GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

Graphene online 2020 October 19-23

Graphene-Protein Interactions Mapped using Quartz Crystal Microbalance with Dissipation Monitoring (QCM-D)

Piramon Hampitak [1], Daniel Melendrez [1], Thomas Jowitt [2], Aravind Vijayaraghavan [1]

[1] Department of Materials and National Graphene Institute, The University of Manchester, Manchester M13 9PL, UK

[2] Biomolecular Analysis Core Facility, The University of Manchester, Manchester M13 9PL, UK

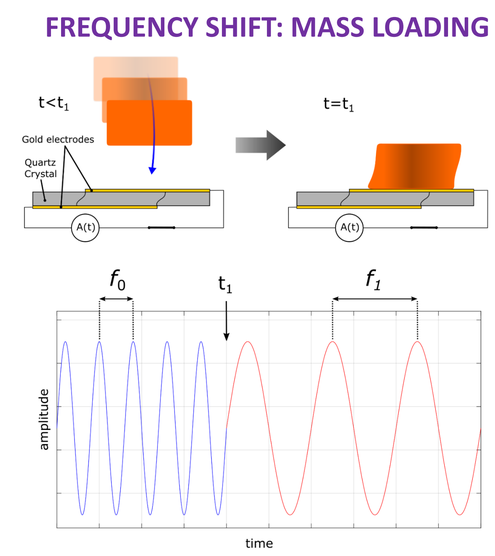
OVERVIEW

Graphene oxide (GO) and reduced-graphene oxide (rGO), have shown great potential for biosensing applications due to the ease of functionalization and biocompatibility [1-3]. Better understanding of interaction between graphene and biomolecules are required to accomplishing graphene biofunctionalization.

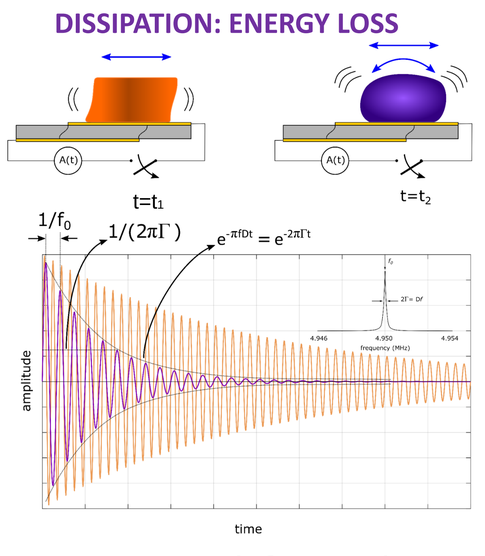
The quartz crystal microbalance with dissipation (QCM-D) is a real-time monitoring technique to assess the adsorption mechanism and the structural conformation of biomolecular events.

In this project, the graphene-based QCM-D chips were developed through spin coating and thermal reduction [2] to investigate the kinetic adsorption and conformation of bovine serum albumin (BSA) on graphene surfaces. BSA was selected for studying protein interaction due to its similarity to human albumin and various applications in biomedicine. The effect of the hydrophobic degree of GO and protein concentration were considered.

QCM-D TECHNIQUE



Frequency shifts with respect to rigid mass adsorption Sauerbrey eq :$\Delta m = -C \cdot \Delta f$



Dissipation shift provides viscoelastic properties of adsorbed materials

Fig. 1 QCM-D theory. Left scheme: Loading mass at $t = t_1$, the resonant frequency f_0 shifts down. Right scheme: the excitation is disconnected at $t = t_2$, an exponential decay begins, the dissipation is measured via the ring-down method.

CHARACTERISATION OF GRAPHENE

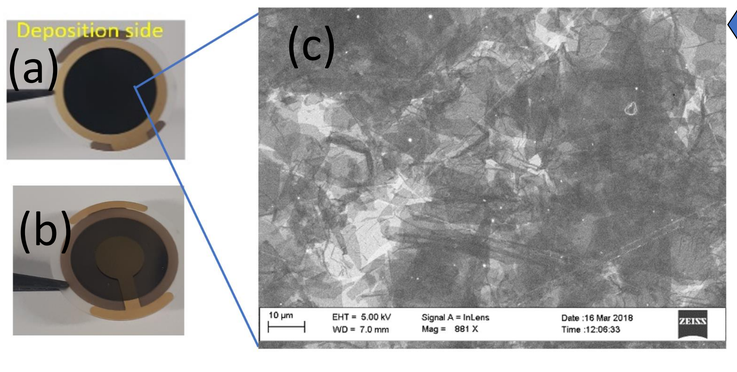


Fig. 2 (a) deposition side (b)back electrode of the QCM-D sensor (c)SEM image of GO coated on the Au sensor, the number of GO layer was varied from few layers to many layers.

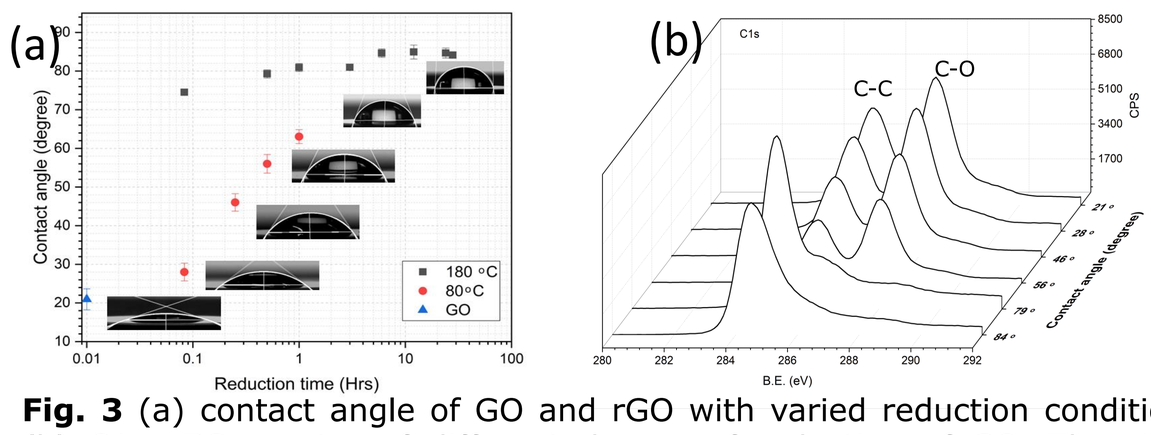


Fig. 3 (a) contact angle of GO and rGO with varied reduction condition (b) C1s XPS spectra of different degree of reduction of GO. The XPS spectra suggest that the degree of hydrophobicity of rGO depends on the quantity of oxygen content.

BSA ADSORPTION STUDY

Effect of hydrophobic degree of GO

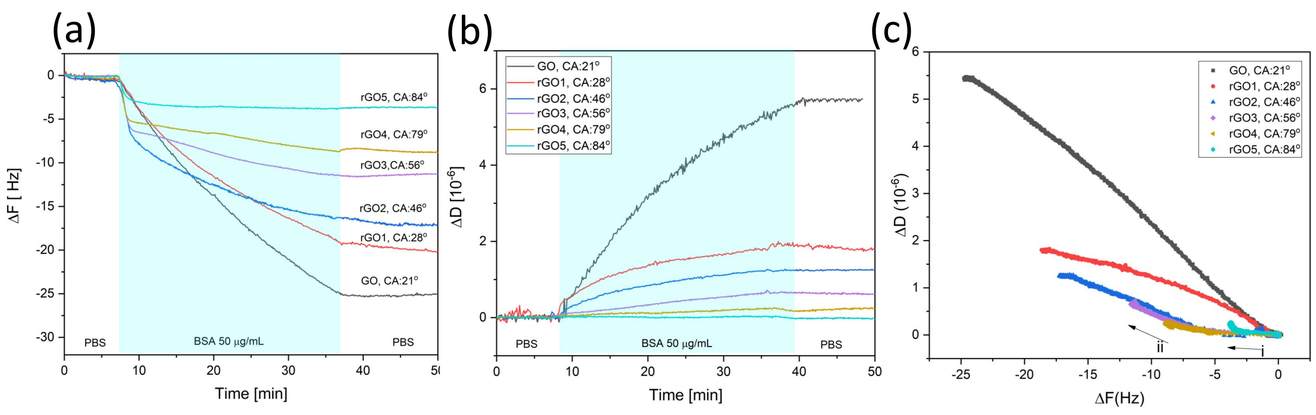


Fig. 4 QCM-D profiles of (a) frequency and (b) dissipation upon BSA adsorption on surfaces with different reduction degrees of the GO (c) ΔD - ΔF plots of the adsorption.

Thickness and proposed adsorption model

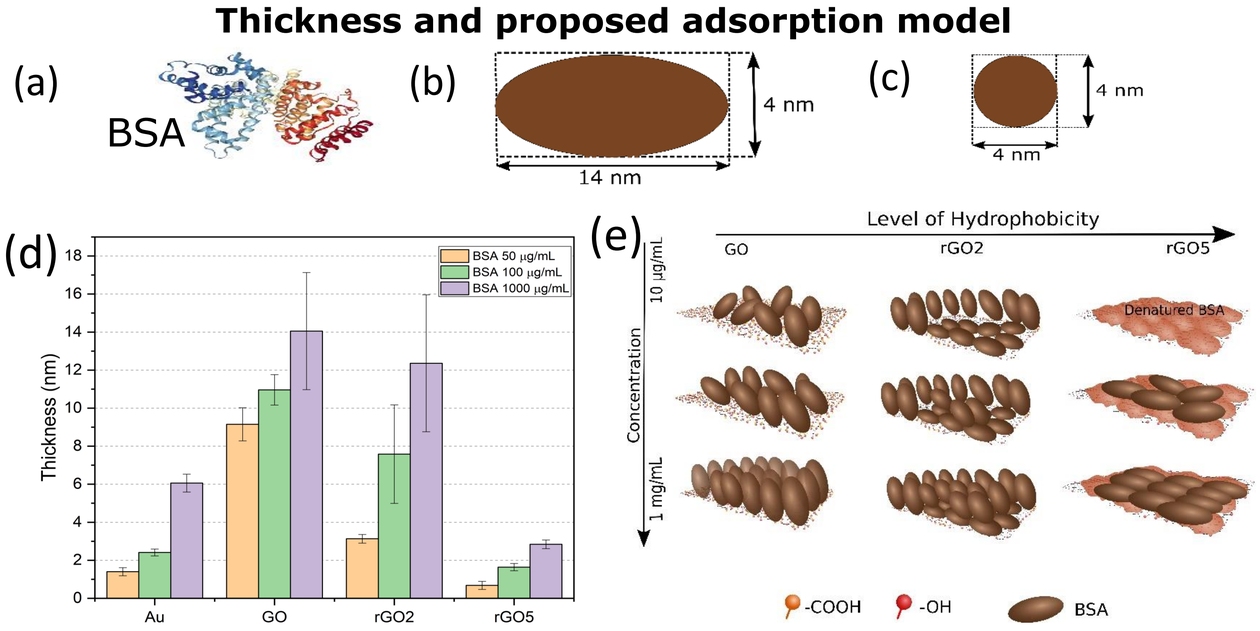


Fig. 5 (a) Ribbon structure of BSA, (b) dimension for side-on and (c) end-on orientation of BSA (d) thickness of BSA film on Au, GO, rGO2 and rGO5 calculated from QCM-D profiles using Sauerbrey eq. and viscoelastic model. (e) the proposed models for BSA adsorption on graphene-based surfaces with the dependence on hydrophobic degree and protein concentration [3]

Protein's functionality

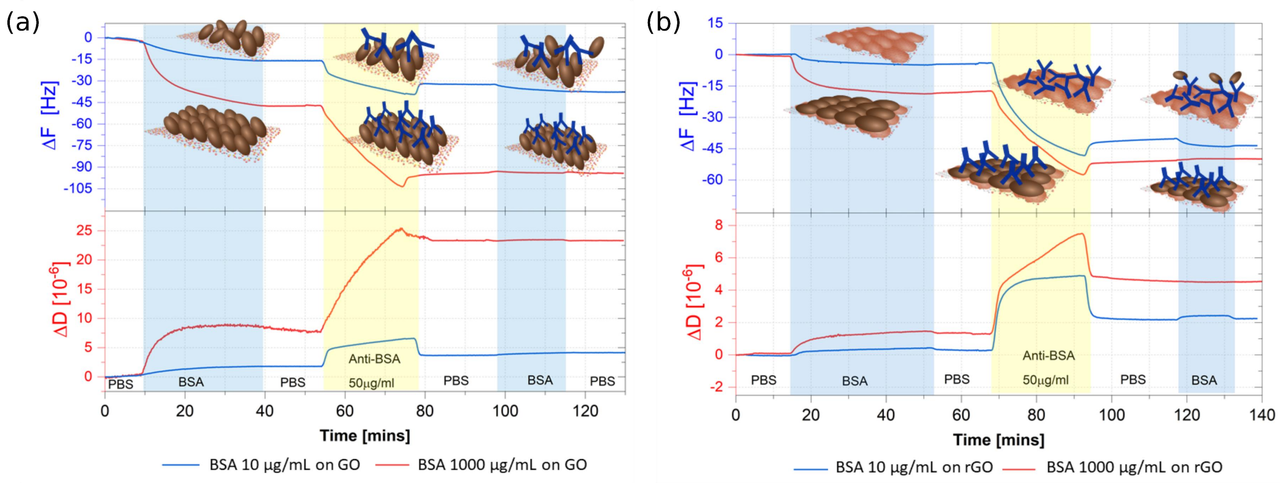


Fig. 6 QCM-D study of interaction between BSA and anti-BSA antibody on (a)GO and (b) highly hydrophobic rGO. The BSA on GO can maintain binding functionality to its antibody. The denaturation of protein was found on rGO but an additional layer of protein can be created on top of the denatured layer without denaturation [3]

CONCLUSION

- ✓ We present the systematic study of protein adsorption on graphene surface which is crucial for utilising graphene in biomedical applications.
- ✓ Protein adsorption on graphene-based materials is highly dependent on its hydrophobicity and concentration of protein.
- ✓ Protein integrity on each supporting substrate was assessed through a high-affinity binding assay. Highly hydrophobic graphene could denature the protein.
- ✓ Highly hydrophobic rGO functionalised with BSA could serve as biotechnological platforms for immunoassay.

CONTACT PERSON

piramon.hampitak@manchester.ac.uk

Tel: 44 78 2372 9762

REFERENCES

[1] Willems, Nathalie, et al. *ACS nano* 11.2 (2017): 1613-1625.

[2] Meléndrez D, et al. Nanoscale. The Royal Society of Chemistry; 2018:2555–67.

[3] Hampitak, Piramon, et al. Carbon (2020):317-327

Graphene online 2020