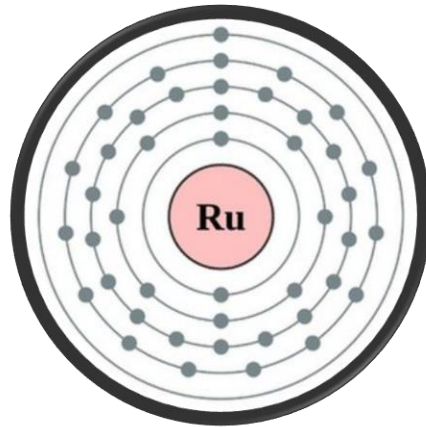


Magnetic sorbents for ruthenium removal from aqueous solutions

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Ruthenium

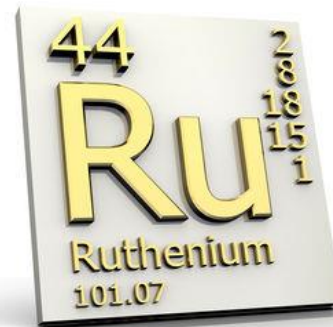


22 Ti Titanium 47.867	+2 +3 +4 23 V Vanadium 50.942	+2 +3 +4 +5 +6 24 Cr Chromium 51.996	+4 +6 +7 44 Ru Ruthenium 101.07	+3 +4 45 Rh Rhodium 101.07	+1 +2 46 Pd Palladium 106.36	+1 +2 47 Cu Copper 63.546	+2 48 Zn Zinc 65.38			
40 Zr Zirconium 91.224	+3 +4 41 Nb Niobium 92.906	+4 +5 +6 72 Hf Hafnium 178.49	+5 +6 73 Ta Tantalum 180.95	+4 +5 74 W Tungsten 183.84	+3 +4 75 Re Rhenium 186.207	+1 +2 76 Os Osmium 190.23	+1 +2 +3 77 Ir Iridium 192.22	+2 78 Pt Platinum 195.084	+2 79 Au Gold 196.967	+1 +2 80 Hg Mercury 200.59
104 Rf Rutherfordium	+4 105 Db Dubnium	+4 +5 106 Sg Seaborgium	+4 +5 107 Bh Bohrium	+4 +5 108 Hs Hassium	+4 +5 109 Mt Meitnerium	+4 +5 110 Ds Darmstadtium	+1 +2 111 Rg Roentgenium	+1 +2 112 Uu Ununbium	+1 +2 113 Nh Nihonium	+1 +2 114 Fl Flerovium

- *transition metal*
- *in nature it occurs in the form of minerals - iridosmium (7-15% Ru), osmoirydium (9-14% Ru), and laurite (RuOs)₂ (65 - 67% Ru)*
- *Natural isotopes: Ru-96, Ru-98, Ru-99, Ru-100, Ru-101, Ru-102, Ru-104*
- *Most stable radioisotopes: Ru-103, Ru-106*

Ruthenium in nuclear energy

- During the process of uranium and plutonium extraction, **HLLW** (*high-level liquid waste*) is produced. HLLW consist of considerable amount of a platinum group metals such as Pd, **Ru** and Rh.



1 TON HLLW from light water reactor = **4kg** of metals from the platinum group

1 TON HLLW from fast breeder reactor = **19kg** of metals from the platinum group



WHY
RUTHENIUM?



Ru - the most difficult nuclide to remove from the HLLW.

Magnetic sorbents

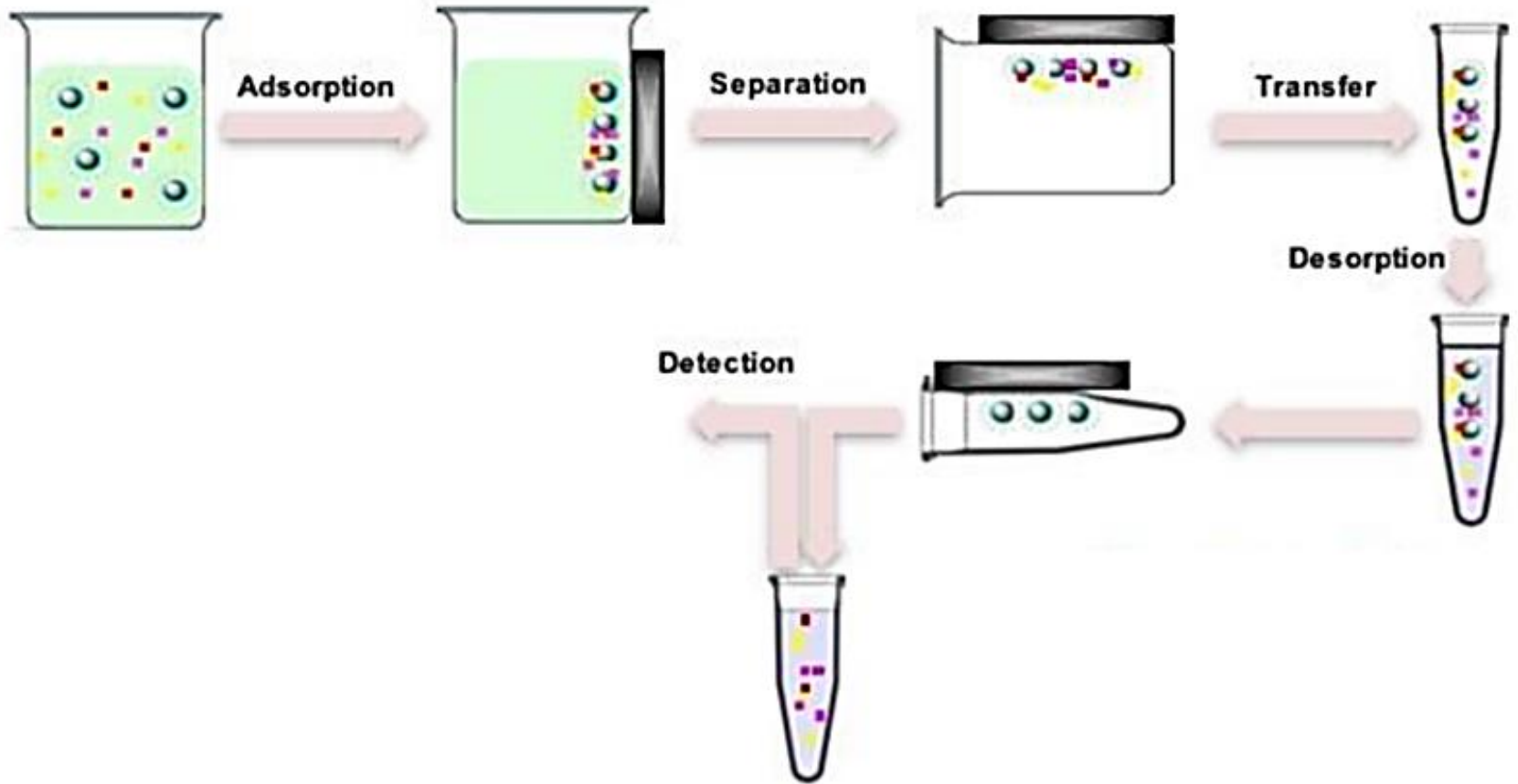
magnetic sorbents
 Fe_3O_4

inorganic coating
 MnO_2 , PbS

organic coating
cellulose,
polyacrylamide



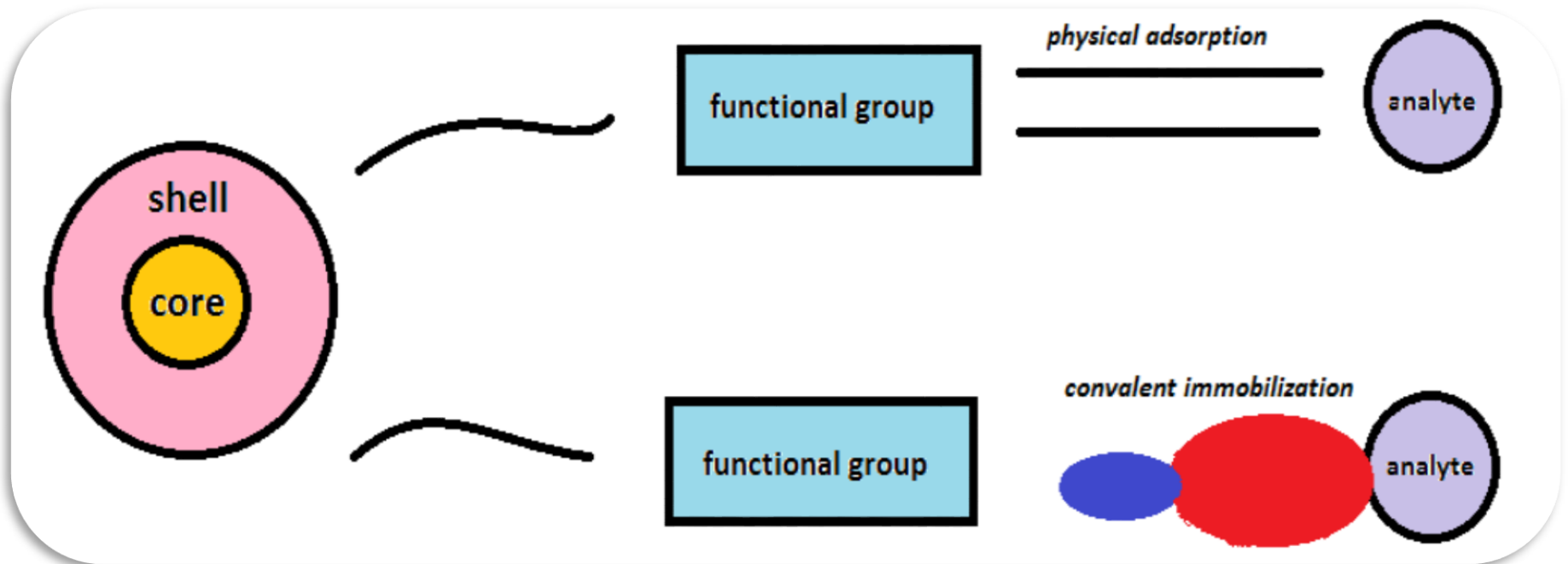
Magnetic sorbents



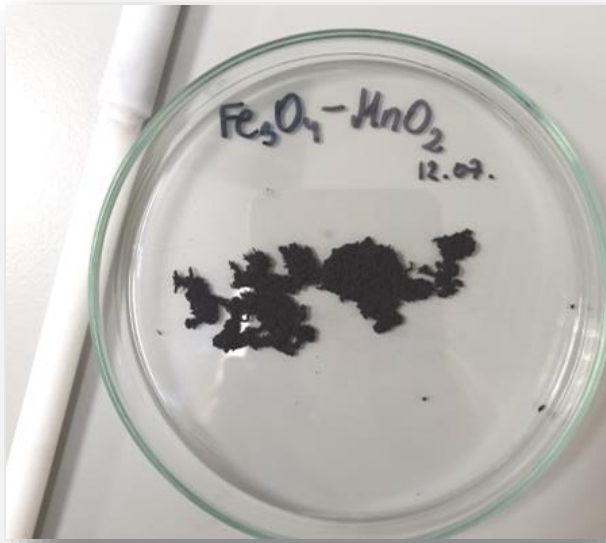
Synthesis of new magnetic sorbents for ruthenium removal

Magnetic sorbents:

- $\text{Fe}_3\text{O}_4\text{-MnO}_2$
- $\text{Fe}_3\text{O}_4\text{-PbS}$
- $\text{Fe}_3\text{O}_4\text{-V}_2\text{O}_5$



Synthesis of $\text{Fe}_3\text{O}_4\text{-MnO}_2$



Synthesis conditions:

- Weigh 1 g of magnetite
- Suspended in 50 mL of 0.3 M MnCl_2
- Stirring 30 min
- Slowly adding 50mL of 0.2 M KMnO_4
- Stirring 24 h
- Water rinsing
- Drying in 120°C, 1 h in oven.



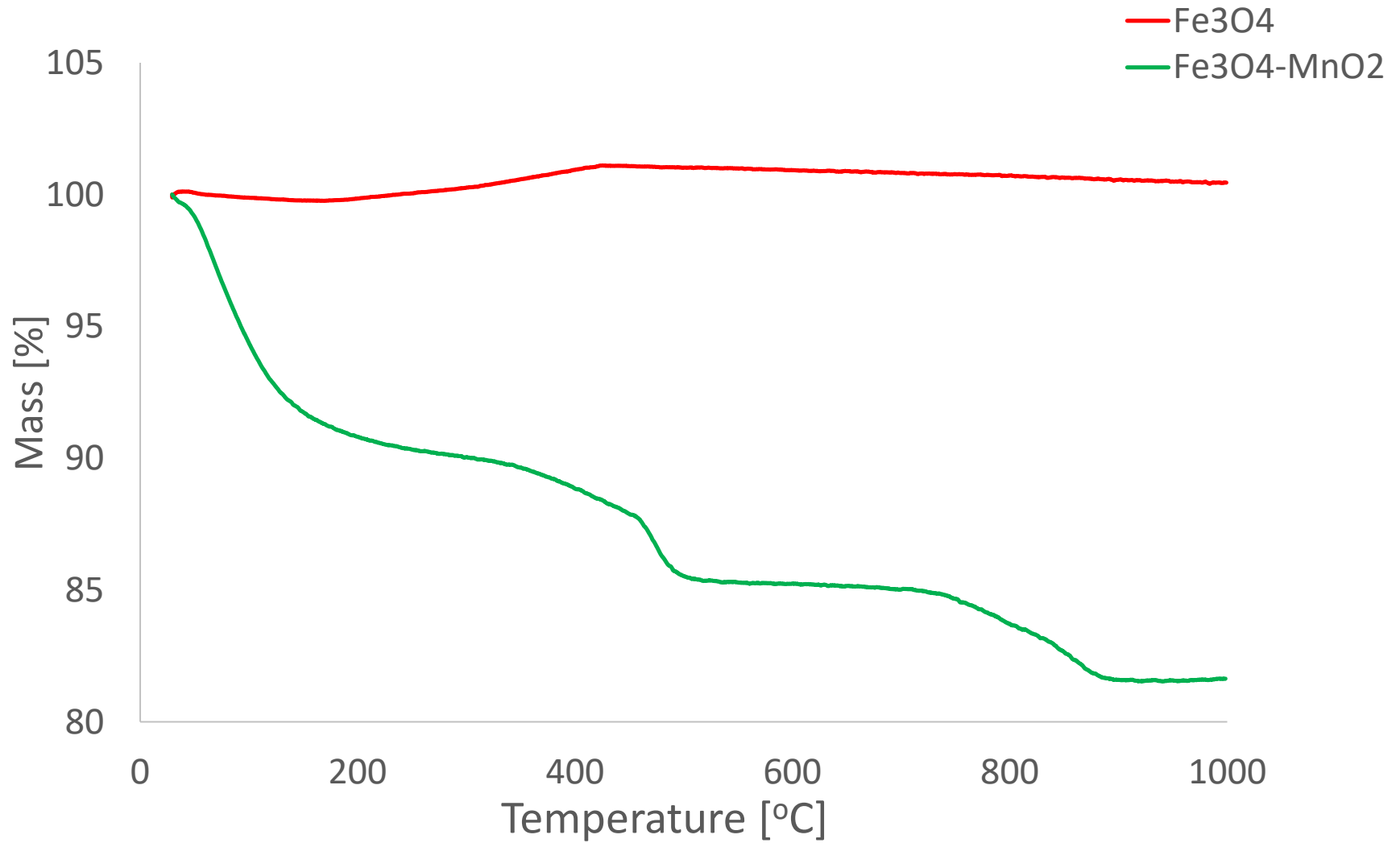
Thermogravimetry method



TG conditions:

- 30-1000°C (10°/min)
- Corundum crucible
- $m = 8.7\text{mg}$

TG measurements



Sorption study

Sorption conditions:

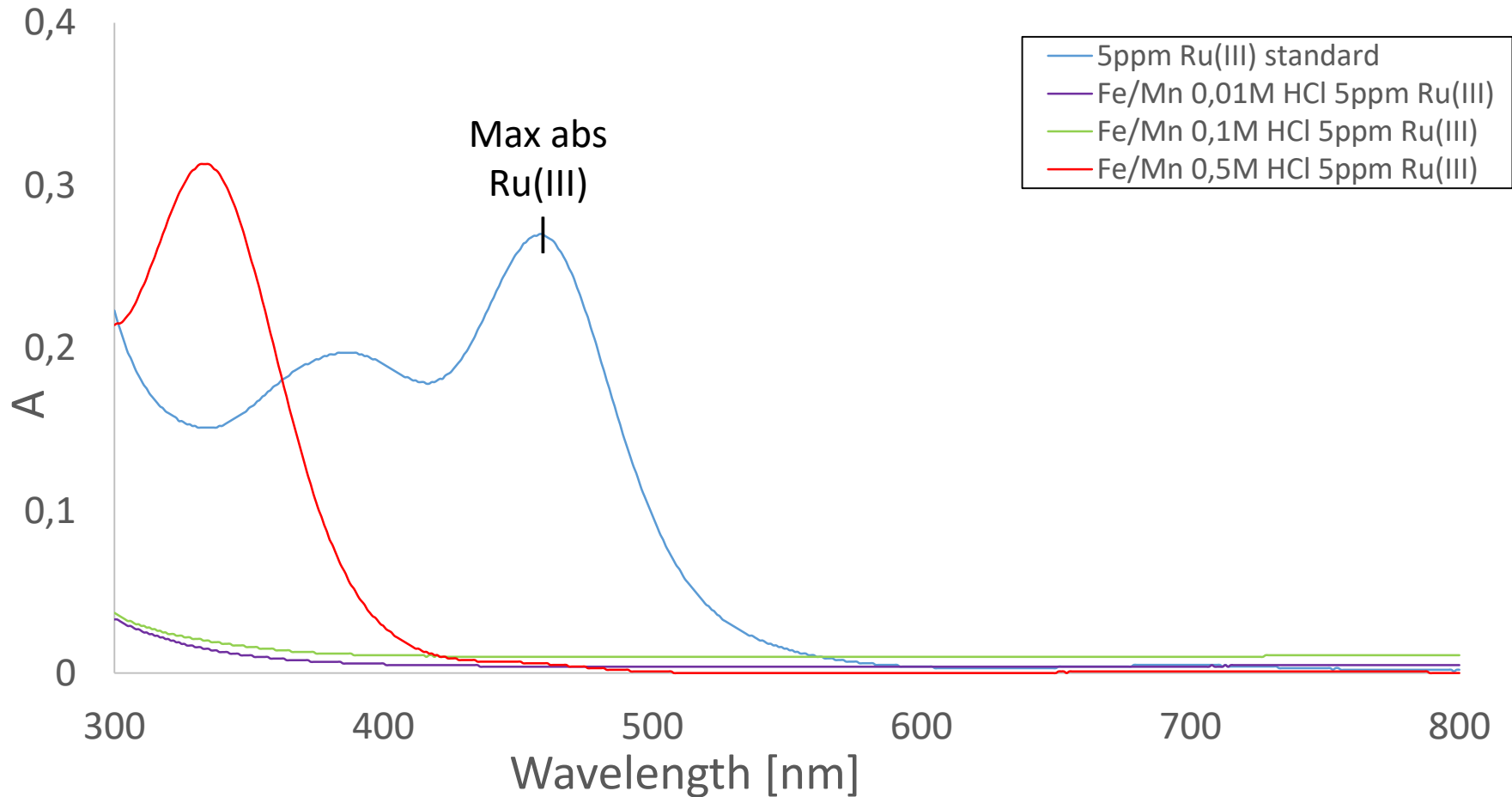
- 0.2 g magnetic sorbents
 Fe_3O_4
- 10 mL HCl (0.01 – 0.5M)
- $5 \mu\text{g mL}^{-1}$ Ru
- 24h stirring

- 0.2g magnetic sorbents
 $\text{Fe}_3\text{O}_4 - \text{MnO}_2$
- 10mL HCl (0.01 – 0.5M)
- $5 \mu\text{g mL}^{-1}$ Ru
- 24h stirring



UV Vis Spectrometry

Sorption of Ru(III) on Fe/Mn



Summary

- *Rutenium* is the most difficult nuclide to remove from HLLW, that's why scientists are looking for new opportunities to extract this element.
- Application of *magnetic sorbents* is one of the ways to remove ruthenium.
- Synthesis of new magnetic sorbents has been confirmed by *TG analysis*.
- Initial studies of ruthenium sorption performed with *UV-vis spectrometry* showed that this element is retained on the new synthesized sorbent - *Fe₃O₄-MnO₂*.



NEXT STEP:

Sorption of ruthenium from various types of aqueous solutions using the radioactive tracer Ru-103 ($T_{1/2} = 39,2d$).

Thank you
for your
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