Engineering Biomimetic Materials for Synthetic Antibody Sensors in Cardiovascular Diagnostics

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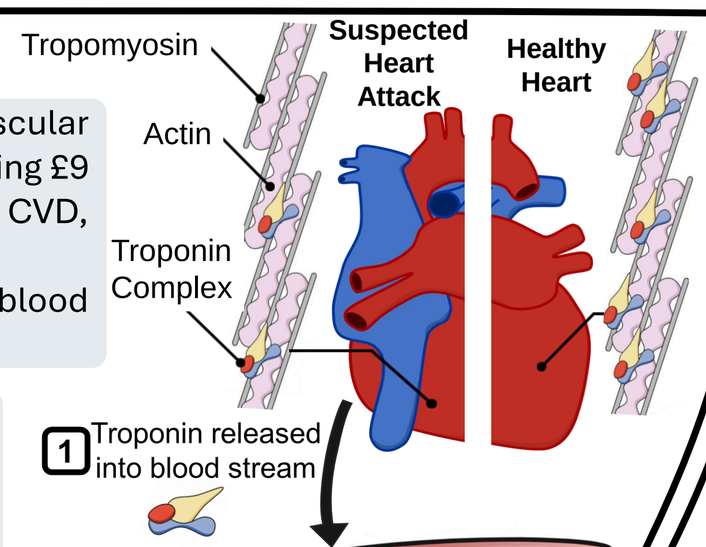
Priority Topic Area: **Food, Health and Well-being**

1 – Justification

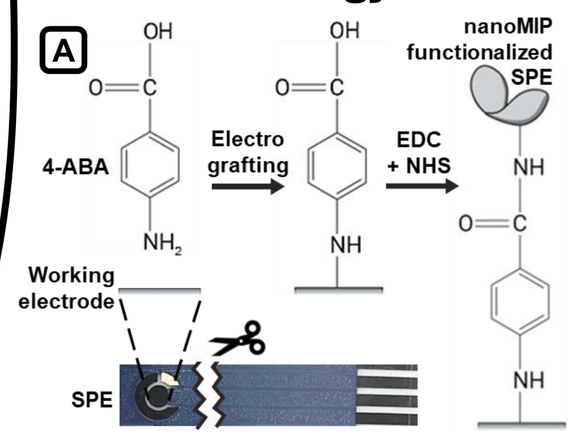
Within the UK, around 7.6 million people live with cardiovascular diseases (CVDs), responsible for 25% of all deaths and costing £9 billion annually [1]. Heart attacks (HAs) are a common CVD, characterized by heart tissue damage.
Troponin I (cTnI), a cardiac biomarker, is released into the blood during HAs and can indicate this damage [2].



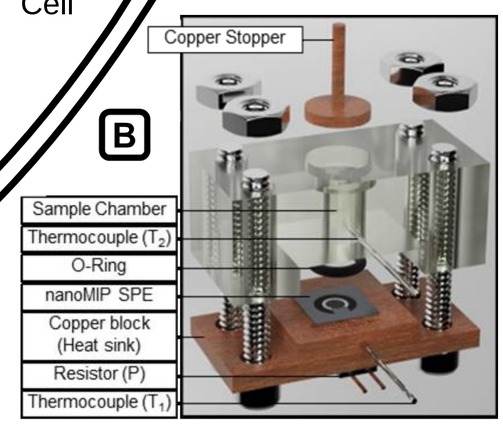
Molecularly imprinted polymer nanoparticles (nanoMIPs) are synthetic antibodies that rival the affinity of their natural counterparts. Unlike biobased receptors, they are:

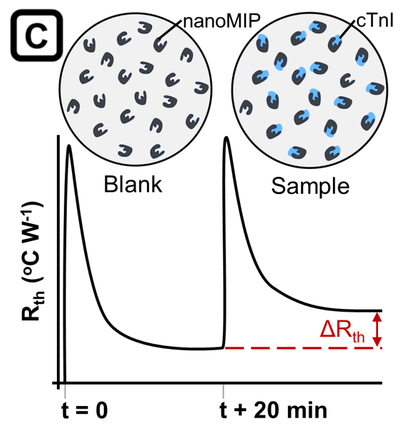
- **highly versatile**, adaptable to detect almost any target.
- **extremely stable**, do not require temperature-controlled storage and show extended shelf life.
- **animal free** technology.

2 – Methodology



Screen-printed electrodes (SPEs) formed the sensor base, nanoMIPs were functionalized onto the SPEs' surface via **(A)** and placed within a microfluidic cell **(B)**.



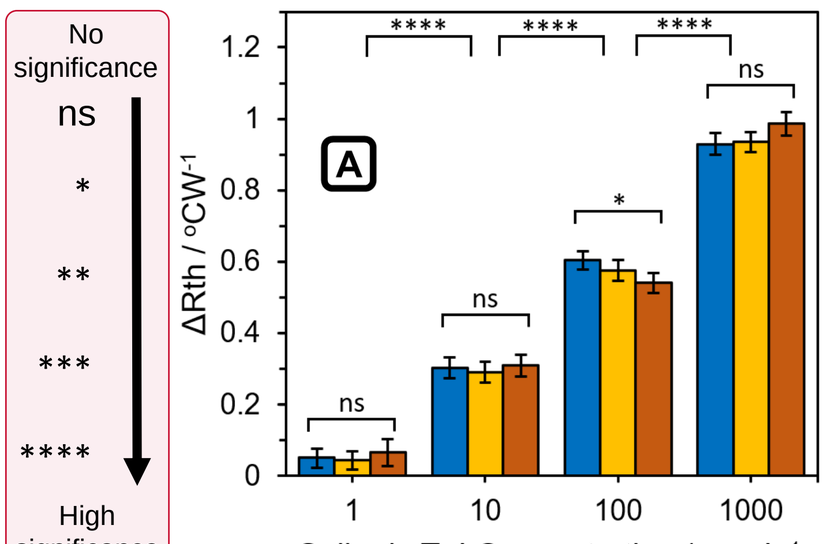


This approach measures thermal resistance (R_{th}) between two probes, mimicking in vivo conditions using a heat sink (T_1) maintained at 37°C. The sample temperature (T_2) is measured, and R_{th} is calculated.

Each run utilized two samples **(C)**: a blank, to provide baseline R_{th}, followed by a spiked or patient sample, containing elevated cTnI. The change in resistance (ΔR_{th}) establishes the cTnI concentration, with higher cTnI levels providing greater insulation, resulting in a larger ΔR_{th}.

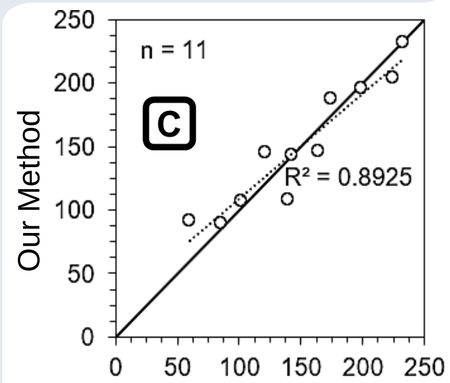
3 – Results

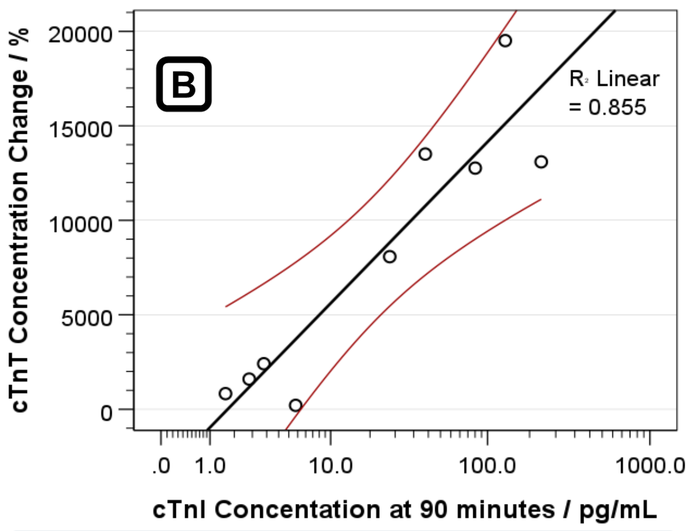
Detection of spiked cTnI was carried out in serum, plasma, and interstitial fluid (ISF) samples **(A)**. The nanoMIP approach effectively identifies concentrations between 1–1000 pgmL^{-1} with high statistical significance.
This suggests a limit of detection of ~1 pgmL^{-1}, this is acceptable due to the 99th percentile for a healthy individual to be at 40 pgmL^{-1} (0.51°CW^{-1}).
This makes our method highly competitive with high-sensitivity devices, while requiring only 20 minutes instead of over 2 hours to obtain results.



Detection was subsequently performed on blood serum from HA patients, providing insight for clinical use. Our cTnI results were then compared to a patient database containing other variables, such as Troponin T, another cardiac biomarker **(B).**

Excellent, statistically significant correlations were observed, suggesting that our method can effectively estimate the severity of the HA suffered confirming its applicability.





A comparison was then performed against the current "gold stand" ELISA **(C)**. Excellent agreement was observed between the two methods for patients with the highest and lowest cTnI levels.

4 – Benefit to society

A synthetic antibody sensor using nanoMIPs has been developed to accurately detect cTnI concentrations in patient samples, both rapidly (20 min) and at low-volume (60 µL), offering environmental stability, simplicity, and cost-effectiveness.

This methodology could therefore be applied to create a portable device for point-of-care detection, giving first responders and clinicians instantaneous information before patients present to A&E.
Allowing for better informed decisions for chest pain assessment and further treatment, improving patient outcomes and reducing NHS costs.

5 – Next steps

We will trial our portable device with NHS partners and first responders, including a case study with more patient samples.
Finally, discussions with our SME and industrial partners will continue to optimize our device for alternative settings, with interest from the food manufacturing industry for Salmonella and E. coli testing.

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References/Acknowledgements

[1] Stepinska, J et al., 2020. Diagnosis and risk stratification of chest pain patients in the emergency department: focus on acute coronary syndromes. Association. Eur. Heart J. Acute Cardiovascular Care.
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I would like to thank both Professor Marloes Peeters and Dr Jake McClements for their supervision and guidance throughout this work. As well as Professor Ioakim Spyridopoulos and the Newcastle NHS Trust for their help in providing patient samples.

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