Two-balance method of Faraday efficiency measurement with external recombiner and open cell calorimetry for identifying origin of excess heat in Ni-H2O electrolytic cells

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It is now three years since the first reports of observation of "excess heat" by Randell Mills and his collaborators[1] during the electrolysis of a light water solution of K_2CO_3 in an open cell using nickel as cathode and platinum as anode. Since then, at least seven other groups [2-8] claim they have confirmed the generation of "excess power" in such Ni-H_2O cells. Most of these groups also have employed open cell calorimetry similar to that of Mills et al.[1] Bush and Eagleton[3] are perhaps the only group to have carried out extensive closed cell experiments which appear to confirm "excess heat" generation in such systems.

Noteworthy features of the Ni-H_2O cells, as described by those who have experimented with them, are: (a) they have very short initiation times, i. e., the "excess power," if present, appears within the first day of electrolysis and (b) the success rate of observing "excess power" is high compared to Pd-D_2O systems. On the whole, the system appears to be much more robust and easily amenable to experimental investigation.

Despite these favorable features, however, it is rather surprising that more groups have not undertaken study of such cells. This is probably because the majority of active researchers continue to look upon excess power claims in light water cells with skepticism, dismissing them as a "chemical effect" of the nickel/carbonate system, most probably due to recombination of H_2 and O_2 within the cell. Indeed, some unpublished studies of Faraday efficiency measurements in open N-H_2O cells carried out simultaneously with calorimetry suggest that the apparent "excess power" at modest levels (<=30%) in their cells could be attributed to recombination effects, or to an incorrect estimate of the system thermoneutral voltage due to electrochemical processes other than the electrolysis of water.

On the other hand, the originators of this concept, namely Mills et al, have presented[9] details of their Faraday efficiency measurements in a heat-producing cell, which clearly rules out recombination effects as the source of excess power, at least in their cells.

The wide disparity of claims and counter-claims has naturally given rise to confusion in the minds of those scientists who are earnestly attempting to interpret these experimental findings. A factor in resolving the question of whether the "excess heat" in Ni-H_2O cells is genuine, or due to an experimental artifact, is the existence of two diverse theories put forward to explain "excess heat" in these systems.

As is well known, Mills et. al.[1] claim that "excess heat" is due to the formation of compact hydrogen atoms (or "dihydri-

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no molecules" as they describe it), while Robert Bush[1] has proposed that it is due to nuclear transmutation reactions involving a proton (from the hydrogen of H_2O) and alkalai metals. But the important point to be noted here is that according to Mills,[9] dihydrino molecules do not combine with oxygen to form water.

To shed more light on these questions, we propose a simple experiment which could possibly resolve most of the issues. The basic objective of the experiment is to measure simultaneously the mass of water lost from a cell due to electrolysis (Faraday efficiency), as well as mass of water reformed in a neighboring flask containing a large area Pt catalyst, into which the electrolytic gases are directed through flexible tubing. These two masses are to be measured while open-cell calorimetry is performed. The ouput of the recombiner flask is connected to ambient atmosphere via a water bubbler. The electrolysis cell and recombiner flask (along with attached bubbler) are placed separately on two independent electronic balances reading to an accuracy of 0.01g.

The interconnecting gas tubing between the electrolytic cell and recombiner flask is strung over a sturdy stand in such a way that it does not "load" the balances and result in erroneous balance readings. It is advisable to ensure that the tubing forms a smooth arc so that no condensed water can accumulate. After inserting the usual temperature sensors and electrode connection leads via the top plug of the electrolytic cell, all gas leakage paths are sealed. The water bubbler serves additionally as an on-line manometer monitoring system pressure, thereby confirming gas tightness.

There are four possible outcomes of such an experiment: (a) Mass of water lost from cell equals mass of water reformed in recombiner, and both correspond to the Faraday value. Simultaneously, if calorimetry confirms absence of "excess heat," then all is well and there is no anomaly to be explained. (b) However, in the above case when Faraday efficiency is 100%, if there is some "excess heat" observed, then one may postulate the presence of some new phenomenon, as suggested by Robert Bush. (c) Alternately, if mass of water lost equals mass of water reformed, but both fall short of the Faraday value, then clearly it must be due to recombination effects. If further calorimetry indicates some amount of "excess heat" generation, then it may be compared quantitatively with the heat due to recombination. (For the present, we rule out the possibility that in this case, wherein Faraday efficiency is less than 100%, there could be a situation wherein no "excess power" is observed with respect to [V-1.482]*I). (d) In the event, however, that the mass of water lost from the cell corresponds to the Faraday value but that of water reformed is lesser, then Mills' theory of formation of dihydrino molecules gains support.

This is what, in fact, Mills[9] claims for his cells. (Before concluding that there is indeed an imbalance between masses of water lost and gained, it has to be ensured that the Pt catalyst is functioning properly and that there is negligible gas leakage). [Note that both the electrolysis vessel and the recombiner flask, as well as all communicating tubing, contain potentially hazardous quantities of H_2 and O_2, and hence any experiment undertaken along the lines suggested above must be performed behind adequately assured shielding to ensure the experimentalist's safety.]

In conclusion, we suggest that this type of two-balance method of Faraday efficiency measurement with simultaneous open-cell calorimetry can help resolve the present impasse regarding the nature of the apparent excess power in Ni-H_2O cells. It would be particularly instructive to carry out the above experiment at both low and high current densities, and with the nickel electrode driven both cathodically and anodically with alkali hydroxide solutions in place of alkali carbonates. Such an experiment was set up at SRI International in March 1994 and the results, if conclusive, will be published in due course. We would like to encourage other interested experimenters to attempt such experiments carefully.

It may be noted that, strictly speaking, in order to establish that recombination is not the source of apparent "excess heat" a single balance for weighing the electrolytic cell would do. The second balance is required primarily to distinguish between the two postulated mechanisms of excess heat production, in the event that it is not due to recombination effects.

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