DIAMONDS IN THE ROUGH
From jewels to drills.

GRAPHENE
Where is it now?

THE HOPE DIAMOND
Solving the mystery.

DIAMONDS IN THE ROUGH
From jewels to drills.
This is now my second issue as editor of resonance, and this issue marks the end of my fifth year studying at the University of Sheffield. Throughout my time here I have been frequently exposed to stories of great accomplishments made in this department, both past and present, and it is my privilege to be able to be one of the first to hear them.

This issue is somewhat oxymoronic, in that its focus is actually incredibly vague when you think about it - carbon. Carbon is all around us: in the air we breathe, the clothes we wear, the things we eat and even our very muscles and organs. It is also fundamental to the field of chemistry, so much so that organic chemistry is based almost solely on the study of its molecular compounds.

This issue aims to bring to light some interesting stories involving carbon, from a supposedly cursed diamond, to a nanomaterial deemed to be the solution to a cacophony of materials chemistry problems. Aside from this, we have an interview with our new Head of Department, Prof. Graham Leggett, detailing his plans for the Department's future. Of course, these plans are likely to include the new laser lab opened by Prof. Weinstein, whom Abbie Sinclair and James Shipp interviewed for details.

If you’re reading this with your lunch, you might find our “kitchen chemistry” section interesting, which explains the science behind crisp manufacture. Alternatively, if you’re more of a history buff, you can read a short biographic article on the late Rosalind Franklin and her many academic accomplishments.

Before you dive in, I’d like to thank my team for this issue and all the hard work they’ve put into writing the articles. Jas Catlow and Mahir Mohammed in particular have written two fantastic and unique articles about two topics I originally knew nothing about! Zoe Smallwood continues to impress with her article on two contrasting uses of diamonds, and Dave Ashworth has applied his research expertise in two-dimensional materials to his feature article.

Once again, happy reading.

Joshua Nicks
Often found glistening in tiaras and engagement rings, diamonds are considered a true symbol of wealth and opulence. Their popularity with jewellers is attributed mostly to their natural sparkle and colour (or, to be more precise, the lack of colour — completely colourless diamonds are extremely valuable). However, the smaller stones that don’t find their way onto rings and pendants are used in performance cutting tools and high pressure cells. 

Whilst these two applications may seem completely unconnected (after all, why would a drilling tool need to be sparkly?), it is the extreme hardness of the stone that links the two. The word ‘diamond’ is derived from the Greek word ‘adamas’ which literally translates as ‘unbreakable’, with a hardness and stability greater than any other natural compound. This supreme strength is due to an ‘infinite’ network of strong carbon-carbon bonds arranged in a tetrahedral structure.

Whilst the demands of drilling are much more intense than normal life, the extreme hardness and scratch resistance means that diamonds keep their sparkle and shine almost indefinitely; a hugely desirable feature in jewellery. Softer minerals such as opals, are brightly coloured but are less common in rings, particularly because they are more easily damaged. Although they often appear colourless to the naked eye, only the highest quality diamonds are devoid of colour. The trace presence of trace amounts of nitrogen replacing carbon atoms in the structure (known as inclusion), varies the colour from colourless to yellow or even brown. The distribution of the nitrogen is as important as the quantity, if spread throughout the stone, the colour is much darker than if they are located in clusters at certain sites - the type of nitrogen inclusion can be detected using electron paramagnetic resonance to help validate the colour. Much rarer colours are caused by other imperfections such as boron (blue), graphite (black) or defects in crystal growth (red). The Aurora Pyramid of Hope, currently an exhibit in the Natural History Museum, displays 296 natural diamonds, each a different colour!

Due to cost and ethical considerations, more and more consumers are buying synthetic gemstones instead of those mined from the ground. Synthetic diamonds can be formed at high pressures and temperatures by crystallising molten carbon in a molten metal solvent, using ‘seed diamonds’. However, the predominant use of these synthetic diamonds is currently in industrial settings. Synthetic diamonds are often more yellow than their natural counterparts due to the inclusion of more nitrogen from their formation process, limiting their aesthetic value in an industry which prizes colourless diamonds.

A comparison between diamond (left) and synthetic moissanite (right).

More recently, another form of synthetic diamond has begun to appear. Moissanite, a crystalline form of silicon carbide, has a hardness only marginally less than diamond and is normally used for cutting of precious metals in the jewel industry. Moissanite is name after Dr Henry Moissan, who discovered trace amounts of the stone in a meteor crater in the late 1800’s. The sparse amounts formed naturally meant it was not until 100 years later that an industrial process for manufacturing jewellery-quality stones was developed. Unlike diamonds, moissanite is only formed synthetically, making it a cheaper and less ethically concerning alternative to some mined diamonds. A bonus is that moissanite has a higher refractive index, making them look more ‘sparkly’! So, next time you are admiring a particularly striking diamond ring, there’s a high possibility the stone may be the same compound used to cut the metal it is held in!


In 1962, the Nobel Prize in physiology and medicine was awarded to James Watson, Francis Crick and Maurice Wilkins “for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material.” However, by their own admission, Watson and Crick could not have arrived at their model of DNA without X-ray crystallographic data obtained by one Rosalind Franklin. Though Franklin’s career, and possible Nobel recognition, were cut short by her untimely death in 1958, this article aims to demonstrate just how significant her discoveries were to chemistry as well as science as a whole. 

Photograph 51, from which Franklin derived the double helix.

Franklin was born in 1920, into a well-educated Jewish family. She attended St Paul’s Girls’ School in London, where she excelled at both physics and chemistry, propelling her to a bachelor’s degree in natural sciences – specialising in physical chemistry, at the University of Cambridge. There she undertook her PhD research, with her thesis titled ‘the physical chemistry of solid organic colloids with special relation to coal and related materials’ being completed in tandem with the British Coal Utilisation Research Association during the second world war. It is often overlooked that her proficiency in X-ray diffractionmetry techniques came as a result of her time spent as a post-doctoral researcher at the Laboratoire Central des Services Chimiques de l’Etat in Paris. Her work there focused on applying diffractometry to imperfectly crystalline materials – namely coal. The papers she published on this research continue to be cited today, and earned her a great deal of respect in the field.

In 1951, Franklin moved to King’s College London, where she worked on DNA for two years. She worked in the lab of John Randall, alongside Wilkins - through the two did not get on. Here, Franklin became the first to identify the two forms, dubbed A and B, in which DNA could exist. She elucidated these through painstaking crystallisation experiments, in which she would alter the degree of hydration of a tiny fibre of DNA to manipulate its dominant crystalline form. As a result, she was able to obtain A and B form diffractometry data, from which she determined DNA’s density, unit-cell size, and water content. This finally culminated in the proposition of a double-helix structure with complimentary strands. This data was a vital factor in Watson and Crick’s model, which would most likely not exist otherwise. This resulted in Watson and Crick’s model being published in Nature, alongside two papers written by Franklin and Wilkins (separately) which supported it.

Franklin did not fit in well at King’s, and chose to leave in 1951, moving to Birkbeck College. Here she began her work on RNA viruses, publishing 14 papers between 1955 and 1958 and becoming an expert in the topic. Her work ethic did not falter, with 13 of these papers having been published after her cancer diagnosis. Unfortunately, three others had to be submitted for publication by her students after her death in 1958. One of these students, Aaron Klug, went on to win the 1982 Nobel Prize in chemistry for his development of crystallographic electron microscopy.

So there you have it, Franklin was an authority in physical chemistry and particularly diffractometry during her career. We cannot know whether her death stopped her from being awarded the Nobel Prize ahead of Wilkins. After all, sexist attitudes were ingrained in science at the time, and even today, few Nobel Prizes are awarded to women. However, what is undeniable true, is that the work of Rosalind Franklin has had a huge impact on our understanding of life, and her passion and dedication to chemistry is something we can all admire. The Rosalind Franklin Institute in Oxford was established in
GRAPHENE: Where is it now?

By Dave Ashworth

What do a pair of headphones, a tennis racket and a supercar share in common? The answer most would give is a confused “not much?”. However, with the roll-out of graphene into usable devices and technology, you can now get your hands on graphene-containing varieties of all three.

Discovered 14 years ago, after decades of being nothing more than theory, graphene has had a relatively short period of time to establish itself as a viable material that can be utilised across global industry. We’re routinely told of its incredible properties – ultra-light, atomically thin, flexible, transparent, more conductive than copper and 200x stronger than steel – scientists have long since run out of superlatives, but has graphene actually lived up to the hype?

What is Graphene?
Graphene is a carbon allotrope, much like diamond (see our factfile for others), with atoms arranged in a flat hexagonal lattice, forming planar sheets just a single atom thick. Layers of this stacked on top of each other form a much more recognisable form of carbon – graphite – otherwise known as pencil lead.

Due to its plethora of extraordinary properties, it is apt to describe graphene as a unique material, at least for now.

- Strength and elasticity: Graphene can be stretched up to 25% of its original length without breaking, and will return to its original length (think rubberband). The flat planes of atoms can flex relatively easily without breaking. In fact, graphene is believed to be the strongest discovered material.

- 200x stronger than steel. This property makes graphene particularly useful in composites with plastics to form stronger, tougher and lighter materials for ships, planes and cars, as well as flexible screens.

- Weight: Being atomically thin, graphene is incredibly light relative to the surface area it presents. You could cover an entire football field with less than a gram! This lightweight nature is particularly useful in materials design.

- Heat and electrical conductivity: Graphene is a far better heat conductor than typical examples, such as silver or copper. The flat hexagonal lattice offers little resistance to electrons. Thus, electrons in graphene have a longer mean free path than in any other material. This allows graphene to conduct electricity superbly, as electrons move through the material at speeds close to the speed of light. This grants huge potential in device manufacture, including batteries, touchscreens, computer processors, transistors, and telecoms.

- Optical: With very few atoms to penetrate, graphene is almost completely transparent. It transmits about 98% of white light (compared to approx. 80% for a pane of window glass), yet another reason for graphene to be incorporated into touchscreens!

- Impermeability: The structure of graphene means that it can act as an ultra-fine atomic net, potentially trapping gases like hydrogen or carbon dioxide for storage.

Barriers to Implementation
Graphene is an awesome material. Combinations of its properties mean it has genuine potential to be a useful material in many diverse applications, as well as representing a major step forward within materials science research. So, why is it not in everything, everywhere?

- Synthesis: At the moment, synthetic methods for creating graphene can either create relatively large amounts in low quality (i.e. large defects, multi-layered, small lateral size) through bulk delamination from graphite; or small amounts in high quality, through chemical vapour deposition (which is not industrially applicable).

- Cost: High quality graphene is incredibly expensive. Low quality graphene can be supplied in large enough quantities for materials research to be ongoing, and companies have made many products incorporating graphene within composite materials. However, high quality graphene is required for electronics, and although demonstrations of potential devices have been made, at the moment the use of graphene is too expensive to be

Outlook
Although an incredible material in its own right, graphene’s most promising uses, at least in the short term, come from using it within composite materials. Much of the research into graphene is still “blue skies,” and it could be a number of decades before it becomes cost-effective and practical to include graphene in our everyday life – but don’t write it off yet. Its discovery was only just over 10 years ago, and it’s already possible to buy consumer products incorporating graphene - shown below! So, although this seems slow in our expectations, is it really taking as long as some think?

Carbon was so-named in 1789 by Antoine Lavoisier, from the Latin ‘carbo’, meaning charcoal. Lavoisier bought a diamond and used a giant magnifying glass to focus the sun’s rays. He burned the diamond in the same way we would burn charcoal on a barbecue, revealing that diamond was made up of the same material. Now we know there are multiple different forms of elemental carbon, known as allotropes, including charcoal, diamond, graphite, graphene and fullerences.

Carbon was formed through nuclear fusion of helium within stars, forming interstellar “dust.” It is the fourth most abundant element in the universe, after hydrogen, helium and oxygen. It is the second most prevalent atom within you and me, accounting for 18.5% of bodymass. You really are made of star dust! Its prevalence throughout chemistry means more compounds are known which contain carbon than those that don’t. Carbon also forms the basis of our materials industry, and is present in everything, from plastics to steel.

Most people have now heard of carbon dating, due to media reports of archaeological discoveries. This technique can give mummies, fossils and ancient artifacts an approximate age. The 14C isotope is radioactive, decaying to 14N through a beta decay process. With a relatively long half-life of 5730 years, the ratio of 14C to 14N can be used to determine the age of carbonaceous materials of up to about 60000 years old. In 1960, Willard Libby was awarded the Nobel Prize in chemistry for developing this dating technique. Much better than Tinder!
Opening of the Lord Porter

On March 14th the new facility for ultrafast laser spectroscopy was opened by Lady Porter in honour of her late husband. Abbie Sinclair interviewed Professor Julia Weinstein to find out more about why she set up this laboratory, and what it will be used for:

Could you tell us about the new laser lab? The lab boasts many advanced laser methods, allowing us to study light-induced reactions from tens of femtoseconds, which is close to the speed at which light is absorbed, to milliseconds. We can cover the whole range of energy transitions in the infrared to high-energy electronic transitions in the UV. We can investigate chemical reactions along a huge range of timescales and energies - that’s an interesting combination that doesn’t exist in any other UK university.

Collaborators from all over the UK will be coming and measuring everything related to photovoltaics, artificial photosynthesis, fundamental light-matter interactions and photocatalysis. We intend to have a dedicated seminar program for people who are very much involved or are interested in laser spectroscopy.

What can these new lasers do that we were unable to do before? This is a new system which has a high repetition rate, ten times faster than a standard laser system, allowing for faster experiments with an improved signal-to-noise ratio. The lasers are also very powerful, allowing us to split the output to different detection ranges, so we would be able to investigate the same sample with electronic and vibrational spectroscopy at different timescales under the same laser excitation and within the same facility. It also has the fluorescence upconversion method, which allows you to follow really fast reactions of emissive species with high sensitivity. Very few people have access to this analysis method!

What brought you to Sheffield? The university brought me to Sheffield. I did my PhD at Moscow State University and then came to England in 2000 for a year as a Royal Society NATO Fellow. I was then introduced to time-resolved vibrational spectroscopy in Nottingham. I realised I’d like to be in this area so started applying for various jobs and fellowships. Sheffield seemed a very nice place, they had a post advertised and I was offered the job!

Research groups in the department are already using the facility, with multiple research papers published based on the data obtained. Its users range from Masters’ students to post-doctoral staff, who utilise the experiments detailed on the right of this double-page spread by Julia’s PhD student, James Shipp.

Interview

Lord George Porter, a Sheffield chemist who won the Nobel Prize in 1967 for his work on flash photolysis.

Laser Laboratory

Transient Absorption

Transient absorption (TA) is the study of ultrafast processes in the UV-vis spectral region. It allows us to easily follow electronic transitions such as metal-to-ligand charge transfer. TA is used in our department for the study of chromophores, such as porphyrins in Dr Adrien Chauvet’s group, and for the study of donor-bridge acceptor complexes in the Weinstein group. Research groups in the physics department use TA for the study of advanced photophysical processes, such as triplet-triplet annihilation.

Laser spectroscopies, such as transient absorption, work by a simple pump-probe method, shown above and to the right. First, the sample is irradiated with a pump laser pulse. This causes the molecules in the sample to be promoted to their excited states. To study these excited states we then shine a probe laser on the sample. This allows us to record the absorption spectra of the excited molecules. By increasing the path length of the probe, we can change the difference in time between the two pulses. This allows us to see different time delays, from a few femtoseconds to hundreds of nanoseconds!

Time Resolved Infra-Red

Time resolved infra-red spectroscopy (TRIR) allows us to follow changes in the vibrational spectra of excited molecules over time. This is incredibly useful as many compounds contain functional groups that strongly absorb IR, such as carbonyl groups. This technique has been used in our department for the study of electron transfer across alkyne bridges in the Weinstein group, as well as the study of mechanisms of photochemical reactions in the Portius group. We can also do sophisticated IR experiments with more than two laser pulses, such as transient two-dimensional IR spectroscopy.

Fluorescence Upconversion

Unlike the other experiments in the laser lab, fluorescence upconversion spectroscopy (FLUPS) does not study a compound’s absorption of light.

Instead we collect the light emitted from the excited state, and observe how this emission changes in intensity and wavelength over time. FLUPS is used in the Weinstein group to study emissive platinum complexes, to answer fundamental questions about their electron transfer processes.

1. bit.ly/2RWf7e2

A porphyrin complex fluorescing under 625 nm (red) light.
The Hope Diamond: Solving the Mystery

By Jasmine Catlow

In the mid-17th century, an exceedingly rare diamond, coveted for its unusual blue lustre and its expansive size, came into the possession of King Louis XIV of France. Known as the French Blue, it displayed a characteristic heart shape cut. However, during the French Revolution, the contents of the royal vault were ransacked, and though almost all the other jewels were reclaimed, the French Blue was never found.

Decades later, in London, another blue diamond surfaced - purchased by Henry Hope, with whom the name and curse of the Hope Diamond originate. Said to bring disaster and misfortune upon those in its custody, it was a lucky charm. That was, until her son died in a car crash, her daughter committed suicide, and her husband was deemed insane. After dying alone, her entire jewelry collection was bought, and the Hope Diamond quickly donated to avoid the curse's wrath. Today, the diamond remains on display to the public, in the US national gem collection.

Given that the French Blue, of acclaimed character, never resurfaced, it was widely thought to have been recut into a less distinctive shape. Add to this, the mystery surrounding the Hope Diamond’s appearance, and it isn’t too much of a step to ask if the cursed Hope Diamond was cut from the stolen French Blue.

To answer this question, a team of scientists and gem-experts recreated a 3D model of the French Blue from a to-scale engraving and a lead replica made during the reign of King Louis XIV. Data for the Hope diamond was also collected and the two computational image sets were compared. At the perfect angle, the Hope diamond was found to fit perfectly inside the structure of the French Blue; confirming that the former was cut from the latter. However, the question remained; where is the rest of the French Blue? Fortunately, modern analytical techniques may shed some light on this.

The exact composition of authentic blue diamonds is vague, as not only are they rare but it's difficult to analyse any impurities are so low in concentration that they can't be detected by infrared spectroscopy, so special techniques such as secondary ion mass spectrometry (SIMS) or phosphorescence spectroscopy must be employed.

When examining the two types of blue diamond - type 1a and type 2b, 1a diamonds are more common, and contain significant nitrogen impurities, as well as hydrogen. It is the presence of hydrogen that gives them a secondary hue (e.g. blue-green). In complete contrast, 2b diamonds contain almost no nitrogen impurities and, instead of hydrogen, possess a quantifiable amount of boron. This means that the rarer type 2b blue diamonds normally exhibit a darker hue, and are the only semiconducting diamonds. The Hope Diamond falls into the type 2b category.

Blue diamonds phosphoresce under UV light - normally a blue/green colour, but the Hope Diamond phosphoresces red. This red phosphorescence was originally thought to be rare, but has been found to be characteristic of all type 2b blue diamonds. The reason the Hope Diamond phosphoresces red is to do with its composition, and is thought to be a reason why it was perpetuated as being cursed. Most blue diamonds exhibit both a red and a blue/green emission, but the red colour is normally masked by the blue/green emission. Diamonds that exhibit both these emissions are higher in boron, with low nitrogen traces; type 2b. Type 1a diamonds exhibit an absence of these two emission peaks. The half lives and intensities of diamond phosphorescence are due to a difference in boron to nitrogen concentrations.

The phosphorescence of blue diamonds provides a unique photophysical identifier, so if the Hope Diamond was ever stolen again it would be easily traceable, even if it was recut. Perhaps more interestingly, other known blue diamonds and those which emerge can now be analysed in a search for the missing pieces of the once great French Blue - solving this centuries-old mystery.

Phosphorescence: A Quick Guide

Phosphorescence is a photophysical process in which an electron in the excited state of an atom or molecule undergoes intersystem crossing, and then decays back to its ground state by emission of a photon - hence the associated colour change! It differs from fluorescence as it is typically spin-forbidden, thus it has a longer lifetime.

As shown in the Jablonksi diagram on the right, intersystem crossing has an associated energy loss. Thus, phosphorescence emissions are redshifted compared to fluorescence, giving the red emission of the Hope diamond!

To learn more about the history of the Hope diamond, and the photochemistry of diamonds and gemstones in particular, check out the following links:

3. https://rsi.edu/3RZJ3W7
**Interviewing Graham Leggett**

Graham Leggett, Professor of nanoscale analytical science and an academic member of staff in the Department of Chemistry for 16 years, was named Head of Department in August 2018. A well-known name in the field of nanoscience, current and future undergraduates will know him well for his numerous lectures, ranging from the role of fuel in our world to nanochemistry and the science of solid surfaces.

I was fortunate enough to find some free time amongst the new Head's busy schedule to talk to him about his new role. This interview focuses on Graham's academic career, where he started, and how he found himself at Sheffield, as well as his current plans for leading the Department, plus a few tips on how to relax after a hard day's work.

**Could you give me a brief outline of your academic career up to now?**

I completed my degree and PhD at the University of Manchester Institute of Science and Technology, which sadly is no more. UMIST has a long history and goes back to the beginning of the 19th century, and is where John Dalton completed his work on atomic theory. I spent some time as a post-doc at the University of Washington in Seattle (Chemical Engineering) and at the University of Nottingham (Pharmacy department). My first lectureship was in the department of materials engineering at Nottingham, where I had to teach chemistry to engineers – which is about as popular as explaining maths to chemists! The course was on the mechanical behaviour of polymers, quite entertaining and different from what I’ve taught subsequently. I went back to UMIST in 1988 where I was promoted to senior lecturer, and in 2002 I came here to Sheffield – somewhere I love living and working. I’m very proud to have become Head of Department here, and I’m very committed to doing my job well.

In particular, what moments in your career are you most proud of?

To be honest, I’m not sure. I’ve said to a few people, the things I’m most satisfied with are actually the people I’ve supervised as PhD students and post-docs. It’s quite a close relationship, and seeing them develop, mature, and go on to have bright careers of their own are some of the most satisfying things I’ve done. Academically speaking, there have been a few things! Some work we’re doing at the moment has taken us in a new direction, which involves gold nanostructures that can couple to proteins involved in photosynthesis. From this, we can attempt to manipulate specific molecules to control this process.

Another project I’m quite proud of was developing a parallel near-field lithography device. Near-fields are found close to very small apertures and they don’t undergo diffraction because they are evanescent waves, which is very useful at the nanoscale! We found out how to make tiny structures using these probes about 15 years ago, but we’ve developed a device to do this over a very large area using parallel scanning near-optical microscopy (SNOM) probes – which we called a SNOMipede! One of the reasons this was so satisfying is because when we put out an advert for post-docs for this project, I got an email from a guy who worked on the original millipede project at IBM, who had decided back then that what they were trying to do was basically impossible! However, we ended up developing two different functional devices. One of the best things about that project was the amount of people from different universities who came together to work on various aspects of it.

**Do you have any specific plans for the Department and how you’re going to lead it?**

That’s a good question. I think one of the things I feel is really great about this department is that everybody is really committed to excellent teaching. Even when we had 200 students in our first year cohort, a number which is very hard work to teach, no one was prepared to compromise. I often think to myself, if my sons were interested in chemistry, I’d be really happy if they came to this department because I think my colleagues really care a lot about the students they teach – unfortunately my sons aren’t that interested in chemistry!

In terms of how I approach leadership, I’ve led a national network on understanding the physics of life, and I’ve found that it’s vitally important to do things as a team. In the department, everybody has a shared understanding of where they want to get to and what the important objectives are and we need to pull together to achieve them. Aside from that, we’ve been through a process where we have to do a regular research assessment and evaluate a wide range of outputs from the department, including research papers. I’ve led that process because I’ve been director of research for the last few years. From that it’s been very obvious that a lot of great work is done in the department and the chemistry is really strong – but we still want to make it better, something I am absolutely certain we can do because I have so many talented colleagues.

It certainly sounds like you do a lot of work, what kind of activities do you enjoy doing outside of your job?

I like quite a range of music, I like to play and own several guitars with which I can play a variety of styles. In fact, I find music is a fantastic way to relax, because when you’re playing an instrument you’re only focused on the music you’re trying to play, so by necessity everything that’s happened during the day is excluded from your mind. I also quite like cooking, particularly Mexican food. I have quite a collection of dried chilies at home - and the cooking is something my wife particularly enjoys! Unfortunately, I don’t have quite as much spare time as I’d like due to the nature of my job, but music is definitely my main form of relaxation.

Any favourite artists?

Now that is a hard question. I’m a big fan of Richard Thompson, I love playing his music and attempting to sing his songs – despite them not being very cheerful. I love jazz as a genre; my favourite jazz musicians are Keith Garrett, Miles Davis and Thelonious Monk, but Allan Holdsworth is probably my favourite jazz guitarist. The band I’ve been to see most is Hawkwind, but I lost track of how many times I’d been to see them after about the 30th gig!

Finally, thank you for the taking the time to let me interview you, and congratulations on your appointment as head of department. Good luck!

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**Research Focus: Leggett Group**

With Graham’s recent appointment, it seems fitting to start our new research focus factfile section with his group! This small section will feature every issue as an accompaniment to other articles, and aims to explain, in a few paragraphs, what each research group in our department focuses on!

**The Leggett group’s main focuses can be summed up in one word: nanotechnology. Their work studies the structures, properties and reactivity of molecular surfaces on the nanoscale. Their website details two main elements to their research:**

- **nanofabrication**, the construction of molecular objects smaller than 100 nm and nanotribology, which is the study of sliding contacts between nanoscale objects. They have found that near-field methods, discussed in Graham’s interview, are fantastic for controlling fabrication, down to tens of nanometres! Their work in nanotribology has discovered a direct link between solution-phase thermodynamics and hydrogen bonding nanoscale molecular contacts.

To learn more about Graham and his group, visit [leggett.group.shef.ac.uk](http://leggett.group.shef.ac.uk)
MChem Wins Best in Europe

A member of our most recent MChem graduates, Josh Lawlor, has won the best in Europe prize for his project thesis at the Undergraduate Awards in the Chemical and Pharmaceutical category.

Josh worked with Dr Rob Dawson and his PhD student Alex James to synthesise an emerging class of material known as hypercrosslinked polymers (HCPs). HCPs are being developed as safer, more cost effective alternatives for carbon capture and sequestration (CCP). CCP is a huge topic in modern science, as it aims to mitigate the effects of global warming.

Utilising Friedel-Crafts alkylation, Josh demonstrated that the HCPs he made, which incorporated monoethanol amine (MEA) to extract CO₂, were much more capable of adsorbing CO₂ compared to the amine-absent standard. He went on to vary the molar quantity of MEA present to identify which quantity produces the optimum capacity polymer.

Steve Armes Hits New Milestone

For those of you who have been in the department for a while, Prof. Steve Armes publishing a new research paper probably isn’t much of a surprise. However, Steve’s most recent article in the Journal of the American Chemical Society (a very highly regarded journal) is now his 600th scientific paper.

The article details the synthesis of highly transparent nanoparticles in non-polar media, including detailed spectroscopic and kinetic studies of the process. Though 600 is an achievement in itself, it comes a mere 3 years after he published his 500th paper. Well done, Steve!

FHEA Status for Jenna

Jenna Spencer-Briggs, a Graduate Teaching Assistant and PhD candidate working with Prof. Simon Jones, has been awarded Fellow of the Higher Education Academy (FHEA) status as part of the university’s Learning and Teaching Professional Recognition Scheme.

Though her status as a Fellow cements her ability as a higher education teacher, she also frequently engages in outreach sessions as well! Jenna joins several other GTAs who have earned this status through their dedication and commitment to teaching, see issue 8 for more details!

1. bit.ly/2NR25eu
Two PhD students have won poster prizes for their research at separate conferences over the summer. Ben Ambrose, from the Craggs research group, took first place at the Imagine: Imaging Life symposium held here in Sheffield for his poster. He also won a Nikon Camera as a result, so congratulations Ben! The poster focused on work in which the Craggs group have contributed to a worldwide study that has established and standardised a new method to measure exact distances within individual molecules down to the scale of one millionth of the width of a human hair. Dr Craggs said: “This will ultimately allow us to design drugs that are much more targeted and block the specific movement or shape change of individual molecules down to the scale of one millionth of the width of a human hair. Dr Craggs said: “This will ultimately allow us to design drugs that are much more targeted and block the specific movement or shape change of individual molecules down to the scale of one millionth of the width of a human hair.”

Kirsty Smitten, who works in the Thomas research group, won a poster prize at a conference on chromogenic and emissive materials in Portugal - a conference for which she won an RSC sponsored bursary to attend. She has also since been nominated for the Nova Prize, an award which recognises female students who have made outstanding early contributions to science, technology, engineering and mathematics during their careers.

The work for which she has been nominated involves the synthesis of new antimicrobial complexes, which she found have a higher activity than clinically available antibiotics, and are also active against the two types of bacteria designated as critical priority by the WHO.

To read more, follow the links below:
1. bit.ly/2q1sSvg
2. bit.ly/2R2a1Nn

Crisps are a British favourite. They have been scientifically proven by Dr Tony Goldstone, a neuroscientist at Imperial College London, to aid relaxation - something I have verified myself. There’s never been a better time to be a crisp fan, as we’ve just reached the 70th anniversary of Walker’s Crisps - but just what chemical and physical factors affect the crunch and flavour of these golden wonders?

When potatoes are fried in oil, a multitude of interesting and exciting reactions occur. Firstly, the water content of the potato hydrolyses the deep fat oil. The oil contains triglycerols, with ester linkages that are susceptible to nucleophilic attack by water. This hydrolysis produces fatty acids and alcohols. One such fatty acid is linoleic acid, which contains certain weak C-H bonds that are easily broken to produce highly reactive radicals, which go on to initiate a polymerisation reaction (figure 1) in which many single molecules join together to form long chains. The result is a set of volatile compounds. There is a deep link between flavour and smell; therefore, it is not unexpected that the volatile compounds contribute greatly to the flavour of the food. One in particular is 2,4-decadienal, a compound found in meat, potatoes, butter, and crisps, among other delicious savoury delights! This explains the presence of the vegetable oil ingredient on crisp packets; in reality, the compounds in crisps are a collection of derivatives that originated from the vegetable oil used to fry them.

The unsaturated nature of dienals (see figure 2) is what gives rise to their volatility. As compounds containing double bonds do not pack together efficiently, the intermolecular forces of attraction are relatively weak leading to a low boiling point. This low boiling point makes the compounds volatile and contributes greatly to the flavour of the food.

Let’s consider the change in physical properties going from the potato to the crisp. Deep-frying potatoes is a violent process that forces the residual water out of potato cells (this also explains the bubbles surrounding the food when it’s dunked in the deep fryer). The potato cells are now hollow, and biting into a crisp quickly releases this air, resulting in the satisfying ‘crunch’ sound. The hard outer surface of the crisp, in contrast to the soft outer surface of the potato, is formed by cross-linking of starch polymers. Potatoes contain a lot of starch (a type of carbohydrate), which is really just a glucose polymer. These polymers can be cross-linked through the radical reactions of deep-frying. As the surface of the potato is now more cohesive and able to withstand greater weight, the surface becomes harder – illustrated in a video by Akzo Nobel (reference 5).

Hopefully, you now have an appreciation of the fascinating chemistry that goes into making each and every crisp in your lunchtime packets!

To read more, follow the links below:
1. bit.ly/2J7xJdp
2. bit.ly/2CurVDl
3. bit.ly/2R03hOJ
4. bbc.in/1E3OwRe
5. youtube.com/watch?v=dXT1r3WA65M
Contributors

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Event and Seminar Listings

Every Friday Until Semester 2
Departmental Seminar
Daintion Building Lecture Theatre 1
12pm - 1pm

21st November 5pm
Fireworks Lecture with Andrew Szydlo

4th December
ChemSoc Christmas Social

More details can be found at:
sheffield.ac.uk/chemistry/events

For more details on their events, or
to get involved with the committee,
contact ChemSoc at
chemsoc@sheffield.ac.uk

NEEDS YOU!

Interested in writing for us?
Thinking of a career in Science Communication?
Have you enjoyed reading this issue of Resonance?
We would love for you to get involved in our next issue! We welcome anyone interested in writing or researchring articles, designing or contributing to our social media presence, regardless of experience or year of study. As a bonus, contributing to Resonance is HEAR accredited.

If you are interested email the team at:
chem-news@sheffield.ac.uk

Don't forget to follow us on Social Media to keep updated.

Resonance NEEDS YOU!

Resonance Contributors

We would like to thank the following students who have contributed to Resonance over the past issue and will graduate with HEAR accreditation:

Jasmine Catlow
Nara Vasa
Abbie Sinclair
Mahir Mohammed

Resonance could not exist without their dedication and hardwork.

Crossword

This crossword is designed to challenge even the most seasoned chemists, if you think you’ve completed it, take a picture and send it to chem-news@sheffield.ac.uk and we’ll announce you as the second chemistry crossword winner in the next issue. Well done to Heather Carson and all those who contributed to completing the issue 8 crossword with her at teabreak!

Chemistry Crossword

ACROSS

1. Aromatic compound once used as a disinfectant (6)
3. Common abbreviation for dimethyl formamide (3)
4. Unit of electric conductance (7)
5. A compound belonging to a series of compounds differing from each other by a repeating unit (9)
7. A species with both positive and negative charge (10)
8. Base which pairs with Adenine (7)
9. Abbreviation for electron transfer from a metal to a compound coordinated to it (4)
10. Common name for the dioxgen anion (10)
11. Name of the ‘acac’ ligand (15)
12. Principle which states no two electrons can have the same four quantum numbers (5)
13. Abbreviation for a technique by which particle size is determined using X-ray light (4)
14. Element named after the father of the periodic table (11)
15. Reaction where a ligand is substituted for water (8)
16. A planar five-membered ring containing one arsenic atom (6)
17. Danish physicist famous for his model of the atom (4)
18. Name of the R-N=N-R functional group (3)
19. Reaction where a compound decomposes due to temperature (9)
21. Metal that form stainless steel as an alloy with iron and carbon (8)

DOWN

2. A molecular ring which contains non-carbon atoms (11)
3. Reaction in which a substance is simultaneously oxidised and reduced (18)
5. Element which condenses below -268.9 degree celsius (6)
6. Name of the CH2 functional group (9)
10. Principle which states no two electrons can have the same four quantum numbers (5)
11. Name for a complex with unpaired d-electrons (12)
12. A planar five-membered ring containing one arsenic atom (6)
13. Danish physicist famous for his model of the atom (4)
14. Element named after the father of the periodic table (11)
