

Excess Heat Might Not Be Entirely From Nuclear Reactions

#David J. Nagel¹, Roy A. Swanson²

¹The George Washington University and NUCAT Energy LLC, USA, nagel@gwu.edu

²University of Colorado, USA

During heavy-water electrochemical experiments in the 1980s, Fleischmann and Pons found that more thermal energy came out of their experiments with Pd cathodes than was put in electrically. The excess heat was greater than could be explained by any chemical reactions. Hence, they postulated that the excess energy was due to unexpected nuclear reactions. Now, it is well established experimentally that the amount of excess heat measured in many experiments greatly exceeds what can be attributed to chemistry [1]. For this reason, and also because of numerous reports of nuclear reaction products and energetic radiations, it is widely believed that excess heat is due primarily, and maybe exclusively, to nuclear reactions. Hence, the field is now often called Low Energy *Nuclear* Reactions.

Given the envisioned simultaneous generation of heat and products from nuclear reactions, it is reasonable to expect them to be related quantitatively. The best linking of heat with nuclear products is the correlation of the produced excess energy with quantities of Helium-4. That relationship was discovered by M. Miles, reviewed by T. Bressani in 2000, and well shown in the work of M. C. H. McKubre and his colleagues. The amount of heat and Helium are related quite roughly by 24 MeV per reaction, close to the gamma ray energy emitted during conventional fusion of two deuterons to form ⁴He. Despite all the work, the heat-He relationship remains contentious. Few other quantitative correlations between excess heat and nuclear products have been reported.

There is an alternative scenario for production of excess heat and the observation of low levels of nuclear reaction products. It is far from new, but has received relatively little attention. Several theorists have postulated the formation of “compact objects” with sizes and energies between those of atoms and nuclei. If such objects do form, they could account for much of the measured excess heat. Nuclear reactions might follow the formation of the compact objects because of their small sizes, similar to how nuclear reactions occur in muon-catalyzed fusion. The presence of a heavier muon in place of a lighter electron results in atoms with much smaller sizes than usual. This brings nuclei into closer-than-normal proximity and increases conventional fusion probabilities.

This paper is a review of the theories of compact objects and their implications. They include work (listed alphabetically) by J. Dufour, H. Heffner, F. Mayer and J. Reitz, A. Meulenberg and K. P. Sinha, and R. Mills. If formation of compact objects is indeed the initial step in the production of excess heat, the total amount of excess energy E_T depends on the number N_C of reactions that form compact objects, the energy E_C released per formation of a compact object, the fraction f_N of the compact object formation reactions that lead to subsequent nuclear reactions, and the energy E_N released per nuclear reaction:

$$E_T = N_C \{ E_C + \sum f_N E_N \}$$

The summation is over the number of subsequent distinct exothermic nuclear reactions. The values of f_N can range from zero (no secondary nuclear reactions) to unity (when a particular nuclear reaction follows each compact object formation event). The fraction of the excess heat due to nuclear reactions, namely $(\sum f_N E_N / E_T)$, can be as low as zero or as high as nearly unity. The energy gain (E_T / E_{INPUT}) will be determined by the values of the parameters, almost all of which are currently unknown. This additional complexity makes the correlation of overall excess heat with the amount of nuclear products difficult to quantify and, possibly, much more variable.

[1] E. Storms, “The Science of Low Energy Nuclear Reaction”, World Scientific, pp.53-61, 2007