

## Protein Adsorption: Effect of Surface Wettability on Protein Structure

Electrochemical impedance analysis is a powerful tool employed in studies of complex biological or chemical phenomena taking place at the solid-liquid interface. One example is the adsorption of proteins to surfaces. In this application note, the z-LAB™ impedance analysis instrument is used to monitor protein adsorption from sera to gold electrodes modified with self-assembled alkanethiolate monolayers with different wettability.

### z-LAB™ features

#### Thin film formation

Real-time monitoring of the change in capacitance during protein adsorption reveals kinetic information

#### Surface insulating properties

The tertiary structure of the adsorbed proteins is reflected in the capacitance of the protein film

The z-LAB instrument (Fig. 1A) is an instrument for measuring changes in the impedance at the electrode-solution interface in real-time. This enables label-free monitoring of protein adsorption in real-time. The technique is extremely surface sensitive and, as long as the bulk solution is conductive, discriminative of other properties such as viscosity or optical density of the sample. Therefore z-LAB measurements can be performed in for example undiluted sera.

Serum protein adsorption is a key process in biomaterials research since the protein film formed at the liquid-solid interface dictates the biological response. Protein denaturation (loss of tertiary structure) upon adsorption is governed by the surface energy. Hydrophobic (water-repelling) protein-surface interactions give rise to dense and insulating protein films which can be distinguished from more loosely bound proteins (that retain their native conformation) using z-LAB.

In this application, protein film formation from sera was investigated with regards to the total surface concentration using a mass sensitive technique (Surface Plasmon Resonance, SPR) and with regards to the structure using z-LAB. Self-assembled monolayers of alkanethiolates with different functional end groups, either hydroxyl (-OH, hydrophilic) or methyl (-CH<sub>3</sub>, hydrophobic) were used to control the surface wettability.



Figure 1: The z-LAB™ instrument (A) and dual microelectrode sensor (B, C).

## Results

As measured by SPR (table 1), after exposure to serum, the surface concentration of proteins is higher on the hydrophilic surface than on the hydrophobic. This could be due to complement activation which can take place when the adsorbed proteins retain their native conformation. The change in capacitance after protein adsorption to the hydrophilic surface is very low, which supports this conclusion. On the hydrophobic surface, however, there is a substantial change in capacitance, which indicates the formation of a dense, insulating film of denatured proteins.

## Conclusions

We have shown that adsorbed protein films with dissimilar surface interactions gives very different capacitive responses. The z-LAB system can be useful for quantitation of the level of hydrophobic interactions between an adsorbed protein film and the surface. The capacitance is largely independent of the surface protein concentration but sensitive to structural and chemical properties of the protein film. The z-LAB system thus provide important complementary information to other (optical or acoustic) mass-sensitive techniques.

## More information

This application study was performed in collaboration with researchers at Gothenburg University. More information can be found in:

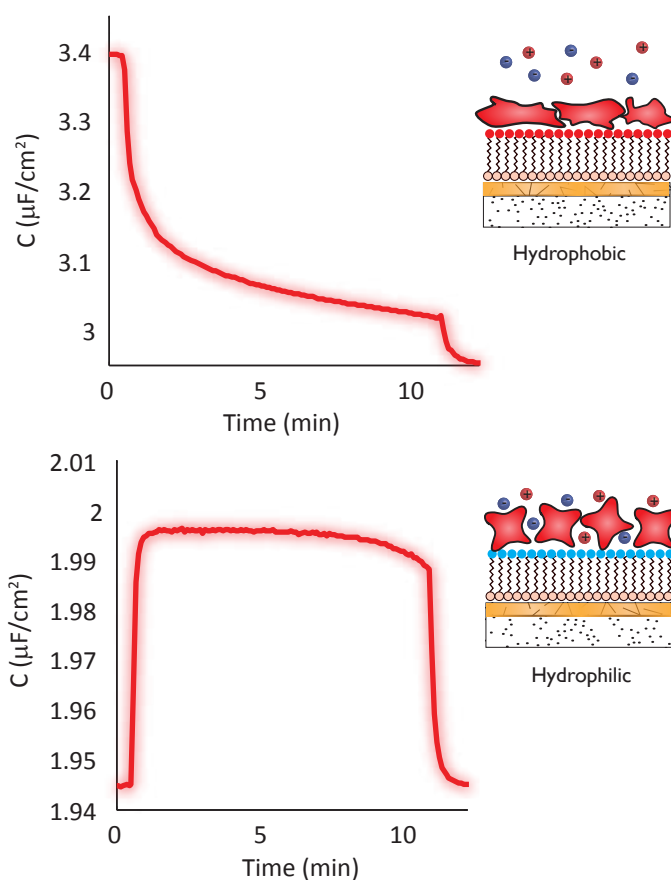
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## Benefits

z-LAB provides a novel approach to measuring the interfacial change in capacitance upon protein surface adsorption. With this information it is possible to discern differences in the protein-surface interactions between surfaces with different properties. Such information can provide new insights in e.g. the field of biomaterial research.

Surface type	Adsorbed mass, $\Gamma$ (ng/mm <sup>2</sup> )	$\Delta C$ (nF/cm <sup>2</sup> )
Hydrophilic	0.63	-1.4
Hydrophobic	0.23	-300

Table 1.



**Figure 2:** Change in capacitance upon a 10 minute exposure of a hydrophobic (A) and hydrophilic (B) surface to serum.