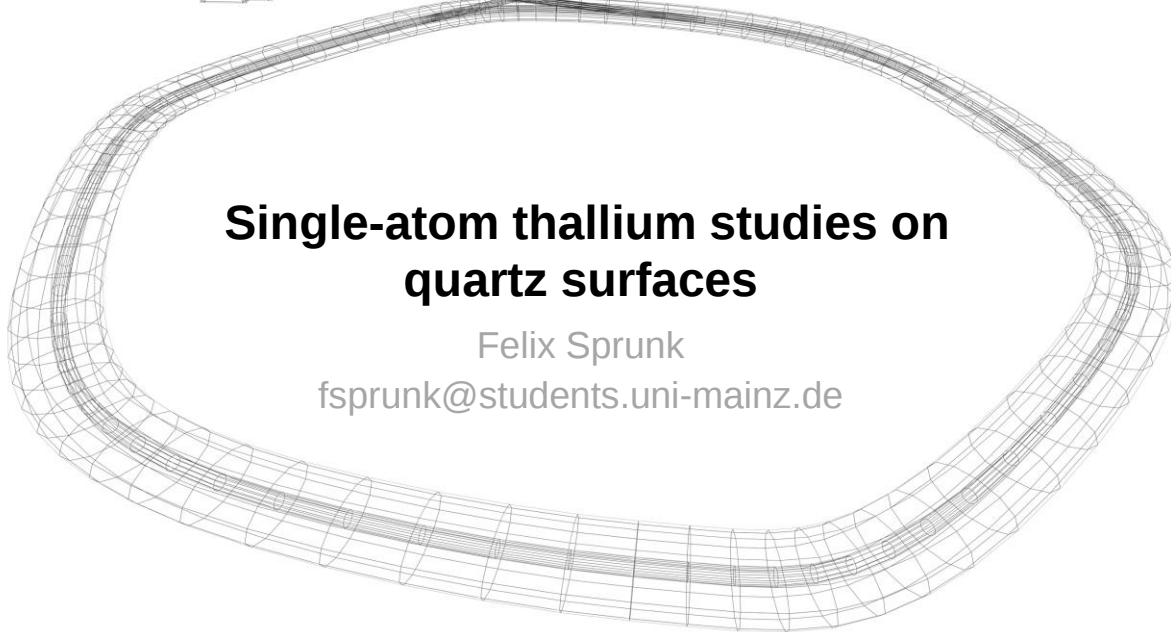


Single-atom thallium studies on quartz surfaces

Felix Sprunk

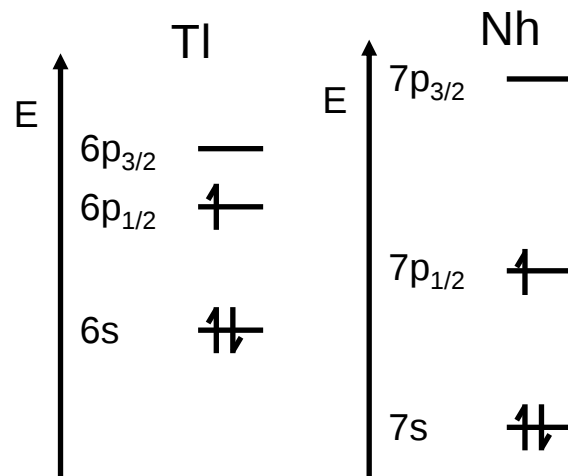
fsprunk@students.uni-mainz.de



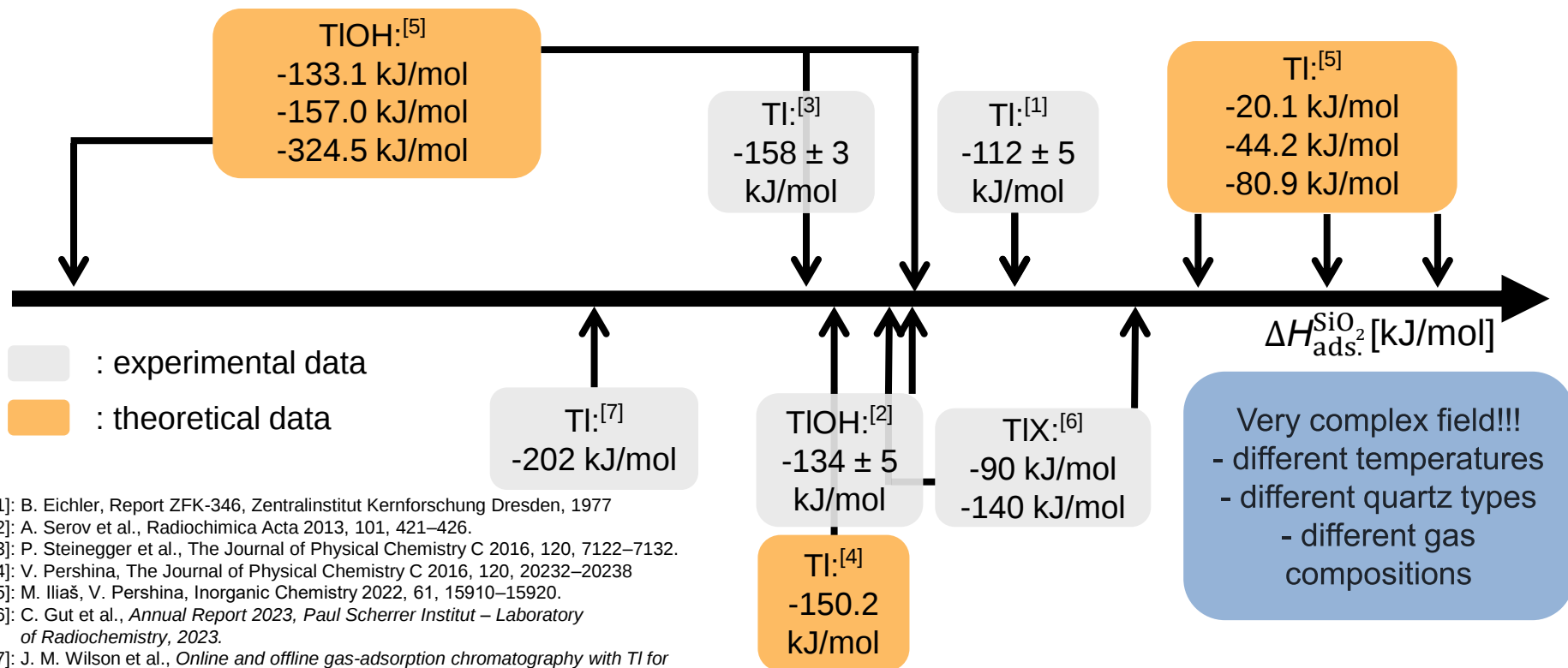
Thallium as a lighter homologue of nihonium

PERIODIC TABLE OF THE ELEMENTS																		18
1 H Hydrogen																	2 He Helium	
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon	
11 Na Sodium	12 Mg Magnesium	3	4	5	6	7	8	9	10	11	12	13 Al Aluminium	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon	
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton	
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon	
55 Cs Caesium	56 Ba Barium	57-71 * La-Lu	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon	
87 Fr Francium	88 Ra Radium	89-103 ** Ac-Lr	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson	
*Lanthanides																		
57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium				
**Actinides																		
89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium				

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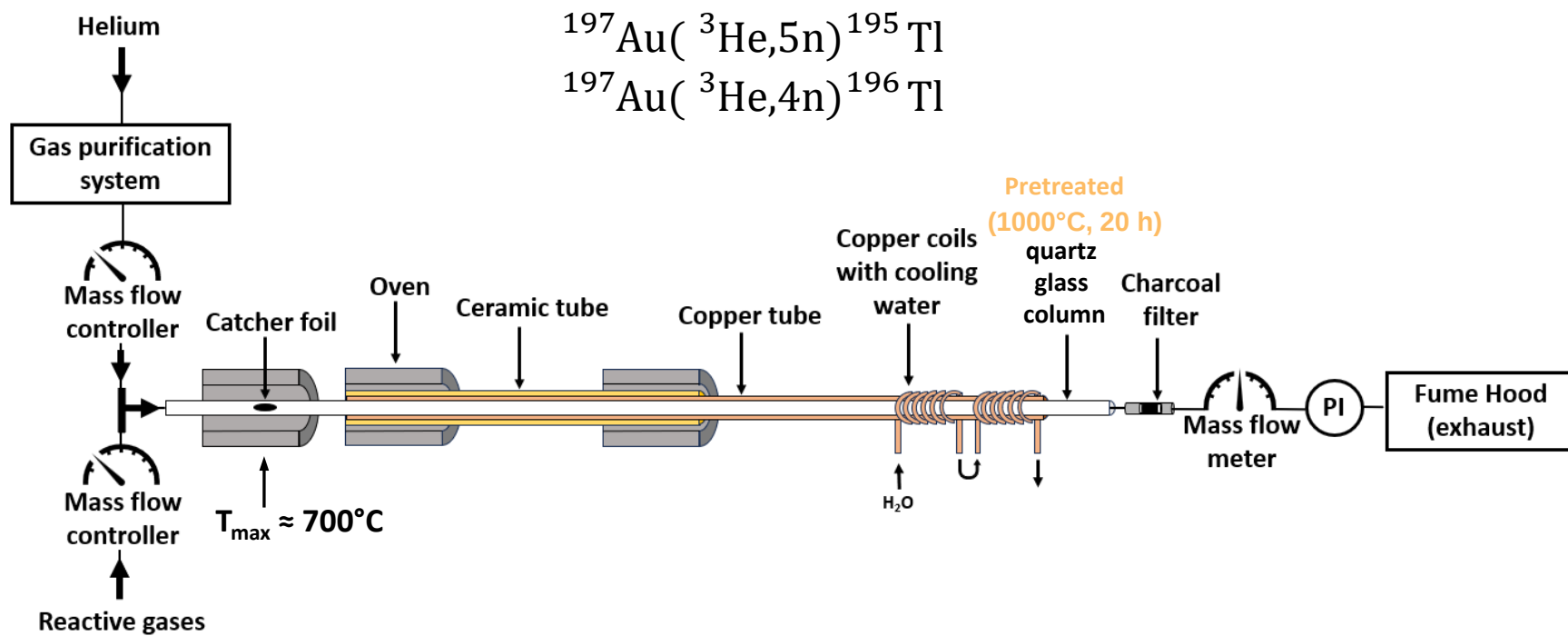


History of single atom studies of thallium on quartz glass

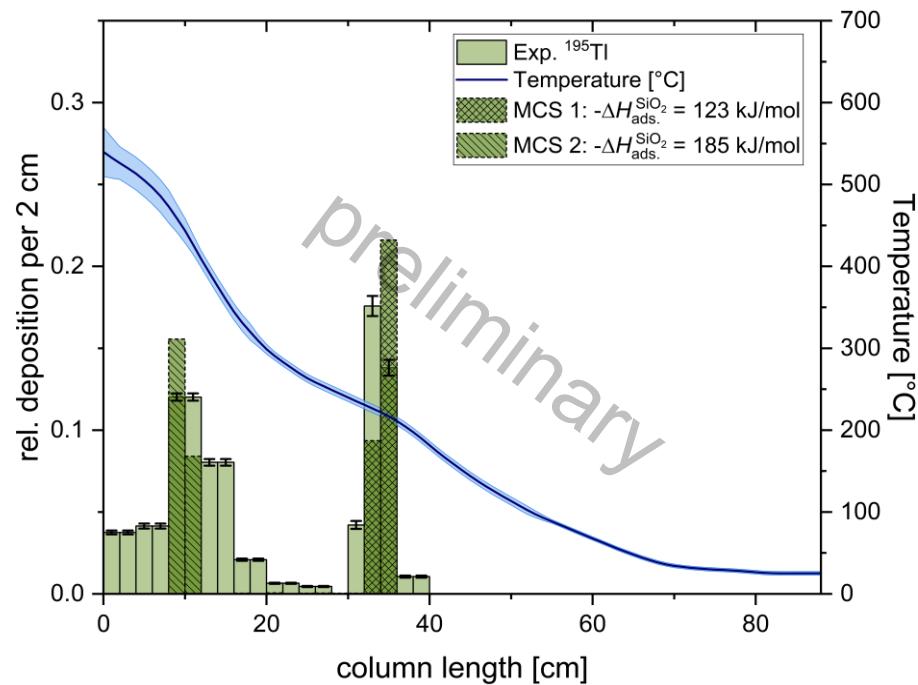


- [1]: B. Eichler, Report ZFK-346, Zentralinstitut Kernforschung Dresden, 1977
 [2]: A. Serov et al., Radiochimica Acta 2013, 101, 421–426.
 [3]: P. Steinegger et al., The Journal of Physical Chemistry C 2016, 120, 7122–7132.
 [4]: V. Pershina, The Journal of Physical Chemistry C 2016, 120, 20232–20238
 [5]: M. Iliaš, V. Pershina, Inorganic Chemistry 2022, 61, 15910–15920.
 [6]: C. Gut et al., Annual Report 2023, Paul Scherrer Institut – Laboratory of Radiochemistry, 2023.
 [7]: J. M. Wilson et al., Online and offline gas-adsorption chromatography with Tl for future Nh experiments, 10th International Conference on Nuclear and Radiochemistry, 2024.

Experimental setup for thermochromatography experiments

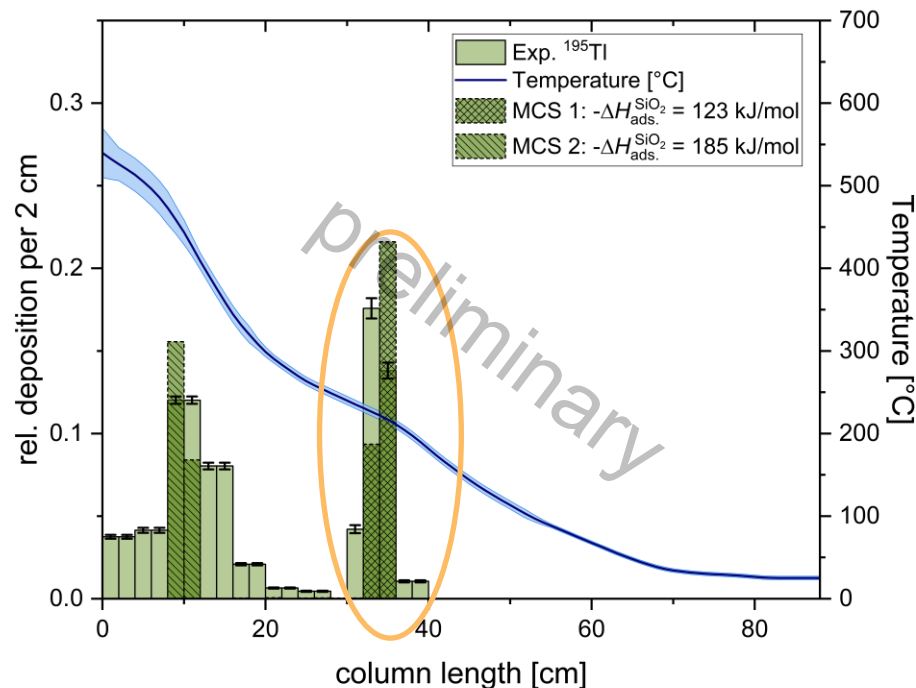
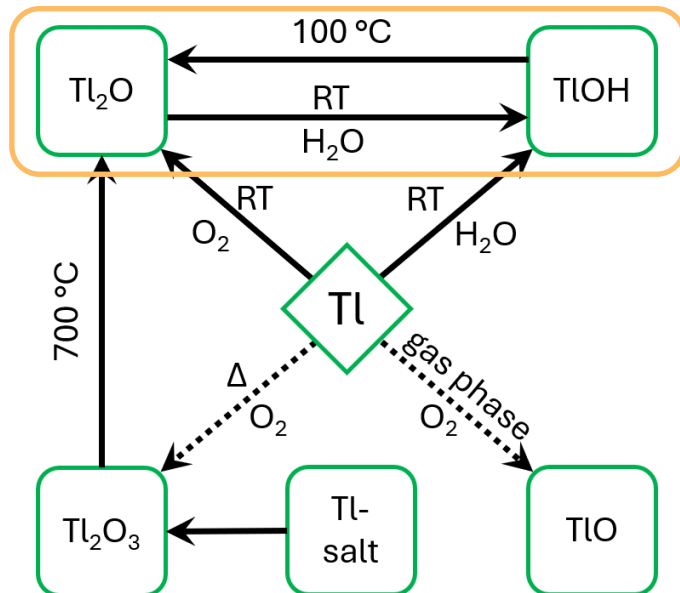


Adsorption of thallium species in pure helium



Adsorption of thallium species in pure helium

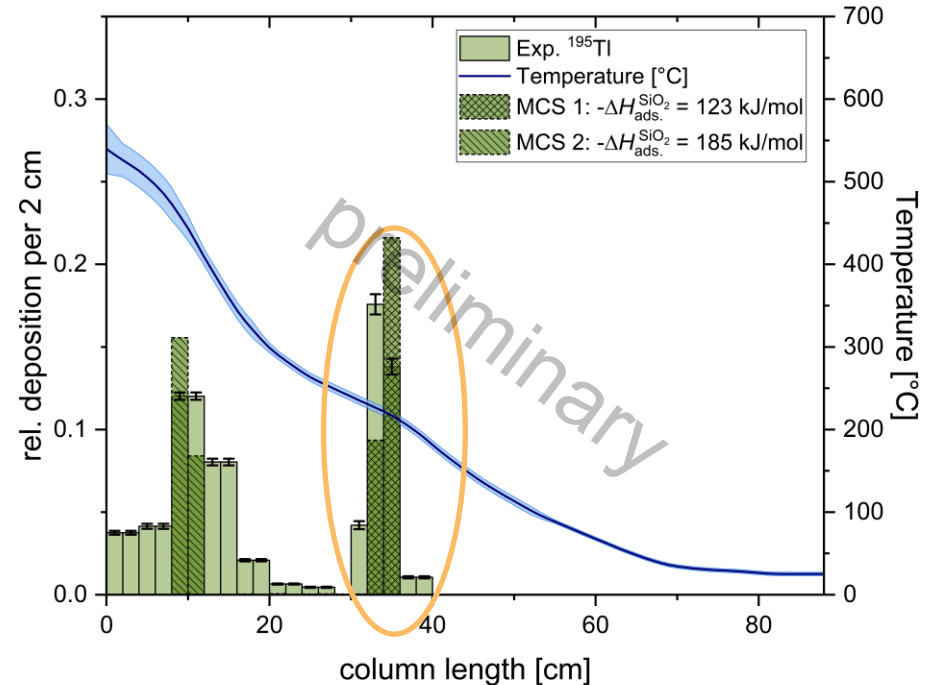
- Highly reactive, known from literature [1]



[1]: E. Wiberg, N. Wiberg, A. Holleman, Anorganische Chemie Band 1 – Grundlagen und Hauptgruppenelemente, de Gruyter, 2017

Adsorption of thallium species in pure helium

- Highly reactive, known from literature [1]
- $-\Delta H_{ads}$ fits with previous data for TlOH [2]
- Elemental Tl unlikely – other species implies reactants in column

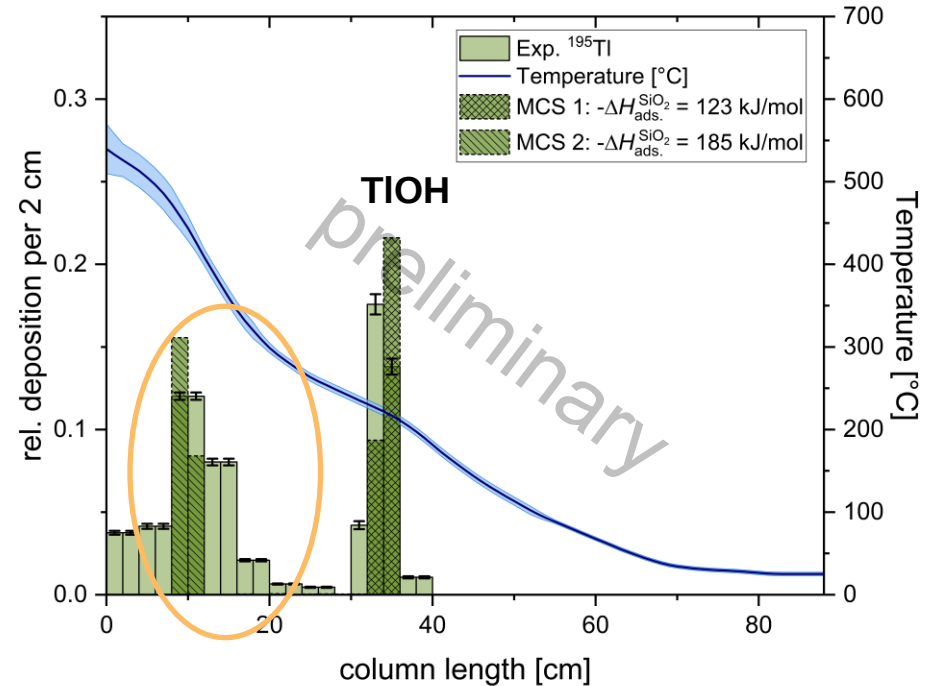


[1]: E. Wiberg, N. Wiberg, A. Holleman, Anorganische Chemie Band 1 – Grundlagen und Hauptgruppenelemente, de Gruyter, 2017

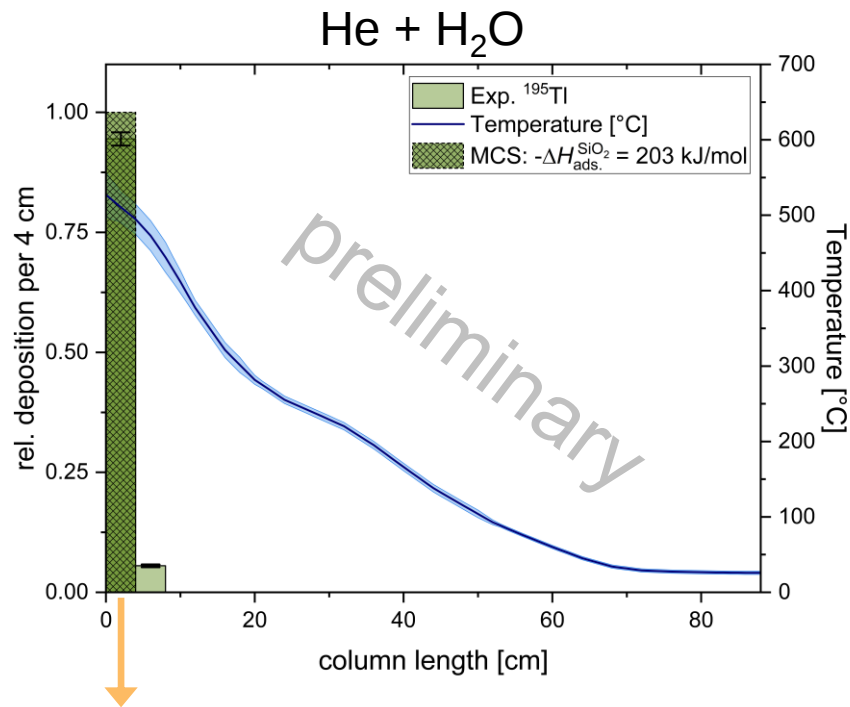
[2]: A. Serov et al. Radiochim. Acta 2013, 101, 421–425.

Adsorption of thallium species in pure helium

- Broad peak – possibly chemical reactions
- Mixture of species or reaction zone?



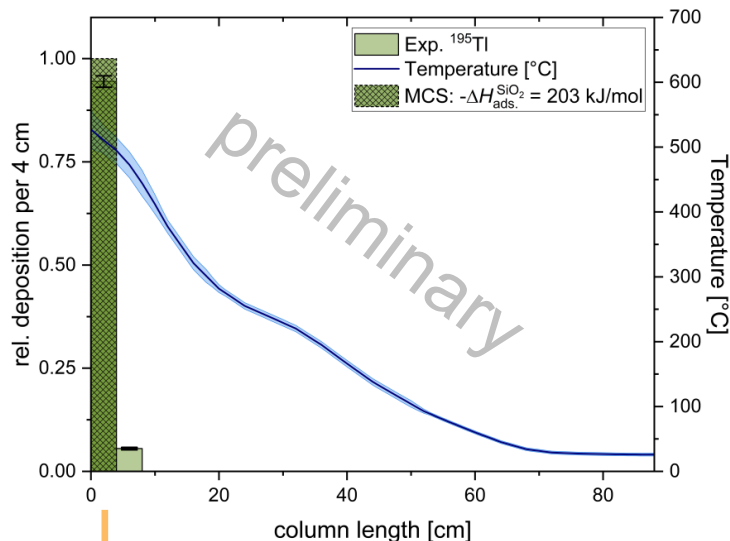
Adsorption of thallium species in reactive gases



strong binding between species and surface

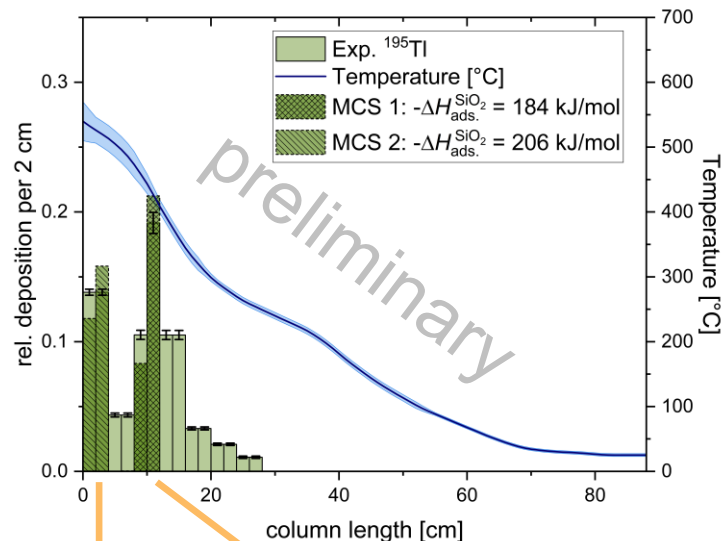
Adsorption of thallium species in reactive gases

He + H₂O



strongly bound species

He + 20% O₂

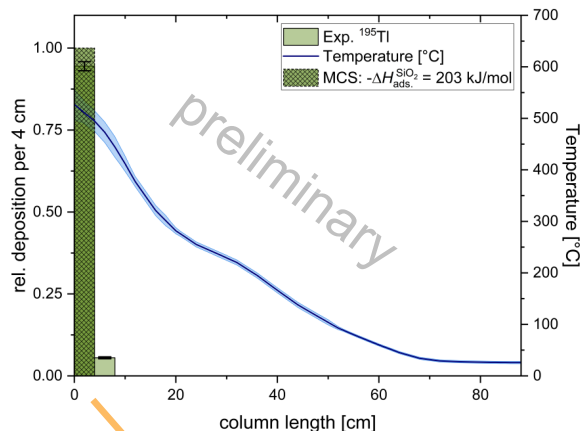


strongly bound species

part of thallium is desorbed as species

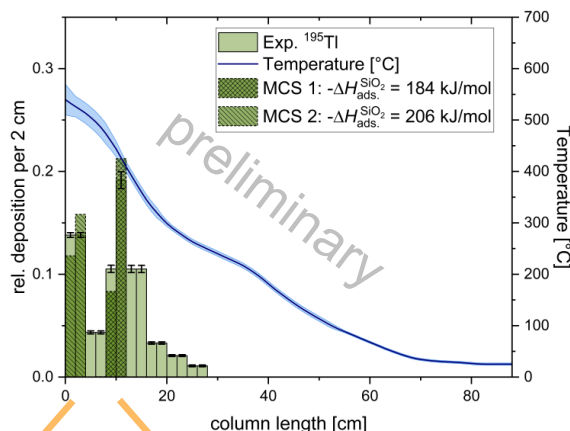
Adsorption of thallium species in reactive gases

He + H₂O



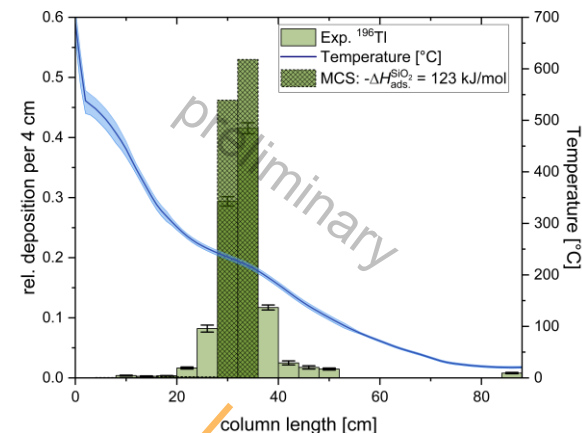
strongly bound thallium

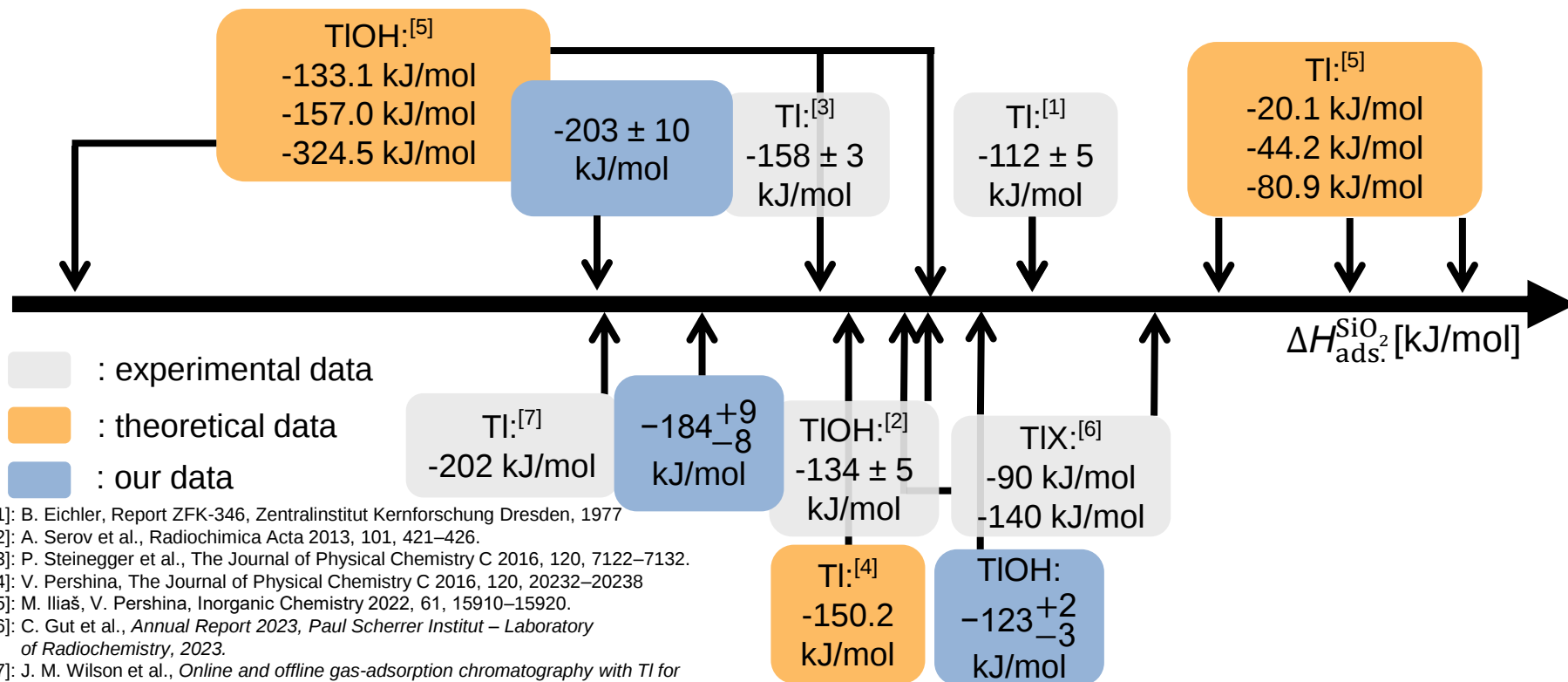
He + 20% O₂



thallium transported further down the column

100% O₂





- [1]: B. Eichler, Report ZFK-346, Zentralinstitut Kernforschung Dresden, 1977
 [2]: A. Serov et al., Radiochimica Acta 2013, 101, 421–426.
 [3]: P. Steinegger et al., The Journal of Physical Chemistry C 2016, 120, 7122–7132.
 [4]: V. Pershina, The Journal of Physical Chemistry C 2016, 120, 20232–20238
 [5]: M. Iliaš, V. Pershina, Inorganic Chemistry 2022, 61, 15910–15920.
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Thank you for your attention