PRODUCT SHEET

# ***TK202 Resin***

## Main Applications

- Separation of technetium
- Separation of rhenium

## Packing

| Order N°. | Form | Particle size |
|---|---|---|
| TK202-B25-K,<br>TK202-B50-K,<br>TK202-B100-K,<br>TK202-B200-K | 25g, 50g, 100g and 200g bottles TK202 Resin | 60 - 150 µm |
| TK202-R10-K | 10x2mL TK202 Resin cartridges | 60 - 150 µm |

Prepacked large volume columns available upon request.
TK202-R10-K cartridges are often used together with these references:

| Order N°. | Form | Particle size |
|---|---|---|
| **C8-R10-M-H** | 10x2mL C8 Resin cartridges | 100 – 200 mesh |
| **AlOxA1-R10-L** | 10x1mL AlOxA Resin cartridges | 50 - 200 µm |

## Physical and chemical properties

Density: ~0.58 g/mL TK202 Resin

## Conditions of utilization

Recommended flow rate: Load and rinse ≤ 1 bed volume (BV).min$^{-1}$ , Elution: 0.25 BV.min$^{-1}$

Recommended T° of utilization: 20 – 25°C

Storage: Dry and dark, T° < 30°C (preferably at 2 – 8°C)

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## TK202 RESIN

The TK202 Resin is based on Polyethyleneglycol (PEG, fig. 1) groups, with high molecular weight, that are covalently bound onto a polymer support.

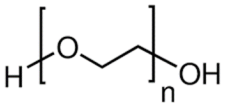


**Figure 1: PolyEthyleneGlycol (PEG).**

The TK202 Resin is based on an aqueous biphasic system (ABS) extraction mechanism with the covalently bound PEG acting as solid separation support. In presence of aqueous solutions with high ionic strength and high content of water-structuring (kosmotropic) anions like $SO_4^{2-}$, $CO_3^{2-}$, $OH^-$, as well as $MoO_4^{2-}$ or $WO_4^{2-}$ [1], it will extract chaotropic ions notably $TcO_4^-$ and $ReO_4^-$, while other non-chaotropic elements will not be retained, molybdenum being an important example.
Accordingly, Tc (and Re) retention will improve with increasing concentration of these anions.
Fig. 2 shows Dw values for Tc, Re and Mo on TK202 Resin at increasing OH concentrations.

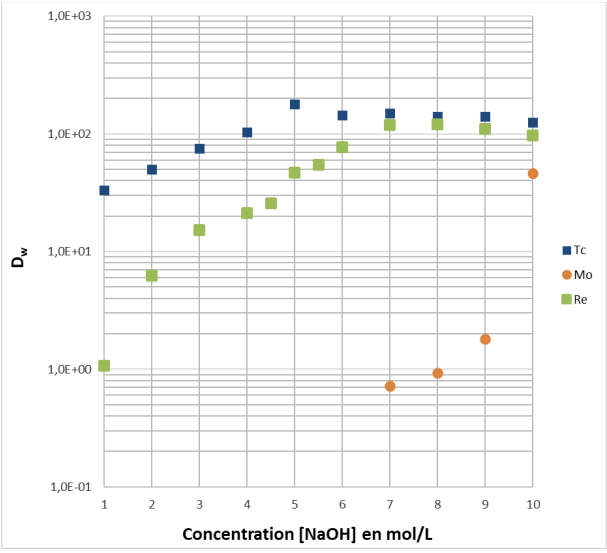


**Figure 2: Dw values for Tc, Re and Mo on TK202 Resin, at varying NaOH concentrations. Tc data taken from Cieszykowska et al.[2].**

Ideally the NaOH concentration should be between 5 and 7M NaOH during load and rinse, as Tc (and Re) retention is highest while Mo retention is very low.

As mentioned before, $MoO_4^{2-}$ itself is a kosmotropic anion. Accordingly, increasing its concentration will lead to higher Tc (and Re) retention in ABS systems like the TK202 Resin, as shown in Fig. 3. A distinct increase of the Tc retention with increasing amounts of Mo is observed.

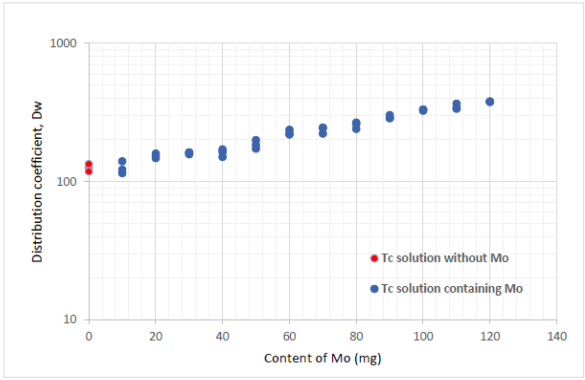


**Figure 3: Dw values for Tc in 5M NaOH using 40 mg TK202 Resin, increasing amounts of Mo. Data taken from Cieszykowska et al.[2].**

This is particularly relevant in case of the separation of Tc from elevated amounts of Mo (e.g. irradiated Mo targets).

Cieszykowska et al.[2] estimated from column studies that 6 to 8g of Mo per g of TK202 Resin allow obtaining high Tc recovery (> 90%). Further increasing the amount to 12g Mo/g of resin lead to a decrease of the Tc recovery to ~82% in their experiments.

The retained Tc and Re can then be eluted with water as the ABS systems breaks down, due to the low concentration of kosmotropic anions, under these conditions.

As mentioned, one potential application of the TK202 Resin is the separation of Tc-99m from irradiated Mo targets. Accordingly, its high selectivity for Tc over Mo, and the fact that the presence of elevated amounts of Mo in solution increases the Tc retention, makes the TK202 Resin particularly suitable for this type of applications.

Indeed, besides the production of Mo-99 for the fabrication of Mo-99/Tc-99m generators via U-235 fission there are several other ways to produce Mo-99[3], and thus Tc-99m. Three of these methods are based on the irradiation of Mo targets:

- Neutron activation of Mo-98 via (n, $\gamma$) reactions (Mo-98 (n, $\gamma$) Mo-99), preferably performed in a reactor with high neutron flux.

- Photon-induced (γ, n) reaction of Mo-100 (Mo-100 (γ, n) Mo-99) using photons (γ) obtained through irradiation of heavy targets (converter) e.g. with electron beams.
- Direct Tc-99m production on a cyclotron using Mo-98 targets (Mo-98 (p, 2n) Tc-99m)[4]. This latter method represents, with respect to the short half-life of Tc-99m, certain logistical challenges and will generally rather allow for supplying users close to the production facility. This method requires a clean, and very rapid, separation of the produced Tc-99m from the target material.

The first two described methods tend to result in Mo-99 of limited specific activity, especially compared to Mo-99 obtained from U fission. Accordingly using them e.g. in alumina column based generator systems will, due to the generally limited Mo capacity of these columns, result in rather lower activity Mo-99/Tc-99m generators.

In such cases employing a resin, such as the TK202 Resin, to extract the Tc-99m originating from Mo-99 decay while letting Mo pass through ("inverted generator") is often a preferred option.

It should be noted that in all three cases the recovery and recycling of the enriched Mo is of very high importance due to the pricing and limited availability of the target material.

The production methods described above all require the use of a resin with high selectivity for Tc over large amounts of Mo. Ideally, as the Mo targets are very frequently dissolved in NaOH solutions of elevated concentration, the resin should show this selectivity under these conditions. This is the case for the TK202 Resin. As indicated before, Tc may then be recovered using water, although further separation steps will be necessary to adjust pH and $Na^+$ concentration of the final product.

Initial elution studies using Re instead of Tc confirmed the high selectivity for Re (and, as could be confirmed in separate tests, also Tc) over Mo.

Fig. 4 shows an elution study performed with trace amounts of Mo and Re. As it can be seen, a clean separation of both elements is obtained. Mo is removed during load and following rinses (both may be performed with 5 – 7M NaOH), while Re elutes in a small water volume.

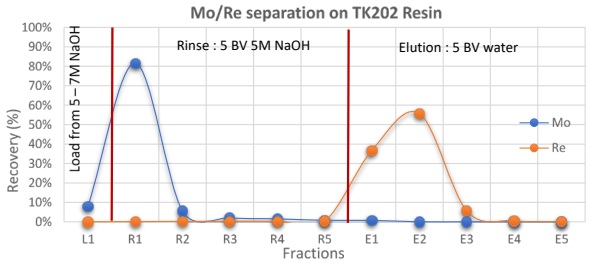


**Figure 4: Elution study, trace amounts of Mo and Re on a 2 mL TK202 Resin cartridge, load and rinse at 1 BV/min, elution at 0.25 BV/min.**

As the general selectivity could be confirmed further tests were performed using larger amounts of Mo.

Fig. 5 shows the separation of traces of Re from 2g of Mo, as e.g. typically required in case of Tc-99m production from Mo-98 irradiation in a cyclotron [4].

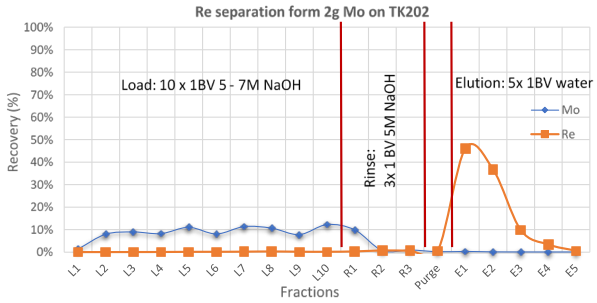


**Figure 5: Elution study, separation of trace Re and 2g Mo on a 2 mL TK202 Resin cartridge, load and rinse at 1 BV/min, elution at 0.25 BV/min.**

It should be noted that purging the resin, e.g. with air, after the rinse and before its elution with water, to remove NaOH from the cartridge/column, is of high importance to reduce the $Na^+$ and $OH^-$ load of the final Tc/Re fractions.
It could further be shown that lower flow rates during elution of the TK202 Resin will result in narrower elution peaks, and thus lower elution volumes.

As discussed previously, the TK202 Resin may also be used to extract Tc-99m from Mo-99 decay present in an alkaline solution. In such cases much larger Mo targets are generally irradiated.
With respect to this, the separation of trace of Re from 100g Mo was tested. As Fig. 6 shows a clean separation of Mo and Re could be obtained here, too. Nevertheless, with respect to the very large amount of Mo present, an additional purification of the obtained Tc will be required.

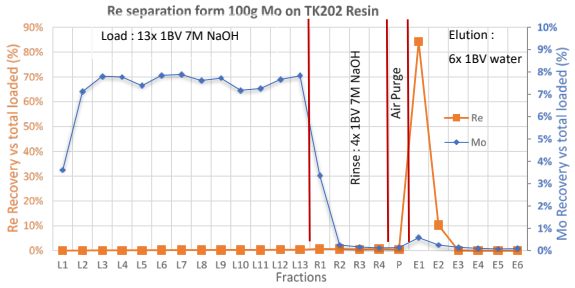


**Figure 6: Elution study, separation of trace amounts of Re and 100g Mo on a 75 mL TK202 Resin cartridge, load at 0.5 BV/min, rinse at 1 BV/min, elution at 0.2 BV/min.**

Methods for the separation of Tc from larger Mo amounts (e.g. ≥200g) are currently being tested.

As shown e.g. by Bénard et al.[4], one convenient option for this additional Tc purification is the use of a cation exchange resin (for $Na^+$ removal and pH adjustment to below pH 7), followed by an alumina cartridge (for Re/Tc concentration and further Mo removal).
Especially for the cation exchange cartridge it is important to adjust the size of the cartridge to the amount of Mo previously present in the sample/and so to the size of the TK202 Resin cartridge employed.
For the size of the alumina cartridge the amount of residual Mo is a decisive parameter.

Fig. 7 shows the continuation of the 2g Mo separation test shown in Fig. 5.
The obtained Re fractions (E1 – E4) were combined and loaded through a C8 cation exchange resin cartridge which was then rinsed with water. The load fractions and the first rinse were collected, analyzed, and then combined for the final step of the separation, as they contain all the Re (or Tc).

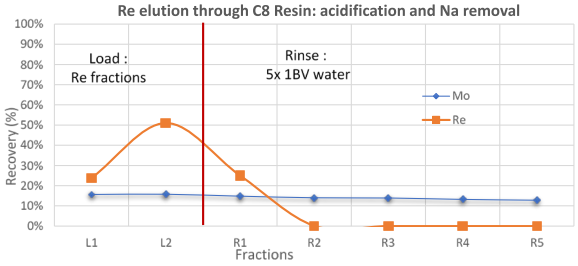


**Figure 7: Continuation of the separation of Re from 2g Mo (see Fig. 5). $Na^+$ removal and pH adjustment of Re fractions on 2 mL C8 Resin cartridge, load and rinse at 2 BV/min.**

As stated before, at this stage the Re fraction should be below pH 7 (typically 3 – 5) and largely free of $Na^+$ cations.
It could be shown that under these conditions, acidic alumina will retain Re/Tc (and Mo). A 0.9% NaCl solution then allows eluting Re/Tc in a small volume (2 – 3 BV) while Mo remains very strongly retained, thus further improving the purity of the recovered Re/Tc. The indicated air purge is not necessary in case of the AlOxA Resin (acidic alumina).

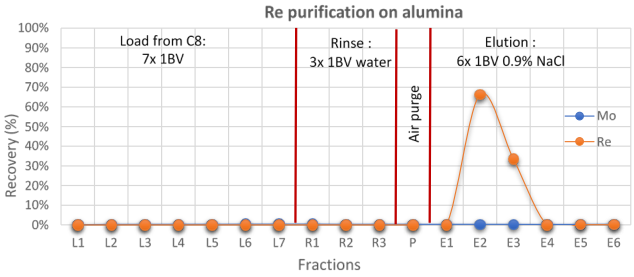


**Figure 8: Re concentration, purification and conversion to 0.9% NaCl solution on 1 mL AlOxA Resin at 2 BV/min.**

This further has the advantage of allowing to obtain the Tc in the same matrix (0.9% NaCl) as delivered by a Mo-99/Tc-99m generator.
Overall, in the cold tests Re recoveries in the order of >90% could be obtained.

A schematic overview of the suggested separation method is given in Fig. 9. The method may be applied for the separation of Tc from Mo targets of various sizes, cartridge/column volumes will need to be adjusted accordingly.

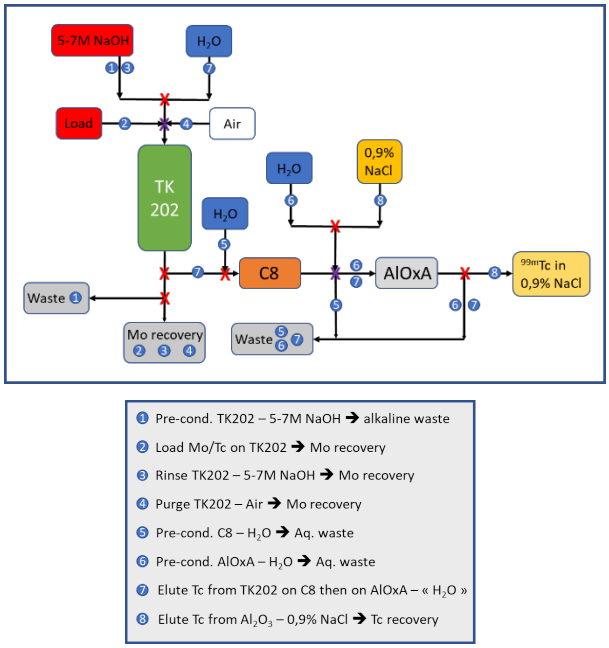


**Figure 9 : Schematic overview, Tc separation from Mo.**

Further to the TK202 Resin TrisKem also supplies C8 Resin, AlOxA Resin.
All resins are available in various columns and/or cartridges of different sizes (depending on the size of the Mo target).
Please contact us for further information.

Besides the described radiopharmaceutical use the TK202 Resin may also be employed in radioanalytical applications, notably in the analysis of Tc-99 in samples that were solubilized via alkaline fusion.
In such cases the solubilized samples (e.g. concrete samples resulting from decommissioning work) may, after removal of insoluble material, be adjusted to 5 – 7M NaOH and then passed through TK202 Resin to separate Tc.

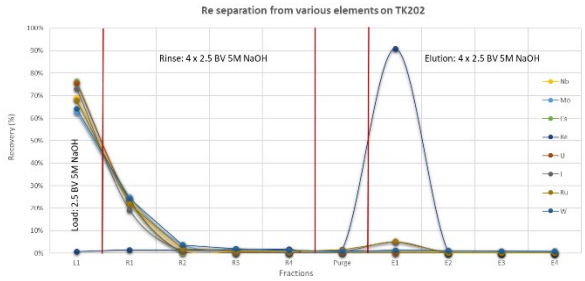


**Figure 10: Re separation from selected elements on 2 mL TK202 Resin cartridge, load and rinse at 1 BV/min, elution at 0.25 BV/min.**

In order to further increase the purity of the obtained Tc fraction it might be passed, as described above, through a C8 Resin, and potentially even AlOxA Resin.

## Bibliography

(1) S.K. Spear et al.: "Radiopharmaceutical and Hydrometallurgical Separations of Perrhenate Using Aqueous Biphasic Systems and the Analogous Aqueous Biphasic Extraction Chromatographic Resins", Ind. Eng. Chem. Res., 2000, 39, 3173 – 3180, https://doi.org/10.1021/ie990583p

(2) I. Cieszykowska et al.: "Separation of 99mTc from low specific activity 99Mo", poster ID 195 presented at the ISTR 2019, October 28 – November 1, Vienna, Austria

(3) IAEA Nuclear Energy Series, No. NF-T-5.4,: "Non-HEU Production Technologies for Molybdenum-99 and Technetium-99m", INTERNATIONAL ATOMIC ENERGY AGENCY, Vienna, 2013

(4) F. Bénard et al.: "Cross-Linked Polyethylene Glycol Beads to Separate 99mTc-Pertechnetate from Low-Specific-Activity Molybdenum", Journal of Nuclear Medicine, 2014, https://doi.org/10.2967/jnumed.114.143834