

UMSAEP UM-UWC Linkage Report
Visit to Missouri July 1 – August 15, 2017

Synthesis and characterization of reproducible PGM metal nanoparticles using Parr reactor for biological applications

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University of Missouri Host: Prof Kattesh V. Katti M.Sc.Ed, PhD, DSC, FRSC, FNAI

Distinguished Curators' Professor of Radiology and Physics
Margaret Proctor Mulligan Distinguished Professor of Medical Research
Director, Institute of Green Nanotechnology;
Director, University of Missouri Cancer Nanotechnology Platform

1. Overview of the visit

I visited the University of Missouri Columbia at a time when It may be claimed that I ran away from winter to enjoy a nice summer time in the USA. However, this was never to be so because the work had to be carried out indoors some of which were colder than our winter back home. During my stay on my exchange visit, I worked at prof Katti's research lab but also visited HRSEM unit at the electrical, engineering department, Fourier Transform Infrared Spectrophotometer at mechanical engineering, chemistry department, animal handling unit in biology and the animal care unit at the vet section. Additionally, my visit included presentations and discussions within the group and a visit to the Missouri Technology Road Show in St Louis courtesy of my host.

2. Proposed Objectives of the visit

Breast cancer which forms part of the major cause of death in women worldwide is presently most effectively treated by using chemotherapy. Furthermore, these chemotherapeutic drugs are not specific and act both on tumor and normal cells bringing many undesired side effects. Therefore, the development of therapeutic strategies involving nanotechnology based drug delivery systems (DDS) represents an area of great interest in cancer research. Through the development of nanotechnology, nanomaterials designed to work as DDS are increasingly importantly being used in nanomedicine. This field has advanced, presenting innovative approaches, allowing the improvement of cancer therapeutic treatments. Among various materials used for DDS, magnetic fluids containing superparamagnetic iron oxide nanoparticles (SPIONs) represent an attractive platform as nanocarriers in chemotherapy. The best nanoparticle qualities are found in the range from 4 to 50 nm in size. These nanoparticles also need to have appropriate shape, should be easily tunable and photostable. The techniques for the production of these nanoparticles include stringent hot injection, solution combustion, solgel to mention a few. The methods used needs to be easily repeatable and therefore reproducible taking into account several parameters such as solvent type, time, capping agents, temperature and pressure which need to be carefully controlled to generate reproducible nanoparticles. It is no doubt that current researchers prefer autoclave reactors which gives the above properties for a reproducible synthesis of the nanoparticles. This formed part of the aim of my visit to Missouri. I had hoped to use the Parr Reactor to synthesize the nanoparticles for the purposes of reproducibility, reliability and validity of synthesizing these important nanomaterials.

- 1) To utilize Parr reactors in the production of palladium nanoparticles as a prime green nanotechnological tool
- 2) To obtain a training in various aspects of Palladium nanoparticles production
- 3) To initiate their applications in medical imaging
- 4) To initiate their applications in catalytic studies for the production of pharmaceutically useful chemical intermediates.

Outcome

1. Lab work

My visit was very fruitful. I found that Prof Katti has an established and reproducible method for the production of palladium nanoparticles. I was able to reproduce the same following a protocol. This technique will be used in the anticipated Green Nano technological Centre to be supported by the South African DST/Medical Council. The application is currently under review. The prepared nanoparticles were fully characterized, first with FTIR, this confirmed the functional groups from the polyphenols while the UV-Vis confirmed the metal reductions. The polyphenols of choice were Epigallocatechin gallate (EGCG), mangiferin (MGF), and resveratrol (RES).

The nanoparticles were tested in the cell culture lab which was conveniently stationed just next to the chemical lab. The MTT assay was conducted and apoptosis assessed.

Several variants of the nanoparticles were suggested for future investigations.

2. Tour of facilities

During my visit, it was also planned to tour the Materials Science and Engineering Department, Division of animal science and Veterinary health centre facilities.

3. Presentations

I was scheduled to present seminars to the group regarding my research.

OBJECTIVE SUCCESSES

Most of the objectives were achieved and further plans are in progress to carry out the catalytic part of the project at UWC. We also hope that current joint funds application would materialize.

4. Facilitation

The success of the visit was due to the input from Prof Katti who was always available 24 hours despite his heavy schedule.

3. Status of Proposed Objectives of the Visit

My visit to Prof Katti's laboratory has just helped to cement the journey of what we envisage as a long term research relationship. We plan a collaboration which will involve co-funded research and student supervision and exchange. We are working on a writing a high-profile review article expected to be published in a RSC journal and a proposal involving green nanotechnology spearheaded by Prof Katti and the rest of the team at UWC. Apart from the therapeutic nature of the nanoparticles made, they shall also be investigated for catalysis. We shall use the nanoparticles for mild oxidation of some of important small synthetic organic molecules. The proposed work is being leveraged for a major International funding at present. Publications and patents are very much hoped out of this collaboration.

3.1 Objective 1

“To utilize Parr reactors in the production of palladium nanoparticles as a prime green nanotechnological tool.”

This technique was not immediately available however, the one in place was easily reproducible. With the availability of funding in the future and a hope to vertically improve the project probably to the industrial scale, this will still be pursued.

3.2 objective no. 2

“To obtain a training in various aspects of Palladium nanoparticles production”

This was successfully achieved. Various nanoparticles were synthesized and a few of them tested. This was done by varying the concentrations and designing different combinations of the polyphenols.

3.3 objective no. 3

“To initiate their applications in medical imaging”

This was left for the host and his group to pursue because it required a longer time.

3.4 objective no. 4

“To initiate their applications in catalytic studies for the production of pharmaceutically useful chemical intermediates.”

This particular objective is ongoing still. We are initiating its inception this year at UWC as part of the continuation of the collaboration. Part of the resolution from my initial visit was to obtain the necessary skills for the preparation of the nanoparticles and apply them on catalysis while our collaborator pursues the biological investigations. I intend to engage a 3rd year BSc or possibly a honours student (though a bit difficult due to the program structure). We hope to update the Mizzou Systems on the outcome of this venture in the future.

4. Additional Important and Timeline of Activities

4.1 Scientific

In addition to the key objectives described above, my Mizzou visit involved a visit to the Chemistry Department where I attended a seminar presentation of one of Prof Katti's co-investigator, Prof Jurrison Silvia. I also attended the mouse handling techniques at the Division of Animal Science. This training involved learning the mouse behavior, restraining techniques, anesthesia application, blood collection and Euthanasia. Dr Sandra Bechtel gave us a tour of the animal centre. This facility is properly equipped for both animal treatment and research. It was amazing to learn how the dogs are so similar to human beings as far as their suffering from prostate cancer is concerned. Their research seeks to use non-radioactive compounds. I also visited the proteomics department and met Dr Brian P. Mooney. We discussed several possible collaborative initiatives using their target analysis technique which is also our approach at UWC. My host was also very kind to sponsor and take me along with him to the annual Mizzou Technology Innovation Road Show held at St Louis. This was a highly informative piece of an invent and a worthy learning course. There were several presentations of various products to the potential product developers.

4.2 Timeline of Activities:

Below is a summative timeline of key activities of which some are described above.

3rd – 4th July 2017 – Arrival and acclimatization

5th – 12th July 2017 – introduction to the research laboratories

11th July 2017, Attended a group meeting on

12th July 2017, Attended a presentation by senior student, Mr Velaphi Thipe

12th July 2017, visited EMCORE for SEM session

12th July 2017, the palladium salt arrived for the research

13th – 14th July 2017 – Set up experiments for the preparation of various palladium nanoparticles of EGCG, MGF and RES.

- Introduced into cell culture lab
- Introduced into the apoptosis assays
- Introduced into cell harvesting and UV-Vis analysis
- Introduced into the zetasizer analyses

16th July 2017 – Attended a University African Initiative function. This is a function geared for the support of the East African countries and this particular day, it was for the support of Somalia.

18th – 21st July 2017

- Attended the mouse handling and techniques training
- Carried out the laboratory work
- Tried to revive the BX41 Olympus Fluorescence Microscope

24th – 28th July 2017

- An undergraduate student, Mr Pierce Bloembergen gave a presentation of his research project.
- Carried out the FTIR experiments at the Engineering building. Here they house old Nicolet Machine which operates on OMNIC software. The amazing experience is that the machine is neatly kept and functions with precision.

31st July – 4th August 2017

- Continuation of lab work
- Attended the group presentation meeting at Chemistry Department. Prof Silvia, is a co-investigator of my host and supervises the graduate student, Mr V Thipe. Literature review and progress reports were presented.
- Visited the animal centre for a tour by Dr Sandra Bechtel
- Visited the Proteomics laboratory where we were given presentations by Dr Mooney.

7th – 11th August 2017

- Finalised the lab work

- Attended the Mizzou Technology Road Show sponsored by my host. Several presentations on the engineering and scientific achievements from Mizzou. Prof Kattesh V. Katti, who is MU Curators Distinguished Professor of Radiology and Physics and Director, Institute of Green Nanotechnology among others presented a sterling work on the topic Nano-Ayurvedic Medicine which he and his research team invented. Prof Elizabeth Lobo, the Dean college of Engineering opened the talks and highlighted impressive biomedical innovations. Mizzou boasts the host of the largest nuclear research reactor on any University in the US. There was a presentation by Dr Tamara Wilgers, about the non-invasive glucometer which the companies shy away from investing. Several snapshot presentations were given before a very warm mixer. They included ; Mark Hunter, Chief, MU Division of Gynecologic Oncology Optical Polarization Tractography Enhanced Colposcopy, Mark Daniels, Associate Professor, MU Molecular Microbiology & Immunology & Department of Surgery POSH Inhibitor-Based Treatment of Leukemia; Teresa Lever, MU Assistant Professor of Otolaryngology Down the Hatch Solutions: Clinical Tool for Early Detection and Monitoring of Laryngeal Dysfunction; Bret Ulery, MU Assistant Professor of Chemical Engineering Antimicrobial Peptide Amphiphile Coatings for Medical Grade Plastics; Hsinyeh Hsieh, MU Research Scientist, Veterinary Pathobiology and Bond Life Sciences Center, A Novel Continuous Flow System for Blood Type Conversion and David Robertson, Associate Director of Research and Education, MU Research Reactor; Professor of Chemistry, Alpha Therapy for Pulmonary Metastatic Disease.

6. Summary

My first ever experience for the UWC-MU exchange program was highly fruitful. A number of goals were achieved and a prospective long-term goals laid down. Briefly, these will include collaborative research and co-supervision as well as article publications. This envisaged goal starts in 2018.

The coordination and inter-departmental collaboration witnessed at Missouri University is commendable. There are a lot that may be achieved when researchers pull together. This was one of the admirable qualities. My host also taught me one more thing, you do not have to be hundreds to dig a hole and that works. A small but highly dedicated team would help to achieve a lot. It is also worth commenting that during my stay, Prof Katti with all the busy schedule was always a phone call away at any given time. When I was moved from respect hall to Excellent hall and there was a problem with the internet, despite it being a weekend, this was solved immediately. During my stay, I got experience a fire evacuation from Respect hall, the student assistants were spot on this however, there was no marking for assembly place and Mizzou systems should look into this. We were advised to move to the open lawn which apparently the regulars are aware of but not the visitors because most of the time visitors would rely on signs.

Another comment is about the visiting times and the subsistence. It is okay how the MU Systems is handling this however, there is a problem with visiting falling inside the vacation times. Most often than not one finds it difficult to use the prepaid cards for food. Most places are closed down and if open, the eating schedule is not practical depending on the activities one is engaged in. The last comment is about the health cover, this should be looked into because it becomes a mission for a visitor who for some reason needs to either obtain a medication or consult a doctor.

In conclusion, I would like to heartily thank Prof Katti for taking his time to first offer himself to teach our MSc nanoscience students, hosting and supervising one of them at graduate level and mentoring and hosting me on top of all these. Prof, the BIG heart you and your team have for UWC is highly appreciated. Secondly, I would like to give a special thanks to the Director of the Program, Prof Rodney J Uphoff for all his kindness and more his patience with me in writing the report. Finally, thanks to the UWC team for their support in the program.

