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A Model for the Impurity Promotion and Inhibition of the Excess Heat Effects of Cold Fusion

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Abstract

A theoretical[2] model describes impurity promotion and inhibition of the heavy water[1] and light water[3,4] excess heat effects of cold fusion based upon the influence on the magnetic properties of Pd and Ni, respectively, of alloying with different metals. For Ni (light water case), promoters, in increasing order of efficiency, are predicted to be Cu, Zn, Al, and Sn. Inhibitors, in increasing order of efficiency, are predicted to be Co, Fe, and Mn. Ag, Au, and Cu are indicated as promoters in the case of Pd (heavy water case). Empirical evidence impacting the model will be presented in another paper (ref. 5) in these Proceedings.

1. Introduction: Basis for the Promotion-Inhibitor Model for the Light Water Excess Heat Effect

Let us hypothesize that cold nuclear reactions have cross-sections highly sensitive to the relative spin orientation of the two reacting particles. In particular, if the product particle has a smaller spin than either of the reacting particles, an anti-parallel configuration of the spins of the approaching particles is hypothesized to be relatively favorable for the reaction as compared to a parallel spin configuration. Thus, an applied magnetic field and magnetization of the Ni cathode material, both of which tend to align the reactant particle spins, tends to diminish the light water excess heat effect. [An important exception to this would be in those cases where the excess heat effect is enhanced via magnetic resonance. Thus, if the excess heat effect is stimulated by employing microwave radiation in the magnetic resonance method to produce spin flips (e.g. Letts[6] and Piantelli & Focardi[7] with Piantelli's experiment as a variation of the Letts experiment), then the presence of a magnetic field with concomitant magnetization of the Ni is necessary.)]

We additionally hypothesize that promotion or inhibition of the magnetic susceptibility of the Ni can be achieved by adding impurities suggested by band theoretic considerations for magnetism.

2. Promotion of the Excess Heat Effect:

Band theory shows that the ferromagnetism of Ni in the solid state is associated with holes, i.e. vacancies, in the electronic d band, with the number of holes in the d band of Ni producing a saturation moment per atom of 0.6 Bohr magnetons per atom. (In this, and what follows, the treatment of the magnetic susceptibility of the transition metals such as Ni, Fe, Pt, and Pd, follows that presented by Mott and Jones[8,9,10] in their classic reference, *The Theory of the Properties of Metals and Alloys*.)

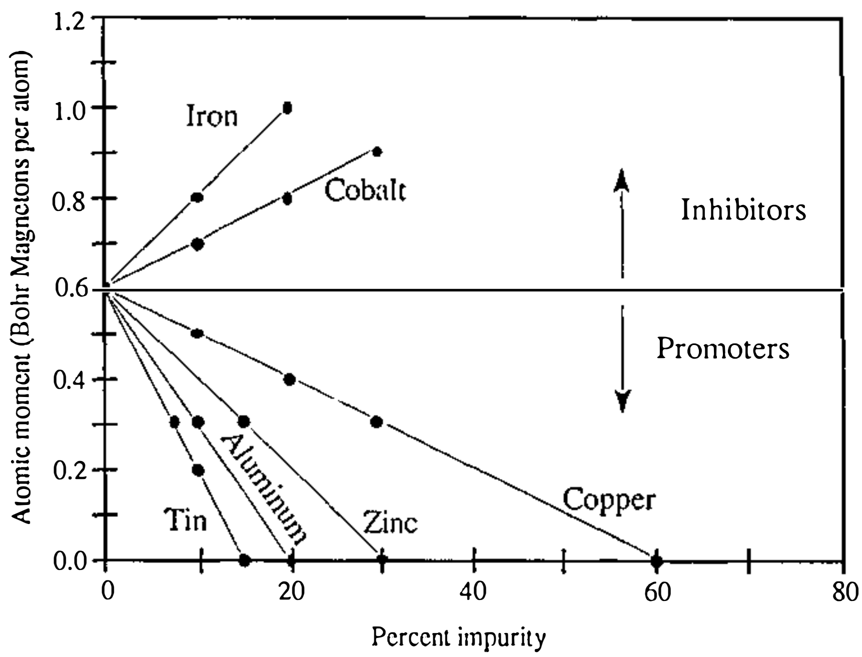
Thus, suppose that Cu is alloyed with Ni, where Cu has one more electron per atom than Ni; Mott and Jones[8] point out that Cu-Ni alloys possess "a face-centered cubic lattice with no superstructure for all compositions," so that "if a nickel atom is replaced by a copper atom in an alloy, we may suppose that the lattice is unaltered except that an extra electron is added." Since, band theoretic considerations show that the d band density of states is much greater than the s band density, this extra electron annihilates one of the holes. Thus, for the case of a 60% alloy, all the holes are filled and Ni's ferromagnetism should disappear. So, for an alloy fraction f of Cu with

Ni less than 0.60, the number of holes, N_h in the d shell for the solid is given by

$$N_h(f) = 0.6\text{-}f \tag{1}$$

The figure, which is based upon one in Mott and Jones[9], portrays this situation with the atomic moment in Bohr magnetons per atom shown as 0.6 for a 0% alloy falling to 0.0 for a 60% alloy. [The plot is equivalent to plotting $N_h(f)$ in (1) versus f.] (Of course, it is not clear that 60% would be the optimal percentage "impurity" to use because of the fact that Ni is known to be a better absorber of hydrogen than Cu.)

Atomic Moment vs. Percent Impurity



Cu has an excess of electrons per atom of +1 over Ni. For the general case of the number of electrons per atom outside that of an inert gas given by n_e, the formula in (1) is generalized to the following:

$$N_h(fn_e) = 0.6 - (n_e - 10)\, f, \tag{2}$$

where n_e = 10 is the number of electrons for Ni outside the closed Ar shell. Thus, for n_e greater than 10, we have the impurity promoters of excess heat as portrayed in the figure and in order of increasing effectiveness as Cu (n_e = 11), Zn (12), Al (13), and Sn (14). Of these, Sn, with the largest n_e value should be the most effective per percent of alloy with Ni. Thus, it would be interesting to try a 15% alloy of Sn with 85% Ni corresponding to f = 0.15 and the theoretical extinction percentage of 15% for the curve for Sn in the figure.

3. Inhibition of the Excess Heat Effect:

If the metal to be alloyed with Ni has fewer than 10 electrons (Ni case) outside an inert gas shell, the value of (10 - n_e) in (2) will be negative and the magnetic susceptibility enhanced. Examples are Co (n_e = 9), Fe(8), and Mn(7). Curves for Co and Fe are shown in the figure, and clearly these are predicted by the model to be impurity inhibitors of the light water excess heat effect in the case of Ni.

4. Application to the Case of Palladium as a Cathode Material:

According to Mott and Jones[10], the strongest paramagnetism of Pd is quenched for about a 55% alloy of Au in terms of numbers of atoms, which gives evidence that there are about 0.55 holes per atom in the 4d band of Pd producing the paramagnetism in comparison to the 0.6 holes in the 3d band of Ni. Au, Ag, and Cu, all of which have one more electron outside of a closed inert gas shell (the Xn shell for Au, The Kr shell for Ag, and the Ar shell for Cu) than does Pd, are, thus, predicted on the basis of the model to be approximately equally effective impurity promoters of cold fusion. (For this same reason, Au and Ag might function about as effectively as Cu as impurity promoters in the case of Ni, assuming that the lattice considerations introduce no major complexities in alloying with Ni.) In support of this, the curves of magnetic susceptibility versus % alloy for all three metals with Pd have been found to be very similar. (However, Ag would have an additional advantage since, as is well-known, Ag functions also to prevent "microcracking" of Pd under the influence of deuterium. The latter process is known to be able to significantly reduce the stoichiometry of the deuterium by leaking it to the surface.)

Additional evidence that there are about 0.55 holes per Pd atom in the 4d shell, and that these produce the strong paramagnetism of Pd, is the fact that the magnetic susceptibility of Pd drops to zero for a deuterium, or hydrogen, stoichiometry of about 0.55. Thus, since hydrogen is absorbed much more strongly by Pd than it is by Ni, it appears that while the impurity considerations of this model (hydrogen not taken as an impurity) may be significant for Pd, they are probably much more important for the light water case of Ni. (Absorbed hydrogen would, of course, also reduce the ferromagnetism of Ni since presumably the hydrogen becomes ionized when it enters the lattice with the one electron per hydrogen atom free to fill a hole in the 3d band associated with the Ni lattice.)

Conclusion

Recent experimental findings at Cal Poly (Pomona)provide strong preliminary support for the author's model. In this regard, please see the Proceedings contribution of reference 5.

Finally, this phenomenon of excess heat effect promotion and inhibition elucidated by band state theoretic considerations sheds an additional light on the entire area of cold fusion research.. It provides dramatic additional evidence for the excess heat effects first elucidated by Fleischmann and Pons[1] , by Mills[3], and by the author[4].

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