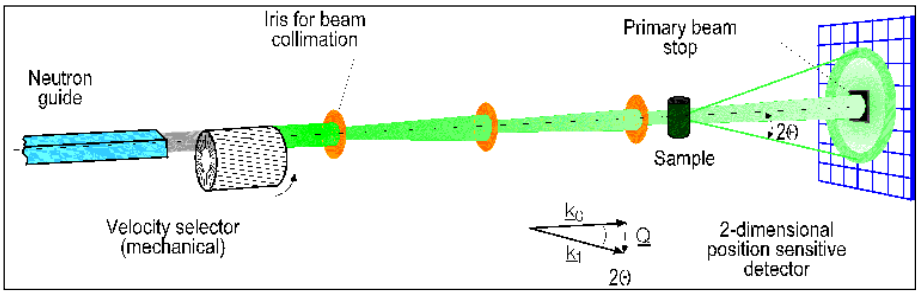
Irish Chemical News

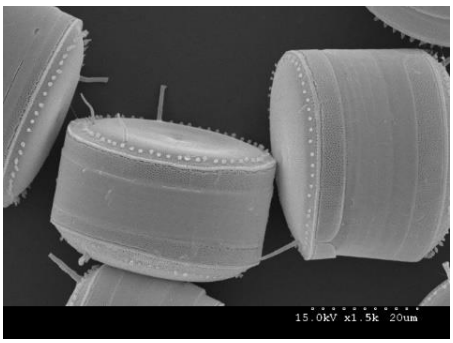
The Journal of the Institute of Chemistry of Ireland

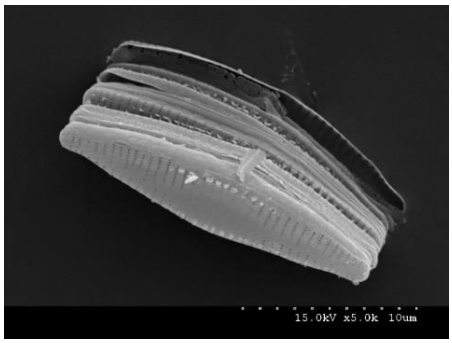
Feature Articles:-

Chemical Physics application of Small Angle Neutron Scattering (SANS)



Natural Resources to Sense and Solve Water Pollution





Engaging with Industry: Research Centres & Technology Transfer Offices, PMBrc

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Irish Chemical News

The Institute of Chemistry of Ireland

PO Box 9322, Cardiff Lane, Dublin 2

www.instituteofchemistry.org

Originated 1922
Incorporated 1950

The Professional Body for Chemists in Ireland

Contents:-

A Message from the President.

Dear Fellows, Members, Graduates and Associates,

This is the 5th Issue of 'Irish Chemical News' to appear this year; quite a record! Congratulations to our Editor, Pat Hobbs, for exceeding the target he set at the beginning of the year, which was to achieve a quarterly publication. We hope you find some interesting reading in this issue.

In my September message, I informed you that we were sending a delegation to Seville, where the General Assembly and the 6th EuCheMS Congress were being held, in order to make a bid to host the 8th EuCheMS Congress in Dublin in 2020. The delegation consisted of Pat Hobbs (Editor and Immediate Past President), Professor Thorfinnur Gunlaugsson of TCD and Noel Mitchell of Keynote Professional Conference Organisers. They had prepared an excellent presentation and made a very strong case for the Dublin Convention Centre. Unfortunately, there were five other countries also bidding to host the Congress and in the end, it went to Portugal. No reason was given for the decision, but as the 7th EuCheMS Congress is to be held in Liverpool in 2018, perhaps geography went against us and they wanted to return to mainland Europe for the next Congress. However, we hope to try again for 2022.

Our 2016 awards event was held at the DIT Kevin St. Campus on November 15th. Two awards were presented on the night. The first was the ICI Industrial Chemistry award, sponsored again this year by Henkel Ireland. This went to Imelda Shanahan, founder and Managing Director of TMS Environment Ltd. She gave an inspiring lecture, entitled 'Strictly Chemistry?', describing the challenges of setting up a company, as well as giving several interesting case studies of problems that her company was able to solve for its clients. Patricia Cullen of Henkel Ireland made the presentation. On behalf of the Institute, I should like to thank her for her company's sponsorship of this award for the second year. The good news is that Henkel will sponsor the award again in 2017, so we shall be inviting nominations for the award early in the New Year.

The second award presented on November 15th was the ICI Annual Award for Chemistry, named in memory of the late Eva Philbin, a former President of our Institute and Professor of Chemistry at UCD. It is given to an individual who has made a significant contribution to chemical knowledge, and is also an excellent science communicator. This year's award went to Professor John Sodeau of UCC, founder of Ireland's only Atmospheric Chemistry laboratory. He gave a most entertaining as well as informative presentation entitled 'Every Breath You Take. (All you wanted to know about Air Pollution but were afraid to ask")'. He gave the first lecture in the series at UCC on November 9th and will give a third lecture at Limerick IT early next year. He may even be persuaded to travel to Waterford to give a 4th lecture! In case you missed it, the lecture is available on YouTube:

https://www.youtube.com/watch?v=7ap8O-M6bIA

In conclusion, I wish you all a peaceful Christmas and a happy New Year!

Margaret Franklin. December 2016

Editorial

Its year end again and with a 5th Issue of ICN we are well on the way to having a bimonthly publication. I hope to achieve this in 2017 with the support of our chemists and contributors working in Ireland across the spectrum of research, academia industry and services. To those who have already written papers a big thank you from our Institute.

In this issue we have two articles from last year's and this year's Industrial Chemistry Award, Dr Donal Coveney and Dr Imelda Shanahan respectively. Our Annual Lecture Series Award won by Prof John Sodeau, UCC was presented on the same night at DIT, Kevin St. and a paper will follow next year. A short report on the award night is included.

A colourful report is included on the International Symposium on Chromatography (ISC2016), held in UCC last August- September attracting some 600 delegates from across the world.

Three of our Institute members won Teaching Hero Awards, Prof Celine Marmion RCSI, Dr Sheila Donegan WIT and Dr Paraic James DCU (posthumously) and a short article is included in this issue.

The Institute's preliminary Calendar of Events is included and also advertisements for 3 large conferences occurring in late January and February in City West Hotel. You need to register in advance - entry is free. These conferences attract 2-3000 delegates with many excellent speakers from across industry and academia. They are the "National Manufacturing & Supply Chain Conference & Exhibition" and concurrently "The 2017 National Sustainability Summit" both on January 31st. The third conference is the "Research and Innovation Conference & Exhibition 2017" on the 14th February 2017. I attended these last year and they are well worth the time and effort. They are organized by Premier Publishing & Events.

An academic paper introduces a relatively new technology with chemical application in materials and forensics titled Chemical Physics application of Small Angle Neutron Scattering (SANS). Not to be found in many labs but is commercially available as a service.

A paper on environmental monitoring and remediation titled Natural Resources to Sense and Solve Water Pollution discusses diatoms and their applications in water pollution.

Our President has commented on our bid to host the 2020 EuChEMS Chemistry Congress in the Convention Centre, Dublin. We did not win this time but we will bid again in 2018 in Liverpool for 2022 Congress. I attended both the General Assembly and the Congress in September in Seville on her behalf as she had family commitments and could not attend during that week. There were two events at the GA which members have been informed about. The first was the "The Seville Declaration on the Use of Chlorine in Warfare," which I signed on behalf of the Institute and the second, "The Seville International Chemistry Declaration 2016" dealing with the role of chemistry and chemists in society. This was emailed to members who can sign up to its principles. In case you have not signed yet here is the link:-

I wish to adhere to The Seville International Chemistry Declaration 2016

The Congress itself was a great success with over 2000 delegates and 900 speakers from Europe, USA, Russia and further afield with 5 Nobel Prize in Chemistry Winners giving plenary lectures. Much to the shame of Irish Chemists and Researchers there were no speakers from Ireland as far as I could determine. This is a major event and growing in importance and size. Are Irish chemists "brexiteers" at heart despite the millions of Euros we get from Europe and Irish tax payers. I hope not. The next opportunity to redeem ourselves is Liverpool 2018, hosted by the RSC who are very supportive of the Institute bidding. Sign up to get updates – see ad next page. Let's show at Liverpool the huge research effort chemists in Ireland are making across the whole spectrum of chemistry and have a huge turnout at Liverpool in 2018. Plan now as it's not far away and time passes quickly.

Have a Happy Christmas and a Great New Year

Patrick Hobbs
Editor ICN December 2016

EuCheMS European Chemical Sciences

ROYAL SOCIETY OF CHEMISTRY

7th EuCheMS Chemistry Congress | LIVERPOOL UK 26–30 August 2018

7th EuCheMS Chemistry Congress

Molecular frontiers & global challenges

ACC LIVERPOOL, UK
26–30 August 2018

REGISTER YOUR INTEREST

About the congress

With a theme of 'Molecular frontiers and global challenges', the 7th EuCheMS Chemistry Congress features five days of scientific and technical sessions, plenary lectures, oral and poster communications, keynote speakers and roundtable discussions, as well as exceptional networking opportunities, an exhibition and a unique social programme.

The EuCheMS Chemistry Congresses reflect the outstanding research being done in Europe and around the world by bringing together chemists from different countries and professional backgrounds to exchange ideas, advance knowledge and discuss key issues for chemistry and society. As such, the 7th EuCheMS Chemistry Congress offers you exceptional opportunities to network with chemists from across Europe and beyond.

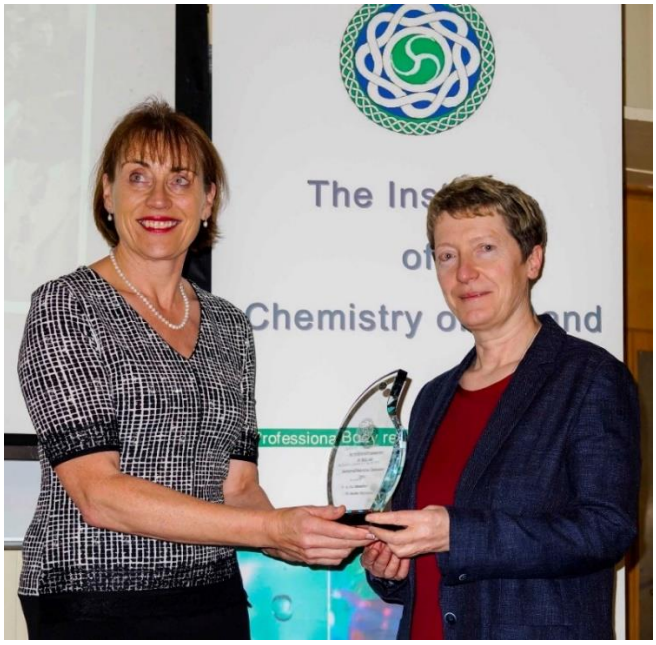
Registration will open in late 2017, and will be via an online system; full payment is required to guarantee your booking.

http://www.rsc.org/events/euchems2018#

ICI Awards Night

Industrial Award & Annual Lectures Series (Eva Philbin)

A very enjoyable night was had at DIT, Kevin Street Campus on Tuesday 15th November with two interesting and entertaining presentations by our two award winners. Below Dr Patricia Cullen from Henkel Ireland, sponsor for the 2nd year running of the Industrial Chemistry Award, presenting the Industrial Chemistry Award to Dr Imelda Shanahan of TMS Environment Ltd. Henkel have kindly committed to sponsoring the Industrial Chemistry Award 2017.



President Margaret Franklin presenting the Annual Lecture Series Award (Eva Philbin) to Prof John Sodeau, Professor Emeritus of Physical Chemistry UCC.

Imelda's article is presented in this Issue along with last year's winner's paper by Dr Donal Coveney of TopChem. John's paper on atmospheric pollution will follow hopefully in the next issue in February.

Again we thank our Sponsors:-

Jumping through hoops and Chasing our tails.

Challenges in securing market approval of Pharmaceutical Products

Dr Donal Coveney, TopChem Pharmaceuticals Limited

This article is based on the lecture presented to the Institute of Chemistry of Ireland for the inaugural Industrial Chemist of the Year Award. The kind sponsorship of Henkel Ireland is gratefully acknowledged.

Introduction

TopChem Pharmaceuticals was established in 2007 as a manufacturer of generic low volume active pharmaceutical ingredients. Our main target market is the US which has a thriving generic market – currently estimated at $70 billion or about 20% of the overall US market value. The volume of US generic prescriptions is running at over 80% indicating the significant cost saving incurred by the use of generics.

The approval process for generics can be lengthy. Both the active ingredient and drug product (i.e. the drug formulation) are carefully scrutinised by the authorities. For the US market the active ingredient manufacturer submits a Drug Master File (DMF) to the US FDA. The DMF details the manufacturing process, specifications, analytical methods, stability and all associated validations of all of these activities. In addition the active ingredient must be characterised fully and compared to the innovators original product to ensure that the correct polymorph, particle size and other physical characteristics match.

In parallel the drug product manufacturer must submit an Abbreviated New Drug Application (ANDA) to the FDA. A primary goal is to demonstrate bioequivalence of the generic formulation with the innovators product. This is generally relatively straightforward for an injectable formulation but is more difficult with oral and topical products where a bio study in patients must demonstrate bioequivalence.

The Table 1 below depicts the parallel activities of the API and drug product and it can take up to seven years to get a generic product to the market.

API (TopChem)	**Drug Product (Customer)**	**Timeline**
Develop Synthesis		3 months
Optimise Process		+3 months = 6m
Develop & Validate Analytical		+3 months = 9m
Scale-up Process	Develop Formulation	+3 months = 1yr
Validate Process	Prepare Exhibit Batches	6 months = 1.5yr
Gather Stability Data	Run Bioequivalence Study	6 months = 2yr
File US DMF	Gather Stability Data	6 months = 2.5yr
	File ANDA	3 months = 2.75yr
FDA Review	FDA Review	2-3 years = 5-6yr
FDA Approval	FDA Approval	1 year = 6-7yr

Table 1: Parallel timelines for the development of a generic API and Drug Product

The regulatory authorities quite rightly judge our products to the highest current standards. But of course many standards are underpinned by guidelines and as such, these guidelines are not absolute. In addition, the standards are constantly being revised and in effect the standards are being raised. FDA is gradually

reducing the backlog of ANDAs but there are currently 2,400 pending ANDA applications. The current review cycle is about three years. Taking all these factors into consideration, it can be an uncertain path ahead when a generic application is made. The standards tend to have shifted by the time our DMF is reviewed.

This article outlines some of our trials and tribulations in getting our products approved in the market. It is of course our responsibility to demonstrate the safety and integrity of our products to the satisfaction of the appropriate regulatory authorities.

Case Study 1

Malathion is an age-old pesticide which is no longer widely used in agriculture. However this product is still used in head-lice treatment. There are many different head lice treatments and this infestation is a problem all too familiar to parents of national school children. Malathion is sold over the counter in Europe but this is a prescription product in the US.

TopChem partnered with a US drug company to offer a generic equivalent of this head-lice treatment. We developed a commercial process of the API based on the published synthesis which is outlined in the scheme below:

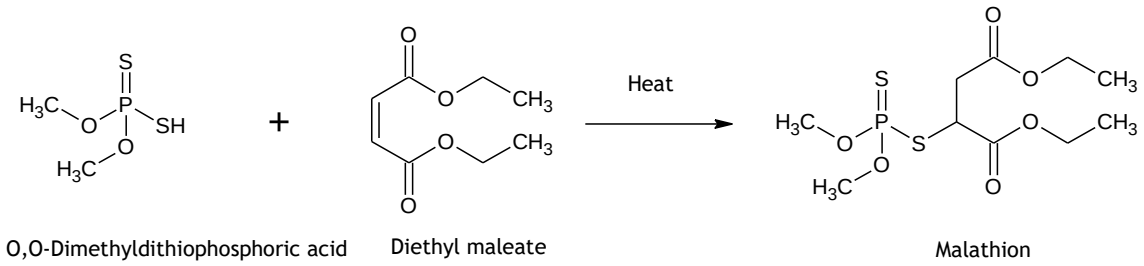
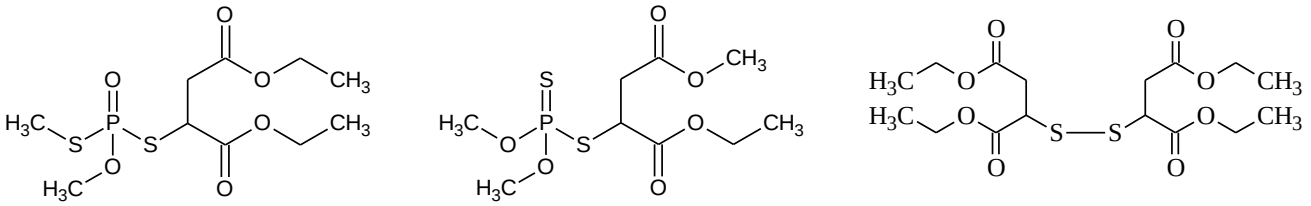


Figure 1: Synthetic route to Malathion

Reaction of methanol with phosphorous pentasulfide yields O,O-dimethyldithiophosphoric acid which is then reacted with diethyl maleate to produce crude Malathion. Malathion is a liquid and thermally unstable which presents some challenges in the purification. Nevertheless we refined the process such that our material met the United States Pharmacopeia (USP) specification.

We filed our DMF and continued to gather stability data. However in conjunction with our US partner we anticipated that the USP specification would not be sufficient to gain market approval. ICH (www.ich.org) guidelines are widely recognised and these general guidelines mandate tight limits on related substances in all pharmaceutical products.

We embarked on a further process optimisation with particular attention paid to the relatively high levels of isomalathion, methyl malathion and Tetraethyldithiodisuccinate (structures depicted in Figure 2) which are present in our product. Isomalathion forms on heating malathion and is a stability indicating impurity. Methyl malathion occurs via ester exchange of one of the ethyl esters with methanol. Methanol forms in the reaction mixture by hydrolysis of the O,O-dimethyldithiophosphoric acid and of malathion itself. The methyl malathion impurity is actually an inseparable mixture of isomers where one of either ethyl ester groups has been exchanged. Tetraethyldithiodisuccinate is another hydrolysis by-product where hydrogen sulfide formed in the reaction adds to diethyl maleate and this adduct then dimerises to form the observed impurity. Diethyl fumarate and methylethyl fumarate are by-products of isomerisation and ester exchange of the starting material diethyl maleate.



Isomalathion Methylmalathion (plus isomer) Tetraethyldithiodisuccinate

Figure 2: Key Malathion impurities

Following further optimisation of our proprietary process we were able to significantly improve the impurity profile as outlined in more detail in Table 2.

Impurity	**Original Process**	**Revised Process**
Methylethyl fumarate	0.06 %	0.02 %
Diethyl fumarate	0.13 %	0.01 %
Isomalathion	0.08 %	0.01 %
Memethylmalathion	0.46 %	0.10 %
Tetraethyldithiodisuccinate	0.16 %	0.02 %
Unknowns (each < 0.10%)	0.11 %	0.04 %
Total	1.0 %	0.2 %

Table 2: Malathion impurity profile in the Original and Revised Process

Thankfully we passed our first US FDA inspection where this product was the main focus of the audit. Therefore our strategy of targeting a higher specification was vindicated.

Case Study 2

We received a customer complaint on one of our regular products. The customer noticed a slight turbidity on dissolution of the bulk material. This turbidity was not noticeable on standard QC testing but was quite evident with a concentrated bulk solution. The active ingredient is a hydrochloride salt of an amine and the solution was aqueous. The identity of the product is withheld for commercial reasons but is secondary to the discussion here.

A kilo of material was dissolved in the minimum water and a fine precipitate formed overnight. The solids were filtered to yield 55 milligrams of an amorphous white solid. The solid was insoluble in all solvents including water and was also insoluble and unreactive to sodium hydroxide and hydrochloric acid. A residue on ignition test indicated that the material was mainly inorganic. Some contamination of the solid with the active ingredient was evident as we had not washed the filtered solid for fear of compromising the isolated material. Scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM EDX) was performed on the residue from the ignition test. An SEM image is depicted below showing the area of the scan (Figure 3).

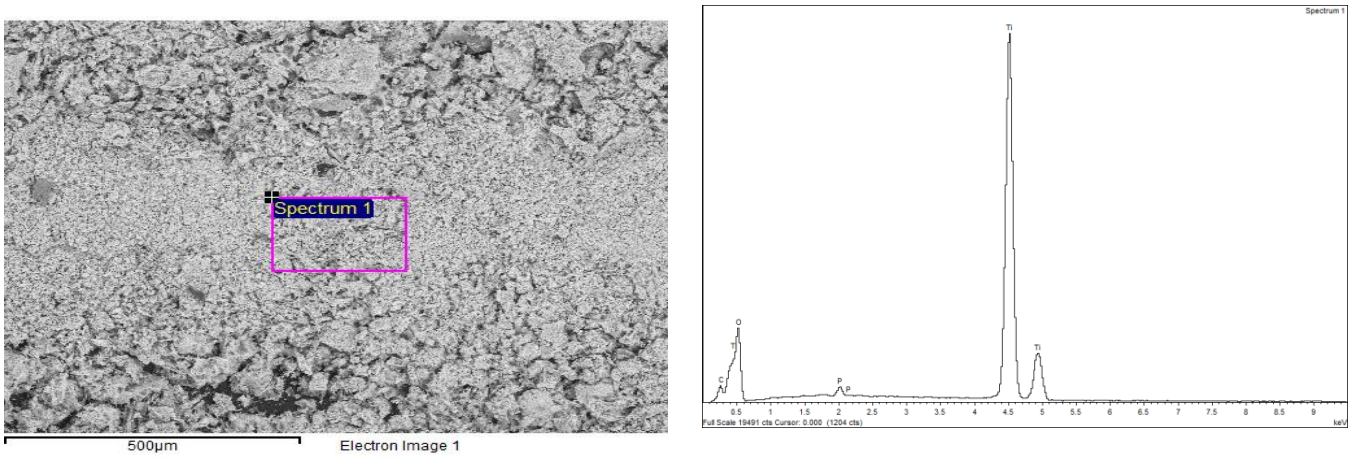


Figure 3: SEM Image of ignition residue (left) and SEM-EDX spectrum of the residue (right)

The scan result was quite informative showing strong signals for Titanium. We confirmed that the material is titanium dioxide. An examination of the process indicated that the turbidity was occurring at the final crystallisation of the API. As the product is crystallised from isopropanol-water, both were examined for traces of titanium.

It was quickly determined that the isopropanol used was the source of the problem. Two problem lots of isopropanol were identified. Both has unusually high residue on evaporation but were still within the specified limit. Evaporation of a large volume of one of the lots gave an oily residue at 0.005% by weight – the same order of magnitude seen in the API. NMR was inconclusive but SEM EDX analysis of the residue from ignition confirmed the presence of titanium dioxide.

We concluded that the isopropanol was contaminated with traces of an organotitanate complex – of which there are many types in the marketplace. Hydrolysis of this complex in the aqueous acidic crystallisation medium leads to titanium dioxide – the observed impurity causing the turbidity.

The isopropanol lots were analysed for titanium levels using ICP-MS and levels of around 40 parts per billion were found. It is remarkable that such a tiny level of a trace impurity can have such an impact on our downstream product.

The exact source of the contaminant in the isopropanol was never identified but it had occurred before the solvent arrived on site. The supplier was removed from our vendor list and a 5 ppb titanium limit was introduced on our incoming isopropanol specification.

The API specification was also revised to incorporate a detailed solution clarity test. Thankfully the problem has not recurred following the introduction of the corrective measures on both the raw material and product specifications.

Case Study 3

It might surprise the reader that there is a common thread which connects TopChem, the former US President Dwight Eisenhower and the fictional movie character E.T. The common thread is a product named Bretylium tosylate, an antiarrhythmic agent used in the emergency treatment of heart attacks. The product was invented in the 60s and President Eisenhower was successfully treated with the drug while it was still at an experimental stage and was credited with saving his life (http://news.minnesota.publicradio.org/projects/2001/02/universalu/topten/3_heartdrug.shtml). The product was subsequently approved and marketed in the US and Canada. At a more trivial level in the movie E.T., the alien is revived following treatment with Bretylium!

TopChem manufactures this active ingredient and is currently the only global source of the API for this life-saving, critical care medicine. The product is marketed in Canada and we are working with a partner to bring the product back to the US market. Bretylium was previously withdrawn from the US market for commercial reasons but there is now a medical demand to reintroduce the product.

The synthesis is relatively straightforward. The reaction of 2-bromobenyzlbromide with dimethylamine yields a tertiary amine which is then reacted with ethyl tosylate to generate the desired product: Bretylium tosylate as depicted in the scheme in Figure 4.

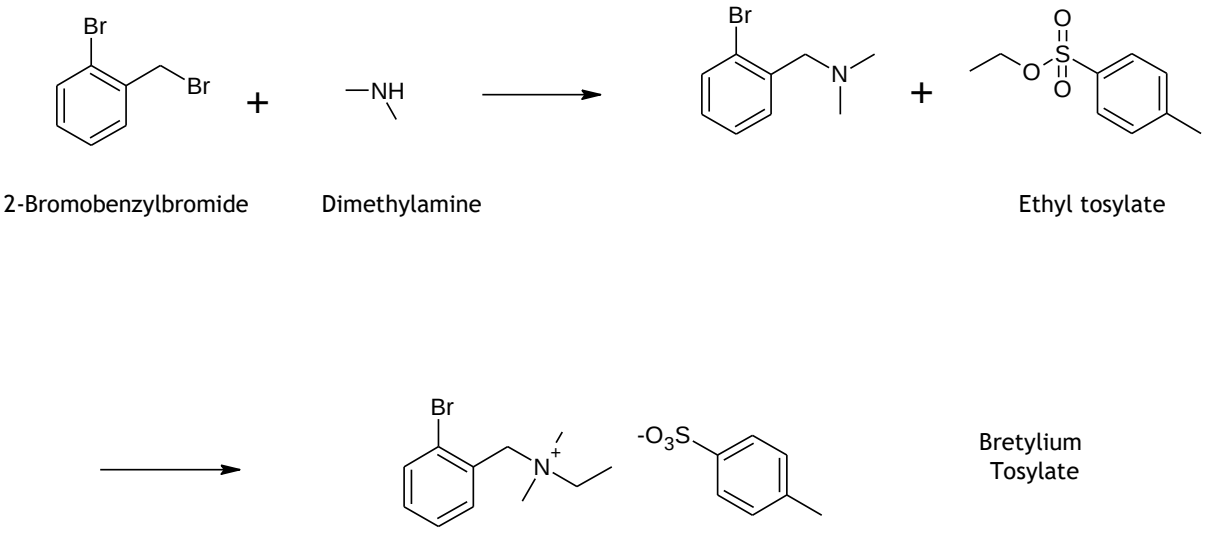


Figure 4: Synthetic Route to Bretylium Tosylate

TopChem optimised and validated the manufacturing process and filed a DMF with the US FDA. The product quality exceeded the requirements of the USP but nevertheless we have received a number of requests from FDA during the review, which require additional process and analytical method refinement.

The first review required a reduction of our limit for ethyl tosylate from 0.10% to 0.00005% (0.5 ppm). The rationale for this reduction is that ethyl tosylate as an alkylating agent is a potential genotoxic impurity. The focus on potential genotoxic impurities began with new chemical entities a number of years ago but has spread to all products including generics. The limit is calculated based on the maximum daily dose of Bretylium of 2.8grams and a maximum daily intake of a single genotoxic impurity of 1.5 micrograms per day.

We were able to validate our existing HPLC method down to a limit of quantitation of 0.02ppm and a limit of quantitation of 0.07ppm. We revalidated our process to demonstrate adherence to this much lower limit.

The second issue concerned the potential for downstream impurities derived from monomethylamine and trimethylamine if present as impurities in our key starting material: dimethylamine. FDA posed the question as to whether these impurities could carry through to the final product.

We spiked dimethylamine with 5mole% of each of monomethylamine and trimethylamine and found no new impurities present in the final product. Of course the downstream impurities had to be synthesised to confirm that the HPLC method used was capable of detecting and differentiating these potential impurities.

Trimethylamine is relatively straightforward in that the reaction with 2-bromobenzylbromide yields trimethyl(2-bromobenzyl)ammonium bromide (Figure 5). There is no subsequent reaction possible when exposed to the final step (reaction with ethyl tosylate).

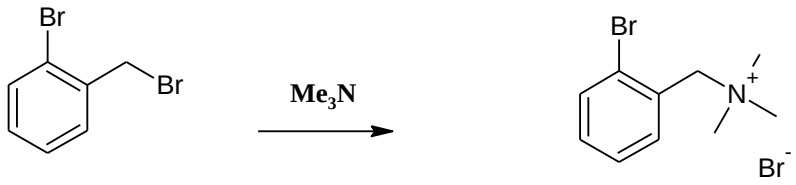


Figure 5: Reaction of 2-Bromobenzylbromide with trimethylamine

The reaction with monomethylamine is a little more complicated and not obvious. Reaction with 2-bromobenzylbromide yields two possible products by mono and dialkylation as depicted below (Figure 6). Trialkylation can be dismissed based on steric grounds. In practice, monoalkylation predominates (>80%). Given that we are considering a trace impurity we can dismiss the minor pathway.

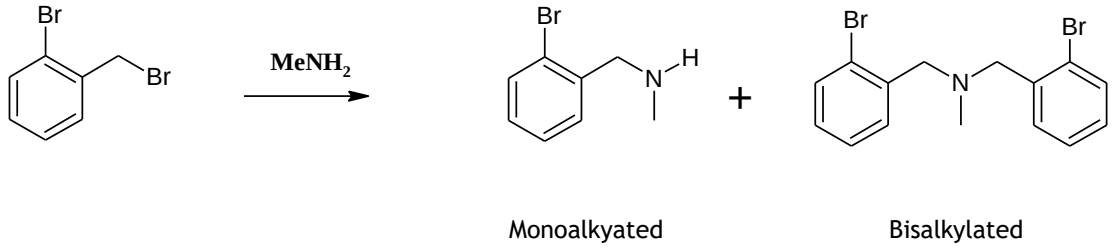


Figure 6: Potential products from reaction of 2-bromobenzyl bromide with methylamine

Surprisingly, reaction of ethyl tosylate with the monoalkyated amine did not produce the expected ethylated product but simply the tosylate salt of the starting material, albeit in moderate yield (Figure 7).

Figure 7: Unexpected product from reaction of 2-bromobenzylmethylamine with ethyl tosylate.

The authentic expected impurity was independently synthesised to confirm the identity of both. All potential impurities were visible on our standard HPLC method which was validated for all impurities. None were detected.

Finally, FDA asked us to consider the presence of dimethylethylamine tosylate in our final product. The logic here was based on the fact that an excess of dimethylamine is used in the first step to promote full conversion of the more expensive 2-bromobenzylamine. Dimethylethyamine tosylate was synthesised and we attempted to analyse for the presence of this in our final product by GC. However we found that heating the final product generated small but detectable amounts of dimethylethylamine due to decomposition of the product itself. At this point the phrase “chasing our tails” came to mind.

An alternative approach was made where we proved the absence of dimethylamine in the penultimate intermediate (dimethyl(2-bromobenzyl)amine as outlined in the scheme above). This was easily demonstrated by GC analysis of this intermediate.

Conclusion

In conclusion we have shown that the challenges in obtaining regulatory approval even for generic products can be at times frustrating but also technically interesting. It has led to additional synthetic work and new analytical method development in order to satisfy the regulatory authorities of the safety and integrity of our products.

Strictly Chemistry?

Dr Imelda Shanahan, BSc, PhD, FICI, C. Chem., FRSC

Acknowledgements

I would like to thank President Margaret Franklin and the Council of the Institute of Chemistry for nominating me for the Industrial Chemistry Award. It was a very unexpected honour and one I am truly thrilled to receive. I also want to thank Henkel for their generous sponsorship of the Award. This paper is the Lecture presented at the Awards Event, perhaps slightly polished.

Introduction

I considered calling this paper ‘50 Shades of Chemistry’ but I resisted the temptation in case I conned any undergraduates into attending the Lecture in vain hope of a more stimulating subject! While I certainly started in Chemistry and have done lots of chemistry along the way, the truth is that in an industrial setting, there’s always a lot more to the story than just one subject. And that’s the theme of this paper - the many other subjects that I as an industrial chemist need to address in the day-to-day routine of running a business. In a business environment, survival depends on multi-tasking, the arts of bi-location and maybe even translocation, so chemistry on its own doesn’t really capture all that is needed. In this paper I talk about some of the chemical and the non-chemical challenges I have addressed and continue to address as an industrial chemist.

In the beginning…….

I learned to love Chemistry from an inspirational teacher in Secondary school in Ennis Co Clare, Sr Angela Hartigan. From there it was on to UCD where I did my BSc and PhD. One of the best decisions I ever made was to study for a PhD in Physical Chemistry and I was fortunate to work under the supervision of Dr Howard Sidebottom. Sadly Howard passed away prematurely earlier this year and it was with great sadness that I learned of his sudden death – may he Rest in Peace. I was PhD Student Number 6 after the illustrious Ken Macken, Colman Concannon, Jack Treacy, Francis McKeown and Barry Foley, with whom I am still in contact – try following that line of eminent chemists.

My first real job was at the then National Institute for Higher Education (NIHE), employed by a Chemist, Prof Albert Pratt (thank you Albert), and I enjoyed 7 great years there. Except of course for the joy of the First Year Engineers Lecture in Material Science during Rag Week! Sadly one of my buddies who got a permanent job at NIHE at the same time as I did, Dr Paraic James passed away prematurely in December 2015 and another great friend of chemistry in Ireland was lost - may Paraic also Rest in Peace. Then I went to the newly established Peat Research Centre established by Bord Na Mona to research new uses for peat – hired by another chemist, Dr Dick Kavanagh. Day 1 was some shock to the system because I and the other new recruits learned on the first day that we wouldn't be working at research, our work probably would not have anything to do with Peat and we had better get ready to be commercial! They say that what doesn't kill you makes you strong and that's probably true of that experience for me, because it was in Bord Na Mona that I learned about personnel Management, marketing, business development, Accounts, and other alien subjects for a technophile – the tools I would need to run my own business. A short stint followed in a commercial organisation and then I took the plunge and set up my own business, TMS Environment Ltd. In 1994. This paper deals with aspects of the work that I and my colleagues have been doing in TMS since 1994.

TMS Environment Ltd

TMS Environment Ltd was established like many small companies from the box room of my home in June 1994. After 3 months we moved to rented incubator space in Dublin City University and in 1997 moved to rented premises in Tallaght where we are still based. Our fundamental philosophy has always been that the only way to do it is the right way – whatever it takes. One promise I made and continue to make is that TMS will always strive to get it right no matter the cost. If we are on the case, we expect to get it right and that has influenced our approach to business and the way we do things. We are not naïve (or arrogant!) enough to suggest that we **always** get it right ……. Just most of the time!

Quality Management Systems and Accreditation

Our aim for perfection led us to ISO17025 accreditation. Accreditation is a formal recognition and certification to an international standard of an organisation's competence to carry out specified activities such as testing or analysis. This certification is independent recognition of the technical competence, impartiality and integrity of TMS in the work we do.

We recognised at a very early stage the importance of formal and independent certification of competence – particularly for a new entrant to the market because the newcomers have to fight harder than established companies to get established. We therefore set about getting accredited and received our first award in 2003 and have added to the Scope of Accreditation most years since then. It was not mandatory in Ireland to have accreditation until the Environmental Protection Agency introduced a Policy in 2013 that for selected work

(stack emissions monitoring) reports would only be accepted from accredited labs from Jan 2014. It's a very expensive process to achieve and maintain accreditation but well worth the effort.

Some highlights in our achievements are accreditation to ISO17025 for the very specialised gas analysis we do as well as being the first, and only, company in Ireland to be awarded accreditation for water sampling and *in situ* analysis of waters. We are one of only four companies accredited by the Irish National Accreditation Board for stack emissions monitoring, and one of many labs accredited for laboratory analysis.

The fundamental features of the accreditation Schemes are:

- Proficiency Testing Schemes
- Independent surveillance and assessment
- A formal and extensive QA/QC Programme with written, well established procedures based on Standard Methods

There are very strict rules to be followed which govern all aspects of the work undertaken and working with an accredited organisation gives confidence in the reliability of the work undertaken. For this reason, most legal work will only be undertaken using accredited laboratories if they exist.

TMS Work Profile

We are a specialised services company providing specialised sampling, analysis and consultancy services. The main theme of our work is all aspects of work relating to Air & Water Quality, Noise and Vibration and Waste Management with a particular specialisation in air quality and odour impact assessment, management and control. We started in 1994 with one employee, grew to 32 employees at our peak prior to the most recent recession and currently employ 25 people.

Our senior Team is small consisting of just two managers, and two senior consultants. Over the years we have employed 208 people for varying terms representing 22 different nationalities and more than two-thirds have been chemists / taken chemistry to at least Year 3 of a Degree.

The work we do is very varied and includes very specialised laboratory analysis as well as some specialised consultancy work. Examples of the work we have undertaken include the following:

- Analysis of odourants in natural gas for Bord Gais / Gas Networks Ireland;
- Identification of residues from cylinders of gas;
- Identifying the origins of explosive gases in bitumen in a tanker;
- Applying analytical techniques to the identification of sources of flammable gases in remote areas;
- Analysis of lipstick to assist in explaining an adverse reaction of a consumer;
- Sampling of water quality from rivers and lakes in support of the National Water Framework Directive monitoring programme.

The non-technical work we get involved in is very varied – accounts, book-keeping, marketing, human resource management, gardening, plumbing, central heating maintenance and many diverse subjects. I learned at a very early stage in running the business that cash truly is king and always will be – we need to constantly watch cashflow and like all small businesses are always looking out for a savings opportunity. In a small company, one gets to try everything – and generally must do so as it is not always possible, or affordable, to hire the assistance that might be needed. That of course adds to both the challenge and the variety and it can be lots of fun juggling all of these roles often simultaneously.

Conclusions

I am fortunate to have had an opportunity to set up my own business and work in an area I very much enjoy. I have learned a lot from many people I have worked with and my guiding principles from those lessons are summarised as follows:

- Perseverance pays;
- Quality matters;
- Cash flow always needs minding;
- People matter more than exam results.

I am looking forward to leading TMS through the next phase of our development and the opportunity to keep playing with the chemistry toys.

- **For Limited Time Free Entry – Register HERE**

National Manufacturing & Supply Chain Conference & Exhibition

31st January 2017

Join us at the 2017 National Manufacturing Conference & Exhibition on the 31st of January 2017 to hear from an impressive line-up of manufacturing leaders, academics and government agencies who will engage in a stimulating blend of key note addresses and debates.

Creating an Innovative Manufacturing & Supply chain Ecosystem

Companies invited to attend include:

Johnson & Johnson, Standard Brands, Intel, Dell Products, Pfizer, Smurfit Packaging, Kerry Group, Boston Scientific, Forest Laboratories, Glanbia, Gilead Sciences, Glen Dimplex, Astellas Ireland, Irish Dairy Boartd, Swords Laboratories, Kellogg Europe, Benex, Aryzta, Dawn Meats, Genzyme Ireland, Irish Food Processors, Abbott Ireland, Atlantic Industries, Pepsi-Cola, Shering Plough, Diageo, Elan, Kepak, Medtronic Vasvular, Glaxosmithkline, Irish Distillers, Organon, Eli Lilly, Fyffes, Lakeland Dairies, Green Isle Foods, Allergan, Bausch & Lomb, Baxter Healthcare, Thermo King, KCI Medical Resources, Phardiag, Greencore, Teleflex Medical, Rosderra Meats, Merck Millipore, McDermott Laboratories, GE Healthcare, Cadburys, Connacht Gold, Donone Baby Nutrition, Liffy Meats, Monaghan Mushrooms, Takeda Ireland, Helsinn Birex, Recordati, Cook Ireland, Teva Pharmaceutical, Henkel Ireland, Fair Oak Foods, Stiefel Laboratories, C&D Foods, Carbery Milk Products, Leo Pharmaceuticals, Project Management, Shire Pharmaceuticals, Tibotec Pharmaceuticals, Vetpharm International, Renishaw Ireland, Proctor &

Gamble, Creganna, FMC International, Donegal Meat Processors, AllTech, Novartis, Rottapharm, UCB Manufacturing, Barclay Chemicals, Cognis Ireland, HJ Heinze, Becton Dickenson, ABB, Bimedia, Bioniche Pharma, Connaught Electronics, Zimmer Orthopedics, Lake Region Manufacturing, Roche Ireland, Sanofi Aventis Ireland, Pinewood Laboratories, Clonmare Healthcare, Schwartz Pharma, Merit Medical and many more….New approaches and technology have been introduced in recent years that have created significant organisational and process improvements. The aim of the conference is to showcase such innovative approaches and to disseminate the cutting edge research that underpins them.

The conference will be of interest to senior management, established practicing engineers and researchers together with those that are much earlier in their careers.

Delegates have registered from leading food, pharmaceutical, medical, chemical, electronics and engineering manufacturing sectors.

Manufacturing on this island of Ireland has some of the best people, products, brands and innovation. We deserve nothing less than the best business environment to chart a new economic course to growth. But government needs to set the climate and conditions to allow this to happen.

Manufacturers small and large from across the country will gather to challenge political decision makers to deliver a business environment which manufacturing deserves. Delegates attending the conference will:

– gain industry insights to help their business plan ahead
– share good practice and learn from each other's experience
– connected with senior business leaders to find new business opportunities
– meet with key technology providers in the dedicated exhibition area

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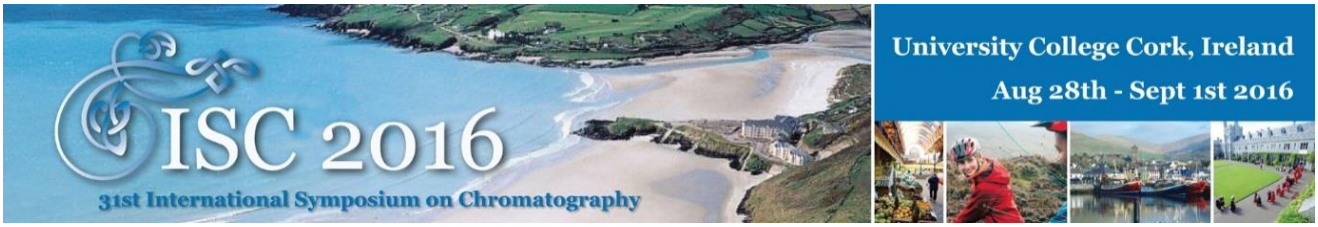
International Symposium on Chromatography (ISC2016) at University College Cork

August 28th – Sept 1st 2016



The International Symposium on Chromatography (ISC) series was first launched in 1956 in London and in bringing this major international event to Cork and southern Ireland for the first time, we were able to showcase the quality and depth of research, innovation and scholarly activity in separation science taking place in Ireland throughout academia, institute/centres and the many major international pharmaceutical and chromatography companies located here. In addition, world leading chromatographers and companies presented the latest advances in research to close to 600 delegates, through invited international and national plenary, keynote and oral presentations, alongside poster, industrial exhibition and seminars. Importantly, ISC2016 provided a forum for students and early career researchers to present their work and learn from the cutting edge of this field through direct oral and poster presentations.

(a) Opening Plenary Speaker Prof. Daniel Armstrong with Prof. Apryll Stalcup and (b) Dr. Damian Connolly (ISSC) welcoming delegates in the UCC Quad.

The conference bid was won by the SFI-funded Irish Separation Science cluster (ISSC) and the co-chairs Apryll Stalcup (DCU) and Jeremy Glennon (UCC), through their international network and industrial collaborations. There is globally a growing awareness of the academic and industrial strengths that exists in Ireland in this field of separation science and materials from publications and innovative products being produced here. Alongside this, chromatography is a rapidly expanding science with important applications across a range of fields, such as forensic testing, drug testing, quality control, food and beverage safety to cancer detection and clinical analysis. The field is thus critically important to Irish biopharma, food and beverage industries, chemicals and to state laboratories. With chromatography also central to the (bio)-pharmaceutical industry and 9 of the top 10 pharmaceutical companies located the region, hosting it in Cork facilitated the showcasing the current size/scale, and future potential for expansion of the (bio)-pharma industry, over the existing 17,000 directly employed in the pharmaceutical industry in Ireland.

Under the theme of ***Innovation and Impact of Chromatographic Separations on Science, Industry and Life***, the major focus of the 31st Symposium was on the impact and continuing contribution of chromatography and separation science to meet the needs of the (bio)-pharmaceutical industry, food, health, science and medicine.

Opening Ceremony in Devere Hall, with performance by members of the appropriately named Affiniti.

The conference programme commenced on Sunday afternoon August 28th with short training courses on Method Development Modelling, UPLC and SFC, consisted of 32 lecture sessions over 5 days (please see final programme at www.ISC2016.ie). In all 568 delegates from 46 countries attended over 5 days, to a programme of 9 plenaries, 27 keynote, 81 oral presentations, 10 tutorial lectures and 4 vendor seminars. As an integral part of the scientific programme, an international exhibition and vendor lecture series on instrumentation and services for chromatography, separation science and mass spectrometry also took place. Two overarching themes at ISC2016 on fundamentals and mechanisms of separation science, and key applications across various sectors, were chosen to reflect the diverse range of activities in the Irish and global separation science research landscapes. Advances made in the understanding of chromatographic and electrophoretic processes, made in parallel with the design of new materials as separation media, were described, advancing the science to new levels in speed of analysis and performance (*separations in seconds!).* The latest developments and emerging trends in HPLC, GC, capillary electrophoresis, mass spectrometry, materials, and sample pre-treatment were on show. New advances in Pharmaceutical Analysis, Metabolomics (Glycomics, Lipidomics and Proteomics), Molecular Diagnostics, Clinical and Biomedical Analysis, Forensic and Environmental analysis in addition to Food and Health, Food Safety and Authenticity were reported. For Biologics and Bioprocessing, where large-scale guaranteed quality purification is of critical importance, new methods in continuous bioprocessing, continuous chromatography and process analytical technologies (PAT) were presented.

These developments sustain the science of chromatography as it continues to meet the ever increasing demand for rapid methods in medicine, pharmaceuticals, food, environment and security. In addition to the scientific programme of lectures, tutorials, short courses and posters, delegates attended a world class exhibition and vendor lectures series on instrumentation and services for chromatography, separation science and mass spectrometry.

(a) ISC2016 Plenary Speaker, Prof. Pauline Rudd (NIBRT) and (b) Delegates meet at the Instrumentation exhibition in the Main (UCC).

This SFI and Meet in Ireland supported event thus provided unprecedented access to international expertise in the fields of Chromatography and Separation Science, techniques and processes critically important in pharmaceutical, food, health, science and bio-medical industries. The successful ISC2016 symposium was spearheaded by the Irish Separation Science Cluster (ISSC) in conjunction with the ISC International Scientific Committee and in association with the European Separation Science Society (EuSSS), the Chromatographic Society (UK) and the Institute of Chemistry in Ireland (ICI). Conference sponsorship from Failte Ireland, Science Foundation Ireland and the Cork Convention Bureau is gratefully acknowledged. Key Industrial sponsors are gratefully acknowledged included Shimadzu, Agilent Technologies, Waters, Merck, Metrohm, ThemoFisher, Linde, YMC, Pepsico, and Eli-Lily. The event was managed by Ali Murphy and her team at MCI Dublin. Reports were globally circulated in trade journals including International LabMate, LC-GC, and Chromatography On-line. Participants can submit manuscripts for publication in the Journal of Chromatography A, in a virtual special issue devoted to ISC2016 at Cork.

ISC2016 Local organising committee members, co-chairs Profs. Apryll Stalcup and Jeremy Glennon with Eileen O'Callaghan (UCC).

Using Inchydoney beach as a key website image alongside the UCC campus and City Hall, we were able to highlight this beautiful city and county of Cork, with its rich history and traditional music and dance to one of

the largest scientific gatherings in Europe in 2016, bringing together scientists from 46 countries across the globe including, Europe, Australia, Thailand, China, and the USA as invited speakers and delegates. This conference was estimated to add over €800,000 to the Irish and local Cork economy.

There were so many highlights, made possible by endless support and advice from UCC staff in catering, security and B&E, starting on a glorious August Sunday evening with the lone piper in the Quad, the talented Sean O'Riordan, the sparkling opening ceremony in Devere Hall, with performance by members of the appropriately named Affiniti, the excellence of presenters, exemplified by our many plenary lecturers (including Prof. Pauline Rudd (NIBRT), Prof. John Cryan (UCC)), the Shimadzu sponsored Welcome Reception in Devere Hall and speakers dinner in Hayfield Manor, the live performance by Pulses of Tradition at the Civic Reception in Cork's historic City Hall, the world class poster session and instrumentation exhibition in the Main, the Gala dinner and party in the Big farm Shed at Ireland's world famous culinary haven Ballymaloe House, with live band Newfoundland. The very successful International Symposium on Chromatography (ISC2016), with over 560 delegates, 117 oral and 330 poster presentations, concluded with the final of the poster competition and award ceremony in Devere Hall on Thursday Sept 1st.

ISC2016 Poster Prize Award Winners Presentation

Back row from left to right: Dr. Gesa Schad, Dr. Gerard Rozing, Frank Hauser, Rob Groarke, Alyah Buzid, Josh Smith, Aleksandra Nikitina, Mari Egeness, Annamária Sepsey, Prof. Jeremy Glennon, Mrs. Petra Russkamp. Front row from left to right: Prof. Apryll Stalcup, Norio Ishizuka, Tanja Melzer, Anatol Schmidt, Romy Vásquez, Kirsten Dowling, Estafania González. Not present Tanja Berg.

Congratulations to all involved and especially to award winners including Alyah Buzid in Analytical Chemistry at UCC. Having opened with registration in the historic Aula Maxima, the conference concluded there with a superbly catered Farewell Gathering.

But an abiding highlight was the warmth and friendliness of our delegate guests, who created the perfect blend of science and social, making it a pleasure and honour to host ISC2016 at UCC.

Apryll M. Stalcup & Jeremy D. Glennon

- The 2017 National Sustainability Summit will be held on the 31st January in the Citywest Hotel, Dublin.

Firstly, thanks to everyone that made last year's event such a success. Over 1000 delegate gathered to hear from 80 speakers and network with over 50 exhibitors offering cutting edge technology and services.

This year we plan to expand the scope over the event with over 120 speakers. The speaker line up is drawn from senior management from the largest and most influential Irish and international companies who have delivered quantifiable eco results. Speakers come from areas such as pharmaceutical, food, aviation, retail, hospitality, food, construction, manufacturing, IT, logistics and supply chain and energy sectors will deliver compelling case studies that will help you create a sustainable business of your own or adapt your current business model.

Get ahead of your peers, and participate in the National Sustainability Summit for a engaging and thought-provoking event, which will stimulate debate and help you to make the correct decisions to improve sustainability and profitability.

Key topics will include:

Water Management, Energy Efficiency, Sustainable Energy, Recycling, Waste Reduction, Sustainable Construction & Buildings, Sustainable Food, Sustainable Manufacturing, Sustainable IT, Sustainable Technology, Consumer Engagement, Sustainable Packaging, Sustainable Logistics and Supply chain, Regulations and Policy, Sustainable Investment, Tax and Legal issues, Sustainable Transport, And Much More …

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CALENDAR OF EVENTS 2017

Date	Venue	Event
February	Limerick IT	Eva Philbin 2016Award lecture Prof. John Sodeau, UCC 'Every Breath you Take'
	Waterford IT	Eva Philbin 2016 Award lecture
April	TBA	Eurachem Analytical Measurement Competition
April 27th (Th.)	**RCSI**	**Boyle-Higgins Award Lecture** **Prof. Henry Curran: 5.00 p.m.** **&** **Institute of Chemistry of Ireland AGM: 7.30 p.m.**
Date???		Heraklion (Crete) EYCN D.A.
June 21st (Wed.)	DIT	**Congress 2017** **Theme 'Food Chemistry'**
June 22nd – 25th	Lismore	Robert Boyle Summer School
June	**DCU**	**Irish Universities Research Colloquium**
Sept. 26 & 27	Rome, Italy	EuCheMS G.A.
October 21stUL (Limerick)		ChemEd Conference
November	**Venue TBA**	**ICI Awards Seminar:** **Industrial Chemistry Award (Sponsored by Henkel) &** **Eva Philbin Award Lecture**

Chemical Physics application of Small Angle Neutron Scattering (SANS) for an SU-8 polymer MEMS Microturbine

Mark Heaton obtained his Doctorate in Nanotech and microengineering from Imperial College London in 2013. This was part completed at The Budapest Neuron Centre, TNI-Cork and Carlow IT, where he obtained four of his nineteen publications.

In this PHD research he fabricated the first nanoscale Axial gas-flow turbines for measuring flow and generating power in confined/remote locations. Prior to this he progressed from Carlow IT to his Hons BSC in physics with electronics, and MSC in optics and holography from Salford and Manchester Uni.

He progressed from years of technician work to being a researcher in corrosion research for Tata Steel using his Physics BSC. His Doctoral engineering and research in environmental monitoring was put to use in his new go-gas-renewables business. Here he has international relationships with key players in the evolving nanotech sector including ANT advanced nanotechnology. He plans to partner with Unison in the US to produce autogas following feasibility discussions at Powerstown, Carlow and Wexford Co Co to start biofuel production.

1.1 Introduction

This article details the development of a microturbine using a full range of micro processing techniques. The microturbine is still the only such axial flow miniature turbine sensor generator working in the world. The benefit of the device is that it can detect low pressure air or gas flow. For example it could detect the flow of dopant gases for IC device fabrication. Also in generating its own power as part of a complete stacked unit with an electromagnetic stage it can operate in isolation without batteries in remote locations while monitoring wind speed. It has involved research work in London, Cork (Ireland), Civitanova Marche (Italy) and Budapest.

The objective of the SANS (Small Angle Neutron Scattering) experiments described in this article was to determine the nanoscale characteristics of SU-8 polymer of the turbine rotor before and after processing [1.1, 1.2].

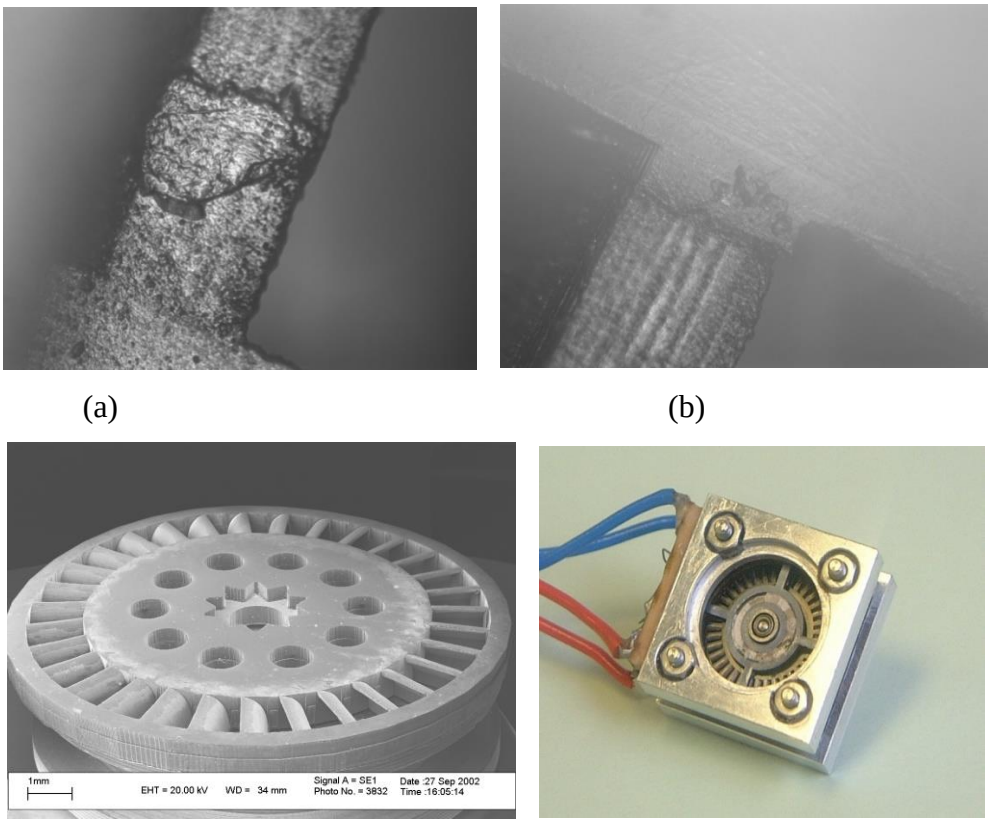
Chemically SU-8 is a photopolymer containing an Epoxy Resin, together with Gamma-Butyro-Lactone (GBL) and small amounts of Triarylsulfonia and Hexafluroantimonate. This mixture forms a negative photoresist which is very popular in MEMS fabrication. It can be processed in very thick layers due to its high optical transparency, and once cured it is both chemically and mechanically robust. The nominal percentages of the different components in the starting material are 35-75% Epoxy Resin (CAS: 28906-96-9), 22-60% Gamma-Butyro-Lactone (CAS: 96-48-0), 1-5% Triarylsulfonia/Hexafluroantimonate Salt (CAS: 89452-37-9)-CAS: 71449-78-0) and Propylene Carbonate (CAS: 108-32-7) [1.3].

SU-8 is a mechanically robust photoresist when in the solid state and is thus well suited to fabrication of micromechanical devices [1.4]. The polymer will however have defects from UV curing and baking and, in

the case of this work, transient heating during laser ablation; it may also suffer further mechanical degradation in its final application. Processing and other defects in the resin matrix will influence the material quality, and this may ultimately affect device performance.

Material damage can occur in the form of micro-cracks and voids in the SU-8 polymer as it is cured and shrunk using UV exposure and final post exposure heat baking from the liquid state to the solid cross-linked state. In the present work these steps were carried out during fabrication of the turbine rotor preforms. There is likely to be a higher density of defects near confined corners because the UV/heat curing process will be less even in such areas than over the general surface of the SU-8 material. This causes stress because the cured areas have not had time to normalise their stresses with the surrounding resin.

The laser ablation process used to shape the microturbine blades into 3-D curves will also generate stress in the cured SU-8. Laser ablation is always accompanied by a localised heat affected zone (HAZ), unless using Femtosecond lasers, and the associated heating can be excessive in confined corners and regions where the sample is thin. For the turbine rotors surface damage was found at the leading and trailing edges of the turbine blades, as seen in Figure 1.1 (a and b of full rotor c).



(a) (b)

(c) (d)

Figure 1.1. Laser-induced damage in an SU-8 microturbine blade, showing (a) 50 µm-wide leading edge and (b) trailing edge of microturbine rotor (c) and (d). The leading edge has cracked during processing, and both edges show evidence of melting and reflow which will have induced stress.

Finding the distribution, type and relevance of the defects that accumulate during processing allows useful information to be obtained in order to better understand where improvements are needed in the fabrication process. SANS analysis could also be used to investigate the development of material flaws due to excessive mechanical stresses during device operation. This is not so relevant to the present work, because the stresses experienced by the microturbine rotor are relatively low. However, for other applications in the area of Power MEMS this could be a significant cause of degradation and failure.

In parallel with the SANS analysis, PGAA (Prompt Gamma Activation Analysis) was used to measure any changes in the percentages of the elements that made up the SU-8. Such compositional changes could occur during UV curing, baking or laser micromachining. The aim was to identify both systematic changes in composition due to processing and differences between samples subject to nominally similar processes. It was also of interest to examine how effective the PGAA technique was for investigating a polymer material like SU-8 [1.5].

1.2 SANS Analysis

The small angle neutron scattering (SANS) method is a technique for studying structural features in various materials such as porous media, ceramics, metals, biological objects, etc. The produced neutrons are water moderated and cooled. The very low energies of thermal and cold neutron beams allow penetration into most materials without causing internal material destruction as tested for in feasibility study [1.6] prior to the full work.

There are many different techniques that allow the characterization of materials on the nanoscale (10Å-1000Å), but SANS remains a novel and highly sensitive process for the investigation of SU-8, particularly in the form of micro- and nano-parts. SANS also has the advantage of being both non-destructive and capable of providing information with high statistical accuracy by averaging over a macroscopic sample volume. SANS can measure, due to its non-destructive nature, the same sample any number of times after either successive usage or heat-treatment. Furthermore, the low absorption of neutrons allows in many cases the investigation of cm-thick material. Finally, neutron scattering has the unique advantage of being able to detect both magnetic spin and the light elements (hydrogen, deuterium, etc.).

With regard to material defects, neutrons have recently become an increasingly significant non-destructive probe in material science, and can reveal significant micro-structural details [1.6-1.9]. Neutron can penetrate deeply into the matter (excluding a strong absorption related to some elements): they are sensitive to isotopes and magnetic structures, and their kinetic energy is comparable to interatomic distances, while their wavelength is comparable to that of atoms in a solid. Neutron scattering metrology is indeed applicable to a wide range of materials, for example polymers, porous media, solutions of micelles, membranes, ceramics and metals.

Another aspect of neutron scattering here is the possibility to substitute Hydrogen for Deuterium. This makes it a unique technique for investigating macromolecular structures in synthetic and biological polymers. This aspect further allows the determination of void sizes and their distribution in porous media as well as the investigation of particle agglomeration and the evolution of pores during sintering [1.10-1.12]. SANS is also useful for investigating the thermodynamics of two-phase systems [1.13].

SANS is applicable to the polymer resin SU-8 because this material can scatter neutrons in either it's cured (cross-linked) or soft-baked form. PMMA in contrast stays in long chain molecules until broken into monomers under neutron exposure. SANS can be used to assess a range of mechanical properties of SU-8 including nano-voids and static density fluctuations caused by non-uniform cross-linking and ageing.

SANS deals with coherent and incoherent scattering. The coherent scattering is related to the structure of the investigated sample, while the incoherent scattering is related to spin and isotope randomness in the sample. In the case of an electromagnetic radiation, the energy E and the wavelength λ are related within Planck's equation:

$$E = hc/\lambda \qquad (1.1)$$

Concerning the neutron radiation, since the neutron possesses a finite mass (m = 1.674∗10^{-27} Kg), one should consider its kinetic energy:

$$E = h^2/2m\lambda^2 = mv^2/2 \qquad (1.2)$$ see Appendix 1

where v is the neutron velocity, c=2.997∗10^8 ms^{-1} and h=6.626∗10^{-34} J is the Planck's constant.
Replacing the neutron's kinetic energy into Eq. (1.1) and solving for λ produces an equivalent wavenumber analogous to those of typical IR/Raman vibrational modes, proving that neutrons can probe the sample's dynamics.
In SANS, as in other diffraction studies, the energy or scattered intensity $I(Q)$ is measured as a function of the scattering direction. The vector $\boldsymbol{Q}$ corresponds to the momentum transfer i.e. difference in $\boldsymbol{k}$ is $\boldsymbol{Q}$:

$$\boldsymbol{Q} = \boldsymbol{k}_1 - \boldsymbol{k}_0 \qquad (1.3)$$

where $\boldsymbol{k}_1$ and $\boldsymbol{k}_0$ are the wave-vectors of the incident and scattered waves. If elastic scattering dominates in the interaction of the neutrons and nuclei, then:

$$Q = \frac{4\pi \sin(\theta)}{\lambda} \qquad (1.4)$$

where λ is the wavelength of the neutrons and 2θ is the scattering angle.

The scattered intensity may be expressed in terms of the incoming neutron flux, Φ, an instrument specific constant, A, the transmission of the sample, T, and the volume of the sample, V_{sample}:

$$I(\lambda, Q) = \Phi A T V_{sample} \frac{d\Sigma}{d\Omega} + bg \qquad (1.5)$$

where Σ is the total area of interface per unit volume of the sample [1.10-1.12], and *bg* is a contrast factor due to the background of the instrument. The dΣ/dΩ term is the so called form factor *F*(*Q*), which contains information about the scattering particles of the sample. The scattering particles are the nano-sized inhomogeneities of the sample, for example, micelles, pores, nano-cracks or precipitates.

The form factor is related to the characteristic size of the scattering particles. In the low, or so-called *Guinier* region, the behaviour of the scattering intensity can be written with the Guinier expression for all shapes of non-interacting scatterers:

$$F(Q) = K^2 V^2 \exp\left(-Q^2 R_g^2 / 3\right) \qquad (1.6)$$

where R_g is the radius of gyration of individual scatterers. This form is applicable when the scattering angle satisfies $QR_g \leq 1$, so R_g ~ neutron wavelength. The parameter *K* is a material-dependent constant (describing the contrast between the embedded medium or matrix and the scattering object), and *V* is the total volume of the scattering particles per unit volume. An important feature of the equation is that R_g can be determined even if *I*(*Q*) is known only in arbitrary units.

In large *Q* regions of scattering, the signal due to the interface between each scatterer and the embedding medium dominates the intensity. This calls for another approach using the Porod law [1.11-1.15]. The Porod law describes this behaviour as follows:

$$F(Q) = \frac{K^2 2\pi A}{Q^4} + bg \qquad (1.7)$$

where *A* is the total area of the interface per unit volume of the sample. The region of applicability of the Porod law is $QR_g \geq 4$.

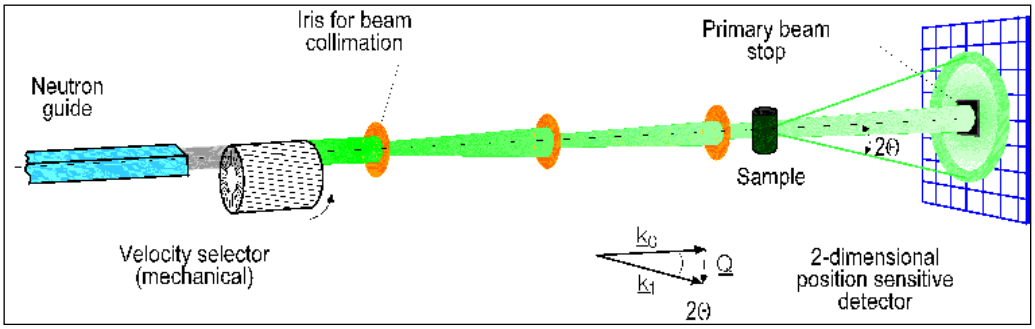
When the voids in the material are permeated by a liquid, for example water or toluene, this will change the contrast between the matrix and the scattering objects. In this way SANS can also show the extent of penetration of the small molecules into the structural volume of a sample. This can be useful for identifying the formation of connected networks of nano-pores or cracks.

SANS could also be used for the detection of long term defect orientations in the SU-8 by placing a given load on a separate piece of SU-8 for a period known from past experience to be best upto seven days while changing the temperature from room temp to 300°C (the max temperature before crosslink degradation). The best molecular orientation (anisotropic scatter pattern) correlates data along with all the SANS tests and

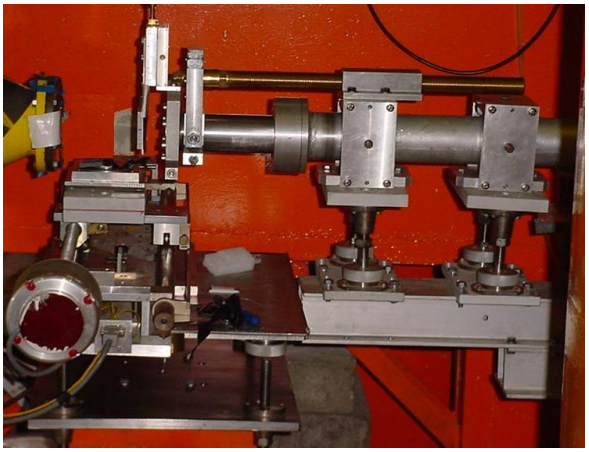
control tests could be presented graphically to produce the best curing times for future preforms. This would allow their structural strength limits, and hence their suitability for particular applications, to be assessed. This would be particularly useful for applications such as micropower generation.

1.3 Instrumentation Setup and Initial SANS Analysis

An initial experiment was performed on two SU-8 microturbine samples. Measurements were made at a neutron wavelength of 9.14 Å and a detector to sample separation of 5.6 m. With this configuration scattering angles corresponding to a Q-range from 0.004 $Å^{-1}$ to 0.5 $Å^{-1}$ could be investigated, which allowed density composition and magnetization fluctuations in the material to be measured on a length scale of 10 Å to 1000 Å [1.6]. Figure 1.2 shows a schematic view of the setup and a photograph of the sample holder and neutron beam exit aperture. Neutrons produced by a 10 MW reactor were guided to the sample by supermirrors. The beam was monochromated by a multi-disk type velocity selector, which could be tuned between 0.7 - 7 krpm. This allowed the wavelength of the neutron beam to be varied from 3.4 Å to 23 Å. The wavelength distribution was varied by changing the angle between the selector axis and the direction of the neutron beam.



(a)



(b)

Figure 1.2. (a) Schematic of SANS diffractometer setup at the Budapest Neutron Centre. (b) Photograph of sample holder and neutron beam exit aperture.

The fractional beam width could be set between 12% and 30%, depending on the requirements of any given measurement. The scattered neutrons were detected by a 64 × 64 pixel array (each 1 cm^2) or two

dimensional position sensitive detectors filled with BF_3 gas. The beam intensity was monitored by a fission chamber, and formed by a 5.6 m-long collimator tube. Figure 1.3 shows a schematic of the entire system.

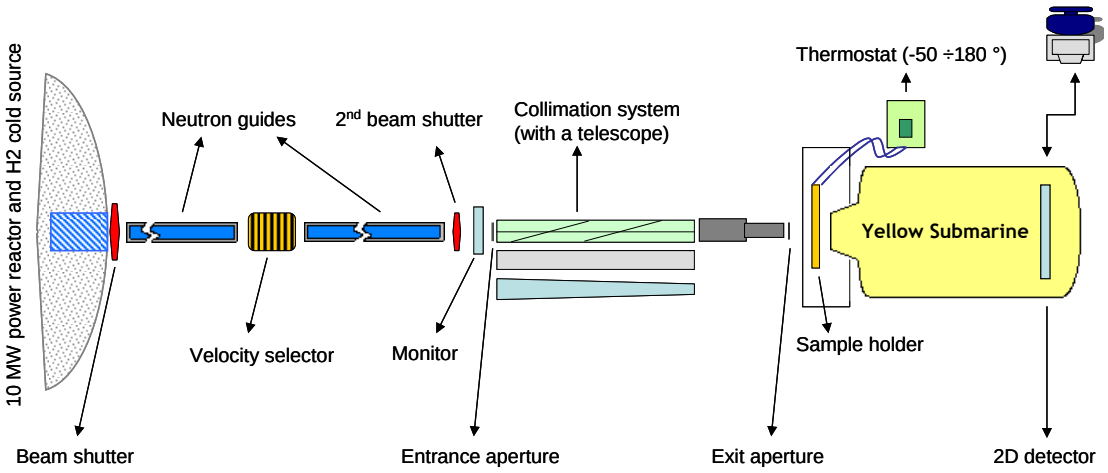


Figure 1.3. Schematic of complete SANS instrumentation. The "yellow submarine" section containing the detector is 15 m in length.

The turbine samples were applicable to a full statistical investigation as they were of an appropriate material makeup thick enough to scatter the neutrons. The full range of *Q* values (momentum transfer coefficients) from 0.004 $Å^{-1}$ to 0.5 $Å^{-1}$ was used for the SANS process, starting with the lowest at 0.004 $Å^{-1}$.

The beam was first carefully collimated using the irises (see Figure 1.2a), and limited in its wavelength spread by setting the velocity selector to rotate at 2.5 krpm. Figure 1.4 shows the measured wavelength distributions obtained at different velocity selector settings. The measurements were made by the time of flight method. The scattered beam intensity was monitored by a fission chamber with the primary data from the 2-D scattering pattern regrouped by a computer (see Figure 1.5).

The function $I(Q)$ was constructed by subtracting the neutron scattering results produced with and without the sample in place. In order to further ensure that the results were due only to the samples a calibration test was also performed using water in a cuvette. Water being homogenous is useful for testing the efficiency of the neutron scattering as it always gives a result of 1±0.1. The water for the calibration test was measured in a cuvette which was 1 mm thick to match the thickness of the SU-8 samples, before finally subtracting the results for water from the results for the cuvette.

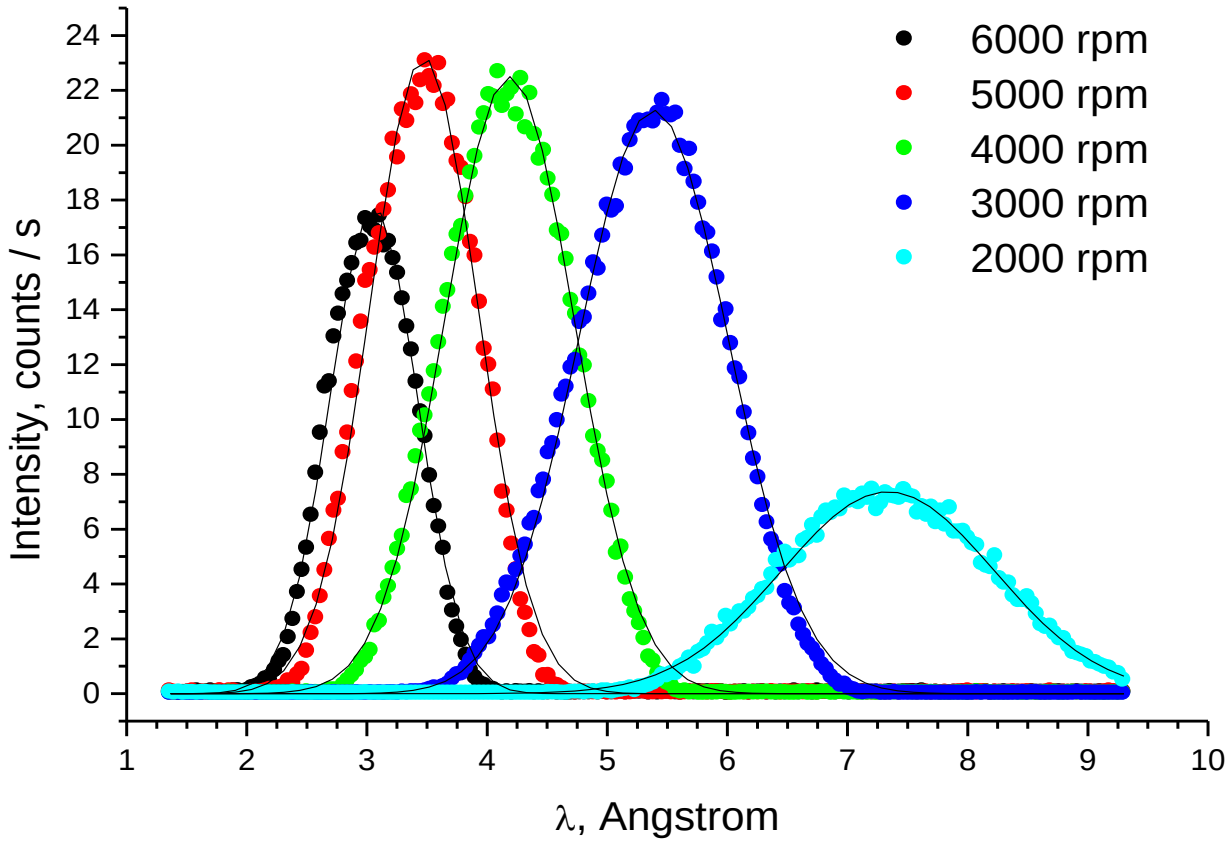


Figure 1.4. Effect of velocity selector rotation speed on measured neutron spectrum.

Figure 1.5. Computer image - full screen (left) and enlarged (right) - showing 2D small angle neutron scattering distribution for a part-finished turbine sample.

The scattering data from the two samples was found to fit well to the Porod model, in the form of a slightly modified version of Equation (1.5):

$$F(Q) = \frac{B}{Q^p} + bg \qquad (1.6)$$

Comparing this with Equation (1.5), the only significant difference is that the exponent in the denominator of the first term is now a fitting parameter (rather than being fixed at $p = 4$). The parameter B contains the total area of the interface per unit volume of the sample, while bg is still the contrast factor due to the background. Figures 1.6 and 1.7 show the measured $I(Q)$ curves for the two samples, together with best fit lines according to Equation (1.6).

The two test samples were fabricated under nearly the same conditions and it is therefore unsurprising that they produced nearly equal slope parameters. The Porod constants for the best fit lines were $p = 4.20 \pm 0.27$ and $p = 4.96 \pm 0.51$ respectively, as seen in Figures 1.6 and 1.7. The different Porod constants may be attributable to slight differences in processing conditions. In particular, the samples were subject to different durations of UV exposure and post-baking: 20 minutes and 30 minutes UV, and 4 hours and 6 hours baking at 300 °C, respectively. Also the first sample was removed from the polymerisation development earlier to test for stress around locally cured and developed areas.

In general a Porod constant between 3 and 4 is an indicator of sharp interfaces between phases, while slopes larger than 4 may be obtained in cases where there are no sharp interfaces, but rather a gradual transition (as would be produced by a smooth composition gradient) between the phases. The initial results seem to suggest the SU-8 samples were in the latter category. However, the apparent Porod constants 4.20±0.27 and 4.96±0.51 may not be correct as the thickness of the turbines was only a tenth on the thickness normally required, and the count rate was low because of the Q setting. The intensities at higher Q values were too close to the background to be considered reliable. While the SU-8 could clearly scatter the neutrons in a measurable way, the height of the error bars could have been lessened by using thicker samples to increase scatter.

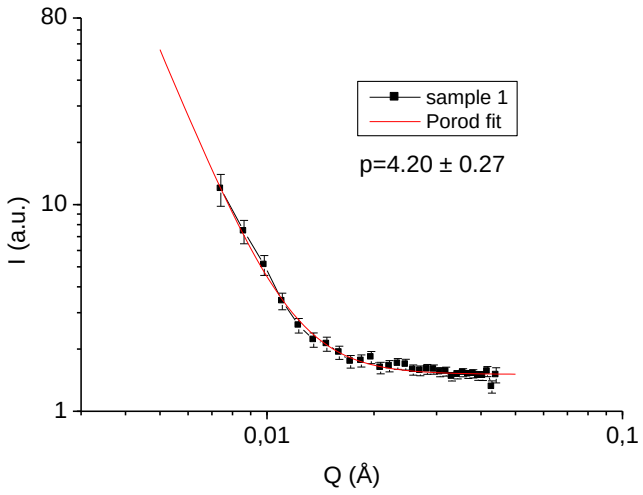


Figure 1.6. Measured SANS data for sample 1, with best fit line according to Porod model.

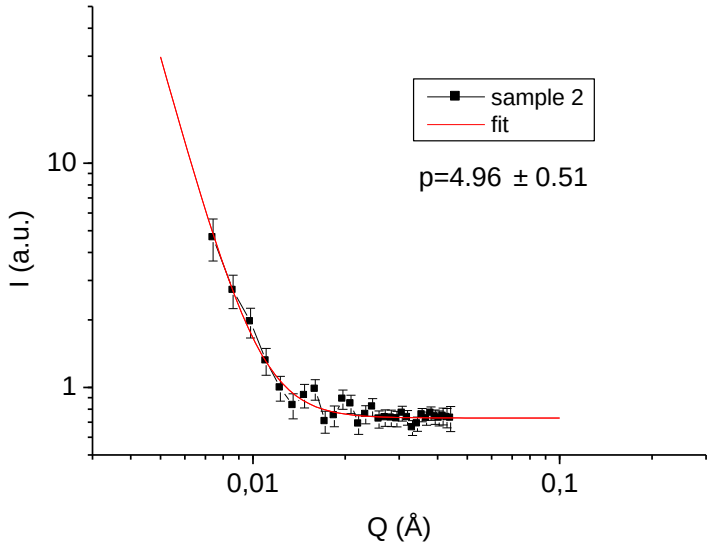


Figure 1.7. Measured SANS data for sample 2, with best fit line according to Porod model.

1.4 Final SANS Analysis of stacked/thick SU-8 samples

Following the initial investigation described in the previous section, a second series of tests was carried out to look at the effects of different process conditions and ageing [1.1, 1.2]. The SANS measurements were also extended to lower Q values to allow investigation of the Guinier region.

Sample groups A, B and C as listed in Tables 1.1 – 1.3 were fabricated under carefully controlled conditions of curing, polymerisation, and wear/ageing. Group A (Table 1.1) consisted of a variety of partially finished or damaged SU-8 turbine parts. Group B (Table 1.2) included a number of similar turbine parts that had been patterned and subjected to different pre-treatments in terms of UV curing and heat baking. Group C (Table 1.3) contained plain, flat 1 mm-thick pieces of SU-8 that had been cured and baked without patterning, and thus were not stressed or exposed to physical wear or usage of any kind.

The 5.6 m collimator tube was changed for these experiments to give a variable collimation path system to optimize the flux and resolution for different sample-to-detector distances. This was to increase the chances of measurable graphical differences being produced under the conditions of widely varying polymerization, wear, etc. After a proper calibration and radial averaging, a Guinier fit was made using a fitting function based on Equation (1.4):

$$F(Q) = C\exp\left(-Q^2 R_g^2 / 3\right) \qquad (1.7)$$

where the fitting parameters are now C, which contains the contrast parameter and the volume of scattering particles per unit sample volume, and the average radius of gyration R_g. The shape of the plot stays the same but according to C moves up the y-axis as in Figure 1.8. Figures 1.8 to 1.10 show the measured $I(Q)$ data for

all the samples, with best-fit Guinier plots overlaid. The radii of gyration corresponding to the best fit plots are given in Tables 1.1 to 1.3 [1.1]. In the case of samples named C11 to C14, no small angle scattering was observed, thus proving the non-existence of cracks/voids in these samples.

SU-8 incomplete microturbine samples A1 - A6	Radius of gyration (Å)
A1 - Part laser ablated, part RIE etched rotor	304 ± 33
A2 - Imperfectly finished rotor (damaged)	340 ± 27
A3 - Second partly laser ablated rotor (aged)	347 ± 16
A4 - Original rotor (unchanged)	350 ± 24
A5 - Broken rotor	359 ± 5
A6 - Rotor made of 2 thick SU-8 layers	369 ± 23

Table 1.1. Descriptions of partially finished/damaged SU-8 samples A1 to A6, with radii of gyration extracted from Guinier plots ($\chi^2 = 1.59$) [1.1].

SU-8 same size samples B7 to B10	Radius of gyration (Å)
B7 - UV 30 min, PEB 40 min	412 ± 59
B8 - UV 30 min, PEB 30 min	361 ± 22
B9 - UV 30 min, PEB 20 min	313 ± 26
B10 - UV 30 min, PEB 40 min (smallest test turbine)	260 ± 31

Table 1.2. Descriptions of differently processed SU-8 samples B7 to B10, with radii of gyration extracted from Guinier plots ($\chi^2 = 0.51$) [1.1].

SU-8 1 mm-thick sheet samples C11 to C14	Radius of gyration (Å)
C11 - UV 10 min, PEB 10 min	0
C12 - UV 20 min, PEB 20 min	0
C13 - UV 10 min, PEB 40 min	0
C14 - UV 20 min, PEB 10 min	0

Table 1.3. Descriptions of unpatterned SU-8 samples C11 to C14, with radii of gyration extracted from Guinier plots [1.1].

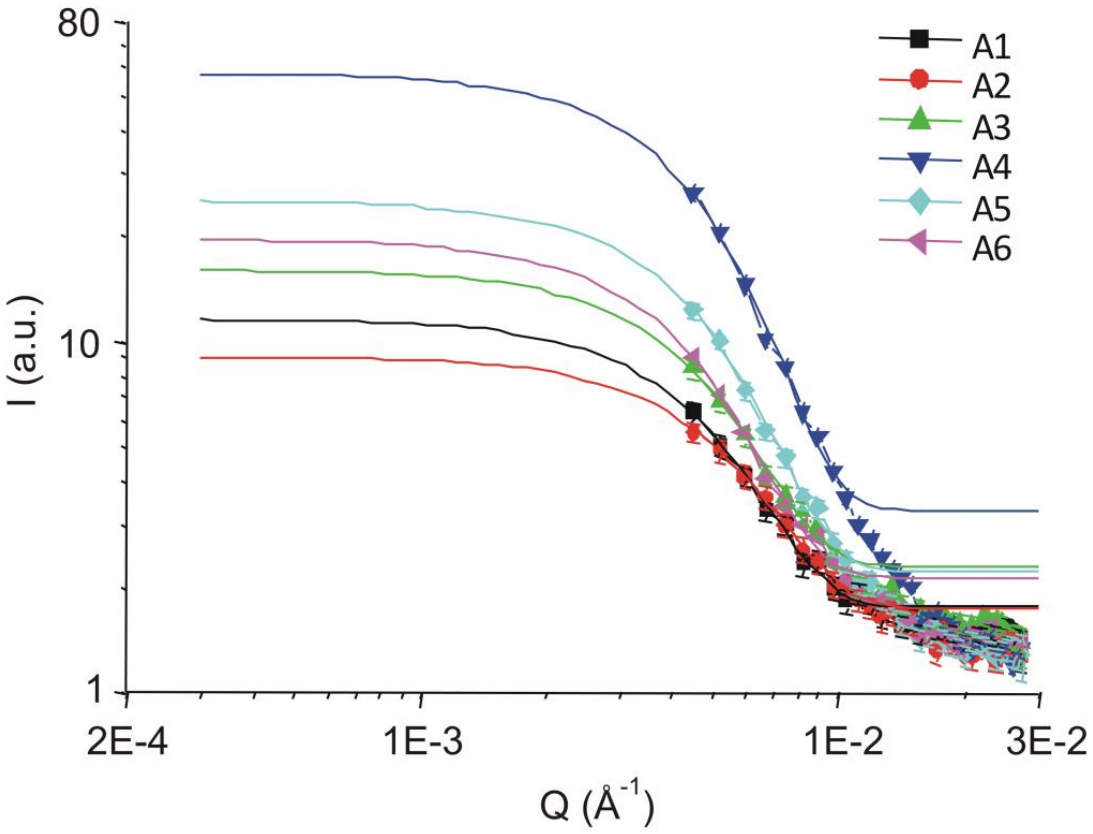


Figure 1.8. Measured SANS scattering data and Guinier fits for SU-8 samples A1 to A6, where the highest Intensity on the y-axis indicates void and crack defects [1.1].

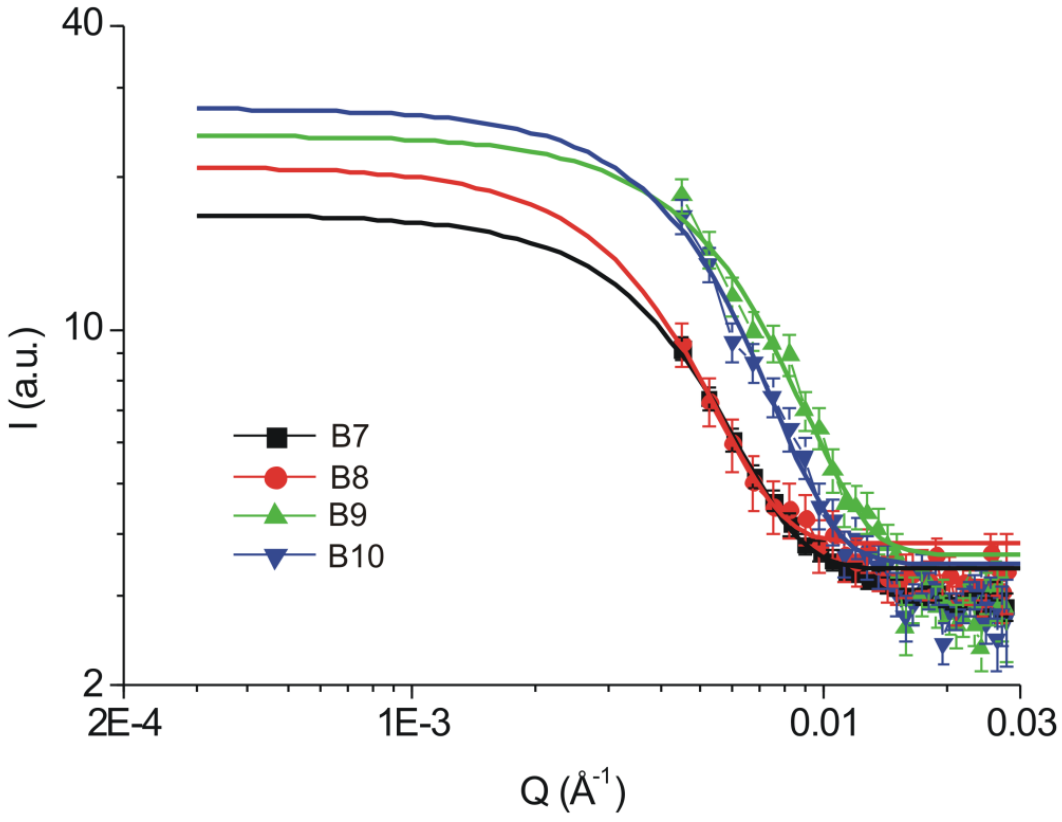


Figure 1.9. Measured SANS scattering data and Guinier fits for samples B7 to B10 [1.1].

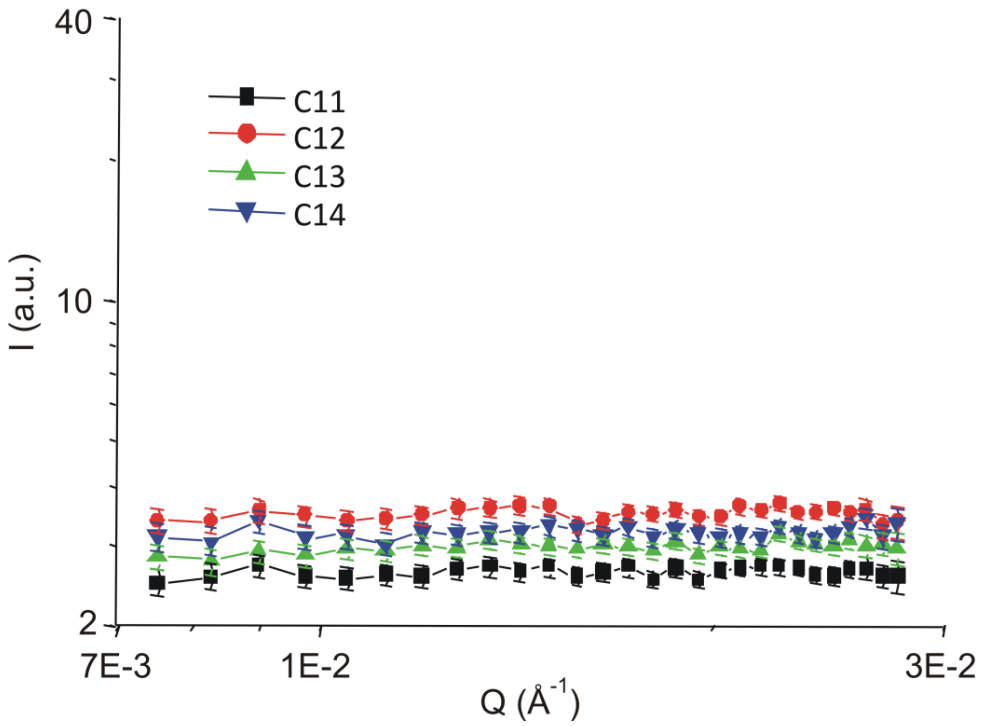


Figure 1.10. Measured SANS scattering data and Guinier fits for samples C11 to C14 showing no defects as the scatter or intensity is similar to background given that *Rg* is fixed [1.1].

1.5 Conclusions from SANS Investigations

With the aid of the SANS method the existence of nanosized objects inside the resin matrix of samples A1 to A6 and B7 to B10 was confirmed. In contrast samples C11 to C14 had a scatter similar to background indicating that they were free from nano-scale cracks or voids. Samples C11 to C14 were 1 mm-thick SU-8 polymer sheets that had not been machined or processed into microturbines. These samples did not have any blade corners or areas of stress due to processing.

In the case of samples A1 to A5 there is a range of defects sizes between 304 Å and 359Å, and the results suggest that laser ablation may reduce the sizes of the defects in comparison to the preforms. The maximum sizes appear in the case of broken rotors. The samples B7 to B9 shows a defect size increasing with the increasing of the PEB (post exposure bake) time. The maximum average defect size is 412 Å which is ~50 Å greater than the largest defect size amongst the samples A1-A5 [1.1].

The above work was done with Massimo Rogante, (Rogante Engineering Office), a Director at the Budapest Neutron Center, BNC, KFKI, Adel Len and Laszlo Rosta at the Budapest Neutron Center, BNC, KFKI.

Appendix 1

Kinetic Energy E is given by:

$E = \frac{mv^2}{2}$ where m = mass and v = velocity

Manipulating this equation by multiplying across by 2 gives:

$$2E = mv^2$$

Multiplying across by mass m gives: $2Em = m^2v^2$

or rearranging $2Em = (mv)^2$

But mv = momentum p

Therefore $2Em = p^2$

Or $p = \sqrt{(2Em)}$

From Quantum Mechanics the de Broglie equation relates wave number to momentum:

$$\lambda = h/p$$

and substituting $p = \sqrt{(2Em)}$

gives $\lambda = \frac{h}{\sqrt{(2Em)}}$

Squaring across to remove the λ results in

$$\lambda^2 = \frac{h^2}{2Em}$$

Rearranging gives $E\lambda^2 = \frac{h^2}{2m}$

And finally $\mathbf{E = \frac{h^2}{2m\lambda^2}}$ Equation (1.2)

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Putting teaching and learning at the centre of sectoral enhancement and innovation

The **National Forum for the Enhancement of Teaching and Learning in Higher Education** was announced by the Minister for Education and Skills in November 2012. The role of the Forum is to enhance the teaching and learning for all students in higher education.

Engaging with leaders, managers, teachers and students, the Forum will mobilise expertise and inputs from across the entire sector to extend and shape best practice in all institutes of higher education in Ireland.

Vision of the Forum

Under the guidance of its Board, whose members are chosen to represent the different areas of expertise in teaching and learning, the Forum will engage in a range of activities aimed at:

- Championing all those who contribute to great teaching and learning in higher education
- Inspiring great practice, by celebrating examples of teaching that have a strong and positive
- impact on learning
- Developing teachers and learners
- Identifying and promoting best practice in professional development
- Building digital capacity
- Promoting key enhancement themes
- Enabling innovation in a fast-changing educational environment.

Teaching Hero Awards

Purpose

These awards celebrate the impact that teachers in Higher Education are having on their students learning at a key transition. The term teacher in Higher Education includes lecturing staff, tutors, supervisors, technicians, librarians and any who are involved in teaching students across the sector.

Process

Individual students nominate their Teaching Hero through the online nomination form. The form asks students to write a short personal piece that explains why this person is their Teaching Hero. A Teaching Hero is an individual who has made an impact at a key transition, innovating and inspiring during a student's learning journey in higher education. Students should only nominate an individual who taught them while they were a registered student.

Based on student nominations, local student working groups will identify up to two Teaching Heroes to receive a National award. The identification process used in each institution is locally implemented but

informed by the National guidelines produced by the National Forum in partnership with USI and other student representatives.

Three Institute of Chemistry of Ireland Council Members win in the 2016 Awards

The National Forum for the Enhancement of Teaching and Learning in Higher Education was delighted to announce the Teaching Heroes 2016. Over 800 teachers from across Ireland's higher sector were nominated for a 2016 National Teaching Hero Award. This unique student-led initiative saw the top 37 of these teaching heroes being awarded at a special national event in October.

Jointly run by the National Forum for the Enhancement of Teaching and Learning in Higher Education and the Union of Students in Ireland, this was the second round of these national awards designed to engage and empower students in defining, identifying and celebrating impactful teaching. The Teaching Hero campaign 2016 focused on innovative, creative and inspiring teaching and its impact on student learning. The 37 top heroes identified received their awards at a ceremony at The Printworks, Dublin Castle on 27 October.

Group photos of the

- **Dr Paraic James, DCU (posthumously)**
- **Prof Celine Marmion RCSI**
- **Dr Sheila Donegan WIT**

More details: http://www.teachingandlearning.ie

The National Forum announces the establishment of the Íontas alliance.

The National Forum is delighted to announce the establishment of the Íontas alliance – this is a new association for Ireland's National Awardees of teaching excellence in Higher Education –

The name used for the alliance, Íontas, is an Irish word that means amazement, wonder or surprise and it can mean all these things together. It is the perfect word to capture what this alliance will represent, our best teachers engaging with learners to give rise to extraordinary learning.

The Íontas alliance is open to all those who have been recognised nationally as award-winning higher education teachers in Ireland. These include all who hold teaching excellence awards presented by NAIRTL (2008-2012), all those who have been endorsed by their institutions and recognised as National Teaching Experts (National Forum 2015) and those who have been given the title of National Teaching Hero (National Forum 2014 & 2016).

Íontas serves to improve teaching excellence throughout the entire sector, Íontas will provide a space where our best teachers can explore and promote teaching excellence of many kinds – excellence for learning impact, excellence within and across disciplines, excellence that inspires, amazes, supports, helps and encourages learners. In addition to providing a forum for our most impactful teachers to make recommendations and have a formal input to the enhancement agenda, Íontas will allow the sector to showcase excellence internationally by positioning Ireland to interact with similar associations around the world.

More Details:

http://www.teachingandlearning.ie/national-forum-announces-establishment-iontas-alliance

- **For Limited Time Free Entry- Register Here**

Positioning Ireland as a Global Innovation Hub by 2020

Join us at the 2017 Research and Innovation Conference & Exhibition on the 14th February 2017 in CityWest to hear from an impressive line-up of industry leaders, academics and government agencies who will engage in a stimulating blend of key note addresses and debates.

Agenda 2020 is an ambitious plan to position Ireland as a global knowledge leader and a major hub of scientific and engineering research. The inaugural Innovate Ireland 2015 Conference & Exhibition brought together over 600 senior management and technical experts from the most innovative Irish and global companies that is involved in cutting edge research and innovation as well as key influencers, decision markers and technical experts from government and academia. This gathering of the leaders in research and innovation from industries such as pharma, medtech, biotech, life sciences, energy & Environment, food & agri, health, transport, chemical, ICT etc is to assist advance the agenda of placing Ireland at the heart of research and innovation.

Our 2017 event will build upon the success of that event and will bring together over 1000 leaders in research and innovation from the leading industries in Ireland as well as key government bodies, research bodies and researchers that are instrumental in creating cutting edge research and bringing that research to market.

The 100+ speaker lineup over 8 stages includes industry leaders from sectors such as pharma, medtech, biotech, life sciences, energy & Environment, food & agri, health, transport, chemical, ICT etc. These leading speakers will deliverer compelling case studies, technical presentations and highly topical presentations that can equip you with the knowledge needed to push forward your own research and innovation and be part of creating a more innovative Ireland.

Some key topics include:

Understand the latest trends and opportunities, Innovative R&D processes , from concept to launch, Consumer engagement in NPD, Avoiding regulatory pitfalls, food science, quality and safety, Labtech , clinical trial implementation, data analysis, ICT research, Medtech research , Basic research, consumer trends, advanced materials, technology transfer, IOT, energy research, , medical

research, Earth and Environmental research , Industry and academia collaboration, Jobs ,skills/Training, 3D printing, policy and regulations, , open innovation ,bioscience, informatics, testing methods, lab management, Life science, smart cities, Biological sciences, Drugs and pharmaceuticals ,computer sciences, ,nanotechnology, materials science, software, webtech, electronics, computer wearables, Chemistry, Lab IT and much more.

Delegates have already registered from leading pharma, medtech, biotech, life sciences, energy & Environment, food & agri , health, chemical, ICT etc as well as key universities, research bodies and government and funding agencies.

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Senior Science Quiz National Final 2016

The National Finals of the annual ISTA Senior Science Quiz took place in the **Tercentenary Hall in Trinity Biomedical Sciences Institute** on **Saturday 26th November**. It was full to capacity with **45 teams** of Leaving Certificate science students representing **20 counties** from all around Ireland and their teachers. Almost 1000 students took part in the Regional Finals held during Science Week and the top teams were invited to the **BioPharmaChemical Ireland** sponsored **National Final**.

The charity associated with the quiz this year was **The Caroline Foundation** in aid of Cancer Clinical Research. The purpose of the foundation is to support the work of Professor John Crown. Like ISTA it is a voluntary organisation and all donations go directly to fund researchers.

Ms. Mary Mullaghy (ISTA Quiz Coordinator), Dr Conor O'Brien (Honorary President of ISTA), Dr Helen O'Sullivan-Dwyer (The Caroline Foundation) & Dr Aoibhinn Ní Shuilleabháin (Guest Quizmaster)

Thanks to all the local coordinators in the 13 Branches who facilitated the Regionals Rounds during Science Week, and the Dublin Branch of ISTA who organised the Final. A special thanks to **Dr. Conor O'Brien**, current Honorary President of ISTA, **Dr Aoibhínn Ní Shuilleabhain** for her continued support and who acted as guest quizmaster, **BioPharmaChemical Ireland** main sponsor, **Trinity College** who provided the venue. Also thanks to **Folens, ICI, IoP Ireland, RSC, SEAI & StudyClix** who provided **spot prizes** at both the regioanls and the final, and last but not least the students and their teachers who attended. Congratulations and well done to **ALL** who participated.

- **St. Peter's College, Wexford**
- **Coláiste Colm Ballincollig, Co Cork**
- **St Paul's, Raheny, Dublin 5**
- **St Jarleth's College, Tuam, Galway**
- **Clongowes Wood College, Clane, Co Kildare**

Dr. Conor O'Brien (Honorary President of ISTA), Joe Wickham, Ger Dempsey, Carl Riordan, Ms. Judith Thomas (Teacher), Dr. Aoibhinn Ní Shuilleabhain (Quizmaster) & Ms. Mary Mullaghy (National Quiz Coordinator)

More photos available in the Gallery on the ISTA website.
http://www.ista.ie

ICI Schools' Chemistry Newsletter Competition

The annual ICI Schools' Chemistry Newsletter competition is now open to all second level students. This year's theme is **'The Chemistry of Climate Change'.** Only individual entrants are allowed. Full details attached and closing date is 23rd of December.

http://www.ista.ie/ici-schools-chemistry-newsletter-competition-2016-17

Natural Resources to Sense and Solve Water Pollution

Dr Yvonne Lang IT Sligo

Yvonne Lang is an Assistant Lecturer in the Department of Life Science, Institute of Technology Sligo. She is a also graduate of IT Sligo, where she completed a Diploma in Analytical Chemistry before continuing her studies at the National University of Ireland Galway. Yvonne obtained her PhD from the NUI, Galway in 2014. Her doctoral research investigated the use of diatoms to fabricate polymeric structures with a defined geometry. Work emanating from this research has been published in peer-reviewed journals and has been presented at several key international conferences. Her current research interests include; (1) Investigation of diatom cultures as decontamination agents for removal of organic pollutants from water (2) Modification of the chemistry of diatom frustules for applications in water purification (3) Investigation and characterisation of exopolymeric substances produced by diatoms.

Preamble

My introduction to the world of diatoms happened by chance. It occurred while I was exploring research opportunities in the field of drug delivery for the treatment of chronic pain. During this period, I became aware of a research project at the National University of Ireland Galway, led by Dr Pamela Walsh, Prof Abhay Pandit and Prof David Finn, that proposed the use of natural resources, such as diatoms, for the design of novel drug delivery platforms. I was fortunate to be considered a suitable candidate for this project and thus began my fascination with diatoms. My interests in these beautiful structures have continued and I am currently exploring the potential to use diatoms as biosensors of emerging pollutants. I had the privilege of being invited to speak at the Institute of Chemistry of Ireland annual congress in May 2016 to share the findings of my research to date. The following short account describes the work that I presented at the meeting.

What are diatoms?

Diatoms are unicellular algae ubiquitous in seawater and freshwater environments, with the number of species estimated to be 10,000-100,000 [1]. The hallmark of the diatom is the intricate architecture of the cell wall, the frustule. The diatom frustule comprises of two valves that sit together like a Petri dish with the overlapping

region surrounded by structures referred to as girdle bands. The frustule is composed of amorphous silica and is sheathed in an organic casing composed of polysaccharides and proteins.

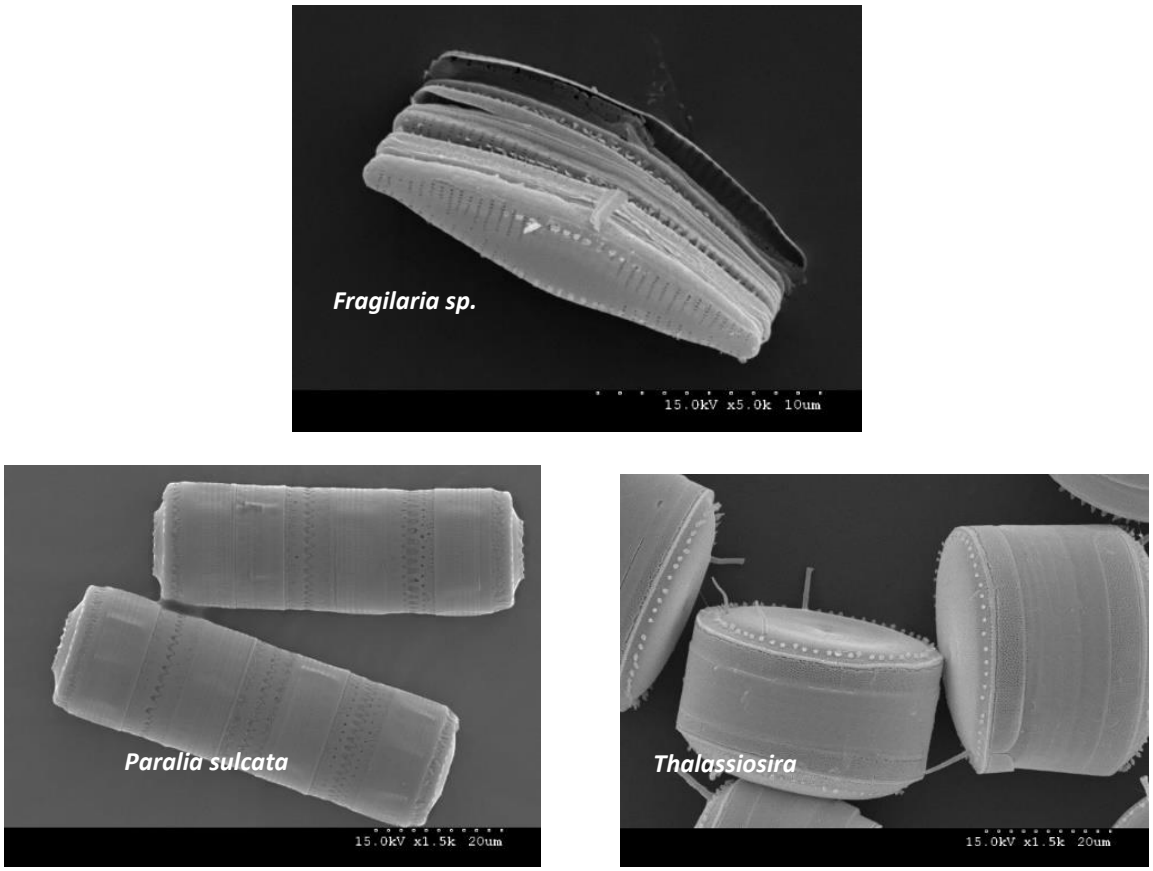

Figure 1. Scanning electron micrographs illustrating the architectural diversity of diatoms
Imaged captured at the Centre for Microscopy and Imaging, National University of Ireland, Galway

Proposed applications of diatoms

The complexity and the precision with which the frustule is synthesized, at both the micro- and nano-scale, has attracted attention from many disciplines interested in the production of nanostructured materials, with proposed applications in catalysis, separation science, filtration, optics, gas detection, nanotechnology, and drug delivery [2-12]. These applications have focused on the use of the cleaned diatom frustule. More recently, interest in possible uses of the living diatom is increasing as the drive towards multi-purpose use of resources gains momentum.

Altering the chemistry of the diatom

The amphorous silica of the diatom frustule is not suitable for many of the proposed applications of these 3D structures. Thus, much of the early work in diatom research has explored altering the chemistry of the frustule through both coating and conversions processes. Coating procedures employed to alter the surface chemistry of the diatom were based on exposure of the cleaned diatom frustule to a precursor solution followed by

thermal reaction to generate a coating [13]. Further exploration in this field led to the use of gas/solid displacement reactions [14,15], sol-gel reactions [16], and atomic layer deposition [17] to coat the diatom surface. Thus, while the coating procedures provide opportunity to alter the chemical composition and the pore architecture, the core diatom material remained intact. Advances in modifying the chemistry of the complete frustule was pioneered by Sandhage and colleagues reporting the conversion of the diatom frustules into inorganic replicas [18]. Subsequent work emanating from this seminal research has refined the procedure [19] and resulted in the generation of diatom replicas composed of ZrO_2 [20] and TiO [21]. Attempts to enhance the success of the coating process led to the investigation of a procedure to amplify the number of groups on the surface of the diatom that are available for reaction [22]. Surface functionalization of the diatom frustule *via* reaction with organoalkoxysilanes has been explored as an avenue to alter the chemistry of the diatom [23-25]. Altering the chemistry of the diatom *via* silanization can be viewed as a means to prime the surface for further reactions and applications. Thus, the possible organo-silica hybrid frustules remain under explored. Consequently, the potential applications for such hybrid frustules will only emerge as the field advances.

Applications of the living diatom

The living diatom is a known indicator of water quality, due to the fact that both the cell morphology and cell physiology are sensitive to the presence of pesticides, herbicides, pharmaceuticals, polymers and personal care products [26-30]. The potential of diatoms to bioaccumulate, biotransform or biodegrade compounds of concern including polycyclic aromatic hydrocarbons, non-steroidal anti-inflammatory pharmaceuticals, endocrine disrupting chemicals, phthalates and metal nanoparticles has been documented [31-37]. The interaction of diatoms with microplastics has revealed important observations, and illustrated that the effect of microplastics on aquatic organisms is complex. It has been demonstrated that the diet quality of mussels can affect their response to pollutants [38]. Thus, should the quality of the plankton be compromised through interaction with microplastics, it is possible that the mussel will be more susceptible to toxic effects of microplastics [39]. Parameters such as habitat, chemical composition, physical characteristics, weathering conditions, and presence of dissolved organic matter will influence the formation of biofilms on plastic, sorption of priority substances and aggregate formation [40-48]. The formation of these biofilms or aggregates will dictate whether the microplastic remains in surface waters or sinks through the water column, and subsequently the fate of the microplastic.

Diatom-microplastic interactions

It is evident that there is a complex interaction between microplastics and microalgae. My current research project is focussing on the following areas (i) Production of extracellular polymeric substances (EPS) by diatoms in the presence of microplastics (ii) Diatom-microplastic aggregate formation (iii) The role of diatom-microplastic aggregates in the sorption of priority substances.

Diatoms can be prodigious producers of EPS that may find a role in decontamination of pollutants through the formation of a gel-like network that sequester pollutants. Production of EPSs by diatoms is responsive to changes in environmental conditions [49-52]. Reports in the literature have observed that both EPS abundance and EPS composition can be modified by alterations to environment including light limitation, nutrient limitation, and exposure to either organic or metal pollutants. In addition, it has been suggested that EPS may find a role in decontamination of pollutants through the formation of aggregates, whereby the EPS sequesters the pollutant forming a gel-like network. Identification and validation of appropriate methods for sampling and detection of microplastics is a key feature of the project. It is recognised that there is a need for harmonisation of sampling techniques and reporting systems for microplastics, as there has been a lack of consistency in sampling and quantitative methodology [53-55].

To conclude, the diversity of functions and roles of both the cleaned diatom frustule and the living diatom in research areas such as separation science, materials science, and catalysis is quite amazing. These "jewels of the sea" that are invisible to the naked eye have the potential to provide solutions to water pollution through a bioremediation approach. Exciting opportunities may arise through functionalization of the living diatom with chemical moieties to enhance the bio-sensing capacity and pollutant sequestration.

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Engaging with Industry: Research Centres and Technology Transfer Offices

Dr James O'Sullivan MBA RTTP

James has managed the Technology Transfer Office in Waterford Institute of Technology for five years. Prior to his role in WIT James worked as a managing consultant in the strategy and science centres of the blue chip organisations of Accenture and PA Consulting respectively. James has also worked for a US semiconductor company as a technologist and as an expert advisor to the European Patent Office. Having graduated more than two decades ago James went on to complete a Ph.D. from Trinity College Dublin and an MBA from the Open University.

Background

Over the past few decades the government has been working to ensure that the activities of the research centres based at academic institutes are meaningful to industry. In December 2015 the government published Innovation 2020[1] – a strategic document for Ireland which underpins the significance of innovation to the competitiveness of our enterprise base.

To achieve this innovation successive governments have provided investment into the academic landscape to increase the capability and capacity of the overall eco-system. A key tenet of the strategy is the coordination of the activities of the various policy instruments such that the maximum benefit can be realised by enterprise. As a small nation Ireland naturally has a limited capacity and hence the need to focus. The National Prioritisation[2] ensures this focus on a discrete number of sectors which can be mapped across six broad enterprise themes. These are ICT, Health and Medical, Food, Energy, Manufacturing and Materials and Services and Business Processes.

[1] https://www.djei.ie/en/Publications/Innovation-2020.html
[2] https://www.djei.ie/en/Publications/Publication-files/Research-Prioritisation.pdf

The various state agencies which are engaged with academic institutes such as SFI and Enterprise Ireland have a remit to address this strategy through a variety of approaches. One key approach has been to create centres of excellence where an already existing capability has been developed. These centres typically have a sectoral approach with respected to engaging with industry and are based at a given academic institute though often have partner institutes involved.

Within Waterford Institute of Technology there are three such centres of which the PMBRC focuses on the pharma and lifesciences which address several of the National Prioritisation priority areas of Medical Devices, Diagnostics, Therapeutics and Processing and Novel Materials. The centre is funded through Enterprise Ireland to assist companies with research and development in these areas.

The Pharmaceutical and Molecular Biotechnology Research Centre (PMBRC)

The Pharmaceutical and Molecular Biotechnology Research Centre (PMBRC) is an applied research centre which aims to support the sustainable growth of the pharmaceutical and healthcare industry in the south east of Ireland. Situated in the heart of the region on the WIT campus, the centre seeks to stimulate research and innovation, allowing companies to embed R&D into their activities. One of 15 Enterprise Ireland Technology Gateways, the PMBRC consists of a 800 m2 state-of-the-art facility with 34 highly-trained research personnel. The PMBRC has established links with national and international partners in industry, academia and medical care institutions.

There are a number of advantages for industry for engaging a centre such as the PMBRC. Firstly academic research centres have a wealth of high-end research equipment. Most companies, even large MNCs, often need only a small range of laboratory equipment on-site which is core to their operations. Accessing specialist equipment and expertise, such as NMR for example, on a pay-as-you-go basis can be a cost effective means of getting the benefit of the equipment infrastructure without the upfront capital expenditure. Secondly, working with a research centre allows companies to access academic and research staff with a wide range of expertise. Finally, there are a number of excellent industry-academic funding schemes available which can substantially lower the cost (and risk) of conducting a research project. Some examples of these schemes are illustrated in the following PMBRC case studies.

So what exactly does the PMBRC do for industry? The following case studies provide three examples of industry engaging with the PMBRC and the specific outcome.

Case study 1: Direct Funded Collaboration with Waters Technologies Ireland

Waters Technologies Ireland, located in Drinagh, Wexford, is the primary manufacturing infrastructure for Waters Corp Mass Spectrometry Instruments, LC Chemistry consumable, Clinical testing and Data Informatics products worldwide. Specifically Waters generates business advantages for laboratory-dependent organizations by delivering practical and sustainable scientific innovation to enable significant

advancement in healthcare delivery, environmental management, food safety, and water quality and employs over 300 people. Waters products are used by pharmaceutical, life science, biochemical, industrial, academic and government organizations working in research and development, quality assurance and other laboratory applications.

The PMBRC has established an ongoing relationship with Waters, supporting their manufacturing and R&D activities. Central to this relationship is the strong analytical capability in the PMBRC including HPLC, LC/MS, GC/MS, NMR, AFM and thermal analysis techniques. The centre has supported Waters in a range of process optimisation, quality investigation and product development projects. The strong research activity in the PMBRC in the area of analytical science has also benefitted the R&D programme at the Waters Technologies Ireland site.

"Having the PMBRC on our doorstep has been really important for us in Waters over the last number of years. The ease of access to the equipment and scientific team in the centre has enabled us to rapidly progress quality investigations and R&D projects which were urgent for the site. We have a very good relationship with the team in the centre and now see their capability almost as part of the overall capability of the Wexford site". Pat Curtis, Principal Process Chemist.

Case study 2: Innovation Voucher with Xeolas Pharmaceuticals

Xeolas Pharmaceuticals is a cutting edge start-up Irish speciality pharmaceutical company based in Dublin. Xeolas develops medicinal products for niche markets, specialising in value-added, innovative or novel formulations of established active substances. Xeolas is an R&D based, technology focussed company. The Dublin base focusses on project management, development planning, clinical development, regulatory, quality and logistics with an expansion plan in 2014 bringing R&D, clinical and small-scale manufacture in-house.

Xeolas is developing a novel, liquid formulation of a drug for the treatment of cardiovascular disease. The drug is normally supplied as a tablet, but Xeolas wish to develop a liquid formulation for use in paediatric patients or patients that are unable to swallow tablets. The drug is not very stable in water however and tends to degrade over time in liquid formulations.

In collaboration with Xeolas, researchers at the PMBRC prepared a number of prototype formulations designed to prevent degradation of the drug in water. The researchers developed analytical methods and used these to assess the stability of the prototype formulations over a period of time. The results have been promising and have proved that a stable formulation of this drug can be prepared if the formulation components are carefully controlled. Xeolas now wish to develop this product further and it has become an important part of the company's R&D portfolio. This project was funded by the Enterprise Ireland Innovation Voucher programme where small companies get a grant of up to €5,000 to engage in a research project with a third level knowledge provider.

Case study 3: Innovation Partnership with Teva Pharmaceuticals Ireland

Teva Pharmaceuticals Ireland is part of Teva Pharmaceutical Industries Ltd, the world's leading generic pharmaceutical company. Teva's Waterford plant is responsible for the manufacture and development of respiratory products for supply to the United States and other global markets. The Spiromax® Dry Powder Inhaler (DPI) is a proprietary technology developed by Teva for the treatment of respiratory conditions. DPIs contain fine drug particles blended with a carrier material (usually lactose). In order to work properly the drug must stick to the lactose particles, but not adhere too strongly such that they do not detach on actuation. The physicochemical properties of the drug and lactose are critical to getting this balance right. This project aimed to help Teva understand the critical material properties required for the optimum performance of the Spiromax® DPI.

The PMBRC Technology Gateway used a variety of characterisation techniques to understand the properties of the raw materials involved and probe the interactions between the drug and carrier. In particular the researchers were able to understand the effect of certain formulation and processing factors which affected the performance of the device. The work in this project focussed on a single DPI product and the work has enabled Teva to understand the optimal formulation and process parameters for the manufacture of that product. The analytical techniques developed as part of the project and the knowledge gained can now be applied to all other DPI products currently in development in Teva, Waterford. A number of invention disclosures and academic publications are currently in preparation. Teva have agreed to fund the continuation of the research for a further two years.

"The work carried out by the PMBRC on the project has significantly enhanced our understanding of the drug-carrier interactions in our DPI product. Pharmaceutical regulators demand a thorough understanding of the factors affecting drug product performance. The knowledge gained in this project will help us to meet our regulatory obligations and will also have a knock-on effect on products currently in development. We are so pleased with the research that we have agreed to fully fund the continuation of the work for a further two years". Dr. Julian Blair, Vice President, Respiratory Product Development Teva Pharmaceuticals.

The centre itself is structured to be responsive and meaningful to industry. The PMBRC is funded by the Technology Gateway programme which was established by Enterprise Ireland to provide Business Development resources to the Institutes of Technology (IoTs) to help them interact with industry on a local, regional and national basis. Up to €23 million will be invested in the Programme between 2013 – 2017 to leverage the capabilities of the IoTs on behalf of industry in Ireland. The Technology Gateways provide the IoTs with dedicated resources who work with industry to articulate their problems in a manner that can be addressed by the Institute's research base. The individual Gateways target industry sectors relevant to the IoTs core research capability. The PMBRC has a dedicated manager with significant industrial experience in the sector whose purpose is to engage with industry in relation their specific requirements. The centre manager is supported by technology leaders who have expertise in certain technology areas such as analytical science and

drug product formulation. Finally, the PMBRC has an industry-led steering committee made up of R&D Directors from 6 local pharma and medical device companies, which oversees the development of the centre. Despite of the pharma/medical device focus of research within the PMBRC, the centre has engaged with companies in a wide range of sectors including food, agri-products, veterinary, analytical and engineering companies. Many of these companies view the offering of the PMBRC to be an extension of their own R&D capabilities. The PMBRC also works closely with other national academic centres and is part of the Synthesis and Solid State Pharmaceutical Centre (SSPC, funded by SFI) and the Pharmaceutical Manufacturing Technology Centre (PMTC, funded by EI). Therefore engaging with the PMBRC opens up wider access to the third level sector in Ireland.

The Technology Transfer Office

So where does the Technology Transfer Office (TTO) fit into the picture. The TTO in each academic institute has a remit to ensure the professional management of the engagement with industry. Put another way the TTO will undertake activities such as contracting and protecting intellectual property on behalf of the industry party. So as for a typical engagement the TTO will be involved right from the start ensuring that confidentiality agreements are put in place and are fit for purpose. The TTO will also work with the company to identify funding models (depending on the project type / company type etc) and ensure that the contract or heads of agreement is signed prior to work commencing. The TTO will work with the academic / research team to ensure any IP developed is protected correctly based on the contract with the company and finally the TTO will ensure the project results are transfer to the industry partner such that they can be exploited as intended.

What is key to the above activities is that the TTO actually provides services both internally and externally such that there is a quick and efficient engagement between the parties. There is no room for mistakes in our fast paced global economy. The TTO by managing the process professionally ensures that all of the necessary steps are performed correctly. The TTO has a set of rules to adhere to which are based on the National Protocol[3] and in essence these follow the principles noted below:

- Commercial agreements are quick and easy to set up
- The central TTO can act as the first port of call
- TTOs retain the freedom and flexibility to “do a deal” with industry that is in the best interests of both parties
- Commercial terms are generous
- More open innovation in multi-party collaborations is encouraged

[3] http://www.knowledgetransferireland.com/ManagingIP/KTI-Protocol-2016.pdf

- Intellectual property is managed in a professional way.

As a result of professionally managed services and our ambition in WIT to provide open access to industry we now completed several hundred contracts with our research partners on an annual basis.

Conclusion

For companies interested in engaging with academic institutes the first port of call is often the TTO. The TTO can provide direction to the internal expertise within institutes and confidence to industry that the engagement with be professionally management. Centres such as the PMBRC have capacity and capability to deliver specific services to industry to enhance their innovation potential.

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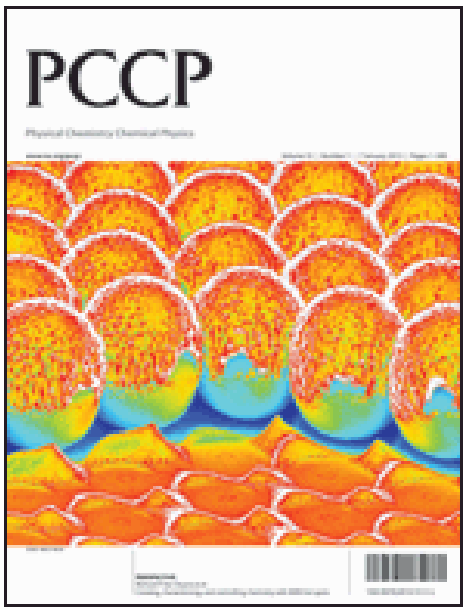

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Job boost for Clare Posted on07 September 2016.

Beckman Coulter, a US bio-medical firm has announced that it will be creating an additional 105 staff at its plant in Clare. The plant currently employs 315 people.

Plans lodged with Clare Co Council confirm that the company is seeking to increase the capacity of its current operations of manufacturing reagent kits and introduce the production of a new product on site – strips for testing urine samples.

The total annual salary spend at the plant is currently €17 million generating an average salary of €54,000 which the company states "is well above the average for the scientific and technical service sectors".

The firm's total export revenues is about €200 million per annum and it spends €14 million per annum on materials and services in Ireland.

Pfizer to acquire US cancer drug company Medivation Posted on23 August 2016.

Pfizer has announced that it is in advance talks to acquire US cancer drug company Medivation for close to $14 billion.

Medivation shares were up 20pc at $80.56 in premarket trade, just shy of the offer price of $81.50 per share in cash.

The offer is at a substantial premium to Sanofi's initial offer to buy Medivation for $52.50 in April that pushed the San Francisco-based company to put itself up for sale.

The deal comes four months after Pfizer and Ireland-based Allergan Plc scrapped their $160bn merger. Pfizer has since bought Anacor Pharmaceuticals in a $5.2bn deal to add an eczema gel to its portfolio.

The deal is expected to be paid for in cash and could be completed as early as today, although the sources said there was still a chance that is could collapse at the last minute.

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Biomaterial and polymer company Ortec creating 110 jobs

Posted on15th September 2016.

IDA Ireland has announced that Biomaterial and polymer company Ortec is to establish its European headquarters in Co Limerick, creating up to 110 jobs for the area.

The new facility, which will also include a manufacturing and operations centre, will be located in Newcastle West. The jobs created will be highly skilled engineering and science posts.

Ortec manufactures customised products for the medical devices, pharmaceuticals and other health-related sectors.

The company is to move into a 13,000 sq foot facility in Newcastle West and will double the size of the plant in the coming months, subject to planning permission.

Minister for Jobs, Enterprise and Employment Mary Mitchell O'Connor welcomed the news. "There are many advantages for companies like Ortec to choose our regions to set up their business and I welcome their decision to choose Newcastle West," she said. "These are exactly the kind of high-quality graduate jobs that we seek to attract and it is a strong vote of confidence for Ireland and our regions that Ortec has decided to establish its European headquarters here."

Biopharma Engineering creating 70 jobs over the next three years

Posted on 22nd September 2016.

Biopharma Engineering has announced that it will create 70 jobs over the next three year, after opening a new office in Dublin.

Speaking at the office opening, Minister for Jobs, Enterprise and Innovation Mary Mitchell-O'Connor said the 70 new positions will be highly skilled graduate jobs.

It is expected that 20 new positions will be created in the company's Cork office and 50 new positions are being filled by its new Dublin office.

Founded by John O' Reilly and Richard Holohan, the Engineering design company has doubled its workforce over the last 18 months and currently employs 80 people.

"Our company has delivered capital projects worth more than €500 million for our clients and we continue to scale in terms of markets, capabilities and ambition," Mr O' Reilly said.

"The new Dublin offices will enable us to serve our clients better and ensure that we continue to deliver the highest quality engineering design solutions," he added.

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GE to invest €150 million in biopharmaceutical manufacturing campus in Cork, Ireland, and establish advanced manufacturing training centre at NIBRT

Posted on21 September 2016.

Ireland's Minister for Jobs, Enterprise and Innovation, Mary Mitchell O'Connor TD, today announced that GE (NYSE:GE) is to invest €150 million in a new biopharmaceutical manufacturing campus on Industrial Development Agency (IDA) Ireland's strategic site at Loughbeg, Ringaskiddy, Co. Cork. GE BioPark Cork, subject to contract and planning approvals, will feature Europe's first KUBio™, prefabricated, off-the-shelf bio-manufacturing facilities, owned and run by GE customers, and will serve as focal point for further investment in next-generation biopharmaceutical manufacturing in Ireland.

Building manufacturing capacity

GE BioPark Cork is expected to be home to more than 500 new jobs when fully operational; 400 with biopharma companies and a further 100 employed directly by GE. The construction phase, subject to planning approvals, is expected to begin by mid- 2017 and create up to 800 construction jobs. The project is supported by the Department of Jobs, Enterprise and Innovation through IDA Ireland.

Developing bio-manufacturing skills for 1,500 bio-professionals per year

To further develop biopharma manufacturing skills and expertise in Ireland, GE and the National Institute for Bioprocessing Research and Training (NIBRT) also announced today their plan to create a NIBRT-GE Single-use Centre of Excellence at NIBRT's Dublin facility. NIBRT expects to train up to 1,500 bioprocessing professionals annually on next-generation biologic manufacturing technologies. These exceptional technologies for biopharma manufacturing will be used in GE BioPark Cork's manufacturing facilities.

GE BioPark Cork will be a GE-managed campus including four fully-equipped KUBio factories owned by independent biopharma companies manufacturing proprietary medicines, with GE running centralised shared utilitiesand site services.

Patient demand for innovative medicines is driving rapid global growth of the biopharmaceutical industry, resulting in significant need for more production capacity. GE's KUBio enables pharmaceutical companies to quickly deploy new biologics manufacturing capacity and bring medicines to market faster. KUBios increase manufacturing flexibility and are between 25 and 50 percent more cost-effective to build than comparable traditional facilities. Carbon dioxide emissions can be reduced by 75 percent and water and energy use by approximately 80 percent. Build time can be shortened to 18 months from the usual 3 years.

Minister Mitchell O'Connor said: "The Biopharma industry makes a huge contribution to the Irish economy in terms of jobs and manufacturing exports, and is one of the fastest growing sectors. I am delighted that GE is making a significant investment in Cork. This is a further testament to our talented workforce. All investment and jobs created has a positive knock on effect on the wider region. Over 28,000 people

currently work in biopharma and 6,000 of those work in biologics. This subsector is expected to double in the coming years and will provide both a challenge and an opportunity for the industry and training providers to collaborate on promoting the range of career opportunities available. I welcome GE's commitment to Ireland and wish them every success in the future."

Mallinckrodt Grows Investment in Dublin College Business and Technology Park to €85 million

Posted on 21st September 2016.

Mallinckrodt plc, a leading specialty pharmaceutical company, today officially opened its new offices in College Business and Technology Park in Blanchardstown, Dublin, and announced creation of a new €10 million state-of-the-art Research and Development (R&D) facility at the location. The R&D facility will house global device engineering for the company and bring 40 more new jobs to the site, bringing the overall total of new positions there to 120 by 2017. With its May 2015 announcement and this commitment, Mallinckrodt's total investment in the site has grown to €85 million. This project is supported by the Department of Jobs, Enterprise and Innovation through IDA Ireland.

Mallinckrodt has a long history of operations in Ireland and has had a presence there for over 20 years. Its new offices at the College Business and Technology Park, Blanchardstown were dedicated this morning by Minister for Social Protection, Leo Varadkar TD, and Mallinckrodt President and Chief Executive Officer, Mark Trudeau.

Commenting, **Leo Varadkar, local TD and Minister for Social Protection, said** "I'm delighted to announce this new investment by Mallinckrodt in Blanchardstown. This company is at the cutting edge of new and innovative treatments and the range of facilities being developed here is an exciting development. The Government has worked hard to create the right conditions for cutting edge Pharma and BioPharma companies to locate in Ireland and the provision of high quality jobs in this new Research and Development facility is very welcome. The number of people at work is back up to 2 million and unemployment continues to fall. This investment means more jobs and more quality jobs in our community."

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Industry and Business at... BioConnect Ireland on Brexit: An opportunity or threat to Irish research?

The consensus at this talk was clear. No one knows what's going to happen now that Britain has chosen to leave the EU. That doesn't mean people don't have a clear idea on what should happen, and what both Ireland and the UK can do to ensure that vital research funding is utilised.

Mike Galsworthy, from Scientists for EU, lamented the UK's decision highlighting how the country may no longer play a key role in the "Science Superpower" that is the EU. UK academia and SMEs benefitted enormously from EU funding but their loss has the potential to be Ireland's gain.

But how? Luckily, there are plenty of ways. Ireland is in a position to capitalise on the uncertainty around Brexit. We can try nabbing the European Medicines Agency from London, attracting the research stars from UK universities, and persuading small innovative companies to set up here backed by EU funding, to name a few

At the same time, as Enterprise Ireland's Catriona Ward pointed out, we are now set to lose our strongest ally in Europe. With the weakening Sterling, our exports could be set for a hit.

The key takeaway from his BioConnect event was that this long goodbye could be a painful one, and Ireland must be proactive in gaining the advantages it can from the situation.

Irish SME's score €26.5 million with highest success rate in Horizon 2020 project

Posted on 11th October 2016.

New figures released by the European Commission show that Ireland has the highest success rate in Europe for the Horizon 2020 SME Instrument, with SMEs in the country securing €26.5 million from the fund.

Horizon 2020 is a massive EU project that aims to transform research and innovation with nearly €80 billion in funding designed to provide more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market.

Irish SME's success rate of 16% is far greater than the European average of 6%. Ireland lies in first place for successful participation in this component of the Horizon 2020 initiative.

The largest beneficiary from the programme in Ireland is Radisens Diagnostics, who has received €4.48 million to date.

The SME Instrument Innovators Summit due to take place on the 10th and 11th of October will gather 250 SMEs from across all member states who have received Horizon 2020 funding to meet 142 investors at a brokerage event to initiate steps to commercialise the outcomes of these SME projects.

According to Enterprise Ireland, Irish SMEs are not only more successful than their European counterparts, they are also targeting larger sums of money from the project.

National Director of Horizon 2020, Dr Imelda Lambkin from Enterprise Ireland, says: "Irish SMEs play a vital role in the growth of the Irish economy. Seeing so many Irish companies successful at a European level validates the supports provided by Enterprise Ireland to develop high growth, highly innovative SMEs who have the innovative solutions and capability to win Horizon 2020 funding."

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Continuous Manufacturing tops the bill at BioProduction Congress

Posted on 25th October 2016.

Another strong endorsement of Ireland's place in the pharmaceutical and biotech world came last month, when it became the venue for the BioProduction Congress. A global event with speakers and exhibitors from around the world, the conference took a deep dive into the nitty gritty, and the finer details, of modern biomanufacturing at the CityWest Hotel on the outskirts of Dublin.

Continuous manufacturing, cell culture & upstream process development, downstream processing and manufacturing strategy & technology: All of these topics had dedicated speakers from the biggest players in the industry.

Roche, Sanofi, Merck and many more were represented as the industry begins to look at how the growing move towards continuous manufacturing can be most efficiently completed and how the problems and challenges can be faced head on.

Across a series of short, snappy sessions typically lasting around a half hour each were punctuated with longer group discussions on topics such as spotlight focus on new facility design and development in Ireland and the UK.

Hearing how mini reactors were mimicking the characteristics of classical bioreactors at microscale, the effect of temperature step change on titer and glycosylation profile of a recombinant human enzyme and the continuous capture of antibodies meant delegates had plenty of options to choose from.

While there is a degree of acceptance on the benefits of continuous manufacturing across the industry, this was a chance to view practical examples of how to solve the complex problems of today's manufacturing demands. The industry has become a lot more flexible since many of the mega-blockbuster drugs began to go off patent at the start of this decade, and manufacturing strategies are really beginning to reflect these possibilities.

On the floor

While there were plenty of exhibitors showcasing their wares to delegates, there were a few that stood out. An indigenous Irish company doing great work supporting the industry here, Micro Industries were showcasing their single use systems.

GE Healthcare, on the other hand, buoyed by their recent announcement of a €150 million investment to build state-of-the-art KuBios (pronounced Queue-Bee-oh), took delegates on a virtual reality tour of their yet-to-built operations in Ringaskiddy.

While it was impressive that we have the technology take this virtual reality tour at all, equally impressive was the tour itself taking in some of the fantastic facilities for cutting edge biologics manufacturing that GE Healthcare will boast at these sites.

This writer got a look inside some of their bioreactors, as well as the extensive labs that will house hundreds of scientists, all while walking around a few square metres in a hotel and conference centre in Dublin. It could be described as surreal, if it didn't feel so real to begin with.

Irishness stands out

The emphasis on Irishness at the event was a welcome opportunity to showcase what Ireland has to offer to the industry as it continues to work to attract further investment in the sector, after recent massive investments from the Pfizer, Bristol-Myers Squibb and Alexion.

The chairperson to kick off the conference was Tommy Fanning, global head of biopharmaceuticals and food at IDA Ireland. The IDA has been central to winning so much investment into the country in recent years and there was no better way to kick off an international conference based in Ireland than with Tommy.

The conference also featured Greg McGurk, executive inspector for the Health Products Regulatory Authority in Ireland giving his perspective on future biomanufacturing facilities that will increase productivity, profitability and product quality, as well as some practical regulatory advice on good manufacturing practice (GMP) inspections.

The National Institute of Bioprocessing Research and Training (NIBRT) does great work in partnering with industry to train the next generation of pharmaceutical scientists, and its chief scientific officer, Michael Butler, led a session on dielectric monitoring of mammalian cells in a bioreactor.

The conference's emphasis on Irishness was not confined to the daytime programme at the event, as former Guinness masterbrewer, Fergal Murray, treated delegates to a session on how to experience and enjoy a great beer.

Verdict

A welcome edition on the conference calendar, Bioproduction Congress offers a heavy emphasis on what's important in the biomanufacturing industry right now. There was a little bit for everyone involved across the whole spectrum of the manufacturing process and the news that the next edition will also be held in Dublin was a welcome one.

Ireland is well on its way to becoming a global centre for biomanufacturing. And the world is watching.

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West Pharmaceuticals Expansion to Create 100 Jobs

Posted on 1st December 2016.

Medical manufacturer West Pharmaceutical Services, Inc. announced on Tuesday, November 29, the completion of a 60,000 square foot expansion at its contract manufacturing facility near Mulhuddart, County Dublin. The expansion was initiated in response to customer demand for medical device manufacturing, especially in the area of diabetes.

West Pharmaceutical Services, Inc. manufactures packaging components and delivery systems for injectable drugs. West is headquartered in Exton, Pennsylvania, and supports its customers from locations in North and South America, Europe, Asia and Australia. West's 2015 sales of $1.4 billion reflect the daily use of approximately 110 million of its components and devices.

West also announced that its contract manufacturing business formerly known as The Tech Group will now align with the West brand and do business as "West." West anticipates 100 new jobs will be added to the business over the next five years as a result of the expansion.

Along with the expansion of its Dublin facility, West is also growing its proprietary product business in Waterford, Ireland. The Company previously announced the construction of a centre of excellence for its proprietary elastomeric sheeting and injectable component product lines. The new plant is expected to begin full commercial operations in 2018.

Martin Shanahan, CEO, IDA Ireland said, "Ireland has seen hundreds of millions invested in recent years in the development and manufacturing of new injectable drugs for diabetes, cardiovascular disease, autoimmune disease and cancer. The patients who will benefit from these exciting new drugs will also benefit from West's innovation in drug delivery devices."

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SEAI Announces €30 Million Community Energy Fund for 2017

Posted on06 December 2016.

The Sustainable Energy Authority of Ireland (SEAI) announced on Tuesday, November 6, that it will offer €30 million in grant supports for community energy projects next year. This represents a 50% increase in funding from the 2016 grant levels – an additional €10 million.

CEO of SEAI Jim Gannon said: "For 2017 we are particularly interested to hear from smaller communities, with smaller projects, that may only be starting out on their sustainable energy journey. We are also providing additional incentives to encourage multiple upgrades in homes that achieve very high performance. All communities with an interest in advancing Ireland's transition to sustainable energy should contact us to see how we can help – with grant support or simply advice. We will be running workshops nationwide for interested community groups over the coming weeks".

SEAI's Better Energy Communities programme supports new approaches to achieving energy efficiency. The programme focusses on improving the energy efficiency of Ireland's building stock, supporting the use of renewable energy and helping communities complete energy improvements in a more efficient and cost effective way by clustering buildings under umbrella projects.

Over the past five years SEAI has provided €85 million support to 300 community energy efficiency projects. As a result, €170 million has been invested in energy efficiency upgrades for over 15,000 homes.

Marking the announcement, Minister for Communications, Climate Action and Environment Denis Naughten said: "By supporting community energy projects for homeowners, communities and private sector organisations we can demonstrate to everybody the real and practical benefits of energy efficiency. It also reduces the amount of money we spend on imported fossil fuels and instead ensures that this money supports local employment throughout the country."

About SAS and JMP

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