TRACE IDENTIFICATION OF CESIUM AND SODIUM IN NEUTRAL BEAM RESEARCH*

Lawrence Ruby

Lawrence Berkeley Laboratory
and
Department of Nuclear Engineering
University of California
Berkeley, California 94720

Cesium and sodium in vapor form are used in two of the approaches[1,2] to negative-ion production for neutral-beam research. Since fusion reactors are sensitive to the presence of high-Z impurities, it is important to monitor the extent to which the cesium and sodium migrate in the beam direction, or travel as part of the beam itself. Two techniques have been developed for the trace identification of either cesium or sodium on targets placed in vacuum. One of these involves neutron activation, and the other alpha-backscattering, to provide quantitative identification. Three types of targets have been employed, polyethylene which is suitable for the activation technique, beryllium which is useful for the alpha-backscatter analysis, and glassy carbon which is usable with either technique, and therefore, for cross comparison.

The neutron-activation technique makes use of the reactions $n + {}^{133}Cs \rightarrow {}^{134m}Cs$ (2.90h), and $n + {}^{23}Na \rightarrow {}^{24}Na$ (15.1h). The 0.128-MeV gamma ray from ${}^{134m}Cs$ and the 1.369-MeV gamma ray from ${}^{24}Na$ are subsequently counted with the aid of a Ge(Li) detector. To make the measurements quantitative, several cesium or sodium standards are irradiated and counted along with the targets which have been exposed in vacuo. The standards are made by pipetting 0.10 ml of solution containing a known amount (several μg) of either cesium or sodium in the form of a soluable salt, onto a polyethylene target and then evaporating to dryness. Before irradiation, each target is inserted into an individual polyethylene

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envelope, in which it remains during the counting process. Thus, any cesium or sodium which sticks to the inside surface of the envelope as a result of the targets becoming warm during irradiation, is not eliminated from the subsequent counting. No interfering activities are present for either the cesium or sodium counting, and no significant long-lived activities are found in the polyethylene targets. The sensitivity of the method is determined by the residual sodium peak which is found in spite of acetone and alcohol precleaning of the control targets, and, in the case of cesium, by the general background in the area of the cesium gamma-ray peak. Irradiations are performed in the "lazy-susan" sample holder of the Berkeley Research Reactor. An irradiation time of 60 minutes is used in a thermal flux of 5×10^{12} $cm^{-2}s^{-1}$, followed by a 2-hour cooling period to allow for the decay of short-lived activities.

In the alpha-backscattering analysis, Be targets are exposed to 1.8-MeV alpha particles produced by a Van de Graaff accelerator. The backscattered alphas are observed at 170° to the incident beam direction by a surface-barrier particle detector. A typical average beam current on the target is 20 nA. When the detector signals are processed by a multi-channel pulse-height analyser, cesium, sodium, and other surface impurities may be seen as Gaussian peaks. Quantitative information is obtained by also analysing a similar Be target onto whose surface a known thickness of gold has been evaporated. Calibration of the mass and intensity scales are performed in the usual way.[3]

Glassy carbon[4] has also been used as a target in both methods of analysis. This ceramic-like material can be obtained in thin sheets, and is enough of an electrical conductor to serve as a satisfactory target for alpha-backscattering analysis, where the integrated charge onto the target is determined in a Faraday-cup geometry. The as-received sheets, however, have a rough surface finish, and must be ground and polished to a mirror finish on one

side, before they produce the peak quality obtainable from a metallic target.

For a roughly equal investment in counting time, the activation method turns out to have considerably more sensitivity. For a signal equal to background (or to residual), a 10-minute count produces a sensitivity of 0.016 $\mu g/cm^2$ for cesium, and 0.0071 $\mu g/cm^2$ for sodium. For alpha-backscattering, the sensitivities are considerably lower. Both methods are capable of identifying other impurities, and in the alpha-backscatter case, oxygen and carbon are identifiable, whereas neither of the latter produces a long half-life which would make it suitable for identification by activation in a thermal flux. However, the presence of both of these elements tends to reflect conditions other than that associated with the original exposure, such as contributions from the Van de Graaff vacuum system. Obviously, in addition, the alpha-backscatter counting is "on line" with the accelerator, and so ties up the latter for the course of the experiment, whereas the activation counting is "off line" and the irradiation can often be carried out coincidently with other kinds of experiments.

REFERENCES

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3. W-K. Chu, J. W. Meyer, and M-A. Nicolet, Backscattering Spectrometry, Academic Press, 1978.

4. Obtained from Gallard-Schlesinger Chemical Mfg. Corp., 584 Mineola Ave., Carle Place, NY 11514, as "Vitreous Carbon".