

Does The Lifetime of ^{40}K Depend Upon its Chemical State ?

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The influence of the chemical state on nuclear decay rates has been observed for a number of isotopes that decay either by electron capture or by internal conversion [1,2]. This is believed to be due to the fact that the density of electrons at the nucleus, upon which such decay rates depend, varies as the chemical state of the radioactive species is altered. The electron-capture decay branch of ^{40}K is the basis of the potassium-argon dating scheme. This decay leads to the 1461-keV first excited state of ^{40}Ar and has a Q_{EC} value of only 44 keV. Because of its low decay energy and its first-forbidden-unique character, it is possible that the lifetime of ^{40}K could depend on its chemical form. In fact, there have been some reports in the literature in which ages of materials derived from K/Ar dating disagree with those obtained from U/Pb techniques [3]. Such discrepancies in apparent ages could be due to effects of the chemical environments in which the potassium is found.

To search for influences of the chemical state on the ^{40}K decay rate, we compared the specific gamma activities of ^{40}K in KCl, K_2SO_4 , KNbO_3 , and KTaO_3 . This was done by combining known masses of each of these compounds with known amounts of La_2O_3 and gamma counting these mixtures. By comparing the measured yields of the 1461-keV line from the decay of ^{40}K to that of the 1436-keV line from the decay of ^{138}La , we were able to determine the specific activity of each potassium compound. We also compared the specific activity of KCl in powder form to that of KCl dissolved in H_2O . Finally, we measured the specific activity of K_2CO_3 , converted it to KCl, and then measured the specific activity again.

The results obtained in all of these studies were consistent with the EC decay rate of ^{40}K being independent of the chemical state. We were able to set a limit on the fractional change in the ^{40}K decay rate to be $\leq 1\%$. Thus, the

reason for the discrepancies in apparent K/Ar and U/Pb ages of materials from the Oklo natural reactor [3] must be something other than a chemical dependence of the decay rate of ^{40}K .

Footnotes and References

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