2 - 6 Mass Prediction of Neutron-deficient $N=Z$ Nuclides ^{78}Y, ^{80}Zr, ^{82}Nb and ^{84}Mo

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We have reported the mass measurements of neutron-deficient nuclides ^{79}Y, ^{81,82}Zr, ^{83,84}Nb in this year's Annual Report. However, for the $N=Z$ nuclides close to A=80, the yield is much lower and even if they can be produced, there is still great difficult to identify them because of their quite similar mass-to-charge ratio and revolution times. However, their mass are extremely important for rapid proton capture process, for example, ^{80}Zr and ^{84}Mo are waiting points of rp-process. Their masses can greatly effect the reaction flow of proton capture on them and then the abundance of the heavier nuclides. In addition, the α separation energy of ^{84}Mo (determined by the mass of ^{80}Zr and ^{84}Mo) has a strong impact on the ^{83}Nb(p, α) reaction rate and plays a key role in the formation of Zr-Nb

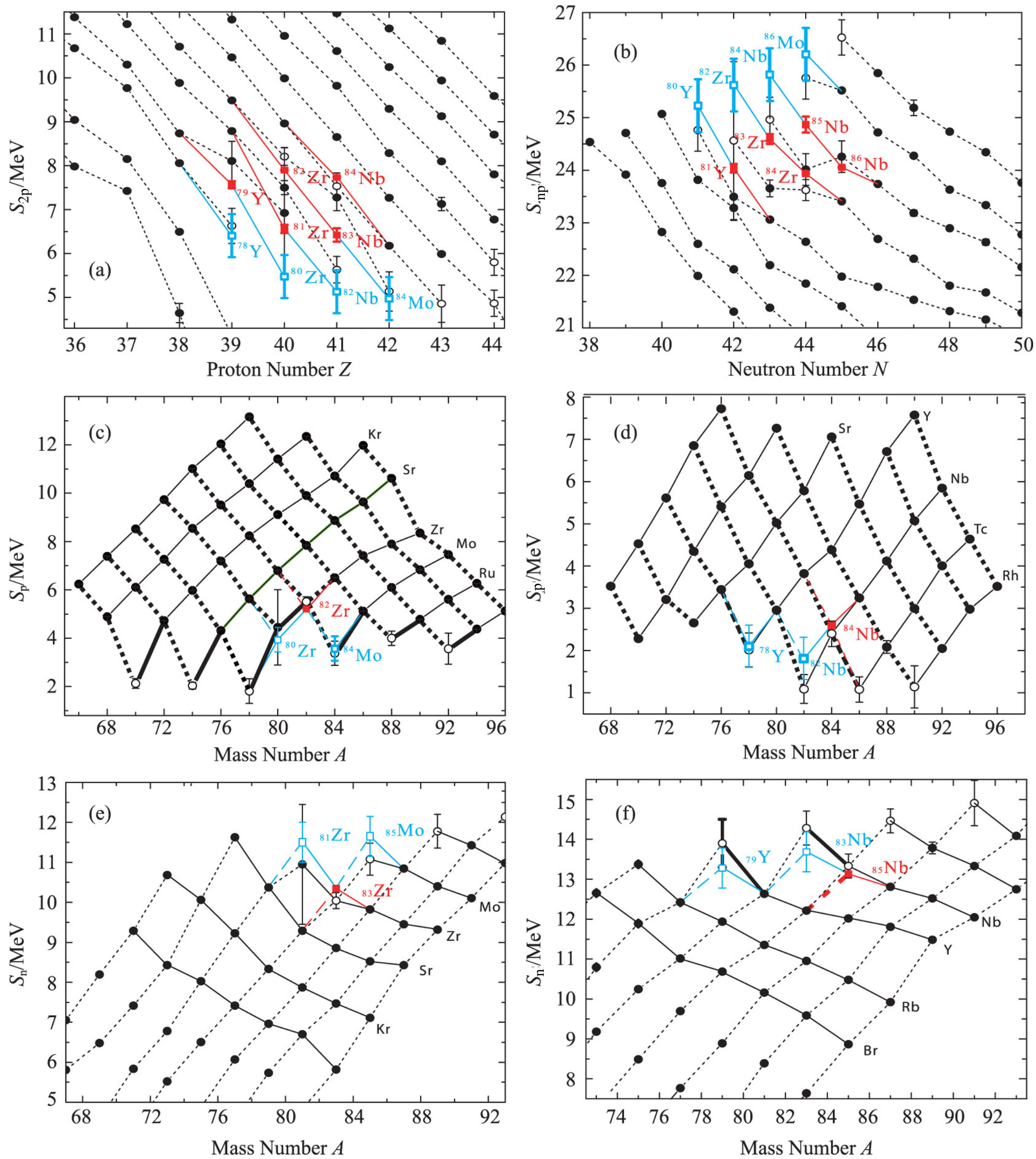

Fig. 1 (color online) Different separation energies. The blue and red squares denote that the data set comes from our measurement and the extrapolation based on the smooth tendency prediction. The black points come from AME12 and the opened ones are based on at least one extrapolations.

cycle in rp-process[1]. The previous masses of these $N = Z$ nuclides are either from the mass extrapolation based on the unreliable neighboring mass values[2] or have large uncertainties[3]. So a new mass extrapolations of these nuclides based on the new measured mass values are needed. This will be more reliable and meaningful for the further rp-process network calculations.

To extrapolated the masses of ^{78}Y, ^{80}Zr, ^{82}Nb and ^{84}Mo, the systematic trends of different separation energies were used. Based on the much more smooth tendency in on the new measured mass values of ^{79}Y, ^{81,82}Zr, ^{83,84}Nb, a much more reliable extrapolation of the separation energies and then the unknown mass of related nuclides have been obtained.

In order to reduce the artificial deviation from a single extrapolation, a total of four kinds of independent extrapolations based on different separation energies ($S_{\rm p}$, $S_{\rm 2p}$,$S_{\rm n}$, $S_{\rm 2n}$) have been done independently just as shown in Fig. 1. In Fig. 1, a much more smooth trend can be found by adopting our measured mass values. Using the separation extrapolations which are shown in blue squares, four independent sets of more reasonable extrapolated mass values of ^{78}Y, ^{80}Zr, ^{82}Nb and ^{84}Mo have been obtained. The final extrapolated mass values of these nuclides come from the weighted average.

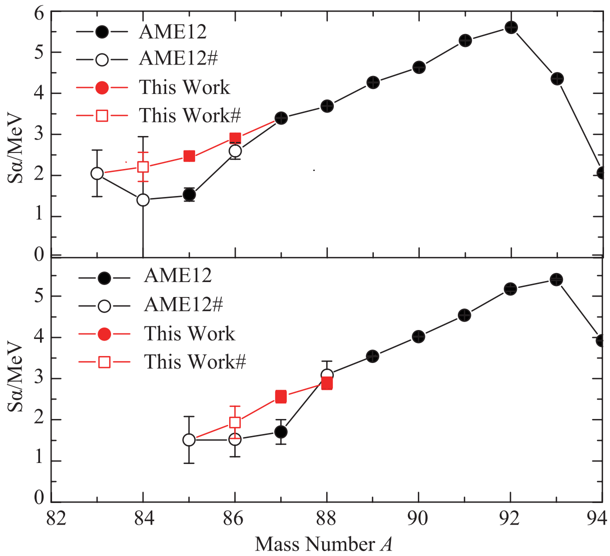

Fig. 2 (color online) α separation energies (S_α) of molybdenum and technetium isotopes according to AME12 (circle) and this work (square, including the latest measured mass values shown as the filled ones). Measured values are indicated by filled symbols, extrapolated values (at least one of the two masses is extrapolated) are indicated by open symbols(#).

Table 1 shows the extrapolated mass excesses of ^{78}Y, ^{80}Zr, ^{82}Nb and ^{84}Mo and their comparison with AME12[4] and AME16[5]. Noting that the AME16 values are extrapolated by the smooth tendency of mass surface which is updated due to the new measured mass values of ^{79}Y, ^{81,82}Zr and ^{83,84}Nb, the AME16 is consistent with our extrapolations, confirming the validity of our extrapolations. However, our extrapolation may be more reliable because the average of multiple independent extrapolations can reduce the deviation induced by single extrapolation.

Using the new extrapolated (as well as the new measured mass values), we calculate the α separation energy (S_α) of Mo and Tc isotopes which are shown in Fig. 2 . Prior to this work, an extreme low S_α around ^{84}Mo was predicted by the finite range droplet mass model (FRDM)[6] and the experimental evidence of the existence was pronounced from the penning trap mass measurement of ^{85}Mo and the neighboring nuclide of ^{87}Tc[1]. However, due to the latest measurement of ^{81}Zr and ^{83}Nb, the very low S_α for neutron-deficient Mo and Tc isotopes is denied. Our extrapolated mass values of ^{80}Zr, ^{84}Mo and ^{82}Nb give a further confirmation. This will have a obvious impact on the formation of Zr-Nb cycle in rp-process.

Table 1 Averaged extrapolated mass excess from this work ($ME_{\rm Ext}$), AME12 and AME16. The differences between this work and AME12/AME16 are given in their following column.

	$ME_{\rm Ext}$/keV	$ME_{\rm AME12}$/keV	ΔME/keV	$ME_{\rm AME16}$/keV	ΔME/keV
^{78}Y	−52 397(300)	−52 530(400)	133(500)	−52 170(300)	−227(424)
^{80}Zr	−54 176(250)	−55 520(1490)	1 344(1511)	−54 360(300)	−184(391)
^{82}Nb	−51 790(250)	−52 200(300)	410(391)	−52 090(300)	300(391)
^{84}Mo	−53 958(250)	−54 500(400)	542(472)	−54 170(300)	212(391)

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