

The Report

on

Doing Research at the Department of Physical Science

Flinders University in Adelaide, Australia

Between 30 June to 22 August 2015

Submitted by

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Preface

This report is a part of MU Undergraduate Exchange Scholarship Program 2015 and shown interesting information about Adelaide, Flinders University, and my research project which I have done for 2 months at Clean Technologies Laboratory. Hopefully, This will be useful and could be adaptable for many fields of works.

Chakkrit Netkaew

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Adelaide



Adelaide is the capital city of the state of South Australia, and the fifth-most populous city of Australia. In June 2014, Adelaide had an estimated resident population of 1.30 million. The demonym "Adelaidean" is used in reference to the city and its residents. Adelaide is north of the Fleurieu Peninsula, on the Adelaide Plains between the Gulf St Vincent and the low-lying Mount Lofty Ranges which surround the city. Adelaide stretches 20 km (12 mi) from the coast to the foothills, and 90 km (56 mi) from Gawler at its northern extent to Sellicks Beach in the south.

As South Australia's seat of government and commercial centre, Adelaide is the site of many governmental and financial institutions. Most of these are concentrated in the city centre along the cultural boulevard of North Terrace, King William Street and in various districts of the metropolitan area. Today, Adelaide is noted for its many festivals and sporting events, its food and wine, its long beachfronts, and its large defence and manufacturing sectors. It ranks highly in terms of liveability, being listed in the Top 10 of *The Economist Intelligence Unit's World's Most Liveable Cities* index in 2010, 2011, 2012 and 2015. It was also ranked the most liveable city in Australia by the Property Council of Australia in 2011, 2012 and 2013.

Education forms an increasingly important part of the city's economy, with the South Australian Government and educational institutions attempting to position Adelaide as "Australia's education hub" and marketing it as a "Learning City." The number of international students studying in Adelaide has increased rapidly in recent years to 30,726 in 2015, of which 1,824 were secondary school students. In addition to the city's existing institutions, foreign institutions have been attracted to set up campuses in order to increase its attractiveness as an education hub.

In addition to the universities, Adelaide is home to a number of research institutes, including the Royal Institution of Australia, established in 2009 as a counterpart to the two-

hundred-year-old Royal Institution of Great Britain. Many of the organisations involved in research tend to be geographically clustered throughout the Adelaide metropolitan area:

- The east end of North Terrace: IMVS; Hanson Institute; RAH; National Wine Centre.
- The west end of North Terrace: South Australian Health and Medical Research Institute (SAHMRI), located next to the new Royal Adelaide Hospital.
- The Waite Research Precinct: SARDI Head Office and Plant Research Centre; AWRI;ACPPFG; CSIRO research laboratories. SARDI also have establishments atGlenside and West Beach.
- Edinburgh, South Australia: DSTO; BAE Systems (Australia); Lockheed Martin Australia Electronic Systems.
- Technology Park (Mawson Lakes): BAE Systems; Optus; Raytheon; Topcon; Lockheed Martin Australia Electronic Systems.
- Research Park at Thebarton: businesses involved in materials engineering, biotechnology, environmental services, information technology, industrial design, laser/optics technology, health products, engineering services, radar systems, telecommunications and petroleum services.
- Science Park (adjacent to Flinders University): Playford Capital.
- The Basil Hetzel Institute for Translational Health Research in Woodville the research arm of the Queen Elizabeth Hospital, Adelaide



The Mitchell Building and Bonython Hall, University of Adelaide.



The Hawke Building, part of the UniSA, City West Campus.



Flinders University buildings from the campus hills.



Torrens University.



SAHMRI.

Flinders University



The Flinders University of South Australia, commonly referred to as Flinders University or simply Flinders, is a public university in Adelaide, South Australia. Founded in 1966, it was named in honour of navigator Matthew Flinders, who explored and surveyed the South Australian coastline in the early 19th century.

It is a member of the Innovative Research Universities (IRU) Group and ranks in the 10-16 bracket in Australia and 36th in the world of those established less than 50 years. Academically, the university pioneered a cross-disciplinary approach to education, and its faculties of medicine and the humanities are ranked among the nation's top 10. The university is ranked within the world's top 400 institutions in the Academic Ranking of World Universities. The latest Times Higher Education rankings of the world's top universities ranks Flinders University in the 251 to 300 bracket.

The University's main campus is in the Adelaide inner southern suburb of Bedford Park, about 12 km south of the Adelaide city centre. The University also has a presence in Victoria Square in the centre of the



The main campus in Adelaide

city, and Tonsley. It also maintains a number of external teaching facilities in regional South Australia, south-west Victoria and the Northern Territory. International students make up 10% of the on-campus student population and a number of offshore programmes are also offered, primarily in the Asia-Pacific region.

Flinders University offers more than 160 undergraduate and postgraduate courses, as well as higher degree research supervision across all disciplines. Many courses use new information and communication technologies to supplement face-to-face teaching and provide flexible options.

Faculties and schools

- Faculty of Education, Humanities and Law
 - School of Education
 - School of Humanities
 - Flinders Law School
- Faculty of Medicine, Nursing and Health Sciences
 - School of Medicine
 - School of Health Sciences
 - School of Nursing and Midwifery
- Faculty of Science and Engineering
 - School of Biological Sciences
 - School of Chemical and Physical Sciences
 - School of Computer Science, Engineering and Mathematics
 - School of the Environment
- Faculty of Social and Behavioural Sciences
 - Flinders Business School
 - School of Psychology
 - School of International Studies
 - School of Social and Policy Studies

Affiliates

- Australian Science and Mathematics School
- Flinders Medical Centre
- The Adelaide Theological Centre Inc (comprising the Catholic Theological College and the Uniting College for Leadership and Theology replacing the Adelaide College of Divinity)
- Helpmann Academy

Clean Technologies Laboratory



A \$1.1 million Clean Technology Laboratory dedicated to developing products and processes in a cleaner, greener way, will officially open at Flinders University today (Tuesday, November 19).

Launched by Minister for Science and Information Economy Grace Portolesi, the state-of-the-art research facility will explore sustainable methods of manufacturing compounds and materials with applications across a range of sectors, including the pharmaceutical, agriculture, food processing, and renewable resources industries, using less energy and generating less waste.

Flinders University Professor Colin Raston, the South Australian Premier's Professorial Research Fellow in Clean Technology, said the laboratory has received more than \$1 million in project funding for the next two years from a number of providers including the Government of South Australia, the Australian Research Council and industry.

He said the laboratory would apply novel "continuous flow processing technology" being developed at Flinders to research more sustainable and cost-effective manufacturing methods.

Various local and international collaborations will also occur through the laboratory, including PhD exchange programs and major multidisciplinary projects involving researchers at Cambridge University, the University of California-Irvine, Ben Gory University in Israel, the University of Malaysia, Shanghai Jiao Tong University in China, CNRS University of Quebec and the University of Missouri-Columbia.

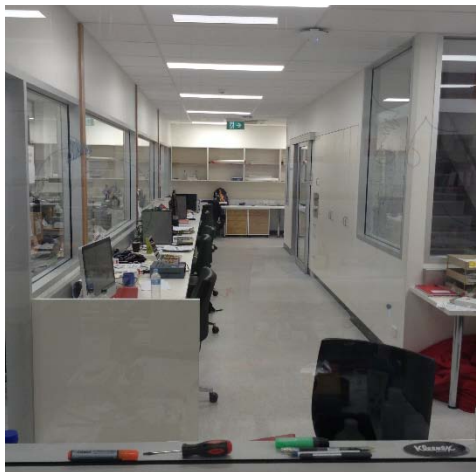
Professor Raston said the laboratory would also engage with industry to facilitate the transition of research to the marketplace.

"The new laboratory will provide a platform for engaging industry in state-of-the-art facilities, with discussions moving forward with industry in South Australia," he said.

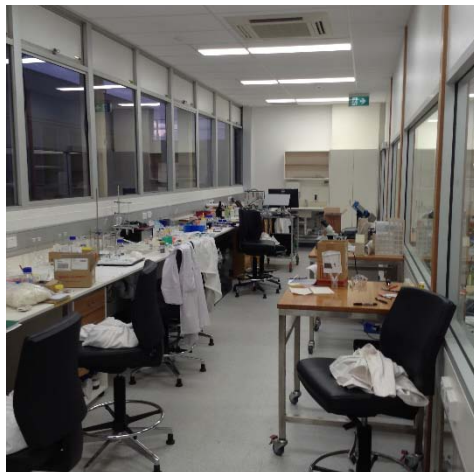


Prof. Professor Colin Raston (right)

“Coupled with various international collaborations and student exchanges, the vibrant research environment created in the lab will translate to world-class research, excellent research training and opportunities for employment in South Australia.”



*Office zone connected to the laboratory
(No lab coat in here)*



Laboratory Zone 1



Office Zone connected to the lab zone1&2



Laboratory Zone 2



Ultrasonicate



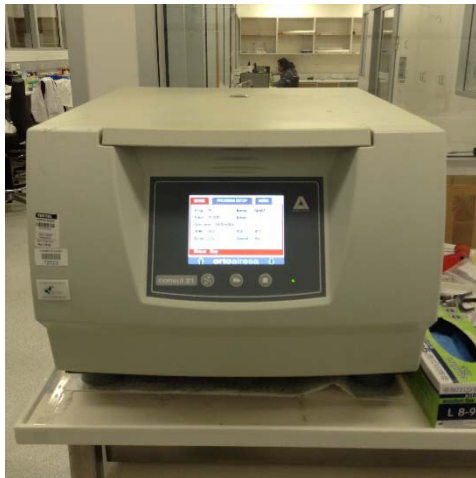
Deionized water producer



Ovens for glassware(left) and sample(right)



pH meter



Centrifuge



Slidable shelf for glassware and equipment



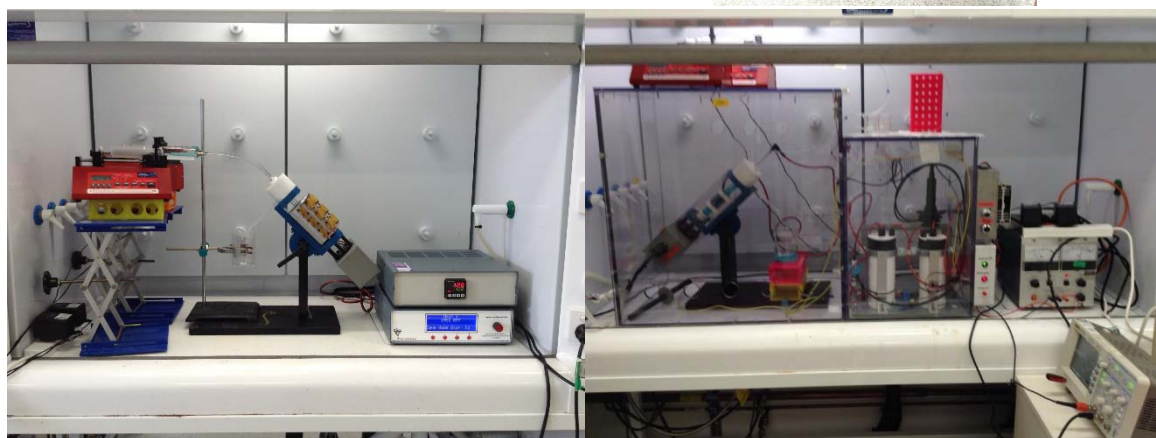
Disposable glassware



Electrical chemical hood



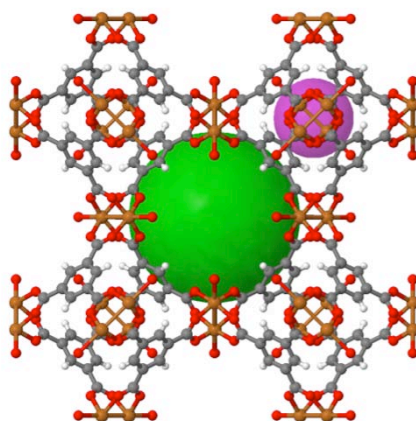
Chemical cubboards(All chemicals are rep)



The VFD with heating unit(left) and the plasma VFD(right)

The Project Research

I went to the Clean Technology Laboratory in order to synthesize HKUST-1(Copper benzene-1,3,5-tricarboxylate) using the vortex fluidic devices(VFD). The VFDs have been improved in many applications for an appropriate work such as the VFD equipped with the heating unit , the laser VFD, or the plasma VFD. For my research, the basic VFD, the VFD with the heating unit, and the plasma VFD would be used to synthesize the HKUST-1.



(HKUST-1 or Hong Kong University of Science and Technology is a metal organic framework made up of copper nodes with 1,3,5-benzenetricarboxylic acid struts between them. The spheres represent the pore sizes within the framework which can be used for gas storage.)

<http://www.chemtube3d.com/solidstate/MOF-HKUST-1.html>

The starting materials are copper ii nitrate and benzenetricarboxylic acid (BTC) dissolved in the mixture of deionized water, ethanol, and DMF. Some triethylamine is involved in the reaction, as well. The three VFDs I referred to at the beginning were used to synthesize the HKUST-1. The VFD can be used two modes: confined mode and continuous mode. The confined mode is suitable for the initial step. It is required small amount of reaction mixtures (not over 0.5ml). When the result of an experiment seems promising, the continuous mode can be used to produce larger amount of product. Basically, time and speed of the VFD are the important variables. It means that time and speed must be varied to find the best condition. 30 minutes and 9000 rpm is the best condition for synthesizing the HKUST-1 via the VFD with heating unit at 120 degree Celsius.

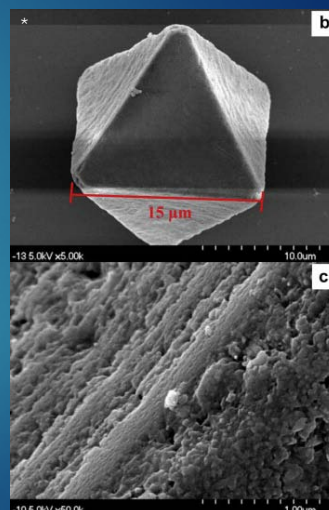
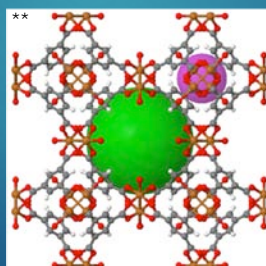
Synthesizing Nanocrystal MOF using VFD

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MAHIDOL UNIVERSITY, THAILAND

HKUST-1 (Cu-BTC)

- ▶ fine porous surface of the octahedral structure
- ▶ The spheres represent the pore sizes within the framework which can be used for gas storage



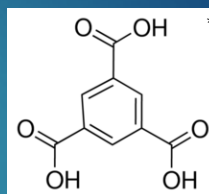
* <http://www.chemtube3d.com/solidstate/MOF-HKUST-1.html>

** <http://www.sciencedirect.com/science/article/pii/S0360319912009986>

Precursors

3

- ▶ Copper(II) nitrate trihydrate
- ▶ Benzene-1,3,5-tricarboxylic acid (BTC)
- ▶ Triethylamine
- ▶ Dimethylformamide (DMF)
- ▶ Ethanol
- ▶ Deionized water

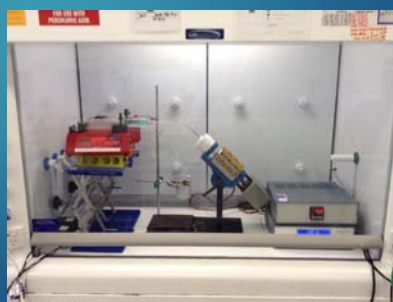
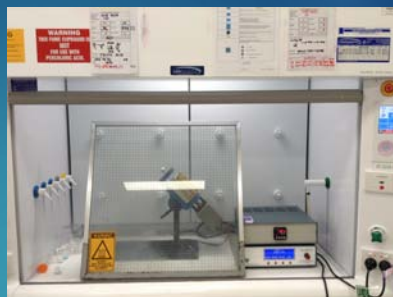


* <http://www.sigmaaldrich.com/catalog/product/aldrich/482749?lang=en®ion=AU>

Running VFD

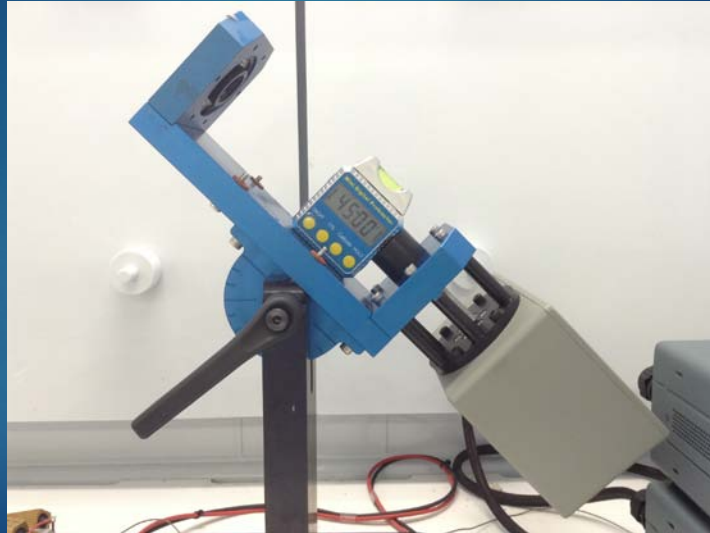
4

- ▶ The Confined Mode
- ▶ The Continuous Flow



Experiment- Confined Mode(3)

7



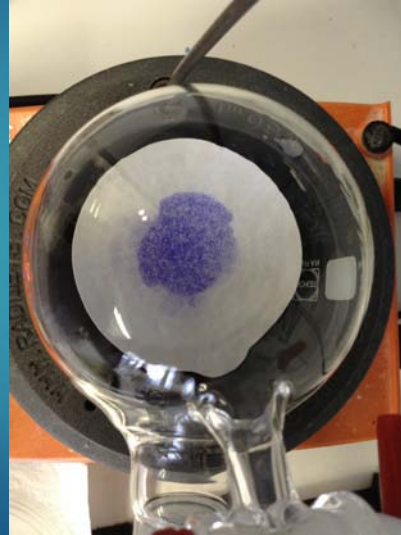
Experiment- Confined Mode(4)

8



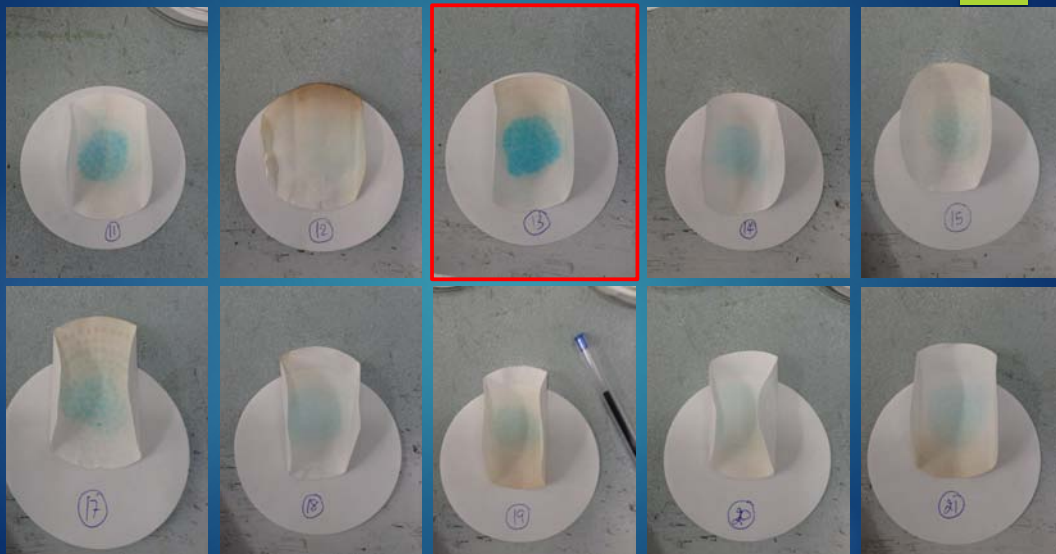
Experiment- Confined Mode(5)

9



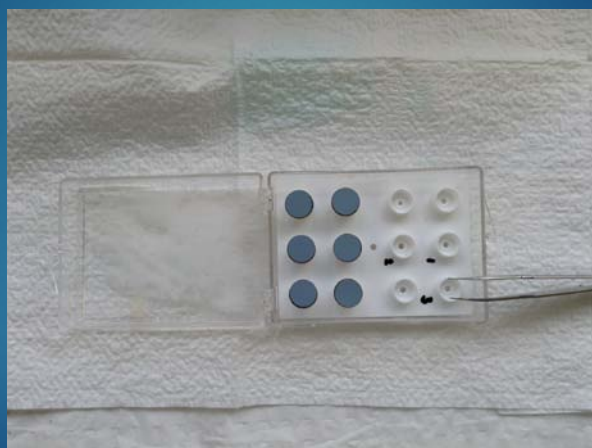
Experiment- Confined Mode(6)

10



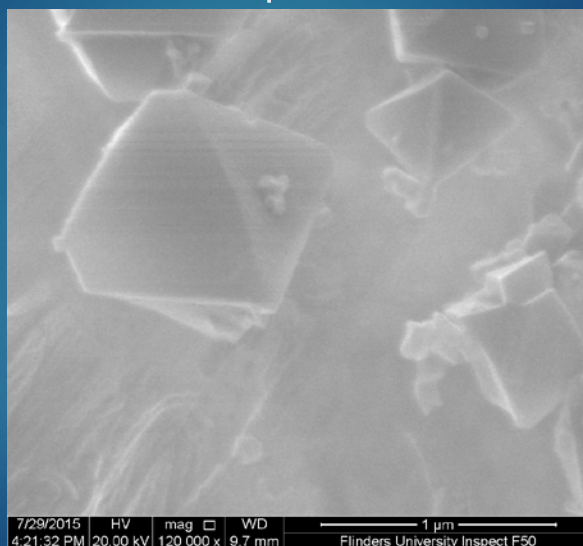
Experiment- Confined Mode(7)

11



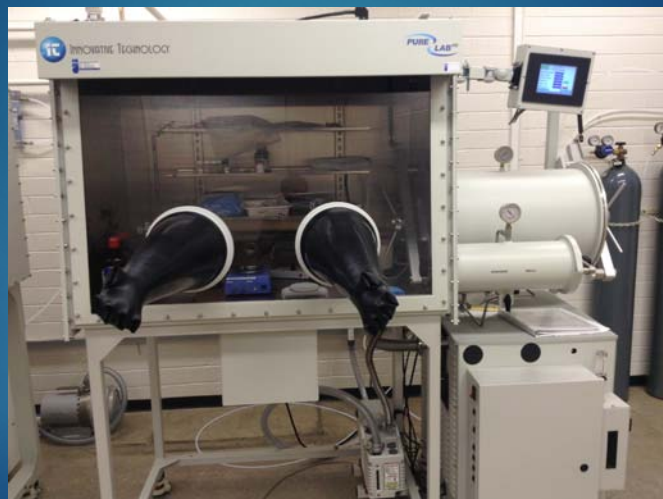
SEM Results @ 6950rpm, 120, 30 min

12



Experiment- Confined Mode(8)

13



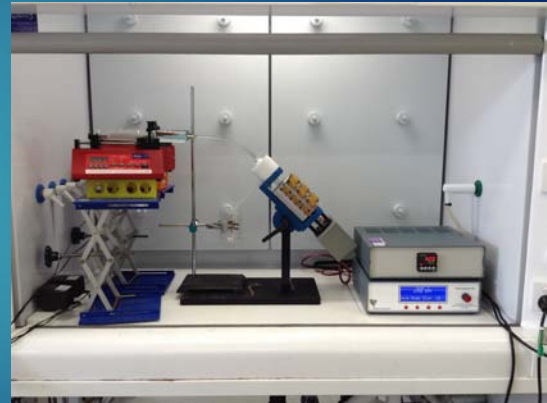
Experiment- Continuous Flow(1)

14



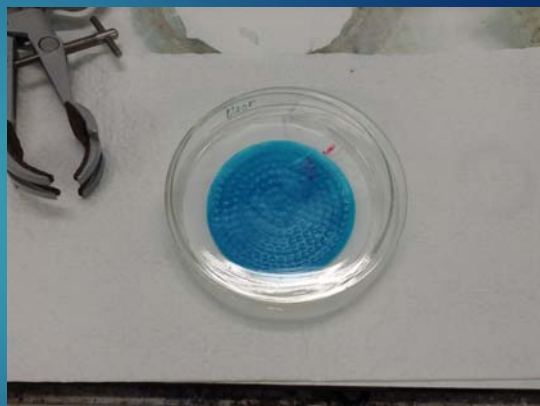
Experiment- Continuous Flow(2)

15



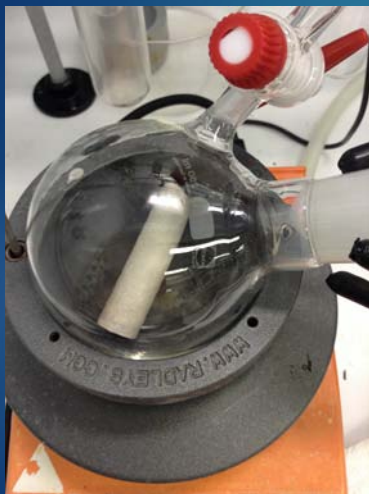
Experiment- Continuous Flow(3)

16



Experiment- Continuous Flow(4)

17



Experiment- Continuous Flow(5)

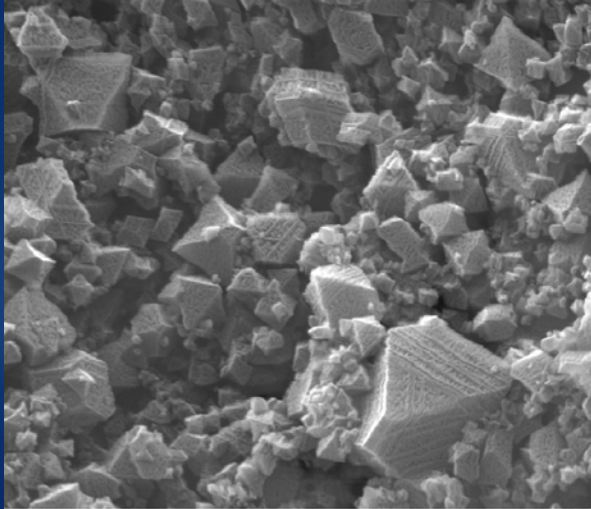
18



62-65 per cent yield

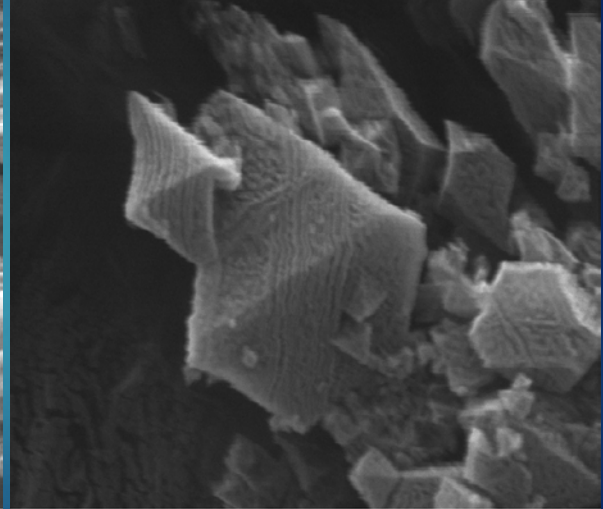
SEM Results @8000rpm, 120, 30 min

19



8/17/2015 HV mag □ WD
11:41:21 AM 20.00 kV 80 000 x 14.5 mm

1 µm
Flinders University Inspect F50

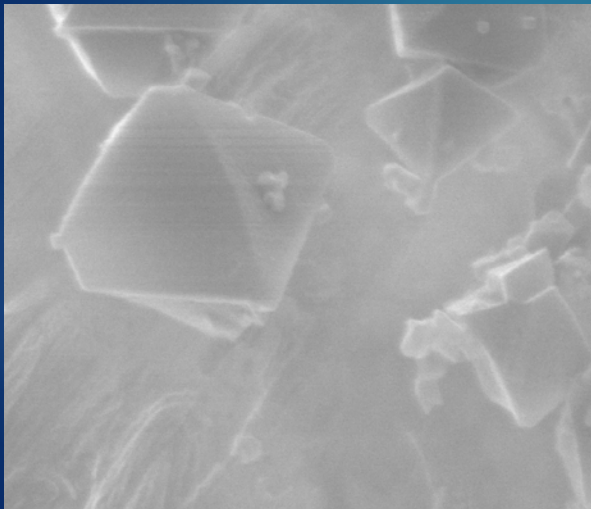


8/17/2015 HV mag □ WD
11:38:26 AM 20.00 kV 160 000 x 14.5 mm

500 nm
Flinders University Inspect F50

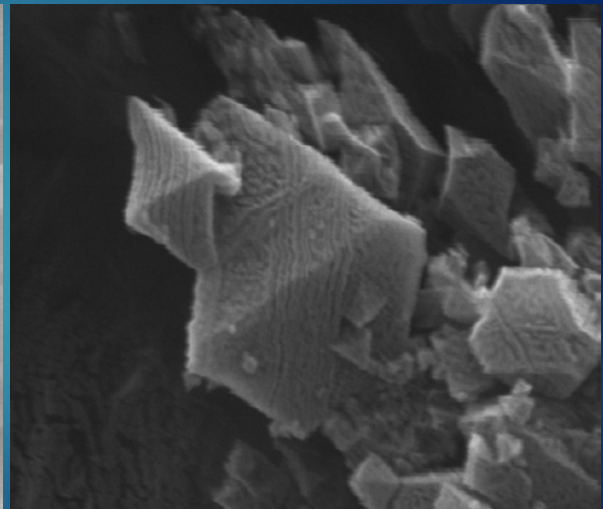
SEM Results @8000rpm vs 6950

20



7/29/2015 HV mag □ WD
4:21:32 PM 20.00 kV 120 000 x 9.7 mm

1 µm
Flinders University Inspect F50



8/17/2015 HV mag □ WD
11:38:26 AM 20.00 kV 160 000 x 14.5 mm

500 nm
Flinders University Inspect F50

Journal of Alloys and Compounds 540 (2012) 113–120

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Journal of ALLOYS AND COMPOUNDS

Electrochemical behavior of $[\text{Cu}_3(\text{BTC})_2]$ metal–organic framework: The effect of the method of synthesis

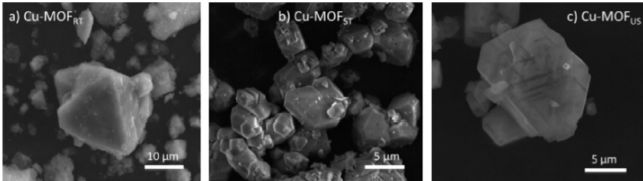
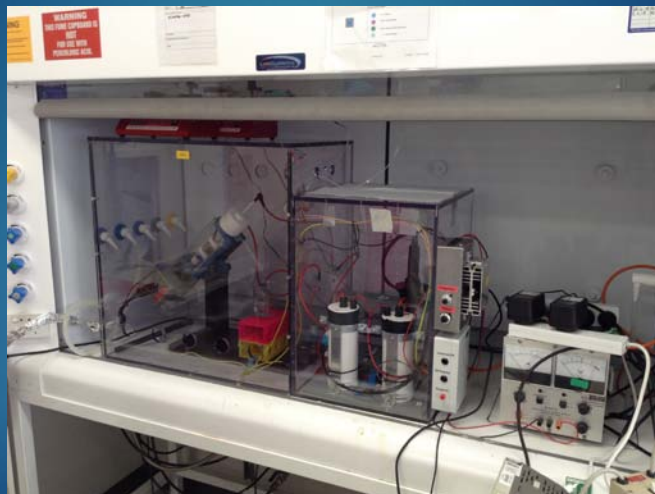


Fig. 4. Influence of the synthetic method on the morphology of Cu-MOF. The scale bar corresponds to 10 μm for (a) and to 5 μm for (b) and (c).



Experiment- Continuous Flow(6)

23



Next Steps

24

- ▶ Running XRD
- ▶ Running BET

Appendix

Cleland Conservation Park (12 July 2015)



Cleland Conservation Park is a protected area located in the Adelaide Hills, South Australia about 22 kilometres (14 mi) south-east of the Adelaide city centre. Cleland Conservation Park conserves a significant area of natural bushland on the Adelaide Hills face and includes the internationally popular Cleland Wildlife Park and the popular tourist destinations of Mount Lofty summit and Waterfall Gully. It is maintained by the South Australian Department of Environment, Water and Natural Resources

The Wildlife Park is accessible by sealed road from both the South Road and Greenhill Road, and on foot on a formed but steep track from Waterfall Gully or Mount Lofty.

Cleland Wildlife Park offers visitors an opportunity to walk through large enclosures and interact with Australian animals such as kangaroos, koalas and emus, and to see others including wombats, dingos and many bird and reptile species. The park also has a variety of rare and endangered species such as the wallaby, bush stone-curlew and brush-tailed bettong.

