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Towards enzymatic production of conducting polymer-DNA hybrid nanowires.

Introduction

DNA is often ascribed potential for use in molecular electronics. However, the electron transport properties of native dsDNA are not sufficient for electronics. Therefore, it has been necessary to add functionality, usually at the polymer strand level through templating techniques, with metal, semiconductors or conducting polymer material. This project will investigate the modifications of the building blocks of DNA, the nucleosides, with units of conducting polymers in order to incorporate them into a complex which are self-assembled by utilising the recognition of the double helix.

Aims

Overall aim is to find the 'perfect' Graphene OXIDE surface on glass slides which can be used to build double strand helix's onto, this therefore entailed:

- Finding the right concentration ratio of Graphene Oxide (GO) and water.
- The thickness of which the GO would be sprayed onto the glass.
- The temperature at which the GO should be sprayed onto the glass slides.
- If the GO glass slides should be baked after spraying.
- The temperature at which the ssDNA should be put onto the GO glass slides.
- If the GO glass slides should be baked after the ssDNA is applied.

Method

Spraying-Glass slides were cleaned using water, ethanol and isopropanol sequentially, then dried with nitrogen steam. They were then put into a diener plasma surface technology for 10 minutes for treatment with oxygen plasma. Glass slides were then suspended onto a hot plate using carbon tape strips. Hot plate was then set to a temperature (varied to find the right temperature) and the pump of the spray gun was set to 10psi and the glass slides were sprayed evenly (number of sprays varied to find the best thickness) at a distance of 3cm and allowed to dry for 10 seconds in- between each layering of material.

Concentration ratio of GO to water-

3 different concentrations of GO mixed with water, these were:

- 484µl GO and 3ml water
- 242µl GO and 3ml water
- 121µl and 3ml water

Temperature at which the GO was sprayed-

The hot plate was set to 3 different temperatures, these were:

- 50 degrees
- 60 degrees
- 70 degrees

Baking-

To obtain if the GO glass slides should be baked, some slides were not baked at all and some were baked at 160 degrees, for 30 minutes under vacuum only before DNA was placed onto them, only after the DNA was placed onto them (not before) and finally baked both before and after DNA was placed onto them.

Temperature at which ssDNA is placed onto GO glass slides-

A stock solution of HATU was already previously made up. This HATU is used to activate the DNA and therefore 40µl of HATU is mixed with 10µl of ssDNA. 1µl of this mixture is doted onto the GO glass slides usually 4 different dots. The ssDNA was then left in a moist environment (4 dots of water in the container) overnight and was rinsed with water and dried with nitrogen steam. To obtain the right temperature, these dots were applied on both a GO slide which had just came out of the vacuum oven (therefore still around 160 degrees) and a baked GO slide which had been left to cool overnight.

Acknowledgements

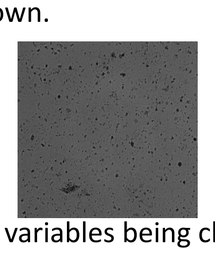
I would like to thank Dr Andrew Pike and all the staff at the School of Natural and Environmental Sciences for providing the opportunity for me to undertake this research project and providing their help and support when needed. Moreover, I would like to thank Newcastle University for providing me with the funding to undertake this research project

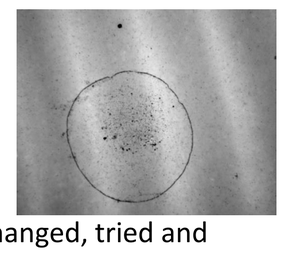
Conclusion

After undertaking 8 weeks of research on this I feel I have advanced the experiment into the right direction of the right variables to use, as seen with these images the two on the left show excessive bulking as there is many black spots visible. At these early stages the spots of ssDNA were shining very bright, do to this bulking causing this reflection. However, the image on the right is of a spot of ssDNA after spending 8 weeks changing a range of variable, spoken about previously, to try and find the right conditions of this early stage in the overall experiment. This image shoes a lot less black spots than that of the left, implying less bulking has accorded, this was also backed up by the fact that under UV this dot shone less than that of the one on the left. Unfortunately, I feel that this is not 'perfect' as when I repeated these conditions a second time there were some contrasts in that of the contact angle as it was a lot higher than previous and the spots did shine a little bit brighter, as a result I feel that these conditions may not be 100% constituent and therefore more research may be needed to perfect these conditions.

Analysis/ Discussion

The end result for the whole project was for when the GO glass slide was put under a UV light with matched dsDNA on it would shine bright only were the matched dsDNA was placed, therefore would not shine when only ssDNA or mismatch dsDNA was placed on it. However, there was a problem because these dots were shining when only ssDNA was placed on them, implying there was a problem in the earliest steps of the experiment (my steps). Therefore, it was believed to be a 'bulking' effect on the surface which was reflecting the light and giving this sign. When viewed under the microscope this was believed to be from these black dots shown.





After strong analysis and many different variables being changed, tried and tested (listed in method) the desired 'best' variables which I found to work were the strongest concentration of 484µl GO and 3ml water with the most sprays of 70 sprays, this was found to be the best as it showed the least black spots, indicating that the GO was hick enough to not allow any material to get under the GO surface and cause a bulking effect, which was believed to be the causing of these black dots. The temperature of the hot plate did not show any specific differences and therefore depicted that this temperature didn't matter as long as above 50 degrees as the GO was able to dry.

The most analysis took place when trying to depict if the GO slides should be baked and if they should be baked both before and after the DNA. After many tries, the best variables were found to be:

- Glass slide baked of 30 mins before DNA was put on
- DNA put on after slide been left to cool and left overnight
- Next day placed back in the oven (before washing) for 30 mins
- Then rinsed with water and dried under nitrogen steam.

These are believed to be the best variables because when the glass slides were not baked before the DNA was put on, when they were rinsed with water, the GO came off (as shown below)

Whereas, when the GO slides were baked, this did not occur, this therefore implies that the baking helps the GO to set properly onto the glass and provides a better surface. Moreover, it was found that putting the DNA on after the slide was cooled was best, this was shown by the contact angle, as I believe that the lower the contact angle on the dot, the less bulking that has occurred and therefore the less that these dots shine. The difference in contact angles between the hot and the cooled GO glass slides is shown below in the table:

Slides hot contact angle	Slides cool contact angle
43.3	28.53
40.7	20.98
48.11	30.945
48.12	20.40

The larger contact angle therefore implies that the bulking has occurred on the hot glass slide, as a result we can infer that this could be due to when the GO slide is hot when the DNA is put on there is a reaction occurring on the surface which is causing it to buckle.

I was also found that it was best to bake the slides after the DNA has been left overnight on the slides (before washing) this was because when it was not baked the DNA seemed to 'come off' as the dots were no longer to be seen. Therefore, this could be that when it is baked the DNA is able to set better onto the surface

Conclusion images