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Polyvinyltriazole (PVT)-functionalized SWCNT ink for printed Arsenic (III) chemistors for drink water monitoring applications

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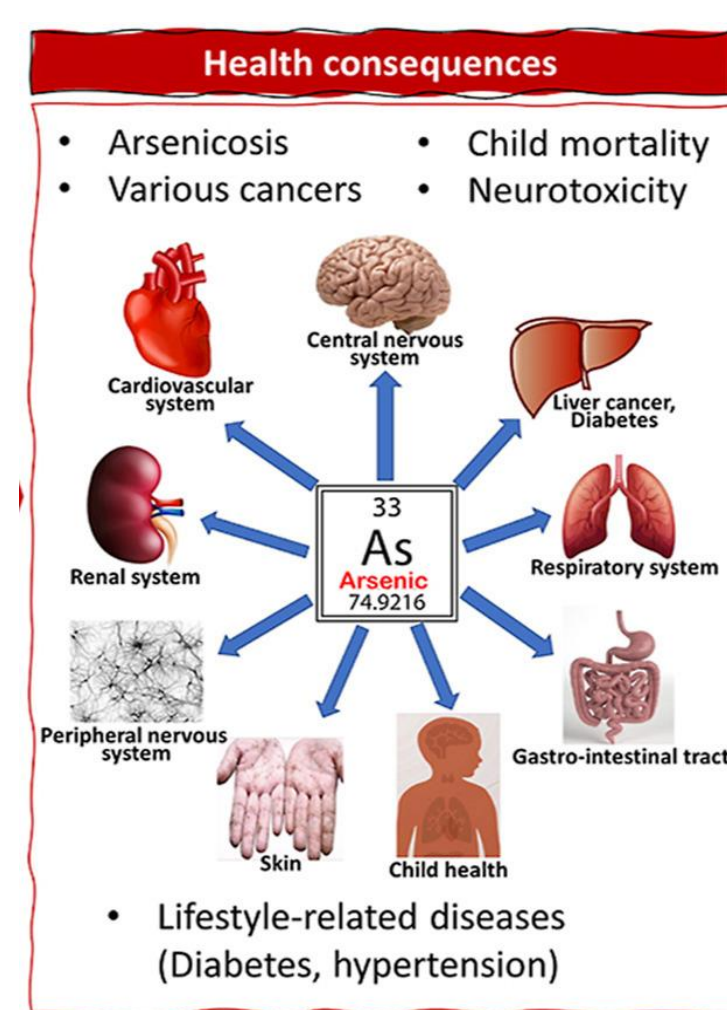
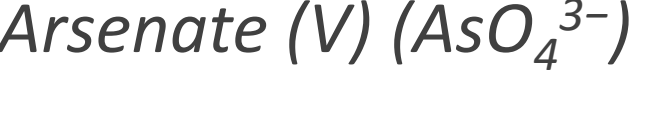
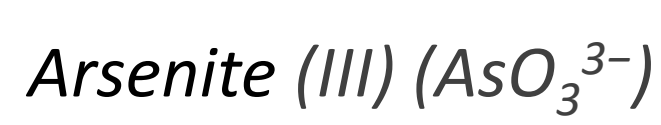
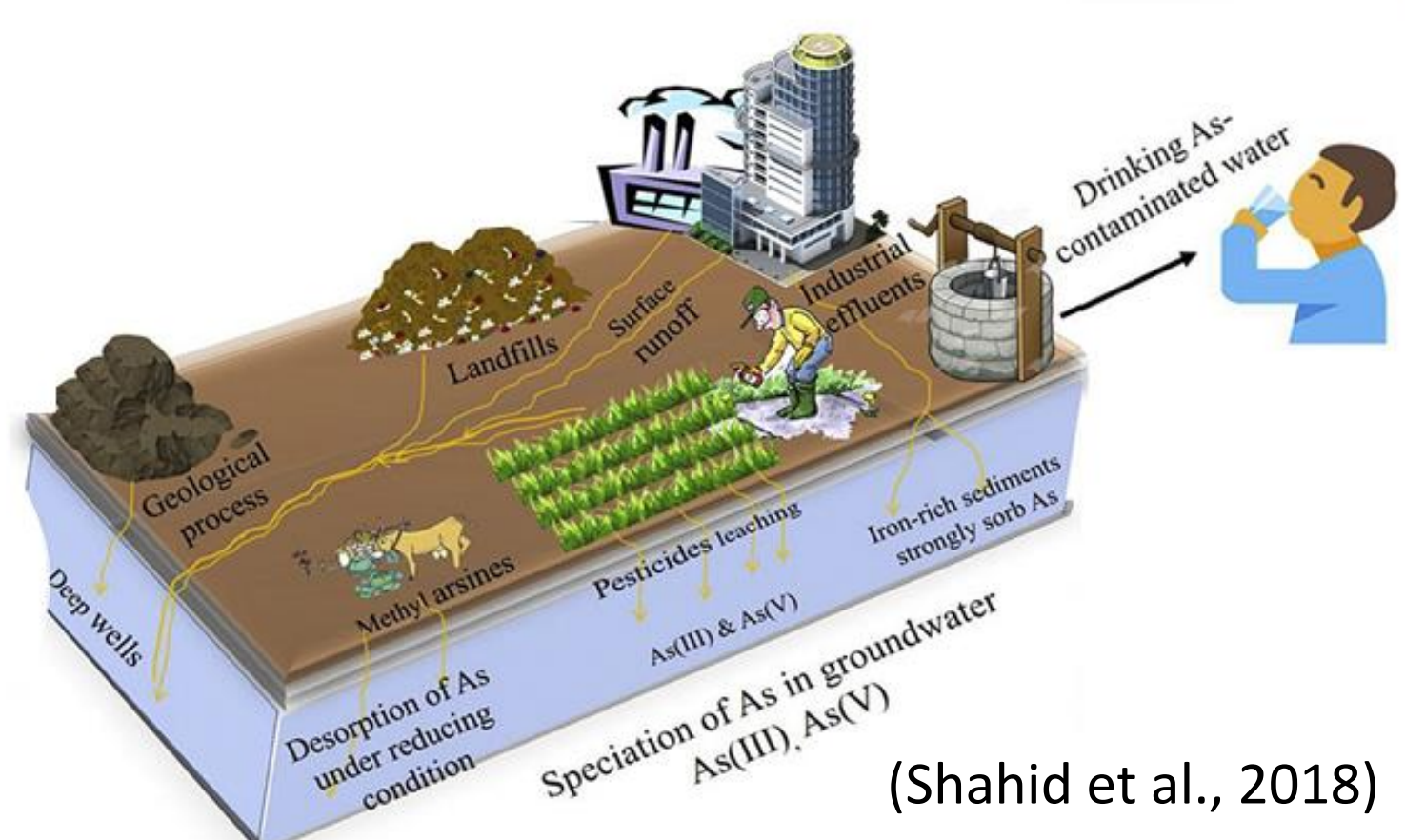
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1. Arsenic in water and Toxicology

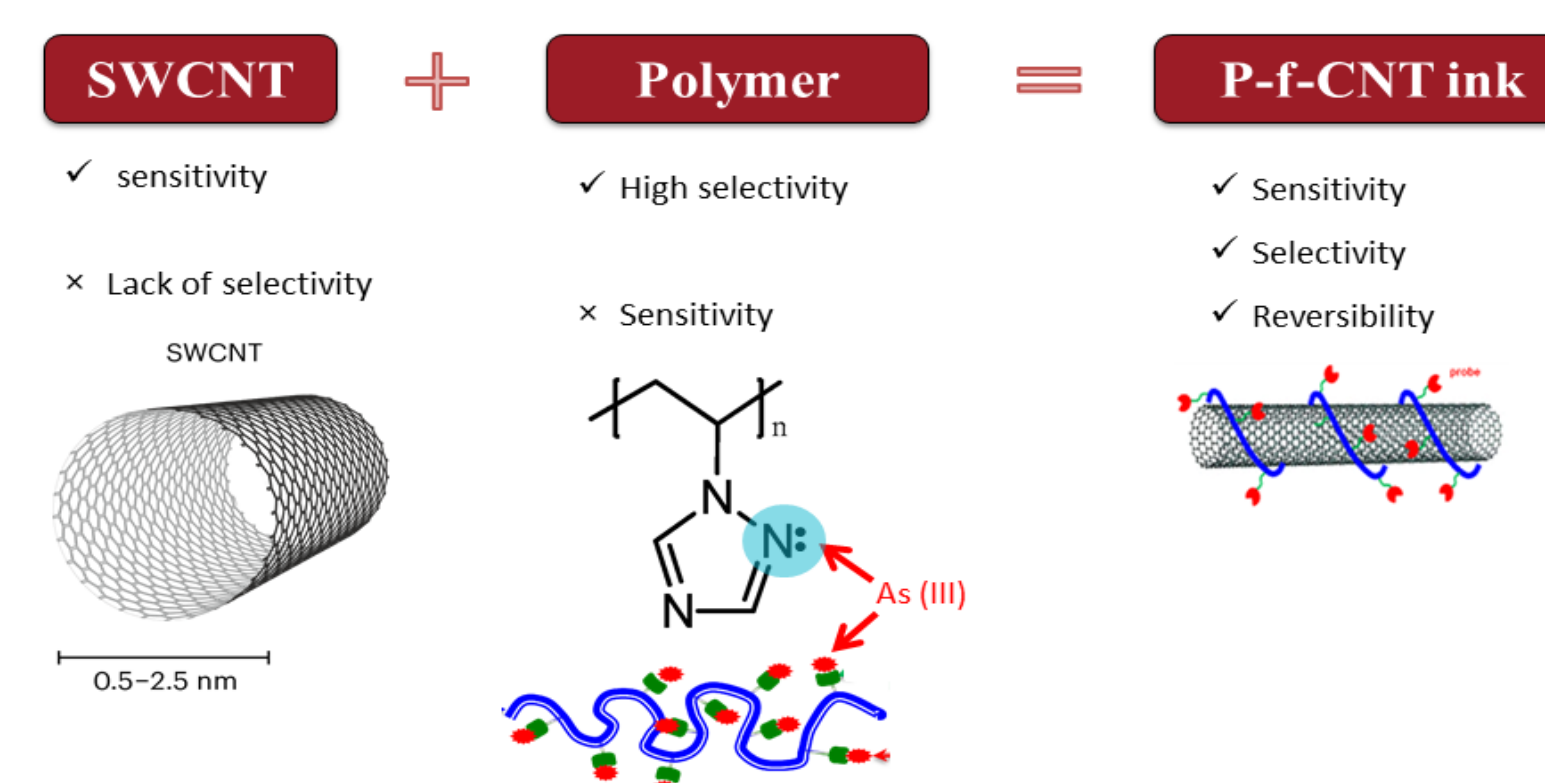
- ✘ Arsenic: **top twentieth** abundant element on Earth
- ✘ **WHO** drinking water quality guidelines: maximum **10ppb**



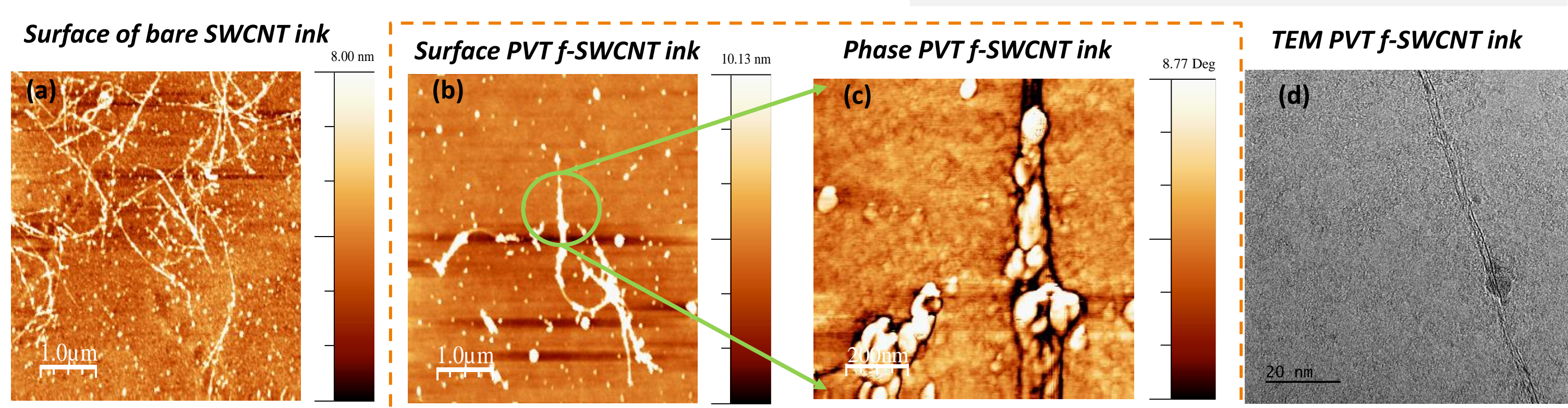
(Rahaman et al., 2021)

(Shahid et al., 2018)

2. PVT functionalized ink and chemoresistive transduction

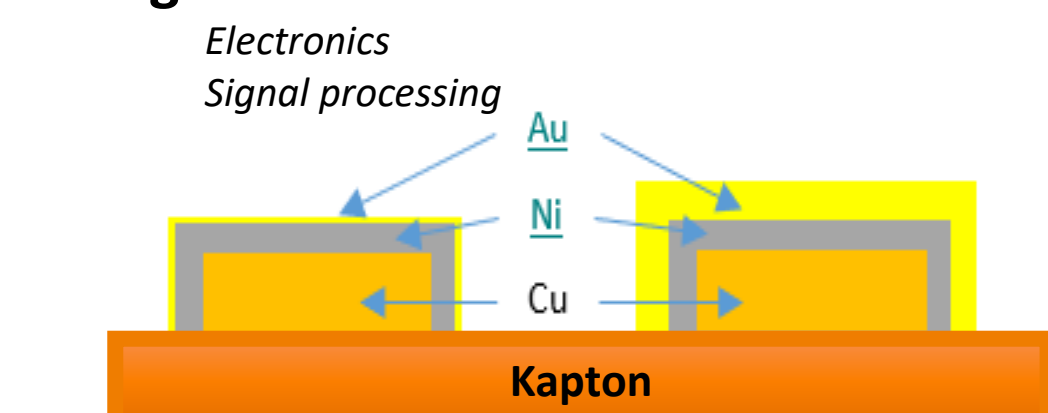


- ✘ The Triazole group ($C=N-N$) present in the PVT molecule has an affinity for the As (III) ions
- ✘ That affinity has been used to obtain the chemoresistive transduction

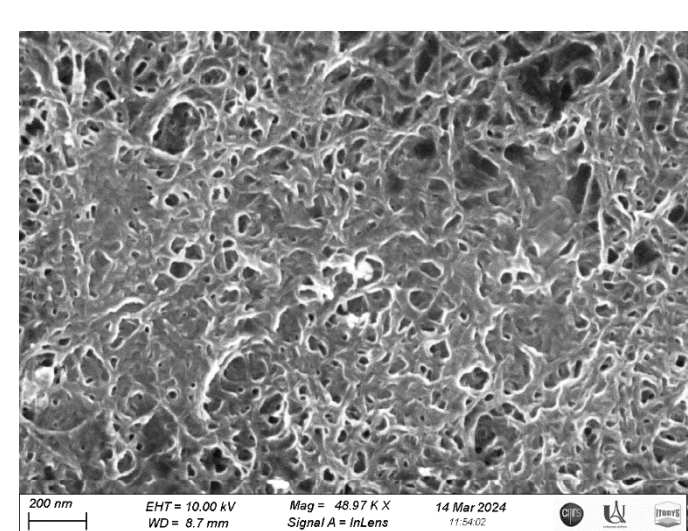


3. 1. Chemoresistive device (chemistors) fabrication

Straightforward device structure



Scan for IDP demonstration



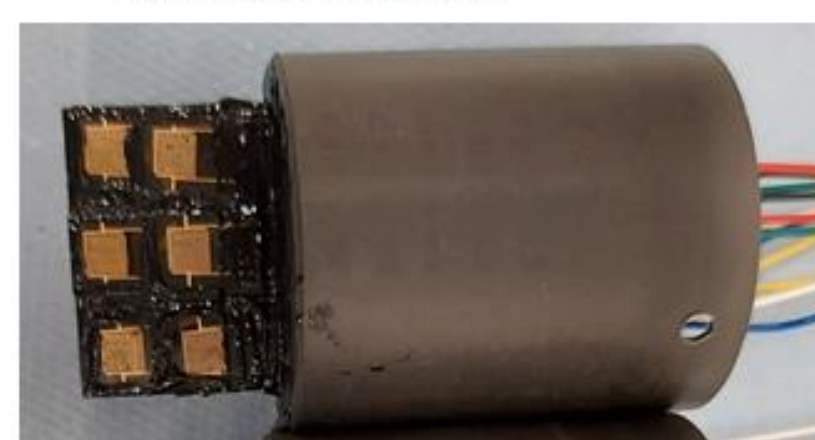
- ✘ Chemistors operate on the principle of **chemoresistive** sensing, where changes in **electrical resistance** are measured

- ✘ PVT functionalized ink deposited on interdigitated electrodes by ink dispersion printing (IDP) using the KELEN DMD 100

- ✘ The SEM morphology of the fabricated chemistors showed the well oriented SWCNT network on the surface of the interdigitated electrode

3. 2. Assembling to the prototype sensor and excitation

Prototype version



Analog Front End (AFE)

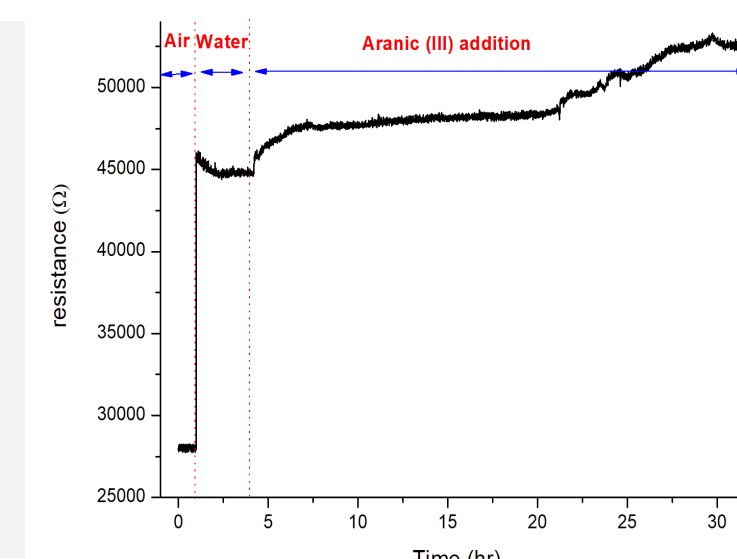


GUI

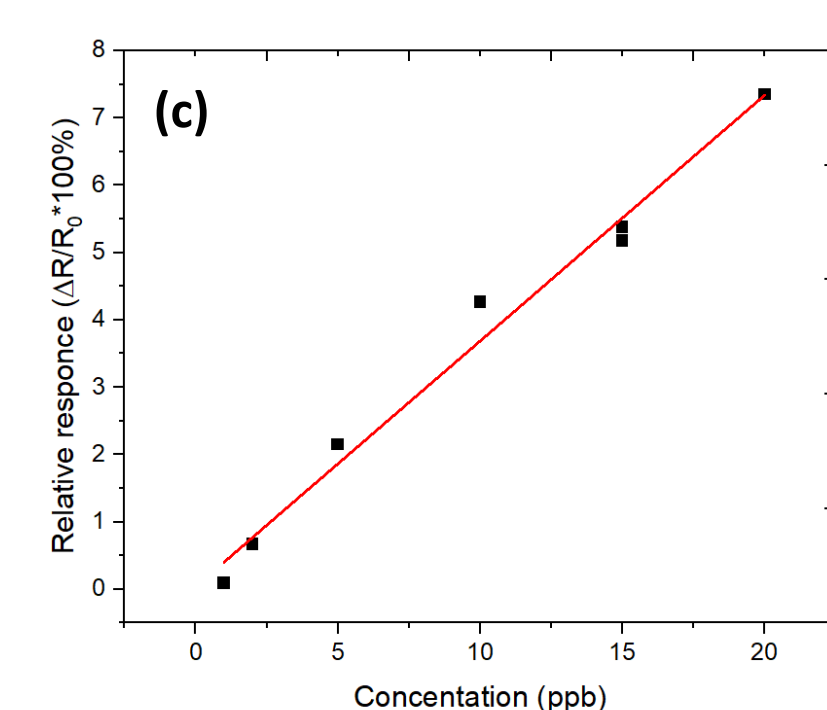
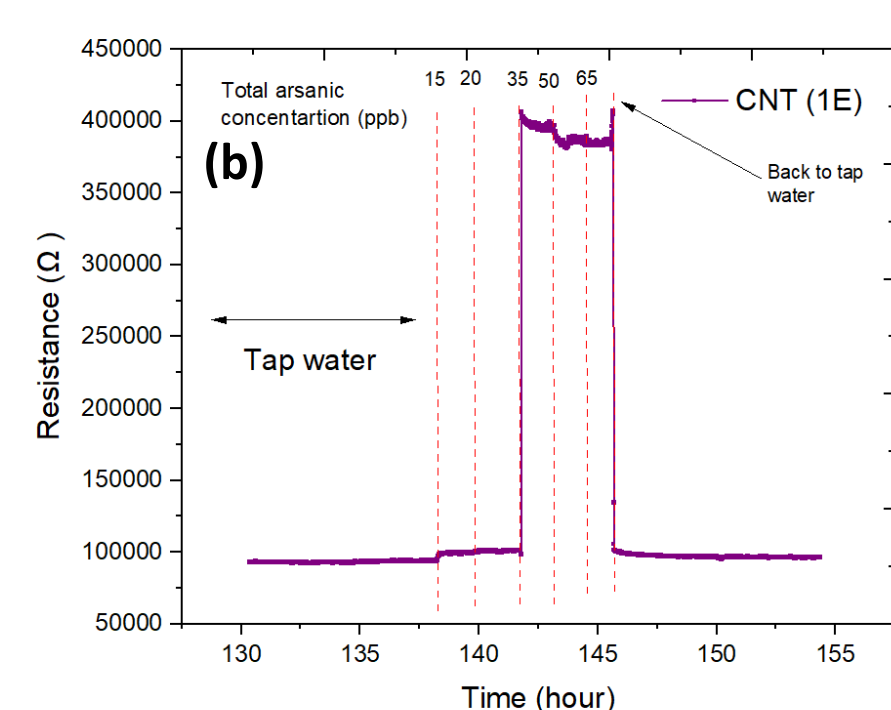
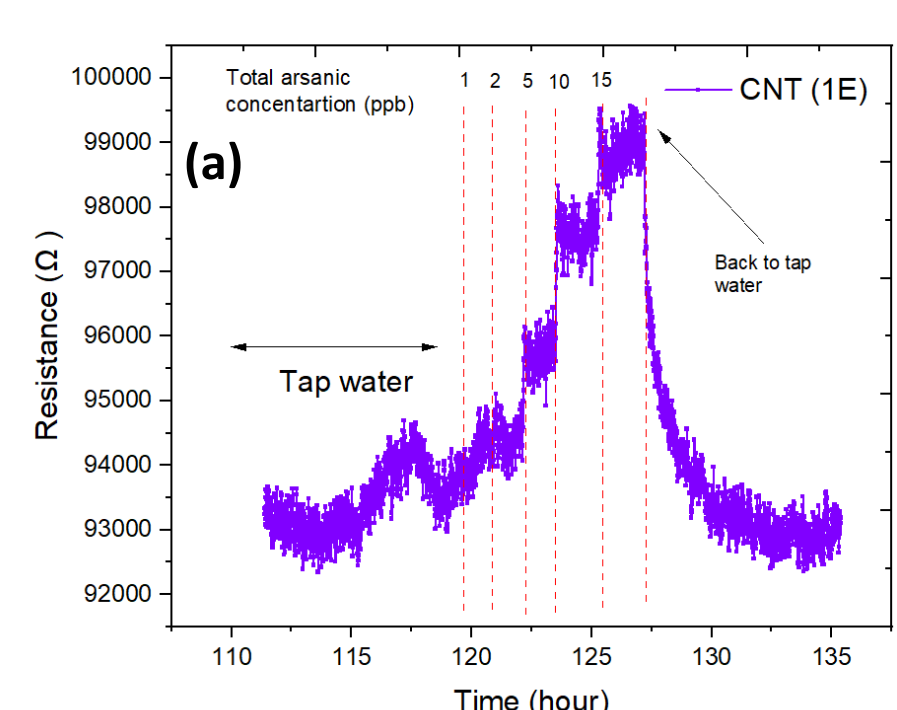


- ✘ 2 SWCNT chemistors
- ✘ 2 PVT-118 functionalized chemistors
- ✘ 2 Polyfluorene based polymer functionalized chemistors

- ✘ **Square wave** used for the excitation with a duty cycle of 50
- ✘ **1.28 μA** used for the excitation



3. 3. Pristine SWCNT chemistors (reference) response



$$\frac{\Delta R}{R_B} \% = \frac{(R_m - R_B)}{R_B} * 100\%$$

R_m = measured resistance (Ω)

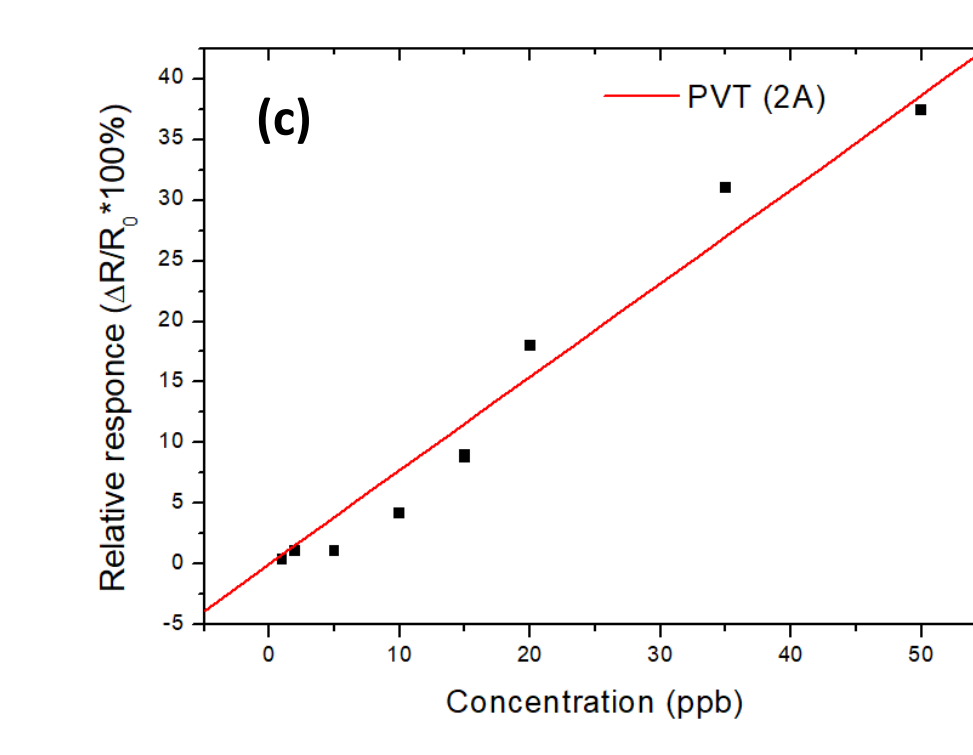
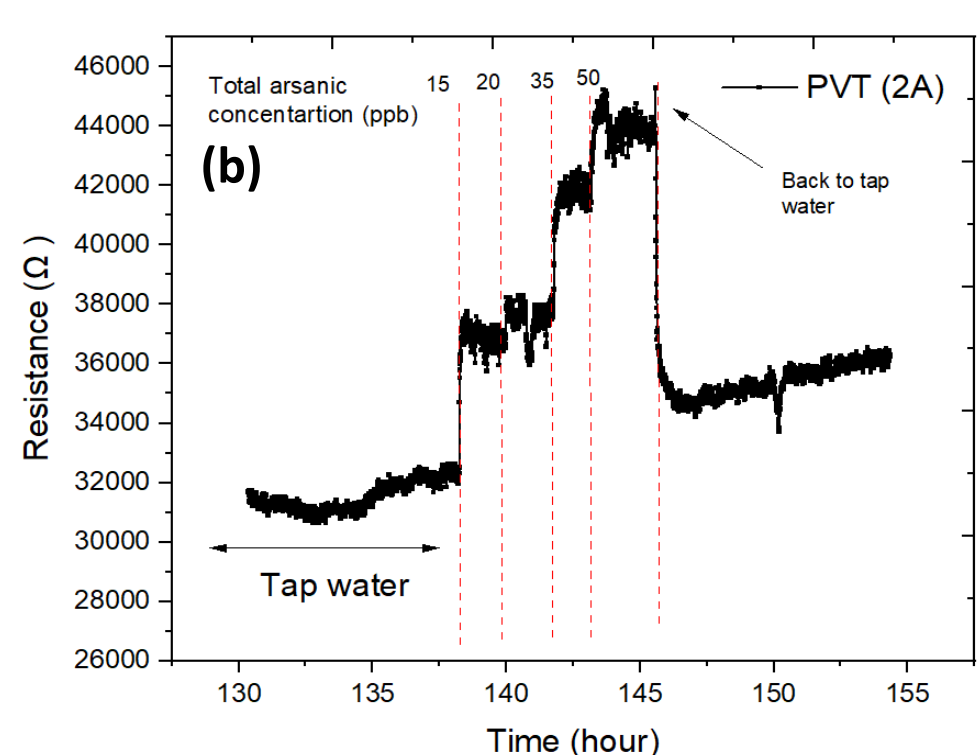
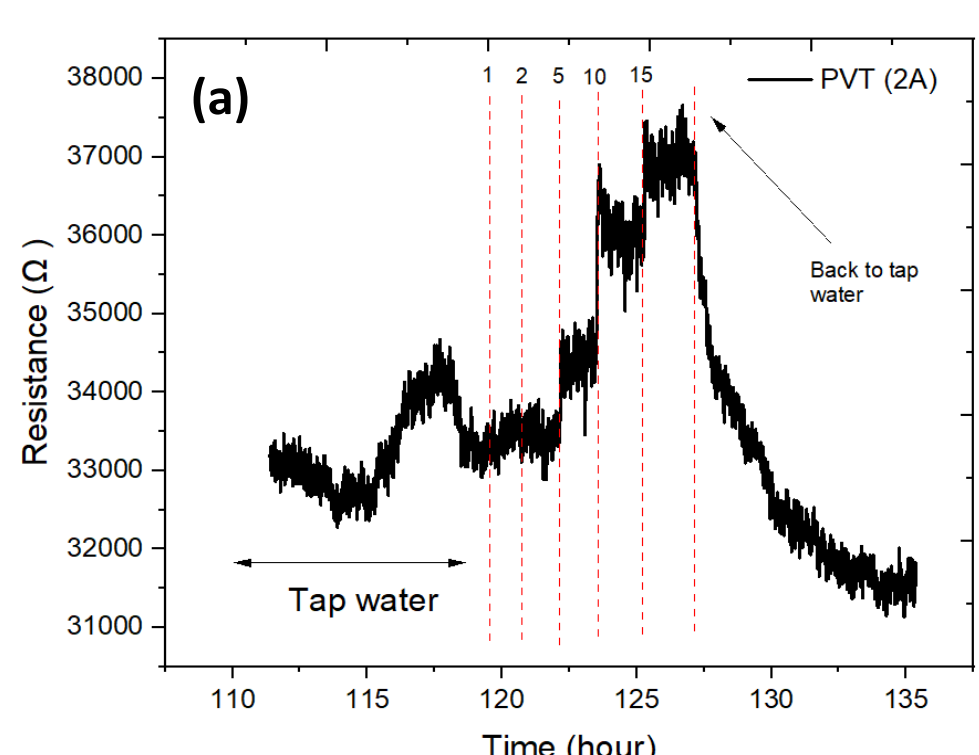
R_B = Baseline resistance (Ω)

- ✘ After 20ppb SWCNT sensor response saturated at 400k Ω

- ✘ From 1ppb to 20ppb sensor response is recognized as linear

- ✘ Up to 20ppb, **0.33% / ppb** and r^2 is **0.98**

3. 4. PVT functionalized SWCNT chemistor response variation

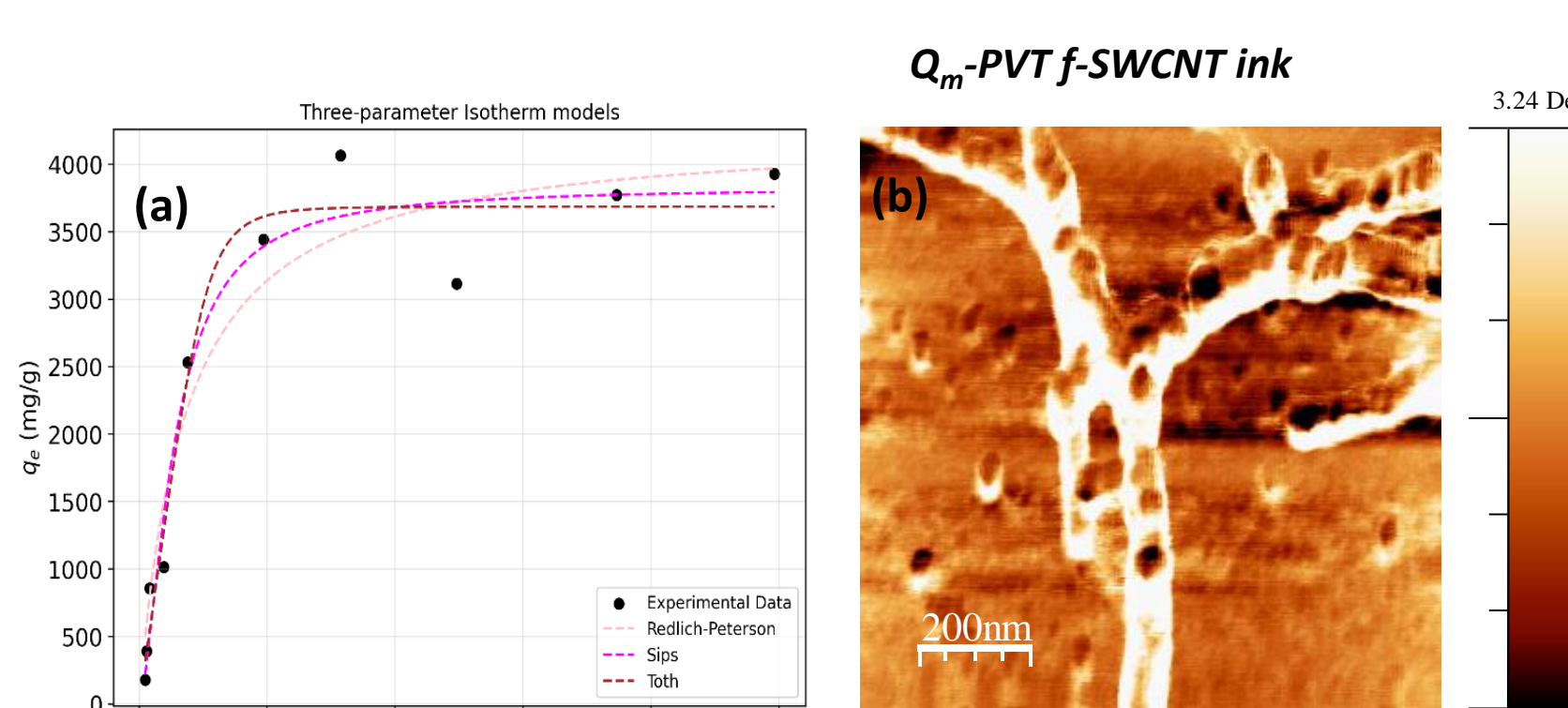


- ✘ From 1 ppb to 65 ppb of As (III) addition, the sensor shows a linear response

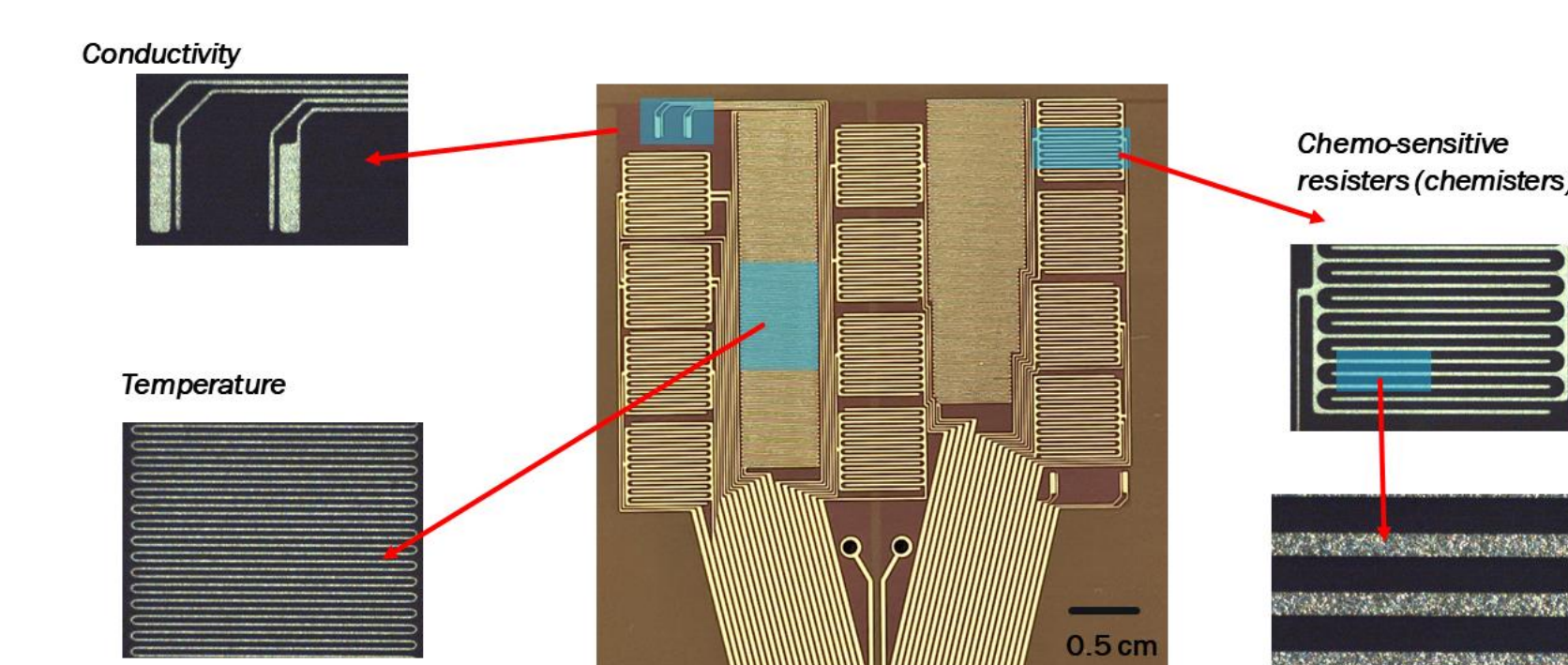
- ✘ After 65ppb, the sensor does not shows a linear response

- ✘ Linear regression slope is **0.77% / ppb** and r^2 is **0.98**

3. 5. Future perspectives



- ✘ The adsorption capacity of multilayer PVT for SWCNT was determined using adsorption isotherm analysis
- ✘ Experimental data are well established for the **Toth isotherm** model and the maximal surface coverage (Q_m) is **3684.54 mg/g** and r^2 is **0.96**



Dispositif pour l'analyse d'un fluide comprenant une portion de conductivité (EU Patent, 2023)

Dispositif pour l'analyse d'un fluide comprenant une tête de sonde (EU Patent, 2023)

- ✘ The LOTUS printed circuit board (PCB) will be used for the future characterization experiments
- ✘ It consists of 12 chemistors, 2 temperature sensors and 2 conductivity sensors
- ✘ Based on the Q_m calculations different stoichiometries will be further investigated to obtain the best sensitivity
- ✘ A pH and chlorine sensor will be integrated into the LPCB platform

4. Conclusion

- ✘ **PVT f-SWCNT** chemistor offers a **MLOD of 5ppb** in tap water with the presence of the active chlorine (ClO^-) along with the minor impurities of other ions (Na^+ , Ca^{2+} , Mg^{2+} , etc.)
- ✘ **PVT f-SWCNT** chemistor showed a dynamic range of 5 to 50 ppb, sensitivity of **0.77% / ppb** with reversibility
- ✘ SWCNT chemistor used as a reference sensor to compare the performance improvements due to functionalization, exhibited a dynamic range of 1 to 20 ppb with a sensitivity of **0.33% / ppb**

5. Acknowledgement

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6. Bibliography

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G. ZUCCHI et al., 'Chemical sensors based on carbon nanotubes functionalised by conjugated polymers for analysis in aqueous medium', US11697707B2, Jul. 11, 2023 Accessed: Sep. 06, 2023. [Online]. Available: <https://patents.google.com/patent/US11697707B2/en>