SYNTHETIC DRUGS OF ABUSE

BY PROFESSOR MICHAEL KASSIOU

The past few years have seen a paradigm shift in recreational drug use throughout the world. There has been a sudden explosion in the availability of many synthetic drugs that mimic the effects of cannabis but are without complete characterisation.

After decades of stable use of a relatively small array of illicit psychoactive substances (e.g., cannabis, cocaine, methamphetamine, MDMA, LSD) there has been a sudden explosion in the availability of novel psychoactives, many with completely uncharacterised potency and toxicity. In 2012, European authorities became aware of more than 70 new compounds, indicative of an exponential increase in the detection of such compounds over time (Fig. 1). The most commonly detected type of new psychoactive substance during 2011 and 2012 were the synthetic cannabinoids (SCs) which are a major health concern.

In America, the Association of Poison Control Centres reported just 13 calls regarding SC exposure in 2009, but this jumped to 6968 in 2011. In Australia, a recent survey of SC users revealed that more than two-thirds (68%) of 300 respondents experienced at least one serious side-effect when last using SCs. The rapid rate of emergence of novel SCs remains an impediment to their systematic evaluation, and the scale and speed of their evolution suggests that it is only a matter of time before a compound arrives that has substantial toxicity.

From around 2010, a range of these SC- products became available under brand names such as Spice, Kronic, K2, Tai High and Zeus. These typically consist of non-psychoactive plant material laced with SC. These are available globally from internet-based vendors, and from bricks-and-mortar retailers such as “head shops”, adult stores, tobacconists, and convenience stores. Although these products are
disingenuously labelled as “incense” or “aromatherapy” products, and “not for human consumption”, their branding and packaging indicates that they are intended for smoking as unregulated, and therefore de facto legal, marijuana substitutes. At least 27 uniquely branded SC products have been reported in Australia alone.

Although use of SCs probably started around 2004-06, the popularity of these substances dramatically increased in 2008 in Europe, and in 2010-11 in the USA, Australia, and New Zealand. Even though acute cannabis ingestion itself is rarely associated with serious adverse effects, consumption of many SCs can be associated with severe toxicity. Case reports of serious adverse events are increasingly common, including severe agitation, disorientation, hallucinations, panic, psychotic episodes, suicide attempts, extreme hypertension, tachycardia, myocardial infarction, convulsion, and coma. These effects are rarely associated with the use of cannabis itself. Most recently, a multicentre study conducted by the Centre for Disease Control and Prevention attributed severe oliguric acute kidney injury (AKI) to SC ingestion. Worryingly, no single product brand or confirmed SC explained all cases of AKI, suggesting that multiple SCs may possess previously unrecognised nephrotoxicity.

Shortly after the identification of the “grandfather” SC, JWH-018 (1, Fig. 2) in herbal blends in 2008, many countries placed this SC in the most restrictive regulatory categories. Manufacturers quickly circumvented these control measures by substituting 1 with one or more unscheduled, congeneric SCs possessing similar effects. Indeed, despite the enactment of legislation banning the sale of JWH-018 and several analogues, the 2012 Monitoring the Future Report in the USA showed that SC use amongst 12th graders remain unchanged. Dozens of SCs have now been identified in unregulated commercial products, with perhaps more than 100 SCs currently available but awaiting formal identification.

The banning of JWH-018 was followed by the release of UR-144 (2) in multiple countries, indicating that the aromatic naphthalene group of 1 is not essential for psychoactivity. Our extensive experience exploiting the desirable physicochemical properties of the adamantane cage in drug discovery allowed us to predict that structure 3 would eventually appear on the SC market, a prediction ultimately validated by forensic reports of this compound as “AB-001”. Similarly, our analysis of recent cannabinoid chemotypes in the scientific literature suggested that 4 (SDB-001, APICA, 2NE1), a molecular hybrid of 3 and a quinolinecarboxamide cannabinoid scaffold, would likely emerge in SC products and this has since been confirmed. The terminal fluorination of JWH-018 to give AM-2201 (5) was reported by Makriyannis and colleagues in to improve CB1R binding affinity, and resulted in the appearance of AM-2201 in SC products. Anecdotal reports by SC users on internet forums that AM-2201 was more potent than JWH-018 led us to propose that the identification of fluorinated analogues of 2, 3, and 4 in SC products was also inevitable. Indeed, 6 (XLR-11) is one of several fluorinated SCs now reported in the forensic literature, the availability of 7 remains unconfirmed, and 8 is currently offered by online SC vendors as “STS-135” (although it has not been reported in the scientific literature).

The rapid rate of emergence of fluorinated SCs like 5–8 is particularly alarming due to their potential to form highly toxic fluoroalkyl metabolites. Nothing is known about the metabolism of fluorinated SCs. However, XLR-11 was implicated in several (but not all) cases of AKI, suggesting that fluorinated SCs may be nephrotoxic. Moreover, since these products are typically consumed by

\[ \text{Figure 1. European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) detection of novel drugs.} \]

\[ \text{Figure 2. Several known and predicted SCs identified in illicit products.} \]
smoking, there is serious pulmonary risk posed by the pyrrolic generation of hazardous hydrofluoric acid. Despite the sheer number of SCs, these compounds possess limited structural diversity. The vast majority of SCs are 1,3-difunctionalised indoles which appear to be generated by clandestine laboratories applying rational drug design techniques to existing structure-activity relationship (SAR) data in the scientific and patent literature. Furthermore, each SC may produce multiple bioactive metabolites, as is the case with one of the first identified SCs of abuse, JWH-018. Several metabolites of JWH-018 have been identified, each possessing different functional activity and pharmacokinetic properties to the parent drug and other metabolites. SCs or their metabolites also interact with non-cannabinoid receptor targets possibly accounting for the cardiotoxicity of these compounds compared to cannabis.

Delay in the conclusive identification and pharmacological characterization of emerging SCs presents a potential danger to the intended consumers, and the pre-emptive identification and thorough assessment of novel “designer drugs” remains an important aspect of proactive public health policy. The implementation of appropriate legal restriction of synthetic cannabinoids is hampered by a scarcity of reference materials and analytical data, a problem that is compounded by the sheer rate of emergence of such compounds. In collaboration with Prof’s Mark Connor and Iain McGregor we are currently identifying structural features of recently identified and predicted SCs, and their metabolites, that contribute to cannabinoid receptor potency and behavioural and toxicological profiles in vivo.

References

PROFILE:
Professor Michael Kassiou

Michael Kassiou received his PhD in Organic Chemistry in 1992 from the University of NSW. Following this he took up a position as research scientist within the Biomedicine and Health Program at the Australian Nuclear Science and Technology Organisation (ANSTO). In 1993 he was appointed as a visiting scientist at the CEA-Service Hospitalier Frédéric Joliot Life Sciences group in France which peaked his interest in methods for studying the living brain. It was here that he first experienced the use of positron emission tomography (PET) as a technique that allowed for the first time to look inside the living brain to study brain neurochemistry and the effects that therapeutic drugs had on it in a non-invasive manner. Shortly after that Michael took up a postdoctoral position at the Johns Hopkins Medical Institutes in Baltimore USA with Professor Robert Dannals and the late Professor Henry Wagner who was known as the forefather of Nuclear Medicine. Living in Baltimore and studying at Johns Hopkins was a very stimulating time, both academically and socially. During this time he learnt three simple principles about research that he still abides by: “is it new?”, “is it true?” and “does it matter?”. In 1996 he was awarded a Fogerty Fellowship that saw him take up a position at the NIH National Institute of Drug Abuse (NIDA) USA with Professor Eddyhe London. Here he developed an interest in looking at the effects of drugs of abuse with a focus on nicotine and the use of PET. He then moved back to Sydney to the Department of PET and Nuclear Medicine at the Royal Prince Alfred Hospital as a Principal Hospital Scientist and in 2006 took up a position at the University of Sydney in which he is currently Professor of Medicinal Chemistry. He has also been elected as a Fellow of the Royal Australian Chemical Institute (RACI) (FRACI, C.Chem) and is currently chair of the Medicinal Chemistry & Chemical Biology Division of RACI.

Michael’s research is interdisciplinary and built around the key themes of medicinal chemistry and drug discovery. In this domain a key component is the development of structure-activity relationships of bioactive CNS molecules which allow the rational design of more efficacious treatments for diseases of the brain. In addition, he has a long-standing interest in development of targeted molecular probes for neuropharmacological studies, including the development of pharmacological techniques for the study of receptor-ligand interactions and radioligands to identify brain regions and neural pathways affected in substance abuse, neurodegenerative and psychotic disorders.
E-NEWSLETTER
As part of the School’s efforts towards a greener future, we’d like to reduce the number of paper copies of this Newsletter we mail out. If you would like to help us in this effort by electing to receive the web-based e-newsletter, please email Anne (anne.woods@sydney.edu.au). To view the e-newsletter please visit http://bit.ly/q9FzMJ

SEMINARS
Upcoming seminars can be found at http://bit.ly/OJfELn. If you would like to be notified of upcoming seminars please email Anne (anne.woods@sydney.edu.au) and she will add you to the electronic mailout each week.

IN THE NEWS
The Open Source Malaria project, run by Dr Mat Todd and Dr Alice Williamson, has been awarded the Accelerating Science Award Program (ASAP) along with two other recipients. Mat was presented with the award at the World Bank in Washington on the 22 October, 2013. For more information please visit http://bit.ly/GZKE97

Congratulations to Associate Professor Lou Rendina who has just been appointed to the ARC College of Experts. ARC College members assess and rank ARC grant applications submitted under the National Competitive Grants Program, make funding recommendations to the ARC and provide strategic advice to the ARC on emerging disciplines and cross-disciplinary developments. This is a prestigious honour for any academic as only a handful of chemists nationwide are appointed to the College each year. http://sydney.edu.au/science/people/lou.rendina.php

SYDNEY UNIVERSITY CHEMICAL SOCIETY
Everyone with an interest in chemistry is welcome to join the Society. For more information please see the website, at http://bit.ly/Zo1lwt or check out our facebook group at http://on.fb.me/17hnMi7.
HANS C. FREEMAN LECTURE

This year the Foundation for Inorganic Chemistry was honoured to have as its guest speaker, Professor Ken Raymond, Chancellor’s Professor from the University of California, Berkeley. Professor Raymond visited the School during October to present a series of lectures, including the 2013 Hans C. Freeman public lecture entitled “Iron, cold iron, is master of them all: a battle between pathogenic bacteria and their human hosts”. This lecture would not be possible without the generous donations of alumni and friends. A list of donors can be found at http://bit.ly/1eJm2hG.

NEW NANOSCIENCE INSTITUTE

On the 24 July, Senator The Honourable Kim Carr, federal Minister for Innovation, Industry, Science and Research, officially broke the ground to start building work on the site for the new Australian Institute for Nanoscience (AIN) at the University of Sydney.

The Australian Institute for Nanoscience will be a world-leading research and teaching facility designed to meet the demanding requirements of nanoscience research in decades to come. It will house a state-of-the-art national nanofabrication facility, providing advanced research capability, in addition to comprehensive research and teaching facilities.

Located at the University of Sydney as part of the School of Physics, the Australian Institute for Nanoscience will include purpose built laboratories for research and practical teaching, teaching spaces, and a new lecture theatre. Many elements of the building have been specifically designed to enable high precision nanoscience research. It is anticipated that the new building should be ready for researchers and students in mid-2015.

While the Institute is formally part of the School of Physics, the specialist equipment and laboratories that will be housed within it will be of use to many researchers from the School of Chemistry who work in the nanoscience area. Research from within the School that will benefit from access to this facility includes areas of photonics, soft materials and solid state materials for a range of applications (e.g. memory storage). The AIN will provide significant opportunities for researchers in the Schools of Chemistry and Physics to collaborate on nanoscience research.
A WEEK IN NEW ZEALAND

BY DR LIZ NEW

I think that one of the best things about academic life is the opportunity to travel, meet new people and talk about science! In August I was able to spend a week in New Zealand doing just that. My main reason for the trip was to speak at a conference, but I also took the opportunity to visit a couple of universities.

First stop was Christchurch, where I spent the day in the Department of Chemistry at the University of Canterbury, giving a seminar and meeting lots of academics there. I then took a day to drive to Dunedin, which was a good chance to see the country! In Dunedin, I gave a seminar at the University of Otago, and again met with many academics in chemistry and pharmacology, including Nigel Lucas and Greg Giles, who’d both been research fellows at Sydney during my student days here.

One thing I love about seminar visits is meeting people at a similar career stage to me – it’s a good opportunity to share the trials, but also the joys, of the job. It’s also great to be reminded of how small the world of academia is – it’s not hard to find connections with people, whether they are collaborators or colleagues we might have in common, or shared research interests.

After my seminars, I spent a day driving from Dunedin to Queenstown – again accompanied by amazing scenery. Each year, Queenstown hosts the Queenstown Research Week (QRW) in August, during mid-semester break for New Zealand universities. This is the main biology conference in the countries, with a thousand attendees, and I was told that people have given up trying to organise meetings at other times of year due to the overwhelming popularity of this conference. As a result, the main conference is accompanied by smaller, satellite meetings.

I was attending the satellite meeting on redox, which is focussed on research into oxidation-reduction processes in biology. This is an area in which research in New Zealand excels, particularly in the discovery of enzymes that catalyse redox reactions. There were about 100 attendees with very varied backgrounds, from practising GPs to physiologists to chemists. I was invited to speak about the work we are doing in developing chemical tools to study redox reactions in biology, and I met lots of people interested in working with us in the future.

Being part of the larger QRW meeting was also interesting. All the breaks were held in the huge trade display areas, full of companies trying to sell their wares and giving out many freebies in the process. I acquired countless pens, but missed out on the major prizes – iPad, camera, coffee machine – for which each company held raffles. The conference is also renowned for its “fashionomics” competition, in which groups enter a fashion show with outfits made from odds and ends lying around the lab. Unfortunately, this took place after I’d left. I was able to see another highlight though – a plenary address from the winner of the 1987 Nobel Prize for Physiology or Medicine, Susumu Tonegawa. Although his Nobel Prize was for his work on the immune system, he spoke about his current interest in understanding memory and how we can form false memories.

All in all it was a busy week, but I met so many new people, and came away full of ideas for new projects and directions my research can take. What a bonus that I got to see some beautiful scenery along the way!
A new nanostructured material with applications that could include reducing condensation in airplane cabins and enabling certain medical tests without the need for high tech laboratories has been developed by researchers at the University of Sydney.

“The newly discovered material uses raspberry particles - so-called because of their appearance - which can trap tiny water droplets and prevent them from rolling off surfaces, even when that surface is turned upside down,” said Dr Andrew Telford from the University’s School of Chemistry and lead author of the research recently published in the journal, Chemistry of Materials.

The ability to immobilise very small droplets on a surface is, according to Dr Telford, a significant achievement with innumerable potential applications.

Raspberry particles mimic the surface structure of some rose petals.

“Water droplets bead up in a spherical shape on top of rose petals,” Dr Telford said. “This is a sign the flower is highly water repellent.”

The reasons for this are complex and largely due to the special structure of the rose petal’s surface. The research team replicated the rose petal by assembling raspberry particles in the lab using spherical micro- and nanoparticles.

The result is that water droplets bead up when placed on films of the raspberry particles and they’re not able to drip down from it, even when turned upside down.

“Raspberry particle films can be described as sticky tape for water droplets,” Dr Telford said.

This could be useful in preventing condensation issues in airplane cabins. It could also help rapidly process simple medical tests on free-standing droplets, with the potential for very high turnover of tests with inexpensive equipment and in remote areas.

Other exciting applications are under study: if we use this nanotechnology to control how a surface is structured we can influence how it will interact with water.

“This means we will be able to design a surface that does whatever you need it to do.

“We could also design a surface that stays dry forever, never needs cleaning or able to repel bacteria or even prevent mould and fungi growth.

“We could then tweak the same structure by changing its composition so it forces water to spread very quickly.

“This could be used on quick-dry walls and roofs which would also help to cool down houses.

“This can only be achieved with a very clear understanding of the science behind the chemical properties and construction of the surface,” he said.

The discovery is also potentially viable commercially.

“Our team’s discovery is the first that allows for the preparation of raspberry particles on an industrial scale and we are now in a position where we can prepare large quantities of these particles without the need to build special plants or equipment,” Dr Telford said.

The other research team members and journal authors are Associate Professor Brian Hawkett and Dr Chiara Neto, both from the School of Chemistry and Dr Chris Such from Dulux Australia, that supported the research through an Australian Research Council Linkage Project grant.

Reference

1. Telford, AM; Hawkett, BS; Such, C and Neto, C. Mimicking the wettability of the rose petal using self-assembly of waterborne polymer particles. Chemistry of Materials, 25 (17), 3472-3479, 2013. DOI: 10.1021/cm4016386
SUCCESS FROM FAILURE

BY MS SALLY SITOU, MEDIA AND COMMUNICATIONS OFFICE

“I want my students to be actively engaged in class, instead of sitting back passively and listening to a lecture”.

An unlikely source of inspiration ignited a love of chemistry in Associate Professor Adam Bridgeman. During high school he was dropped from the top chemistry class to the second top. This spurred him on to do better.

“I had a teacher who didn’t teach chemistry in a way that was engaging, and as a result I lost interest in the subject,” Adam said.

“The next year I got dropped to Mr Pritchard’s class. He made chemistry fun by using lots of experiments. He explained in a way that I understood by relating it back to how the world works. It became my best and favourite subject.”

Almost three decades later Adam is using many of the same philosophies Mr Pritchard used to teach his first-year chemistry classes.

“I want my students to be actively engaged in class, instead of sitting back passively and listening to a lecture,” Adam said.

“Chemistry can be quite hard because it’s fairly abstract. By relating it back to the real world and using demonstrations, like chemical explosions and colour changes I can draw the students in and engage them.

“I know students can’t concentrate for an hour, so I break my classes into blocks and I use different modes of teaching. It’s effective because it gives students a chance to listen, practise right away and then understand the information.

“It can be a risk to move away from being a teacher, step back and talk less. But if you do this, you make the students do more. Ultimately, it is more enjoyable for them and me.

Another way Adam involves his students is by getting them to source good chemistry resources online. He terms this ‘crowd-sourcing resources’.

“It’s great for getting students involved, especially first years.”

Adam has used what he has learned in his own lectures and classes to become an educational leader in his faculty and the wider University. He has been awarded the Outstanding Teaching Award from the Vice-Chancellor’s Awards for Learning and Teaching for his commitment to helping his colleagues and his innovative approach to teaching.

“I enjoy research and it is very satisfying. But sometimes I find teaching can be even more satisfying than research because you get to have an immediate impact on thousands of students,” Adam said.

“My most satisfying moments are when students come up to me and say, ‘I thought I was going to hate chemistry but now I love it.’

On Thursday 16 May 2013, the School of Chemistry held its annual student scholarship & prize awards ceremony and luncheon. Guests included Professor Kate Jolliffe (Head of School), Professor Trevor Hambley (Dean of Science) and Mrs Dorothy Lamberton (wife of the late John Lamberton). Mrs Lamberton presented the John A Lamberton Research Scholarships. These scholarships and prizes would not be possible without the generous contributions of our benefactors. A full list a recipients and benefactors can be found at: http://bit.ly/14ag0OD

STUDENT SCHOLARSHIP & PRIZE RECIPIENTS

Photo courtesy of Ms Dimetra Skondra-Silva, School of Chemistry
A common interest in the fundamental science of chemistry brought together a diverse group of ambitious young researchers and 34 Nobel Prize winners at the 63rd Lindau Nobel Laureate Meeting, held from June 30th to July 5th on the beautiful and quaint island of Lindau, Germany. As one of eight representatives from Australia sponsored by the Australian Academy of Science and the Science and Industry Endowment Fund, I was fortunate to partake in the lectures and discussions, which provided an unparalleled opportunity to learn from some of the most accomplished and inspiring chemists.

On the island of Lindau, the festivities kicked off with dinner and a chance to meet the other delegates, who represented nearly 80 other countries from around the world. The following morning, the Nobel Laureates began their plenary lectures, with each Laureate providing perspectives on their own prize-winning research as well as insight into a variety of global issues, focusing specifically on the role of young researchers in solving these pressing problems. I found that the most inspiring talks provided a mix of technical science and a personal narrative of the experiences—both triumphs and struggles—that each Laureate encountered during the course of his or her career.

The eye-opening work of Steven Chu on alternative energy, Gerhard Ertl’s fantastic video footage depicting the movement of molecules on catalytic surfaces and Dan Shechtman’s perseverance through years of rejection and courage to question the central dogmas of his field were among the most memorable lectures. I will take away numerous ideas and words of wisdom from these sessions, not the least of which is a newfound motivation to make a meaningful contribution in my own field of research.

Interaction with Nobel Laureates in a more intimate environment was facilitated through a variety of smaller sessions, including workshops and discussion sections. For me, the most advantageous portion of the meeting, however, was the opportunity to talk one-on-one with the Laureates, an opportunity that was largely unique to the Australian delegation, thanks to the organization of our delegation leaders. We met with a number of Nobel Laureates at lunches and dinners throughout the week, including Robert Grubbs, Richard Schrock, Harry Kroto, Jean-Marie Lehn, Ada Yonath, Martin Chalfie, Walter Gilbert and Rudolph Marcus. These informal meetings provided a means to get to know the Laureates and hear about their unique experiences—the origins of their ground-breaking discoveries, what motivated them to overcome difficulties along the way, and even where they were when they received the life-changing phone call informing them of their award. Despite their enormous successes in science, the Laureates were remarkably grounded. I was struck by how down-to-earth they were and how comparable some of their experiences in scientific research have been to my own. The values of intellectual curiosity, hard work and a vision for a better future were common to both the Laureates and the diverse mix of young researchers present. For me, Lindau was therefore an embodiment of the cross-national, collaborative nature of scientific research, defying age, experience and cultural boundaries, and proving to be a truly inspiring experience.
CHEMISTRY IS GOOD FOR YOU!

I’m just back from a meeting of Australian Head’s of Chemistry organised by the Royal Australian Chemical Institute. It was interesting (and somewhat comforting) to hear that many of the issues we are facing as a School are issues at Universities nationwide. There was much discussion about what the future is for chemistry in Australia and in our universities.

One of the recurring issues that arose was the need for chemists to work together to educate the public about chemistry in order to improve our public image. At present the words most members of the general public associate with chemistry are negative (e.g. grey goo, genetically modified, toxic). There is a general perception that chemicals are bad for you. How many times do you see products labelled ‘chemical-free’ as a marketing ploy? Of course with the issues in many of our sporting codes, recent interest has been focussed on peptides as a class of chemicals that are particularly evil. (Personally, I was pleased to see Essendon relegated to 9th place on the AFL ladder as it meant my team made the finals after all!) Many people don’t realise that the term ‘peptide’ simply refers to a string of amino acids linked together and without them life as we know it wouldn’t exist. As a community of chemists we need to work together to improve the public image and understanding of chemistry and point out the good it has done (and is still doing) for our society.

With this in mind, it was particularly pleasing to see and speak to the large numbers of students at the University Open Day in September who were interested in studying chemistry and the even larger number of people who enjoyed the hands-on chemistry demonstrations running outside the Chemistry building throughout the day. One of the key factors in improving the image of chemistry is having more people understand what it really is, and that ‘chemicals’ include everything from the water we drink to the plastic cup or glass we drink out of, to the soap we use to wash that up with, so if more students do first year chemistry and get that basic understanding things can only improve.

One of the particular challenges we face in attracting students is that there is no clearly identified career path at the end of a Science degree with a Chemistry major. Our graduates end up in so many places, doing such a diverse range of things. Having plenty of detailed examples illustrating where a degree in Chemistry might lead is key to helping students (and at Open Day often more importantly, their parents) understand what a Science degree with a chemistry major leads to, so I encourage you, as our alumni, to get in touch if you’d like to share your career path with a new generation of potential chemists*.

Chemistry is so often seen as the ‘enabling science’ on which other, potentially more exciting areas (nanotechnology and biotechnology are two examples) rest, but I think it is time to turn the tables and see it as the ‘essential science’, without which those areas wouldn’t exist at all.

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Professor Kate Jolliffe
Head of School

*If you would like to share your career path please contact Anne Woods. Contact details are given below.
As a PhD student in the Cotutelle stream, I was offered the opportunity to spend twelve months of my PhD researching at the University of Ca’ Foscari in Venice, Italy. The Cotutelle program means that I am enrolled at both the University of Sydney and the University of Ca’ Foscari, and I will be awarded my PhD from both universities.

People often ask me “Why Venice?!“ Considering the rich cultural and artistic history of the city (as opposed to research reputation), that is probably a fair question! The answer is that my supervisors, Prof Thomas Maschmeyer and A/Prof Tony Masters, have a strong collaboration with Dr Alvise Perosa and A/Prof Maurizio Selva, who became my supervisors in Venice. Moreover, Ca’ Foscari has a strong tradition in green chemistry, having formerly hosted the Green Chemistry Summer School for many years. In Venice I worked on tuning the selectivity of different catalysts for upgrading lignin model building blocks. I performed these reactions using green solvent and reagent dimethyl carbonate, with which my Venetian supervisors are leading experts. Living in such a culturally and historically amazing city was really just a bonus!

The organic and inorganic chemistry departments at Ca’ Foscari are located in the lagoon of Venice itself. Most mornings I would walk from my apartment in Castello (one of the sestiere of Venice), over bridges, and through small calli, to get to work in Dorsoduro (another sestiere, where many of the university buildings are located). Walking through Piazza San Marco every day, especially in the foggy winter mornings before the tourists were up and about, was a truly special experience. Of course, on days when there was acqua alta (high water), the walk was a little more challenging! Luckily I had a smartphone app that told me the tide levels at different landmarks around the city, and I subscribed to daily email and SMS updates that alerted me of changes in the tide forecasts. If all that failed, sirens warn the entire city’s population in the case of very intense tidal events!

Aside from walking, the main mode of transport in Venice is by boat. Everything in Venice, from bringing in goods for the supermarkets, to rubbish collection, to moving house, happens by boat. The vaporetti provide transport for locals getting to and from work, while many locals have boats that are used for personal transportation. During my twelve months in Venice, the America’s Cup World Series was held in the Basin of San Marco, right in front of the Doge’s Palace, and I was lucky enough to spend a day out on my friend’s boat enjoying a picnic while watching the race! In July is Redentore, when Venetians give thanks for the end of the bubonic plague in the city. The main event is fireworks which last about half an hour. These are also held in the Basin of San Marco, and again I was able to enjoy the spectacle up close by boat!

Needless to say, my trip to Venice was an extremely rewarding and extraordinary experience for both personal and professional development. I felt that the city was small enough that I could get to know it pretty quickly, and I had plenty of friends with whom to enjoy after work spritz and cicchetti (Venetian bar snacks). Venice has become my other home, and I look forward to going back to visit when I finish my PhD.
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