Anisotropic silver nanostructures for determination of FKBP12

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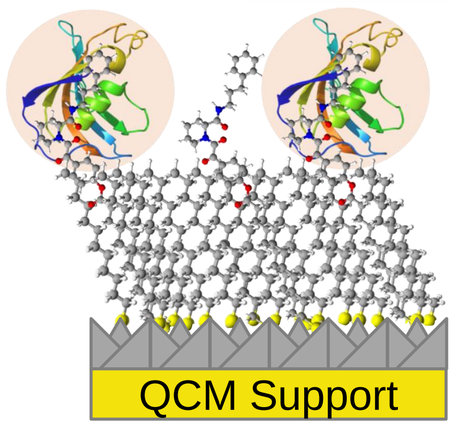
PROJECT

The aim of the work is the realization of metallic anisotropic nanostructures (AgNPs) for the rapid and selective determination via QCM, SERS and SPR of the FKBP12 protein in biological fluids (CSF and blood). FKBP12 is a peptidyl-prolyl cis-trans isomerase with a clear role in cancer, neurodegenerative processes and in the anti-rejection response after surgical transplantation.[1]

PROPOSED PLATFORM



GPS-SH1 receptor molecule was designed and synthesized specifically to bind FKBP12[2] in biological samples.

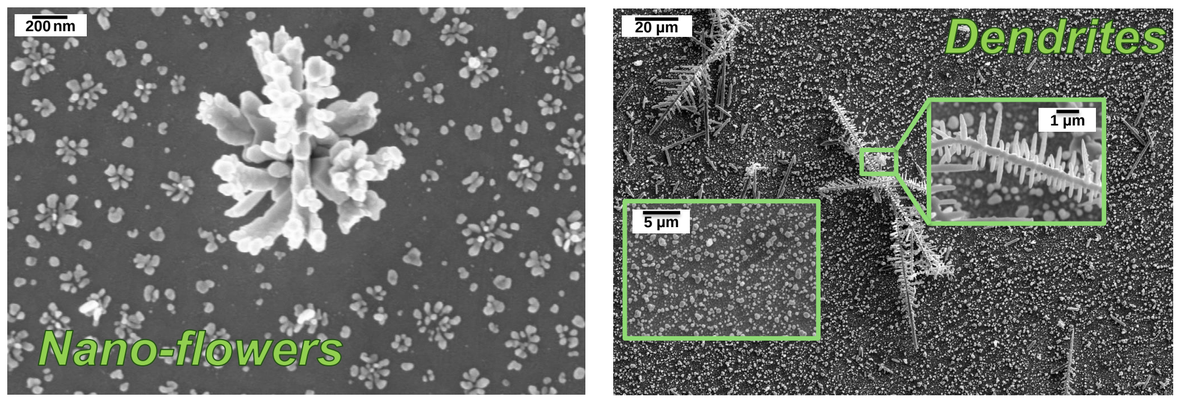
METHODS

- Direct electrodeposition of compact arrays of silver anisotropic nanostructures on ITO and gold QCM supports
- Optimization of different experimental conditions to prepare flower-like and dendritic silver nanostructures
- Characterization of Ag nanostructures by means of UV-Vis and reflection spectroscopy, SEM, contact angle and SERS.
- SAMs containing GPS-SH1 receptor were built on the silver nanostructures by monitoring the formation with Quartz-Crystal Microbalance

NANOSTRUCTURES

SEM IMAGES

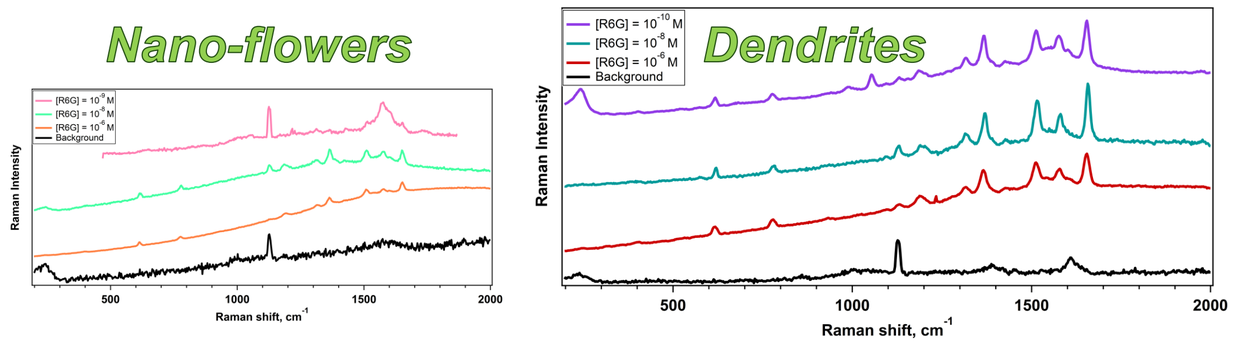
The images reveal a dense concentration of silver nanostructures on the substrates with the desired morphologies.



The preparation of the nanostructures was reproducible and provided homogeneous coating of the surface with the AgNPs

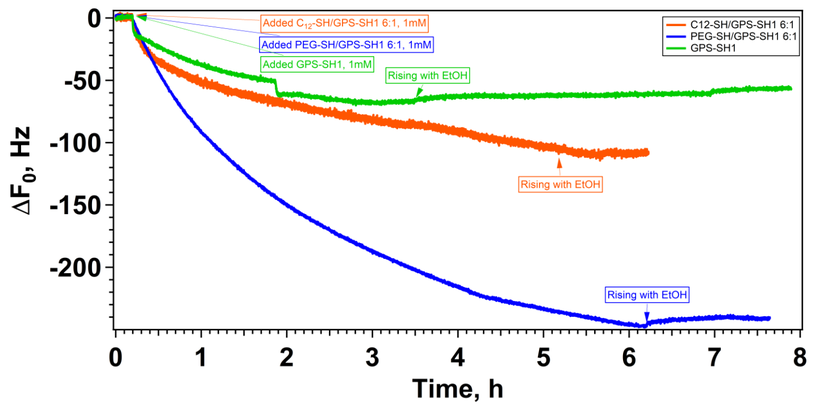
SERS PERFORMANCE

The SERS performance was studied using R6G as analyte. Currently, we are studying FKBP12 detection through SERS.



The measurements revealed low detection limits for both nanostructures suggesting the silver dendrites as the most promising platform for SERS-based nano-sensor. Therefore, we focused further QCM studies on the dendritic nanostructures.

SAMs FORMATION

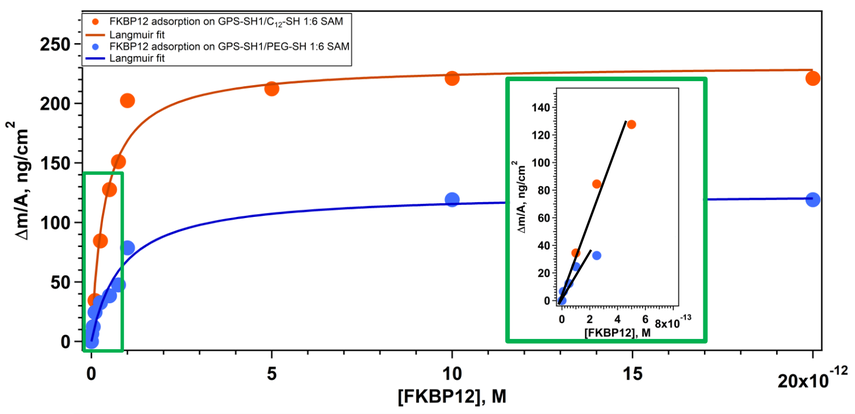


The presence of Ag dendritic nanostructures increase the number of GPS-SH1 receptor molecules adsorbed on the QCM support.

	GPS-SH1		GPS-SH1/C_{12}-SH 1:6		GPS-SH1/PEG-SH 1:6	
	F*	D**	F	D	F	D
m/A [ng/cm2]	322.9	1036.6	135.6	1855.4	321.7	1699.2
#molecules/A (x10^{13}) [cm^{-2}]	196	105	32	432	11	56.9

*QCM support without dendritic layer; **QCM support with dendritic layer

FKBP12 DETERMINATION



The Ag dendrites, functionalized with SAM containing GPS-SH1, enabled the detection of the FKPB12 protein at picomolar concentrations.

	GPS-SH1/C_{12}-SH 1:6		GPS-SH1/PEG-SH 1:6	
	F*	D**	F	D
Linear Range	4 x 10^{-12} M 8 x 10^{-11} M	2 x 10^{-13} M 8 x 10^{-13} M	4 x 10^{-12} M 6 x 10^{-11} M	1 x 10^{-14} M 1 x 10^{-13} M
LOD [pM]	8.3	0.2	6.5	0.1
R^2	0.98576	0.96398	0.98562	0.97401

*QCM support without dendritic layer; **QCM support with dendritic layer

CONCLUSIONS

- The implementation of dendritic nanostructures results in a lower limit of detection (LOD) compared to flat metal surfaces.
- SERS and SPR measurements are currently being conducted to determine the presence and concentration of FKBP12.

REFERENCES

[1] G. Caminati et al., **2021**, International Publication Number WO2021/124269A1.
[2] M. R. Martina et al., *J Med Chem*. **2013**, 56, 1041-1051.

AKNOWLEDGEMENTS

Funded by the European Union - NextGenerationEU - NationalRecovery and Resilience Plan, Mission 4 Component 2 - Investment 1.5 - THE - Tuscany Health Ecosystem -ECS00000017 - CUP B83C22003920001.