



# Reactivity of polonium towards quartz surfaces

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# Towards chemistry with livermorium

1 1A H Hydrogen	2 2A He Helium																	18 VIII A
3 Li Lithium	4 Be Beryllium																	10 Ne Neon
11 Na Sodium	12 Mg Magnesium	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 Lanthanides	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 Actinides	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	

■ SHE studied chemically

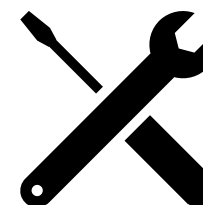
■ Focus of future studies

*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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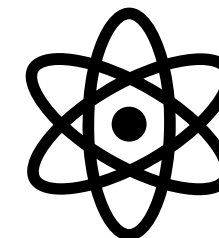
Mc and Nh studied recently<sup>[1]</sup>

Studying heavier SHE requires...



...Technical developments

➤ Unicell

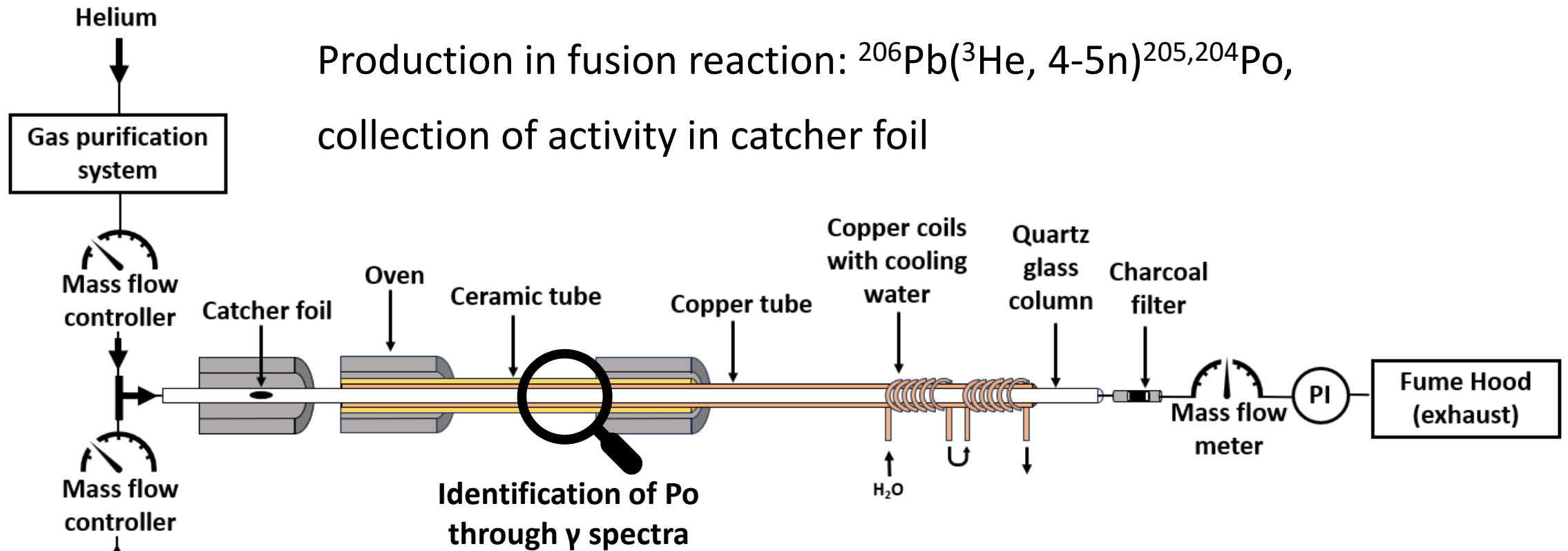


...Studying the chemistry of homologues

➤ Polonium, Astatine

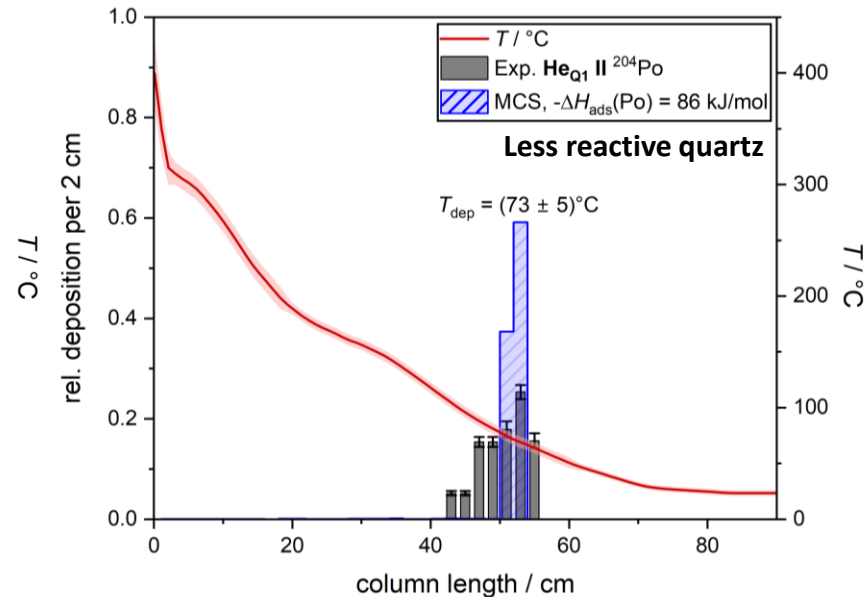
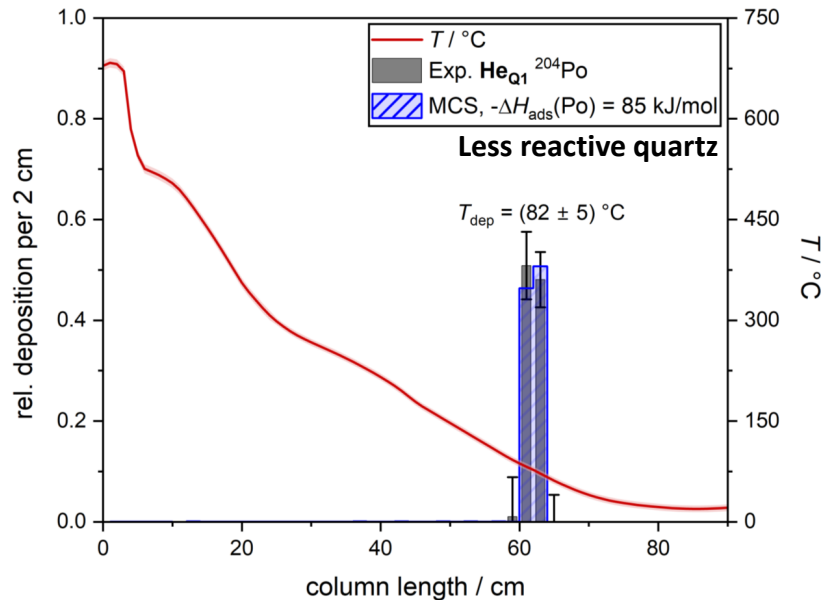
[1] A. Yakushev et al., *Front. Chem.* **2024**, *12*, 1474820.

# Studying Po at the atom-at-a-time regime

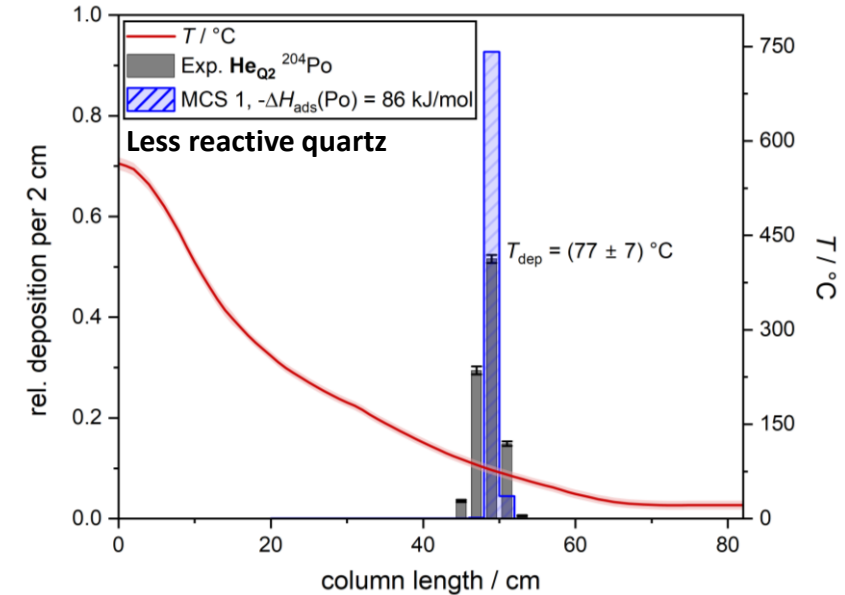


# Adsorption enthalpy of elemental polonium confirmed in multiple experiments

## On quartz glass produced in vacuum



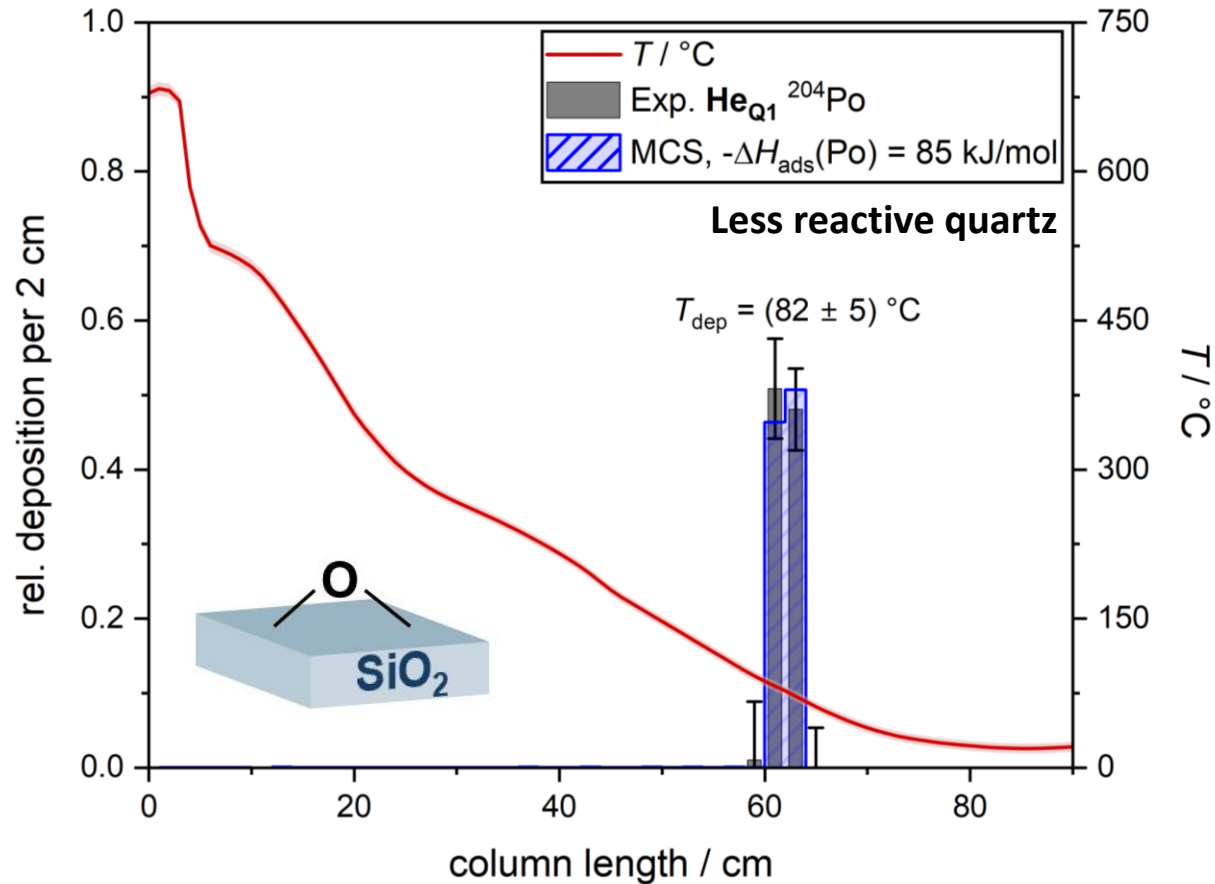
## On thermally treated quartz glass



- All experiments conducted in pure helium.
- Species is assigned to elemental polonium.

$$-\Delta H_{\text{ads}}(\text{Po}) = 85^{+3}_{-2} \text{ kJ/mol}$$

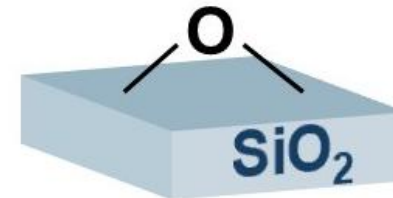
# Unravelling the influence of the quartz surface



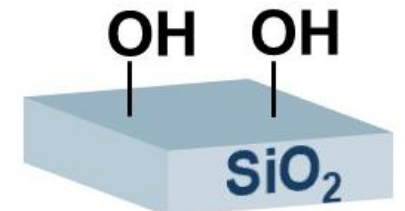
Quartz surface reactivity is not constant:[2]



Can be reversed by high temperature treatment



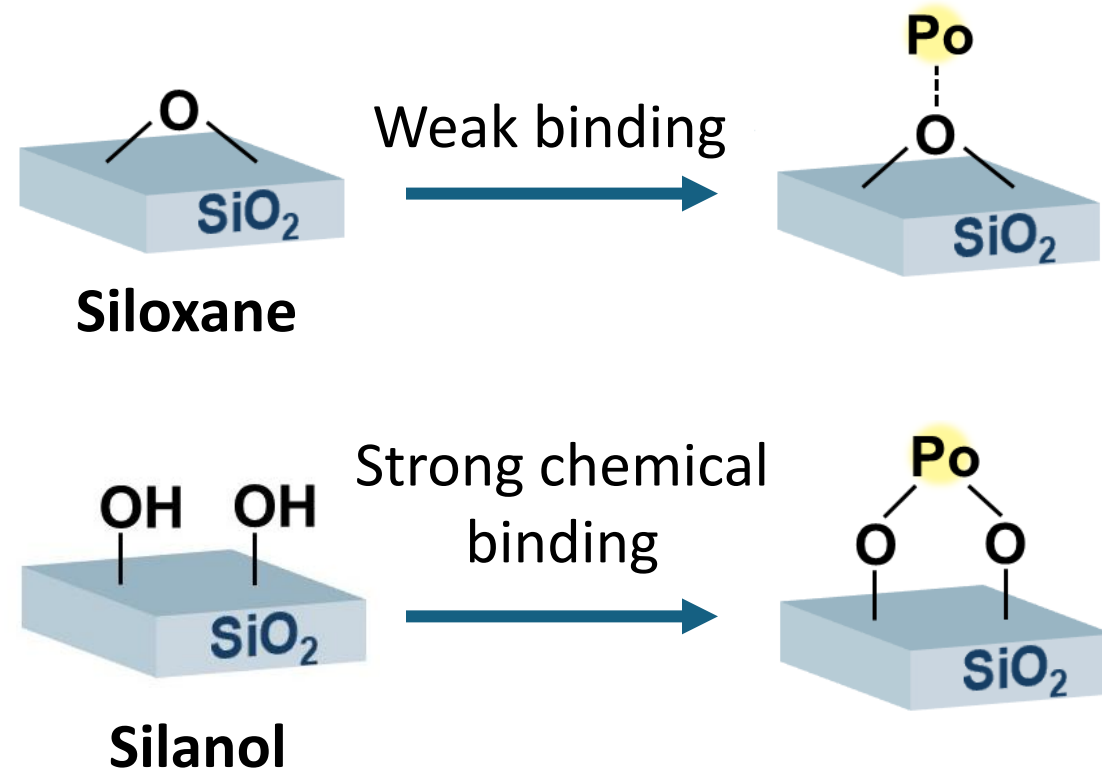
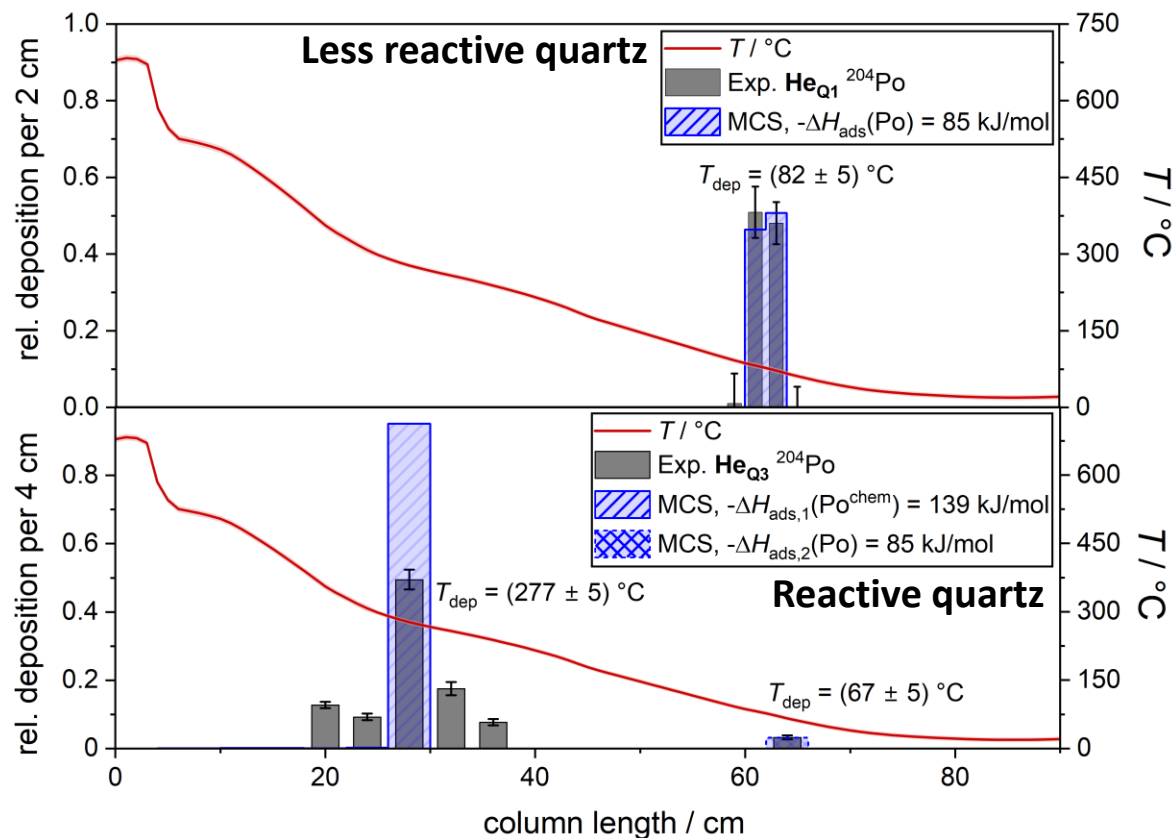
Siloxane



Silanol

[2] J. E. Shelby, *J. Non-cryt. Solids* **1994**, 179, 138-147.

# Unravelling the influence of the quartz surface

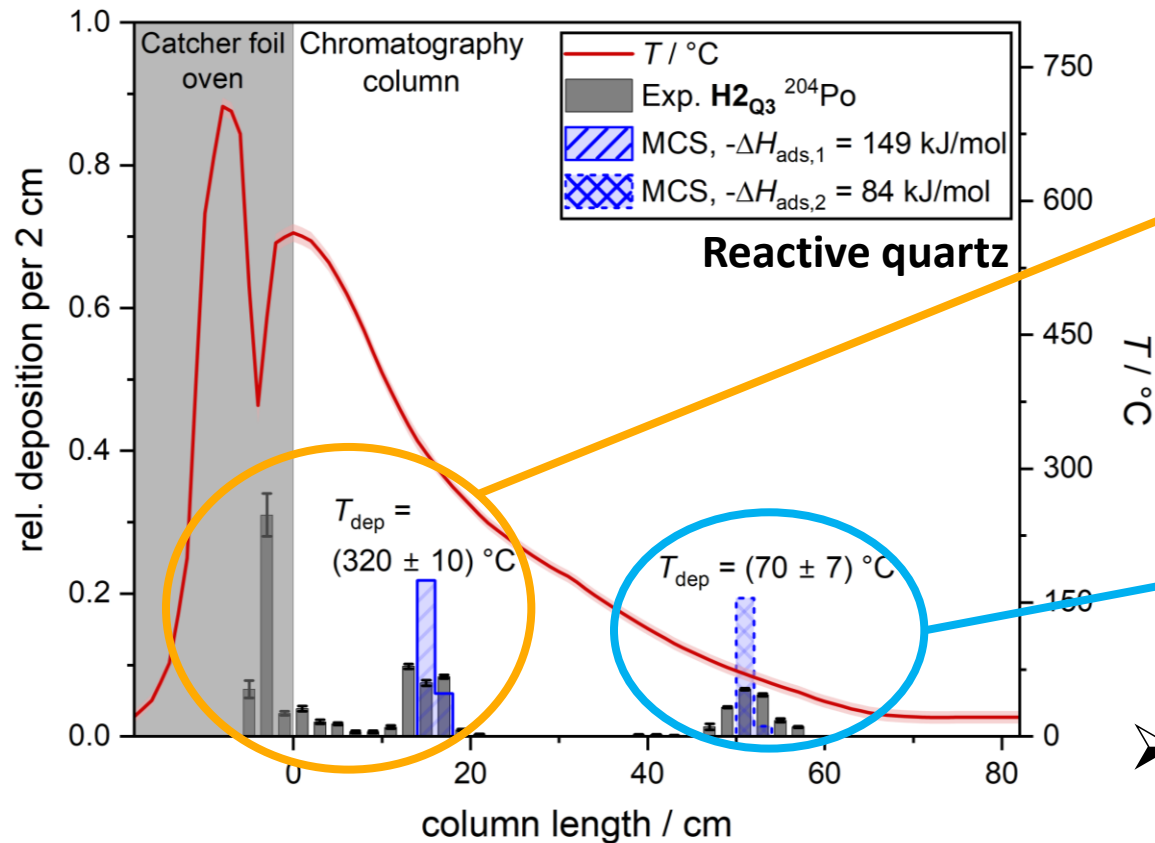


➤ Has been observed for Co on hydroxylated  $\alpha\text{-Al}_2\text{O}_3$ .<sup>[3]</sup>

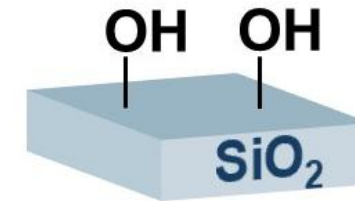
[3] S. A. Chambers, *Science* **2002**, 297, 827-831.

# No experimental evidence for reaction of polonium with hydrogen

## Hydrogen atmosphere, reactive quartz



Chemical reaction with the surface

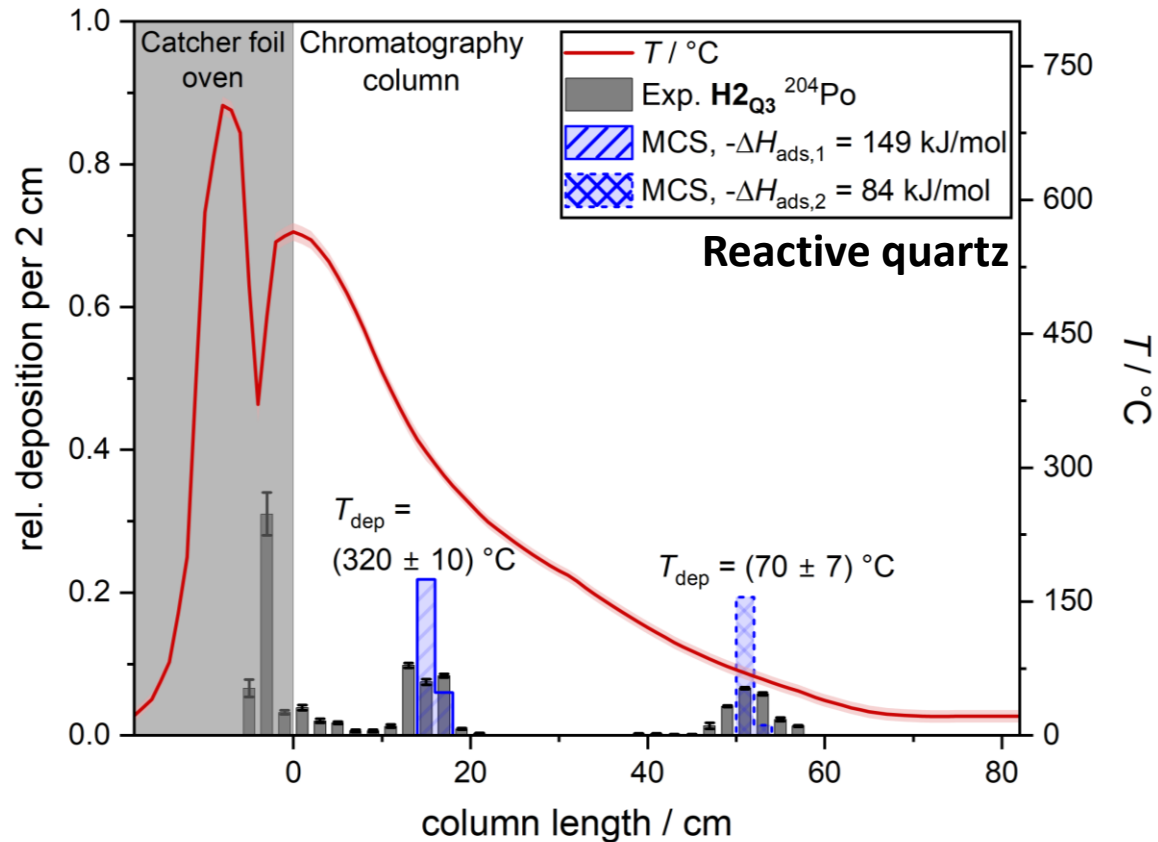


Deposition of elemental polonium

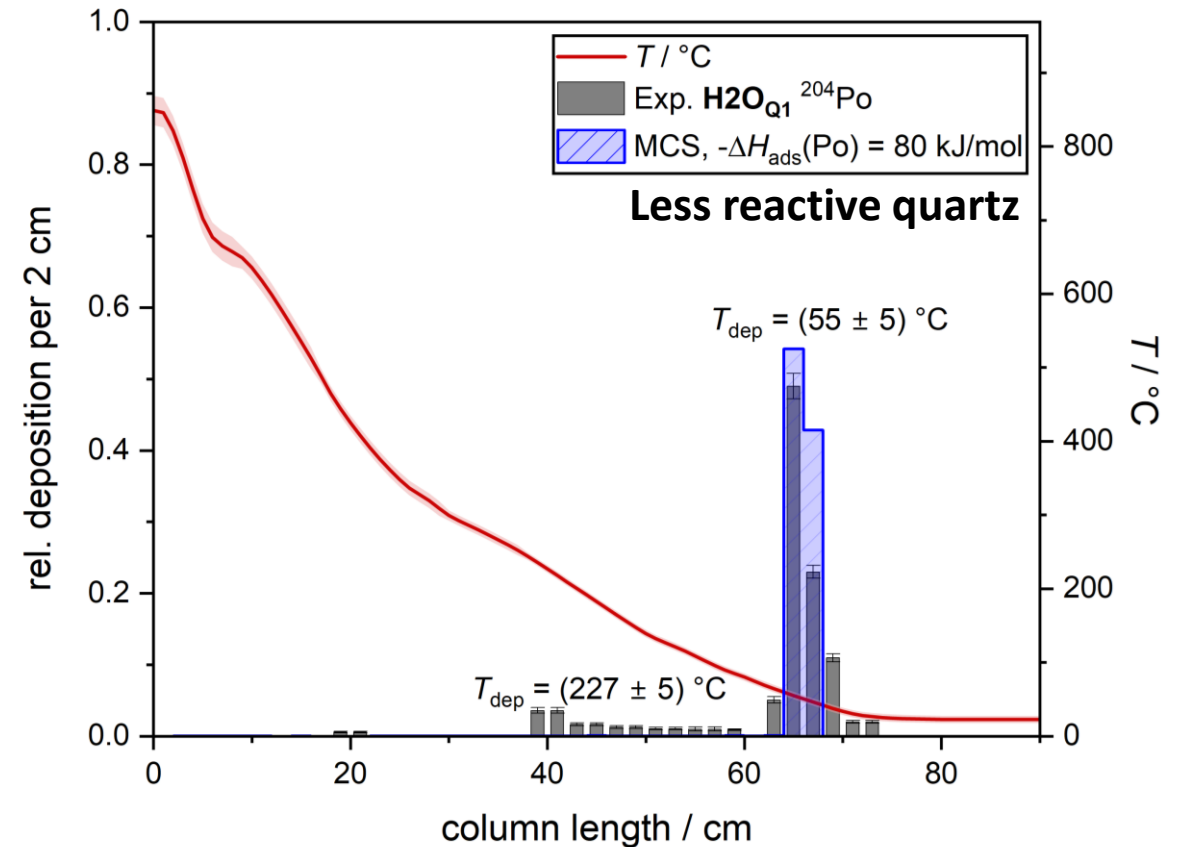
➤ No additional species observed in hydrogen

# No experimental evidence for reaction of polonium with hydrogen and water

## Hydrogen atmosphere, reactive quartz

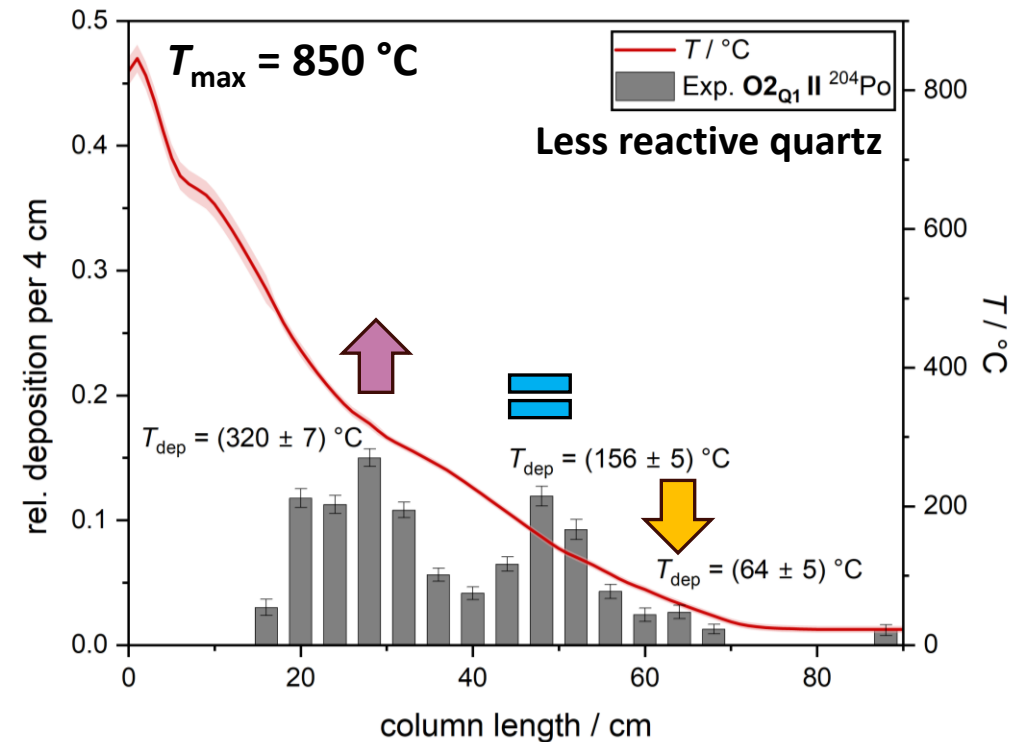
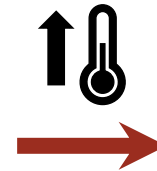
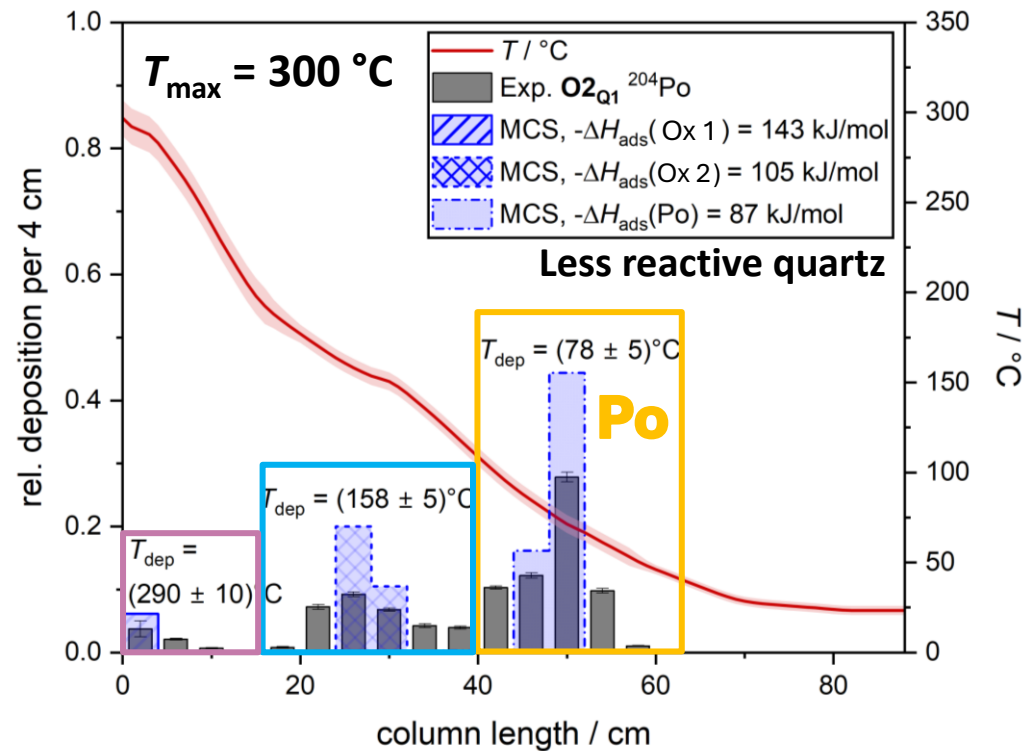


## Moist atmosphere, less reactive quartz





# Reactions of polonium with oxygen



➤ Two oxidized species involved.

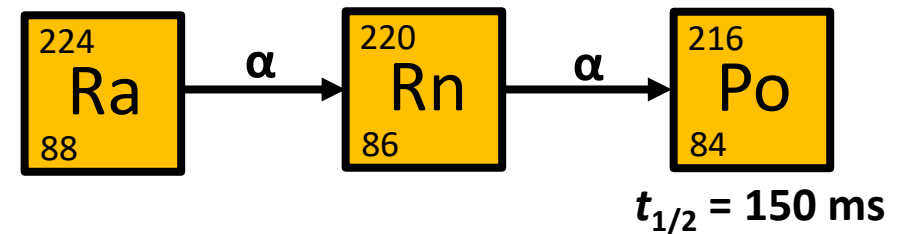
➤ Signs of chemical reaction!

# Summary and outlook

- Elemental polonium ( $-\Delta H_{\text{ads}}(\text{Po}) = 85^{+3}_{-2}$  kJ/mol) was the most volatile species observed.
- The reactivity of the quartz surface is decisive.
- No observation of a reaction of polonium with hydrogen or water.
- Two oxygen-containing polonium species detected in oxygen atmosphere.

**Experiments suggest to study livermorium in the elemental state, in agreement with theory**

**Transition to experiments with short-lived  $^{216}\text{Po}$**





# Thank you for your attention!