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Ruthenium isotopes in single presolar SiC grains

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We report here Ru isotopic compositions of single presolar SiC grains from the Murchison meteorite. Ruthenium has seven isotopes: two *p*-process, ⁹⁶Ru and ⁹⁸Ru; one *r*-process, ¹⁰⁴Ru; one *s*-only, ¹⁰⁰Ru; and three *r*- and *s*-process, ⁹⁹Ru, ¹⁰¹Ru and ¹⁰²Ru; ⁹⁹Ru is also the daughter of *s*-process ⁹⁹Tc ($T_{1/2}=211,100\text{y}$).

The most common type of SiC grains, the mainstream ones, are believed have formed around AGB stars. On plots of $\square^{\text{X}}\text{Ru}$ vs. $\square^{104}\text{Ru}$, normalized to ¹⁰⁰Ru, grains from AGB stars are expected to lie along straight lines between the initial (assumed to be the same as the solar system) and He shell compositions, which are mixed in the envelopes of these stars [1]. Sixteen SiC grains data lie along such lines for ⁹⁹Ru, ¹⁰¹Ru and ¹⁰²Ru. The He-shell composition of the parent star for each grain, or G-component, can be calculated by extrapolation to $\square^{96}\text{Ru} = -1000\text{‰}$. The weighted average G-components for mainstream grains are $\square^{99}\text{Ru} = -754\text{‰}$; $\square^{101}\text{Ru} = -823\text{‰}$; and $\square^{102}\text{Ru} = -494\text{‰}$. Calculated G-components for a 1.5 solar mass, solar metallicity AGB star are $\square^{99}\text{Ru} = -856\text{‰}$; $\square^{99}\text{Ru} + ^{99}\text{Tc} = -735\text{‰}$; $\square^{101}\text{Ru} = -841\text{‰}$; and $\square^{102}\text{Ru} = -560\text{‰}$. Grains and predictions for ¹⁰¹Ru and ¹⁰²Ru agree within the uncertainties of the neutron capture cross sections used [2]. Unfortunately, the cross section for ⁹⁹Ru has not been measured; the value [2] we use was obtained by comparing the most recent theoretical estimates [3] with experimental data for nearby isotopes. Use of [3] directly would lead to lower predicted $\square^{99}\text{Ru}$ values. The cross section for ⁹⁹Tc has been measured with an uncertainty of 6%. The SiC grain measurements are suggestive of in situ ⁹⁹Tc decay in grains. Measurements of the Ru cross sections are needed.

One SiC X-grain, likely from a Type II supernova, was analyzed and found to be enriched in all isotopes relative to ¹⁰⁰Ru by 1000–5000 ‰. This requires mixing of a number of different shells of supernova ejecta, including those near the mass cut that are enriched in *p*-process isotopes [4].

References

[1] Lugaro M. et al. (2003) *Ap. J.*, in press. [2] Bao Z. Y. et al. (2000) *Atom. Data Nucl. Data Tab.* **76**, 70. [3] Rauscher T. & Thielemann F.-K. (2000) *Atom. Data Nucl. Data Tab.* **75**, 1. [4] Rauscher T. et al. (2002) *Ap. J.* **576**, 323.