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The Use of Oxide Targets in 2-keV Average Neutron Capture Measurements

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Abstract. Large samples ($\approx$10-100 grams) are usually required for "2-keV" filtered-beam measurements and such samples invariably come in the oxide form. Monte Carlo calculations show that the resulting neutron spectrum is degraded by $\approx$0.2 keV in a $^{145}Nd_2O_3$ sample. Otherwise, oxide samples are acceptable for such measurements.

Monte Carlo calculations of neutron energy spectrum in a neodymium oxide sample have been performed. The continuous energy Monte Carlo code PXMORSE (Waddell 1980) was used in the calculations. A monodirectional neutron beam uniformly impinging on one side of the sample is shown in Fig. 1. The neutron beam has a rather narrow energy spectrum (Greenwood and Chrien 1976) which ranges from 0.5 to 3 keV and peaks at $\approx$2.0 keV. Neodymium in the sample is assumed to be 100% ^{145}Nd. Neutron cross-section data used in the calculations were obtained from ENDF-IV library. The sample weighs 643 grams and therefore constitutes an "extreme case."

In the Monte Carlo calculations, source energy biasing was applied to sample the source energy spectrum. This biasing increased the number of source neutrons on both sides of the energy spectrum and thereby improved the statistics by reducing the uncertainties of results in these energy ranges. The neutron spectrum in the sample was estimated using both the track-length estimator and the collision estimator. The track-length estimator scored on neutron trajectories (tracks) in the sample while the collision estimator scored on neutron collisions in the sample. Excellent agreement between results of the two estimators was achieved. A boundary-crossing estimator, which scored on neutrons crossing a surface outside the sample, was used to obtain the source spectrum.

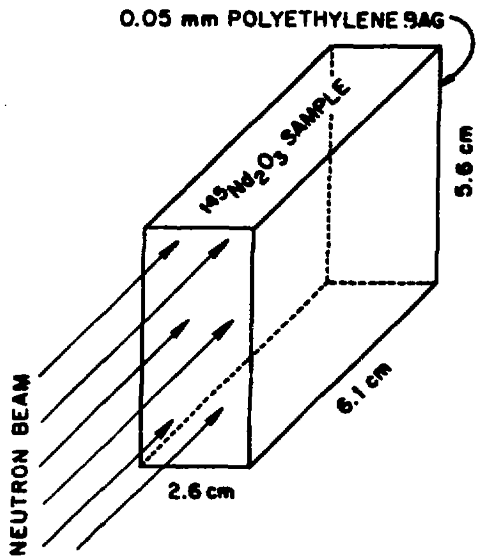

Fig. 1. Problem geometry

Figure 2 shows the normalized neutron spectrum of the source and the spectra in the oxide sample with and without a 0.005 mm thick polyethylene enclosure. As expected, the neutron spectrum is softened in the sample. The polyethylene bag has negligible effect on the spectrum except below 0.7 keV. All neutron interactions are elastic scatterings because the energies are below inelastic thresholds of the scattering isotopes. More than 90% of the scat tering was by Nd and the rest mainly by O (neutron interaction with polyethylene was <1%).

From elastic slowing-down theory (Lamarsh 1966) the minimum neutron energy (in the laboratory system) after an elastic collision is $E(min) = \alpha E_0$, where the elastic slowing-down parameter $\alpha = (A-1)^2/(A+1)^2$ with A being the mass number and E_0 the initial neutron energy in the lab system. Let us define the elastic slowing-down power of an isotope in a mixture as the product of the maximum fraction of energy loss and the fraction of the total elastic scattering. That is, for the i^{th} isotope in a mixture, $P_i = (1-\alpha_i)f_i$. The α values for ^{16}O and ^{145}Nd are 0.779 and 0.973, respectively. At an elastic scattering ratio of nine-to-one between Nd and O in the sample, the elastic slowing-down powers are 0.243 for Nd and 0.221 for O. Therefore, these two elements contribute about equally to the neutron slowing down effect.

The centroids of the neutron source spectrum and the oxide spectrum are at 1.90 and 1.73 keV, respectively. The oxide spectrum is also ≈10% wider. It may be concluded that the averaging process in "2-keV" filtered neutron beam experiments is not adversely affected by the use of oxide targets.

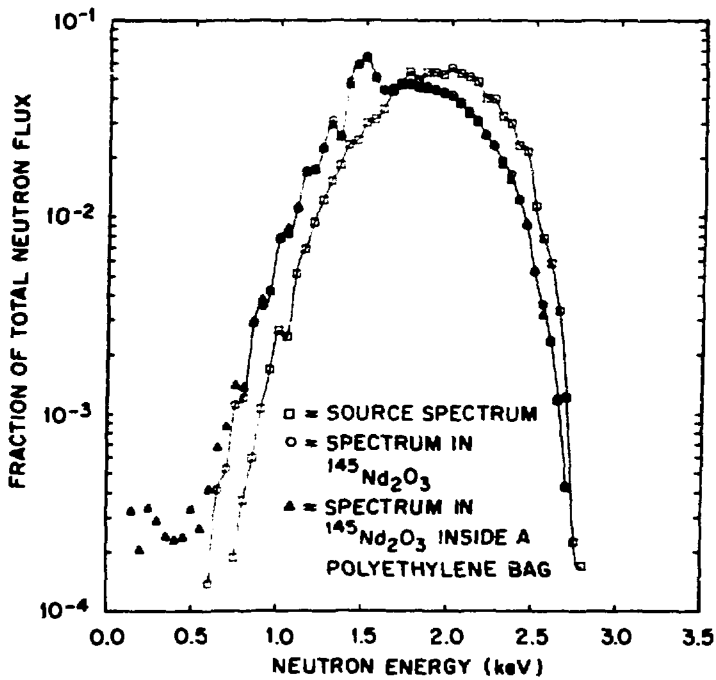

Fig. 2. Results of Monte Carlo Calculations

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