Beta decay of ^{96}Ag isomers and delayed proton emission to ^{95}Rh levels

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The decay of ^{96}Ag was first investigated by Kurcewicz et al. [1], who measured a half-life of 5.1(4) s and observed the emission of β-delayed γ rays (βγ) and β-delayed protons (βp). Later on, Schmidt et al. [2] inferred a half-life of 5.22(15) s from βp data, and found it to be different from the weighted mean (4.50(6) s) of the half-lives of the βγ transitions, indicating the existence of two decaying states in ^{96}Ag. This result is in agreement with shell-model calculations, which predict two closely spaced 2^+ and 8^+ states to occur at low ^{96}Ag excitation-energy. However, the previous works [1,2] did not draw definite conclusions concerning the two ^{96}Ag states. The aim of the present study was to clarify the decay characteristics of these isomers by reinvestigating their βγ and βp properties. We used a total absorption γ-ray spectrometer (TAS) [3]. TAS was expected to be more suitable for this purpose as it is capable of detecting the whole γ cascade following the β decay rather than individual γ transitions. Concerning the βp decay, a coincidence condition between a proton detector and TAS was used. This condition was expected to select the cascades of γ rays de-exciting the ^{95}Rh levels populated by proton emission.

The neutron-deficient isotope ^{96}Ag was produced by fusion-evaporation reactions of a ^{40}Ca beam from the heavy-ion accelerator UNILAC with a ^{60}Ni target. The reaction products were separated at the GSI on-line mass separator by using a chemically selective FEBIAD ion source. The mass-separated A=96 beam was implanted into a transport tape, with the resulting radioactive sources being periodically moved from the collection position to the centre of the TAS, where it was viewed by two 0.5 mm thick silicon detectors. One of them, placed at the side of the tape where the ions had been implanted, was used to detect positrons and protons. The other detector placed at the opposite side of the tape served to record positrons and thus distinguish the protons emitted after β^+ decay from those related to EC decay.

The ^{96}Pd levels populated via ^{96}Ag β-decay are shown in Fig. 1. The analysis of TAS spectra yields evidence for β feeding of both the 2^+ and 8^+ levels in ^{96}Pd. This result indicates β-decaying isomers in ^{96}Ag with low and high spin, respectively. The ^{95}Rh levels populated via βp emission are also displayed in Fig. 1. The strongly populated ^{95}Rh level at 1350 keV can be unambiguously related to the $13/2^+$ level established by in-beam spectroscopy [4]. Besides the agreement in energy, this assignment is supported by the observation that the decay curve for this level is similar to that for the 8^+ ^{96}Pd level. Several new ^{95}Rh levels have been found in addition to those established earlier by in–beam spectroscopy and β decay of ^{95}Pd. One of them, the strongly populated 680 keV level shows the same decay characteristics as that observed for the β feeding to the 2^+ ^{96}Pd level. The evident shell-model counterpart to this level is that with a spin-parity assignment of $7/2^+$ and calculated energy of 650 keV [5], which corresponds to the first excited state built on the proton $g_{9/2}$ single-particle ground state. Tentative spin assignments of $5/2^+$ and $11/2^+$ can be deduced for the other new ^{95}Rh levels on the basis of the comparison with shell-model predictions [5], and by taking into account that they are not populated by the yrast cascade identified by in-beam spectroscopy.

The half-life of the high-spin isomer was determined by evaluating the time characteristics of the β^+ feeding to the ^{96}Pd 8^+ level. The half-life of the low-spin isomer was deduced by using the decay curves of the TAS peak corresponding to the 2^+ ^{96}Pd level and the 680 keV ($7/2^+$) ^{95}Rh state. The βp branching ratios, indicated in Fig.1 for both isomers of ^{96}Ag, were determined on the basis of a decomposition of the decay curves for βp events and positron-coincident γ rays detected by TAS. The additional uncertainties, which are due to the non-observation of EC-delayed γ rays, were estimated not to exceed 10% of the presented values. Making use of the new half-lives and branching ratios, one can estimate that the summed βp Gamow-Teller strengths for the two isomers are remarkably different. This result probably points to the effect of proton-γ competition for highly excited ^{96}Pd levels.

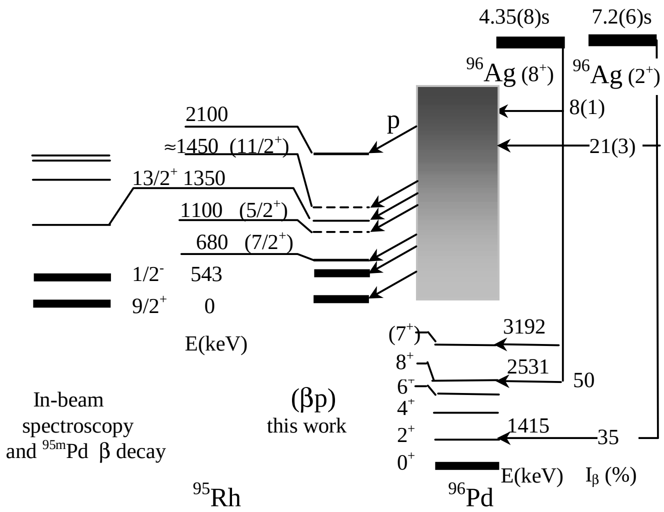

Fig. 1. Excited states in ^{96}Pd and ^{95}Rh populated by the ^{96}Ag β decay and β-delayed proton emission. For unbound ^{96}Pd levels, only βp-intensities are presented.

[1] W. Kurcewicz et al., Z. Phys. A 308 (1982) 21.
[2] K. Schmidt et al., Nucl. Phys. A 624 (1997) 185.
[3] M. Karny et al., Nucl. Instr. and Meth. Phys. Res., B 126 (1997) 320.
[4] H.A. Roth, Phys. Rev., C50 (1994) 1330.
[5] I.P. Johnstone and L.D. Skouras. Phys. Rev, C55 (1997) 1227.