PRODUCT SHEET

TK221 Resin

Main Applications:

- Separation and concentration of lanthanides (e.g. ca and nca Lu-177)
- Separation of actinides
- Separation of actinium

Packing

Order N°.	Form	Particle size
TK221-B25-B, TK221-B50-B, TK221-B100-B, TK221-B200-B	25g, 50g, 100g and 200g bottles TK221 Resin	100-200 µm
TK221-C20-B	20 and 50 2 mL TK221 Resin columns	100-200 µm
TK221-R10-B	10 2mL TK221 Resin cartridges Cartridges with larger or smaller volumes are available upon request	100-200 µm
TK221-B25-T, TK221-B50-T, TK221-B100-T, TK221-B200-T	25g, 50g, 100g and 200g bottles TK221 Resin	50-100 µm
TK221-R10-T	10 2mL TK221 Resin cartridges Cartridges with larger or smaller volumes are available upon request	50-100 µm

Physical and chemical properties

Density: 0.35 g/mL TK221 Resin

Conditions of utilization

Recommended T of utilization: room temperature
Flow rate: B grade: ≥0.5 mL/min
Storage: Dry and dark

TRISKEM INTERNATIONAL
ZAC de l'Eperon – 3, rue des Champs Géons – 35170 Bruz – FRANCE
Tel +33 (0)2.99.05.00.09 – Fax +33 (0)2.23.45.93.19 – www.triskem.com – email : contact@triskem.fr
SAS au capital de 100.000 euros – SIRET 493 848 972 00029 – APE 2059Z – TVA intra communautaire FR65 493 848 972

TK221 RESIN

The TK221 Resin is based on a mixture of a diglocylamide and a phosphine oxide. It further contains a small amount of a long-chained alcohol and the organic phase is impregnated onto an inert support containing aromatic groups for increased stability against radiolysis.

Graphs 1 – 11 show the selectivity of the TK221 Resin for a wide range of elements in HNO_3 (fig. 1 – 5) and HCl (fig. 6 – 11). All Dw shown in these graphs were obtained through ICP-MS measurements.

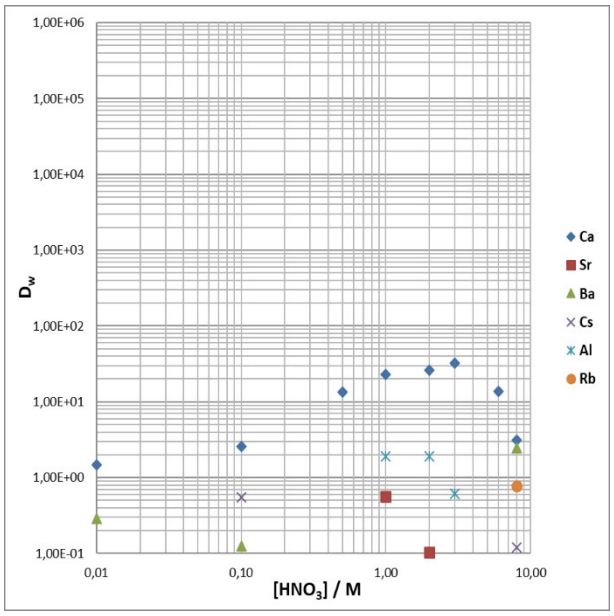

Figure 1: Dw values of selected elements on TK221 in HNO_3

Out of the tested elements only Ca is weakly retained on the TK221 Resin in HNO_3. Other alkaline, earth-alkaline elements and Al are not retained.

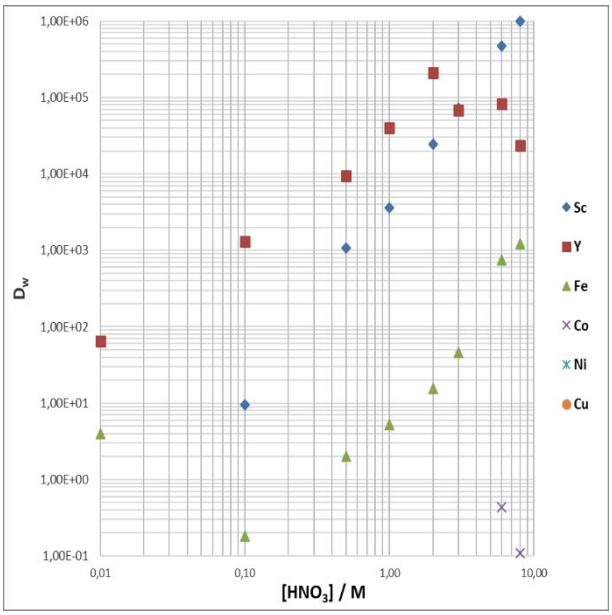

Figure 2: Dw values of selected elements on TK221 in HNO_3

Y and Sc are very strongly retained from HNO_3 of elevated concentration. Fe(III) is also well retained at HNO_3 concentration ≥ 3M HNO_3.
A wide range of transition metals such as Zn, Ga, Co, Ni and Cu are not retained from nitric acid.

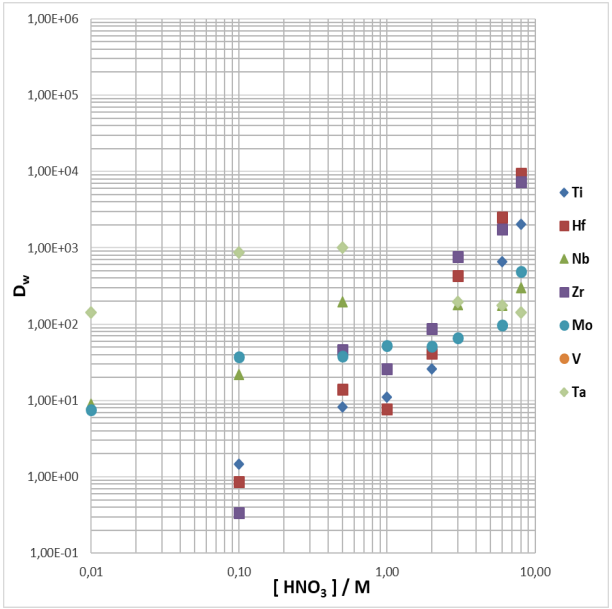

Figure 3: Dw values of selected elements on TK221 in HNO_3

The TK221 Resin generally retains tetravalent elements such as Zr and Hf at elevated HNO_3 concentrations.

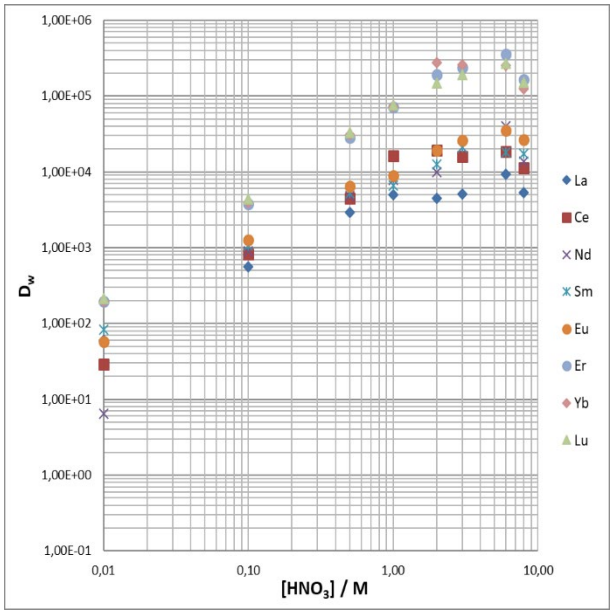

Figure 4: Dw values of selected elements on TK221 in HNO_3

The TK221 Resin shows very high retention of lanthanides at HNO_3 concentrations ≥ 0.1M HNO_3, heavy lanthanides are even well retained in more dilute HNO_3 (≥ 0.01M). The retention of the lanthanides is significantly stronger than on TRU Resin.

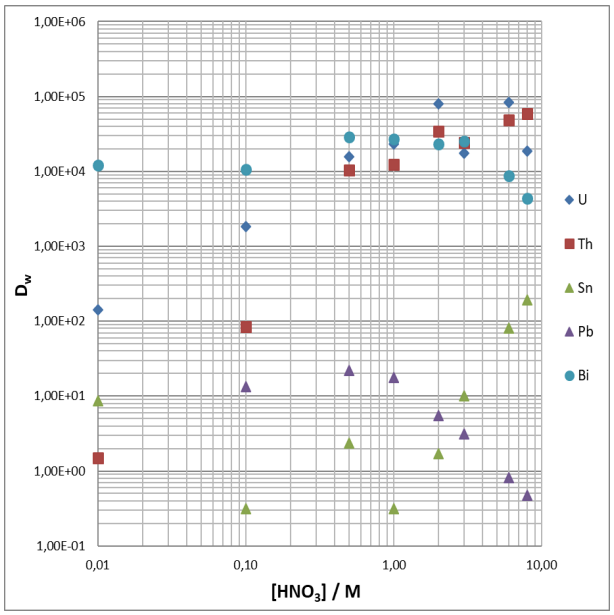

Figure 5: Dw values of selected elements on TK221 in HNO_3

U and especially Bi are well retained over the whole HNO_3 concentration range, while Th is well retained at HNO_3 > 0.1M. U retention is significantly higher than on other diglycolamide based resins such as DGA Resin. Pb and Sn are only weakly retained.

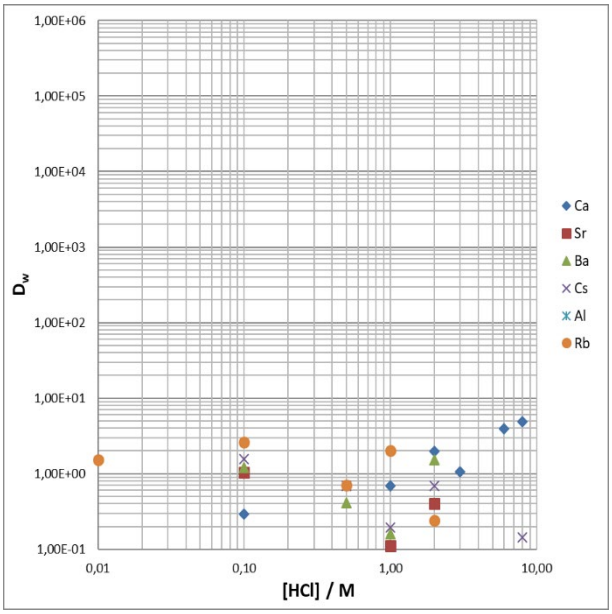

Figure 6: Dw values of selected elements on TK221 in HCl

In HCl medium, none of the tested alkaline and earth-alkaline elements were retained on the TK221 Resin the same is true for Al.

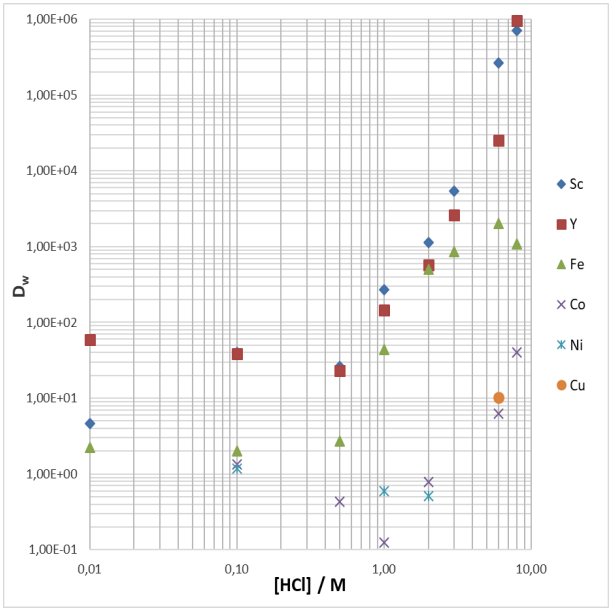

Figure 7: Dw values of selected elements on TK221 in HCl

Y and Sc are very strongly retained from HCl at elevated concentration (≥ 2M HCl). Fe(III) is also well retained at HCl concentration ≥ 3M.

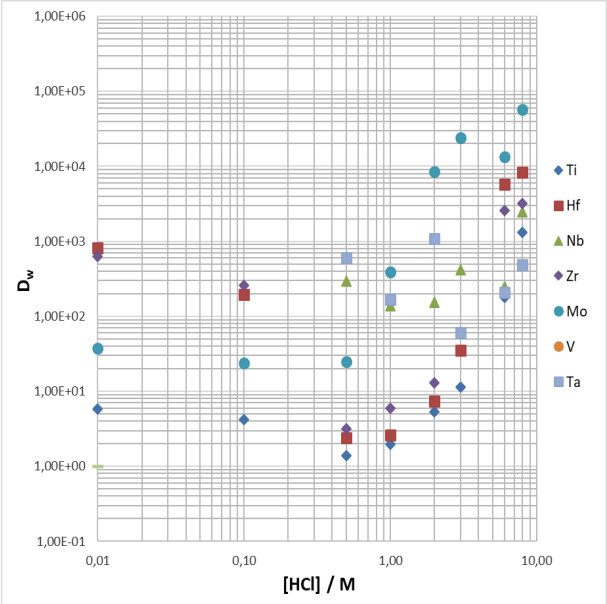

Figure 8: Dw values of selected elements on TK221 in HCl

Elements with a valency of +IV and higher such as Nb, Zr, Hf and Mo are very well retained at elevated HCl concentrations.

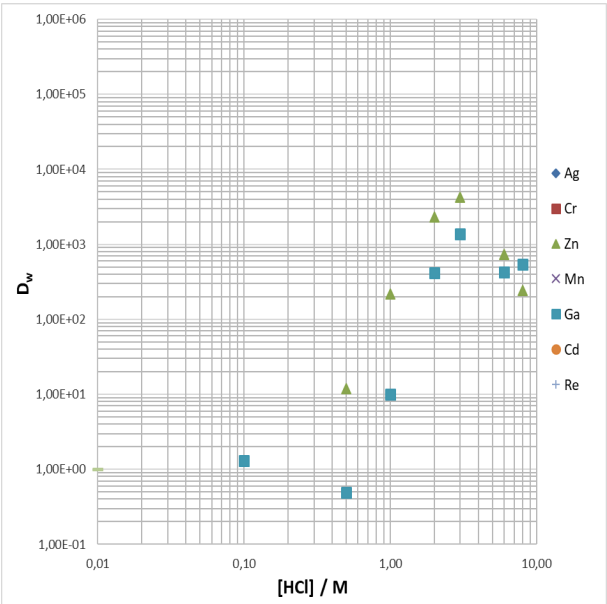

Figure 9: Dw values of selected elements on TK221 in HCl

Other than many other transition metals, Zn and Ga are very well retained from ≥ 2M HCl. Both may be easily eluted in dilute HCl.

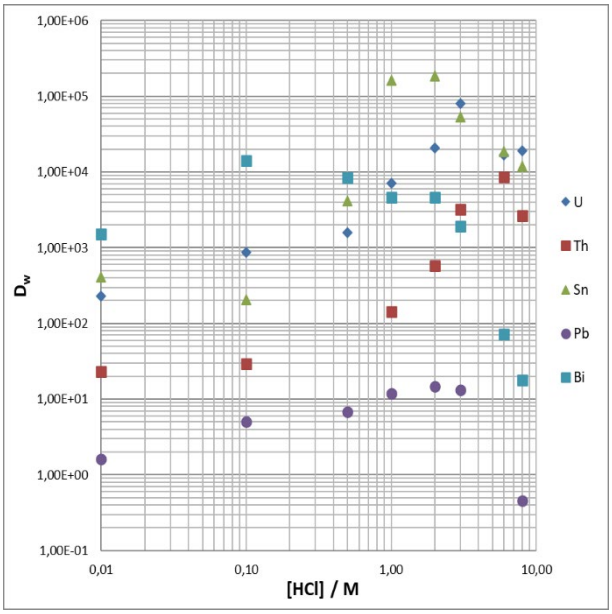

Figure 10: Dw values of selected elements on TK221 in HCl

U, Sn and Bi are well retained over the whole HCl concentration range, while Th is only well retained at ≥ 3M HCl. Pb is generally only very weakly retained.

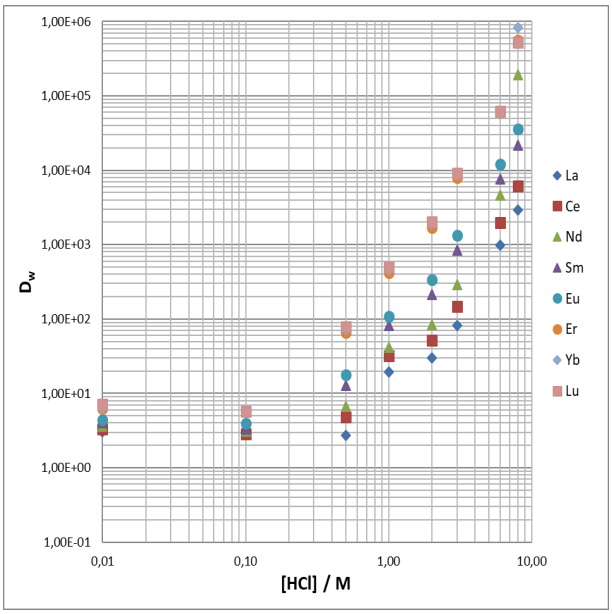

Figure 11: Dw values of selected elements on TK221 Resin in HCl

Lanthanides are generally very well retained at HCl concentrations ≥ 3M HCl, heavy lanthanides even at ≥ 1M, and they may be eluted in dilute HCl.

One of the main applications of TK221 Resin is the concentration, purification and conversion of heavy lanthanides such as Lu from highly acidic solutions into dilute HCl (typically ~0.05M HCl) conditions.
It allows e.g. to elute Lu in a smaller volume than DGA,N Resin. Accordingly, it may e.g. find use in the production of Lu-177.

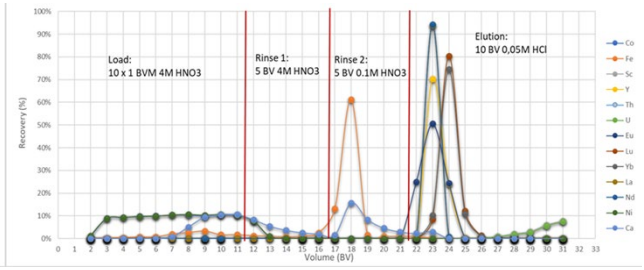

Figure 12: Elution study, various elements on TK221 (1)

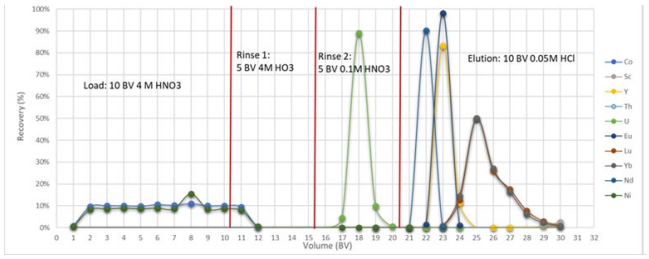

Figure 13: Elution study, various elements on DGA, normal Resin

A number of separation methods based on the TK221 Resin are currently being developed particularly for ca and nca Lu-177 purification, as well as the use of TK221 as part of the separation of nca Lu-177 from up to 500 mg Yb-176.

The final product obtained using the TK221 Resin is typically additionally passed through a 1 mL A8 cartridge for trace nitrate removal.

The fact that the TK221 Resin is showing higher U retention compared to e.g. DGA,N Resin might further allow for its use in a two column separation method for sequential actinides separation.

Fig. 14 shows an elution study of various elements including U on TK221.

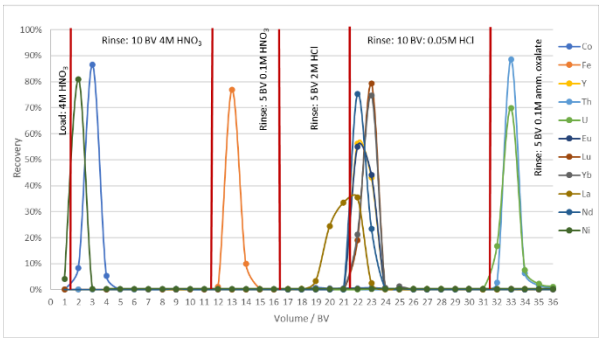

Figure 14: Elution study, various elements on TK221

U is very well retained under all employed HNO_3 and HCl concentrations and may finally be eluted in 0.1M oxalate. Am is expected to be eluted before U in dilute HCl.

With respect to the TK221 selectivity a stacked TEVA/TK221 method for the separation of U, Th, Pu, Am/Cm and Np seems thus very well possible.

N. Vajda et al. (2) developed such a method for the separation of Pu, Am, Th and U from water samples based on the TEVA/TK221 system. The development work was based on a typical Ca-Phosphate preconcentration step, and took into account the possible presence of Fe(III) originating from the oxidation state adjustment. Through a very thorough optimisation of the Am elution volumes a clean separation of Am and U on the TK221 could be achieved. Figures 15 and 16 show typical chromatograms obtained during the optimisation work using spiked tap water samples.

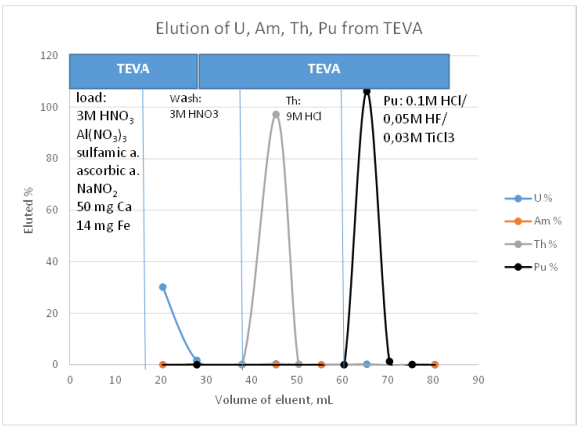

Figure 15: U, Pu, Am and Th separation on 2 mL TEVA cartridge (data courtesy of N. Vajda et al. (2))

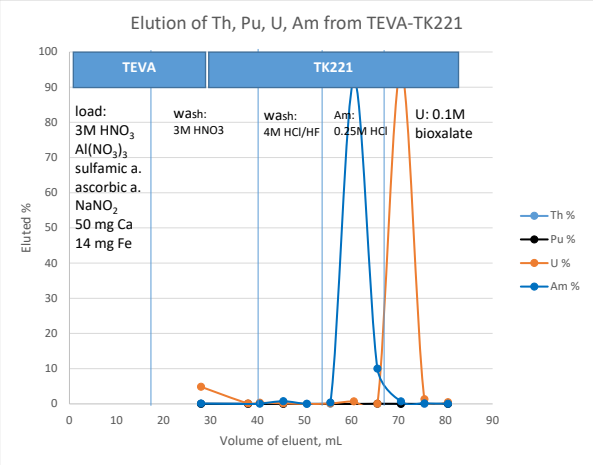

Figure 16: U, Pu, Am and Th separation on 2 mL TK221 cartridge (data courtesy of N. Vajda et al. (2))

Overall, the authors reported high chemical yields (92 – 106%) under the given conditions, and very good decontamination of the obtained actinide fractions (cross-contamination <1% respectively).

The developed separation protocol is summarized in figures 17 to 19.

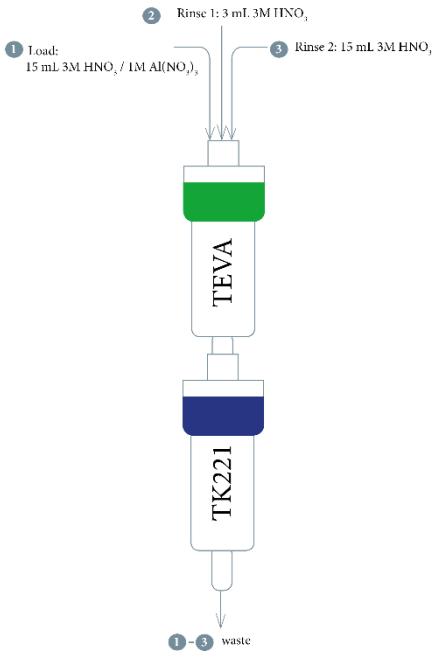

Figure 17: U, Pu, Am and Th separation on TEVA/TK221, stacked cartridges (according to N. Vajda et al. (2)

The dissolved CaPhosphate precipitate is first passed through stacked TEVA and TK221 cartridges (Fig. 17). The cartridges are then rinsed with 3M HNO_3 to assure matrix removal and quantitative transfer of U and Am onto the TK221 cartridge. Both cartridges are then separated: Pu and Th are separated on the TEVA cartridge (Fig. 18), while U and Am are separated on the TK221 cartridge (Fig. 19).

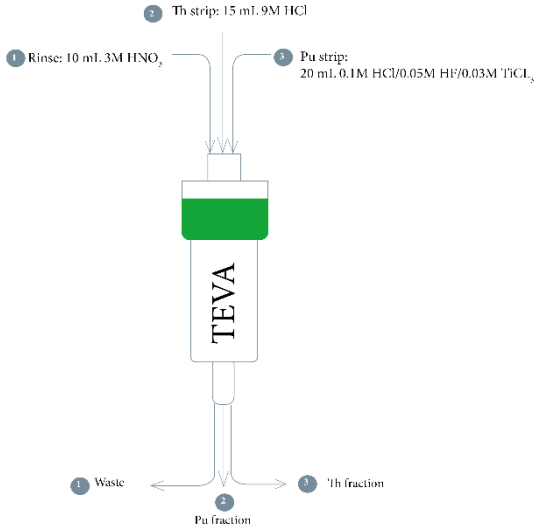

Figure 18: Separation steps on split TEVA cartridge (according to N. Vajda et al. (2))

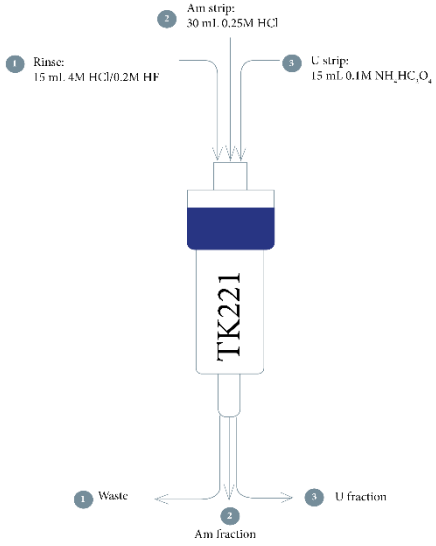

Figure 19: Separation steps on split TK221 cartridge (according to N. Vajda et al. (2))

When applying the developed method to the alpha spectrometric determination of tap and a sea water samples spiked with Pu-239, Am-241, Th-230 and U-233 they could confirm the clean separation of

the actinides, as well as the fact that high chemical yields may be obtained, as shown in table 1.

Table 1: Chemical recoveries of actinides analyzing 800 mL tap and sea water samples (data courtesy of N. Vajda (2))

	counts	time s	efficiency -	act. measured Bq	act. reference Bq	yield %	yield unc %
TAP1							
^{239}Pu	9660	64397	0,17	0,882	0,815	**108**	7,1
^{241}Am	8809	61566	0,17	0,842	0,816	**103**	7,2
^{230}Th	1255	12421	0,17	0,594	0,66	**90**	7,6
^{233}U	2488	13883	0,17	1,054	1,02	**103**	7,3
SEA2							
^{239}Pu	29690	236576	0,17	0,738	0,815	**91**	7,1
^{241}Am	29214	235520	0,17	0,730	0,816	**89**	7,1
^{230}Th	5356	66999	0,17	0,470	0,66	**71**	7,2
^{233}U	10649	69526	0,17	0,901	1,02	**88**	7,1

Even for a highly charged matrix such as a sea water sample, chemical yields were in the order of ~90% for U, Pu and Am and ~70% for Th, only about 10 – 20% lower compared to the tap water samples (90 – 108%), making this a very promising alternative to the classical TEVA/TRU methods with the additional benefit of a more robust Am retention.

N. Vajda et al further examined the TK221 Resin with respect to Ac retention (3).
Fig. 20 shows the Ac retention on TK221 in HNO_3.

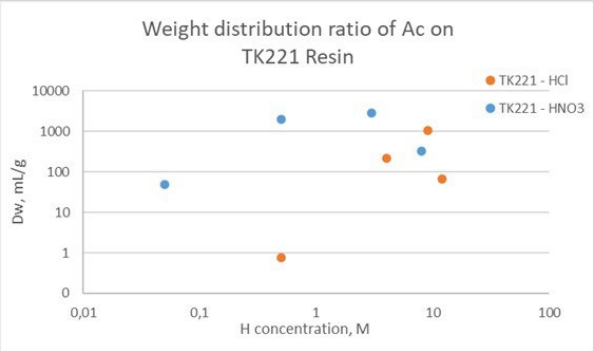

Figure 20: Weight distribution ratios (D_W) of Ac on TK221 Resin from various HNO_3 and HCl solutions. Data courtesy of N. Vajda et al. (3)

Overall, the D_W for Ac are elevated in HNO_3, even at very high (e.g. 10M HNO_3) or very low (e.g. 0.05M HNO_3) concentrations.
D_W determination in HCl is currently ongoing, it could already be shown though that the D_W for Ac are very low in dilute HCl.
The high retention of Ac over a wide HNO_3 concentration range could further be shown through elution experiments, as can be seen in fig. 21 and 22.

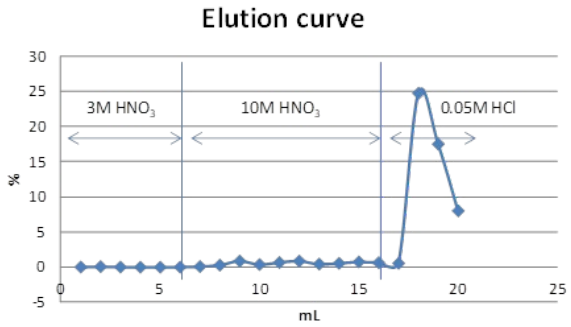

Figure 21 : Elution of Ac from TK221 cartridge with 10M HNO_3, 1mL TK221 column, data courtesy of N. Vajda et al. (3)

Other than the DGA Resins the TK221 doesn't allow for Ac elution in 10M HNO_3, a step frequently used for Ac/Lanthanide separation.

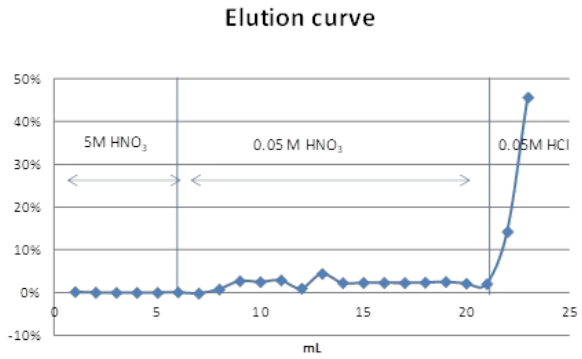

Figure 22 : Elution of Ac from TK221 cartridge with 0.05M HNO3, 1mL TK221 column, data courtesy of N. Vajda et al. (3)

TK221 does not allow, contrary to the DGA Resins, Ac elution in dilute HNO_3.

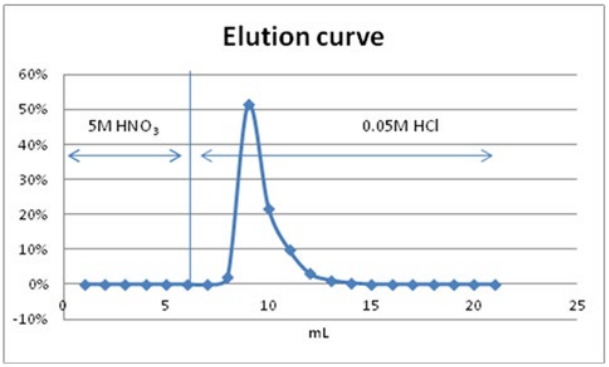

Figure 23 : Elution of Ac from TK221 cartridge with 0.05M HCl, 1mL TK221 column, data courtesy of N. Vajda et al. (3)

Fig. 23 shows that dilute HCl on the other hand elutes Ac in 0.05M HCl.

The fact that TK221 retains Ac from dilute HNO_3, and allows its elution in dilute HCl might open the possibility of converting Ac solutions from dilute HNO_3 to dilute HCl using TK221.

Overall, a separation method similar to Lu-177 purification seems possible: Ac retention from elevated HNO_3, rinse with dilute HNO_3 to remove impurities and lower HNO_3 concentration on the resin, followed by elution in HCl. Ideally the final product should be loaded through a small anion exchange resin cartridge (e.g. 1 mL A8) to remove last traces of nitrate.

Additional work on the Ac separation on TK221 Resin is currently on-going.

Bibliography

(1) S. Happel: “An overview over some new extraction chromatographic resins and their application in radiopharmacy” presented on the 4th of June 2019 at the 102nd Canadian Chemistry Conference and Exhibition (CCCE 2019) in Quebec City, QC
(2) N. Vajda et al. (RadAnal): “Report: Investigation on TEVA/TK221 resins for separation of actinides”, Budapest, April 2021
(3) N. Vajda et al. (RadAnal): “Report: Actinium retention on TK221 resin. Results on batch uptake and column elution experiments” Budapest, May 2022