most modern analytical methods must work under high vacuum conditions. The mobility of hydrogen atoms on the surfaces of noble metals is very high, including quantum effects.

(Due to the limitation of my information sources, I am not current on latest publications regarding surface dynamics of Pd, Ti and Ni hydrides - the considerations are usually restricted to the motion of hydrogen atoms.)

In my opinion, the cold fusion phenomena are localized at active sites (similar to catalysis), and characterized by intense surface dynamics. This is the unique possibility to justify their hypersensitivity which needs a "sufficiently" chaotic factor. It is intuitive to imagine how a few foreign atoms e.g. silicon or zinc are restraining the motion of the topmost layer of the metal atoms. A minimal quantity of organic matters adsorbed here when touching the electrode with a hand not protected by a glove can have the same catastrophic effect.

In order to have a theory, you need reliable facts; emissions of neutrons, tritium, heat etc. are not reliable, on the contrary, lack of reproducibility is reliable, it's rock-solid and reproducible! **This means: <u>paradoxically, lack of reproducibility has an amazingly great informational value.</u>** When understood, generously unmasking itself, it gives us the solution how to destroy it... and to

understand what actually cold fusion is. The low energy emissions from palladium loaded with hydrogen or deuterium, recently discovered by BARC scientists [13] cannot be unambiguously correlated to chemical reactions, lattice phenomena or cold nuclear fusion. I suggest that this form of radiation is caused by the peculiar surface dynamics of the Pd hydrides/deuterides and is a precursor of cold fusion.

**DISCUSSION**

* A new concept regarding cold fusion has been presented, for the sake of brevity we shall name it the SURFDYN concept (from surface dynamics).

* This concept is only a part of a theory. It has to be combined with reactions, mechanisms for two and multi-body fusions, quantum and electric field effects etc. in order to solve the other puzzle of the field: variety. **This is not the task for one man.**

* There have been elaborated many surface models of cold fusion in the past e.g. [24, 25]. These can be now revived and adapted.

* SURFDYN is fusion on the lattice and not in the lattice. Theorists wouldn't like it. How is the Coulomb barrier penetrated? Perhaps by dynamic quantum effects: cooperative motions of deuterons, protons, metal atoms of the topmost layer and alkaline metal atoms (ions). What about energy transfer? Or T/n production ratio? If the lattice isn't the locus for the nuclear reactions, is it a competitor for hydrogen/deuterium? High D/Pd values have been considered as essential, this concept remains valid but for an other reason -- to assure high surface mobility. In my opinion, multi-body fusion is more easily conceivable on the surface than in the lattice. (Will Dr. Bush return to the two-dimensional TRM?)

* What the nature, rise and dynamism of the active sites are, is an open question. A very rapid and massive information influx from the field of science and technology of catalysis could be useful to get the answer(s).

* It is possible that surface dynamics could be used to explain some special events like cells out of control (explosion at SRI) or electrochemical cells producing heat without current (Wolf, Mizuno).

* The process used by our Japanese colleagues for producing "cold fusion quality" electrodes, according to the technical folklore, can confirm or contradict the SURFDYN concept.

* More extended comparative studies of the surface dynamics of Pd, Ti, Ni, alloys vs. their behavior and efficiency will contribute to the metamorphosis of "compelling evidences" in "certitudes."

I hope that the SURFDYN concept will prove to be no more but no less than the (now missing) link between the theory and the practice of cold fusion.

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