Cluster decorated functional DNA origami based biosensor: Towards Safe Nano-innovations

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DNA origami based biosensor

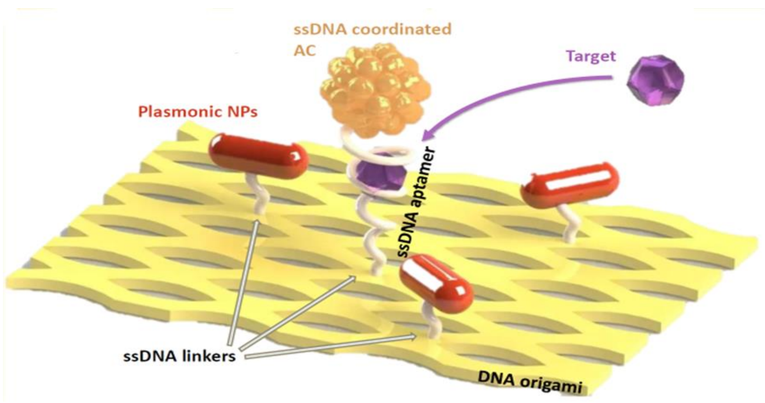


Figure 1. Cluster decorated DNA origami based biosensor

DeDNAed project intends to:

- Develop a **sensitive, versatile and ultrafast cutting-edge bioanalytical platform** by assembling and integrating sensing elements using DNA origami.
- **Use single-stranded DNA (ssDNA)** as "**solder**" to attach elements to DNA origami.
- Design and synthesize an appropriate DNA origami platform.
- Use atomic nanocluster decorated aptamer as bioreceptor elements for aflatoxin B1 detection and use atomic nanocluster decorated antibodies as bioreceptor elements.
- **Design appropriate plasmonic nanoparticles** for SERS and their surface functionalization.
- Integrate the DNA origami hybrids onto solid and flexible surfaces.
- **Integrate and validate** the DeDNAed SERS biosensor for potential application in the Biomedical and Food Safety sectors.

Aflatoxin B1 detection - A potent carcinogen

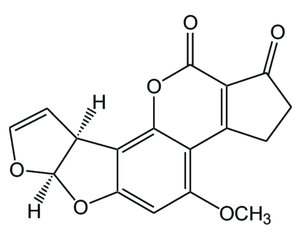


Figure 2. Aflatoxin B1 structure

- Detection of Aflatoxin B1 (AFB1)
- Most potent genotoxic and carcinogen mycotoxin
- Linked to hepatocellular carcinoma (HCC)
- High risk for grain mill workers
- Contaminant in food such as cereals
- MRL limits = 2 µg/kg in cereals

Nanomaterials in SERS readout strategies

- **Surface-enhanced Raman Scattering (SERS) enhancement**[1,2], **Raman hot spot,** is formed in the interparticle gaps of DNA origami functionalized with gold NPs specific spatial arrangement due to coupling of the surface plasmon resonance.
- However, nanocomponents' effects on humans and environment need to be studied using SbD actions during the product life-time.

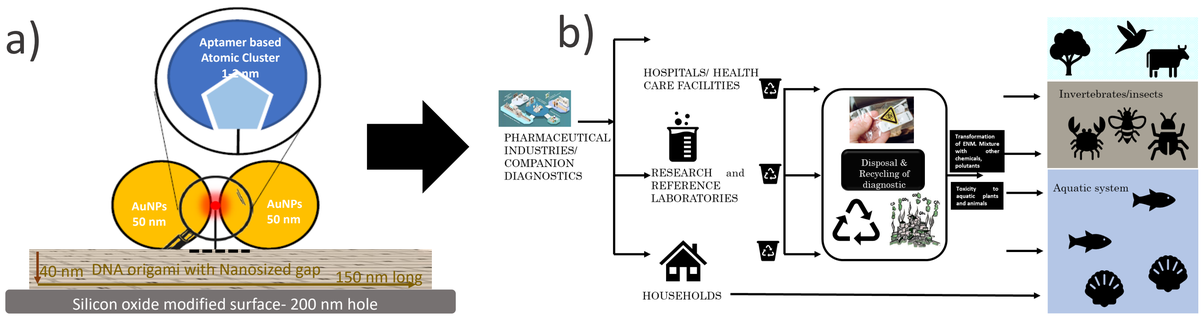
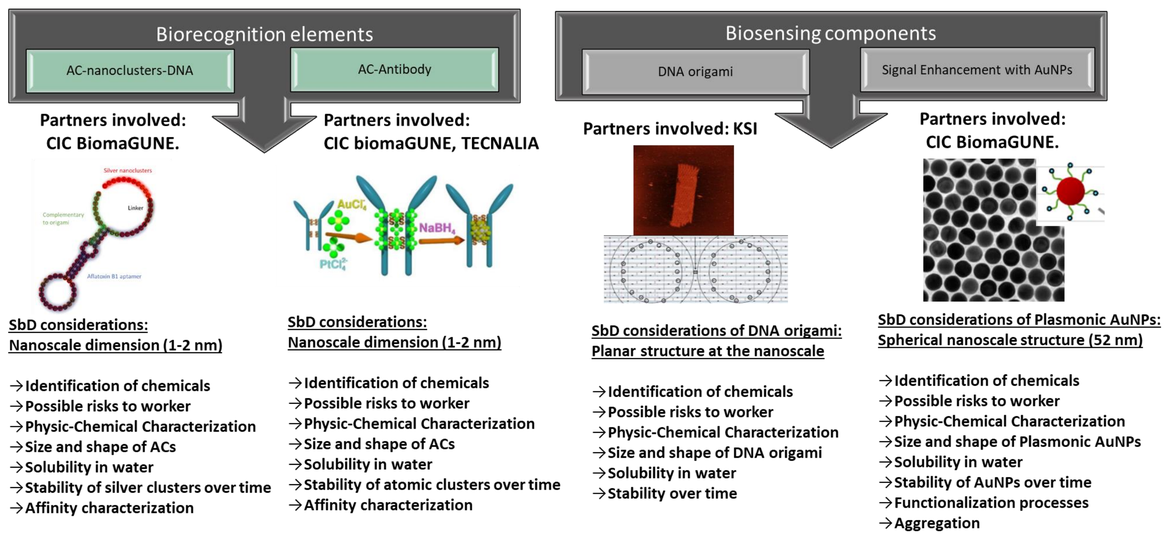


Figure 2. a) Integration of nanoscale components in DeDNAed biosensor and risks of nanoIVD devices life-cycle

Safe-by-Design actions



Risks of integrating nanoscale dimension materials:

Phase 1 design, synthesis of nanoscale dimension materials:

- **SbD assessment –** Several types of nanoscale materials are in development phase → Define complete Phys-Chem characteristics.

Phase 2- integration of nanoscale materials to DNA origami:

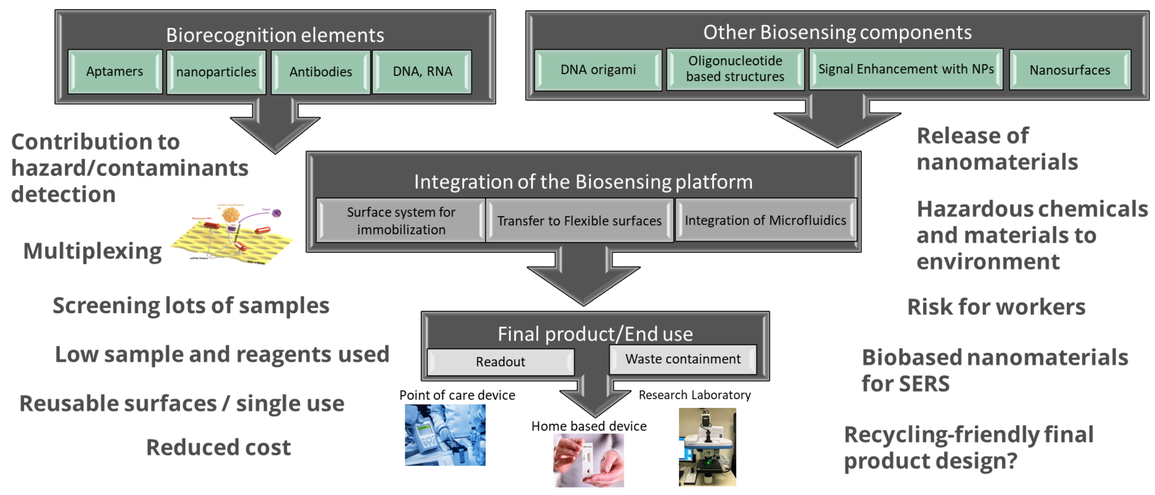
- **SbD assessment –** Integration of nanoscale materials to DNA origami surface by complementary short oligo → Size, shape, stability under consideration.

Phase 3 – integration of DNA origami hybrids on surfaces:

- **SbD assessment –** Integration of DNA origami hybrids to SiO_2 modified wafer (nanometer surface 200 nm holes), stability of DNA origami hybrids on surface and risk of release → Check stability of the oligos binding and risk of release.

Sustainability considerations

- Multiplexing consideration:
  SusbD consideration: detection of multiple analytes in one device.
- Environmentally friendly components:
  SusbD consideration: bio-based nanomaterials for SERS.
- Miniaturization: reduced reagents volumes and samples needed:
  SusbD consideration: lower cost in reagents and samples.
- Designing sustainable surfaces:
  SusbD consideration: recyclable, reusable and friendly design.



CONCLUSION

DeDNAed will foster a safer nano-enabled biosensor considering the Safe-by-Design approach and sustainability aspects[3]. Several nanocomponents are in the development stage such as atomic nanocluster-decorated aptamers and antibodies as well as DNA origami and gold NPs. Unique and novel properties and materials attributes need to be checked for unanticipated hazard or exposure behaviours. DeDNAed will define a preliminary hazard/risk assessment and control plans for the DNA origami biosensor nanocomponents.

[1] *J. Phys. Chem. Lett.* 2013, 4, 23, 4140–4145. DOI: https://doi.org/10.1021/jz402076b.
[2] *Nat Commun* **5**, 3448 (2014). https://doi.org/10.1038/ncomms4448
[3] European Commission, Joint Research Centre,, 2022, **https://data.europa.eu/doi/10.2760/487955**

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