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Importance of 24 for Thermal Breeders.

The recent experiments on the properties of 23 indicate capture of neutrons in 23 leading to the formation 24. That is to say, $\alpha_{23} \neq 0$. It is therefore desirable to consider the effect of 24 on the problems of a 23 breeder. If the 24 and 25 which is produced are kept in the reacting unit indefinitely while the 23 is replenished from the production in thorium, the amount of 23 produced in the thorium per distruction of 23 in the reactor is (in equilibrium) not the usually quoted result:

(1a) η_{23} - 1 - losses to moderators and structural materials, but this result plus

(1b) $$\frac{\alpha_{23}}{1+\alpha_{23}}\left(\eta_{24}-1\right) + \frac{\alpha_{23}}{1+\alpha_{23}}\left(1-\frac{\sigma_{f_{24}}}{\sigma_{a_{24}}}\right)\left(\eta_{25}-1\right).$$

The relative number of 24 to 23 nuclei present is

$$N_{24}/N_{23} = \frac{\sigma_{a_{23}}}{\sigma_{a_{24}}} \quad \frac{\alpha_{23}}{1+\alpha_{23}}$$

and the 25 is present as

$$N_{25}/N_{23} = \frac{\sigma_{a_{23}}}{\sigma_{a_{25}}} \quad \frac{\alpha_{23}}{1+\alpha_{23}}\left(1-\frac{\sigma_{f_{24}}}{\sigma_{a_{24}}}\right).$$

The lower η_{23} proves to be, the more important for the breeder the terms in (1b) become. It is quite possible, on the basis of our present knowledge, that they may increase the rate at which the 23 supply may be accumulated by a factor of 1½ to 2 times that predicted from (1a) alone.

The great significance for 23 breeders of the terms (1b) makes it appear advisable to add to the program of measurements at the Argonne Laboratory a series of determinations of the properties of 24 - $\sigma_{f_{24}}$, $\sigma_{a_{24}}$, η_{24} and ν_{24}. For this purpose it is necessary to obtain samples containing 24 in moderately high concentration, the higher the better.

Another possibility is that 24 may be considered as a valuable isotope for fast reactions. In this case instead of accumulating pure 23 it would be possible to accumulate a mixture of 23, 24 and 25. The pure 23 produced in the thorium would be fed back into the

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breeder, and the gain taken out from the reactor region where 23, 24 and 25 would be extracted. In this system (at equilibrium) the total amount of 23, 24 and 25 per destruction of 23 is also $\eta_{23} - 1 - \text{losses} + \frac{\alpha_{23}}{1 + \alpha_{23}} f(23,24,25)$ where $f(23,24,25) \simeq 1$ and depends on the properties and 23, 24, 25. Whether $f(23 = \eta_{24} - 1 + (1 - \frac{\sigma_{f24}}{\sigma_{a24}})(\eta_{25} - 1)$, which is the corresponding function taken from (1b), is bigger or smaller than $f(23,24,25)$ depends on the details of the properties of all the elements. For example, however, if $\sigma_{a24} = \sigma_{f24}$ and $\eta_{24} = 1.5$, $f(23,24,25)$ is very close to 1 but $f(23) = .5$. That is to say, in this case the possible 23 + 24 production is significantly greater than the possible 23 production. The possibility of mixed 23 and 24 production makes it again important to find out about the properties of 24 not only in the thermal region but also for fast reaction.

The measurements of the properties of 24 which are suggested here are exceedingly difficult with the amounts and concentrations currently available. Probably only the fission cross-section can be known until there are larger quantities and higher concentrations. In measuring the absorption cross-section at the present time the experimental inaccuracies are of the same magnitude as the result to be expected. Other measurements seem to be even less promising. The main purpose of this note is to point out the importance of obtaining good samples of 24 for future work. η_{23} does not tell the whole story of the thermal breeder. Eventually the thermal breeder may stand or fall according to the properties of 24.

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