NDnano Undergraduate Research Fellowship (NURF)
2015 Project Summary

1. Student name: Darragh Lombard

2. Faculty mentor name: Professor Kyle Doudrick

3. Project title: Project: Nano-structured arrays for sustainable water treatment technologies

4. Briefly describe any new skills you acquired during your summer research:

Throughout my 10 week research I gained many new and useful skills. Having never worked in a chemistry lab before I obtained invaluable experience which has helped my technical skills within the lab. My focus for the program was on the synthesis and characterization of a new photocatalytic material. In order to achieve this I was required to become familiar with various synthesis techniques. I was also trained on a vast array of analytical instruments such as the XRF, TOC and DLS which I used in the characterization process. Presentation skills were also improved as I was required to give numerous progress reports during my 10 week project. Due to the working environment I was in my research skills also improved as I was surrounded by graduate students who work efficiently and diligently.

5. Briefly share a practical application/end use of your research:

A practical application of which my research can be applied is the use of photocatalytic cells in water treatment processes. The aim of the research is to produce a sustainable, low-cost way of removing harmful substances from water.
Hydrogen fuel can also be produced from the water by water splitting which can be caused by a photocatalytic reaction

6. Project Summary

Water is one of the essential resources on our planet. Therefore, fresh water and the recycling and purification of waste-water are very important topics in various areas. Energy-saving green technologies are a demand in this area of research and a lot of focus and effort is being put in at present in order to find a cheap and sustainable product which can achieve the required results. One promising way in which this may be achieved is by utilizing a photocatalytic material. Semiconductor photocatalysis is an emerging technique used for pollutant degradation and hydrogen production by water splitting. Photocatalysis can be defined as a “catalytic reaction involving the production of a catalyst by absorption of light”. The appropriate positioning of valence (VB) and conduction (CB) bands in semiconductors determines the suitability that a

material possesses for the absorption of light and photocatalytic action. One of the most commonly used materials used in this branch of research is TiO_2 due to its high stability and low-cost. However its band gap isn't the most optimal for photocatalysis and therefore there is a need for alternative materials.

The material which I focused on throughout my stay was the oxygen-rich bismuth oxyhalide, $Bi_7O_9I_3$. This material was seen as having suitable photocatalytic activity due to its narrow band gap energy and high oxidation ability. For my research I synthesized, characterized and tested this material. To show the photoactivity of a certain material, a common experiment involving the degradation of a dye such as methyl orange is explored using that photocatalyst under light irradiation. It was shown that the dye was reduced due to catalysis by approximately 52% when $Bi_7O_9I_3$ was used which is far superior to the commonly used TiO_2. Having showed superior photocatalytic ability of the material the next step was to characterize it. Various analytical instruments were used in the characterization process. XRF was used for the elemental analysis of the powder whilst the DLS was used to determine the surface charge which the material possesses. I also constructed an adsorption isotherm for the $Bi_7O_9I_3$ which tells us the adsorption characteristics which it possesses.

In the future the hope is that this research could help in the formation of a working photocatalytic film using the $Bi_7O_9I_3$ material which can hopefully be made viable for the use in various water treatment technologies.

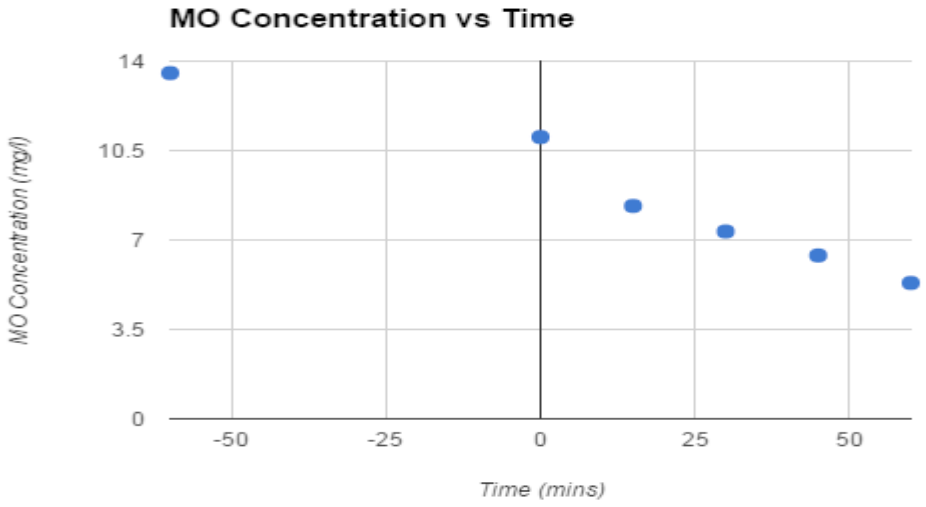

Figure 1: Methyl Orange Concentration vs Time when $Bi_7O_9I_3$ is used as a photocatalyst