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Adsorption of metabolites to polyethylene oxide(PEO) thin films and its influence on protein adsorption

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Introduction

To test if small molecules interact with the non-fouling PEO layer and its ability to inhibit protein adsorption, we use mass spectroscopy techniques to quantify if the ~100 metabolites bind to PEO thin film on Au-surfaces. The results show that many uremic toxins with different chemical properties bind to PEO film. Indoxyl sulfate(IS) is a common uremic toxin which is difficult to be removed by hemodialysis because of its protein bound property. QCM-D data further confirmed adsorption of IS to the PEO film that seemed to significantly increase HSA adsorption. This may indicate small molecules have a large effect on non-fouling ability of PEO. Moreover, these surfaces may act like a reservoir allowing toxins adsorb at the interface that may affect subsequent cellular activities.

Materials and Methods

PEO solutions were prepared at 5 mM with phosphate-buffered saline (PBS). IS and HSA solutions were prepared at 0.04 mg/ml and 0.25 mg/ml in PBS, respectively.

Materials and Methods

The chips and sensors used in mass spectroscopy work and QCM-D were cleaned by exposure to UV light, immersion into base piranha solution (1:1:5 volume ratio of mixture of 30% hydrogen peroxide, 30% ammonium hydroxide) at 75 °C, rinsing with mixture of ethanol and MilliQ water (1:1 volume ratio) and dried with inert gas before final exposure to UV light.

1) LC-MS work

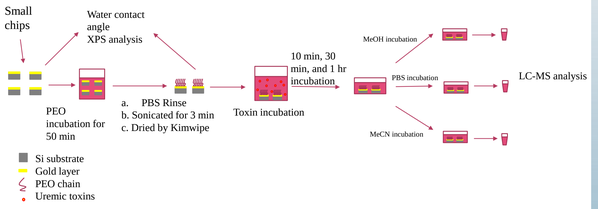


Figure 1. LC-MS work process.

2) QCM-D work

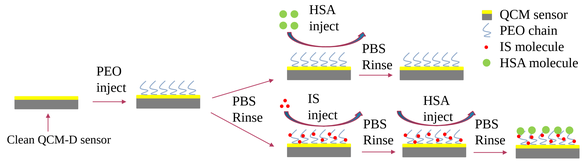


Figure 2. QCM-D work process.

Preliminary Results

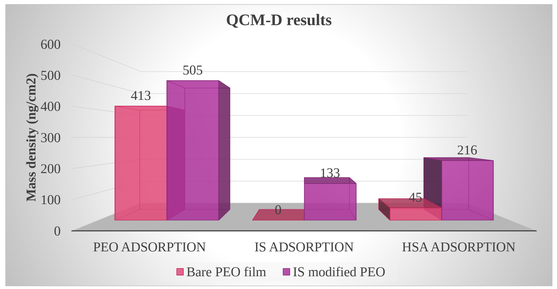
1) Change in contact angles confirmed PEO modification of the Au surface.

Surface	Advancing angle	Receding angle
Bare gold	63.0 ± 2.2	30.2 ± 2.2
Thiol-PEO-modified	46.8 ± 5.2	17.9 ± 3.3

2) Atomic composition of the Au surface further confirmed the presence of PEO.

Surface	Au (84 eV)	C (285 eV)	O (532 eV)	S (162 eV)	C/O theory	C/O actual
Bare gold	53.72	34.95	11.33	Not detected		3.08
PEO-modified	34.00 ± 2.60	32.46 ± 2.12	31.69 ± 0.89	1.8 ± 0.66	2	1.02

3) PEO film density on the sensor was 413 ng/cm^2 and subsequent HSA adsorption to this PEO film was 45 ng/cm^2. IS adsorption was found to be 133 ng/cm^2. Further adsorption of HSA to IS-incubated films was 216 ng/cm^2: fivefold that adsorbed to virgin PEO control.



Discussion and Conclusion

1. Mass spectroscopy indicated that around 80 out of 100 small toxin molecules adsorb to the PEO film.
2. The adsorbed species are dynamic in composition but follow with definite properties of the toxin molecules.
3. HSA adsorption was reduced in the presence of PEO films to QCMD chips.
4. PEO films showed that a large amount of IS was retained on the surface, even after copious rinsing. This IS adsorption yielded a ~5x increase in HSA adsorption compared to virgin PEO films.

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