Volatile Organic Compound Detection Using Insect Odorant-Receptor Functionalised Field-Effect Transistors

by

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Acknowledgements

Thanks for all the fish.

Abstract

This is a thesis skeleton written with quarto. Make a copy of this thesis repo and start to write!

Make a new paragraph by leaving a blank line.

Table of contents

1 Introduction

This is a book created from markdown and executable code.

See **knuth84?** for additional discussion of literate programming.

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[1] 2
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2 Carbon Nanotube and Graphene Field-Effect Transistors

2.1 Device Functionalisation

2.2 Insect Odorant Receptors

3 Carbon Nanotube and Graphene Field-Effect Transistors as Biosensor Platforms

4 Fabrication

Stuff I did to get the results.

5 Functionalisation of Carbon Nanotubes and Graphene with Odorant Receptors

5.1 Linker molecules

5.1.1 1-Pyrenebutanoic acid N-hydroxysuccinimide ester (PBASE)

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1-Pyrenebutanoic acid N-hydroxysuccinimide ester (also known as 1-Pyrenebutyric acid N-hydroxysuccinimide ester, PBASE, PyBASE, PBSE, PANHS) is an aromatic molecule commonly used for tethering biomolecules to the carbon rings of graphene and carbon nanotubes. The use of this bifunctional molecule for noncovalent functionalisation of proteins onto a single-walled carbon nanotube was first reported in 2001 by Chen *et al.* [1] . Two methods for protein functionalisation were successfully used, with the only differences being the solvent used to dissolve the PBASE powder (DMF, methanol) and the final concentration of the resulting solutions (6 mM, 1 mM respectively). The lower concentration may have been used for PBASE in methanol as PBASE appears to dissolve poorly in methanol at higher concentrations. Subsequent publications appear to have largely either chosen or slightly adapted one of these two methods, as outlined in Table 5.1.

Table 5.1: Comparison of PBASE functionalisation processes used for liquid-gated CNT-FET and graphene FET sensors

Solvent	Channel	Conc. (mM)	Incubation type	Time (hr)	Rinse steps	References
DMF	CNTs	5	Immersed	1	PBS	Maehashi et al.
		6	Immersed	1	DMF, PBS	García-Aljaro et al.
		6	Immersed	1	DMF	Chen et al.
		6	Immersed	1	DMF	Cella et al.
		6	Immersed	1	DMF	Das et al.
	Graphene	-	-	2	DMF	Tsang et al.
		-	-	20	-	Wiedman et al.
		1	Droplet	6	DMF, IPA, DI water	Nekrasov et al.
		5	Immersed	1	DMF, DI water	Hwang et al.
		6	Droplet	2	DMF, DI water	Nasufiya et al.
		10	Droplet	2	DMF, DI water	Campos et al.
		10	Immersed	2	DMF, PBS	Kuscu et al.
		10	Immersed	1	DMF	Xu et al.
		10	Immersed	12	DMF, ethanol, DI water	Khan et al.
2-Methoxyethanol	Graphene	1	Immersed	1	DI water	Ono et al.
Methanol	CNTs	1	Immersed	1	Methanol, DI water	Zheng et al.
		1	Immersed	2	Methanol	Kim et al.
	Graphene	5	Immersed	2	-	Sethi et al.
		5	Immersed	1	Methanol, PBS	Ohno et al.
DMSO	CNTs	10	-	1	DI water	Lopez et al.
		10	Immersed	1	PBS	Strack et al.
	Graphene	10	Immersed	2	DMSO, ethanol, DI water	Yue et al.

We purchased PBASE from two suppliers, Sigma-Aldrich and Setareh Biotech. Sigma recommends DMF and methanol as suitable solvents for dissolving PBASE alongside chloroform and DMSO. Setareh Biotech indicates methanol can be used as a solvent. The two suppliers have conflicting information for suitable storage of PBASE, with Sigma recommending room temperature storage while Setareh Biotech recommends storage of -5 to -30°C and protection from light and moisture.

6 Results

What I found out.

See for more detailed results

7 Results

What I found out.

See for more detailed results

8 Summary

In summary, this book has no content whatsoever.

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References

[1] R. J. Chen, Y. Zhang, D. Wang, and H. Dai, “Noncovalent sidewall functionalization of single-walled carbon nanotubes for protein immobilization,” *Journal of the American Chemical Society*, vol. 123, no. 16, pp. 3838–3839, 2001, doi: 10.1021/ja010172b.