Proceedings

Teaching Chemists to Communicate? Not my job!

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Nyholm was an exceptional chemist, who was recognised internationally not only for his research, but also as an avid supporter of quality and innovation in teaching. I believe he would have been an enthusiastic advocate of the importance of developing the communication skills of our up-and-coming chemists. After all, research is of little value if it is not transmitted effectively to others, and teaching is the profession of communicating knowledge, method and reasoned argument to students. Nyholm might not have expected employability to be another factor in the case for teaching communication skills at university, but it undoubtedly is – our students expect it, employers expect it, and with more than half of chemists entering other professions after graduation we have a responsibility to provide a broad and rounded education for our university students. But are these arguments really convincing, or should we instead concentrate on ensuring that the chemistry we teach is of the highest standard, without diluting the syllabus with generic skills? And even if these skills should be part of our undergraduate degree programmes, should we, as professional chemists (but generally untrained as teachers), undertake the teaching of communication skills, or should we leave this task to those with the appropriate qualifications?

In this paper, I:

- Re-state the case for embedding the teaching of communication skills within a chemistry degree programme;
- Present the case for communication skills being taught centrally by universities, as a generic skill;
- Give the counter argument for these skills being taught by chemists within the chemistry degree programmes;
- Provide my own view of the key features of communication skills that all chemistry degree courses should embrace, with some examples and sources of material.

The terms 'generic skills' and 'transferable skills' will be used synonymously, to refer to skills that are generally supposed to be not subject specific, and which can be applied to many disciplines and situations. 'Communication skills' are also largely generic and concern all aspects of transmitting and receiving information and ideas; but in spite of this there is a strong case for teaching them within a subject context.

Why teach communication skills within degrees?

During the past five years three bodies have emphasised the importance of communication skills within degree courses: the Dearing Committee, the Quality Assurance Agency and employers, with their views being supported by major reports or research data.

The Dearing Report.[1]

The Dearing committee was composed of individuals from a diverse range of backgrounds: academic, industrial, educational and public sector. They appeared to be strongly united in their support for the final report, which made 93 main recommendations. Of these, three have had a major impact on the universities. The first concerns student fees, which were intended to provide money to help redress the serious under-funding of the infrastructure of universities. The second concerns the provision of wider access to HE. The third concerns the content of HE degrees, and what they should aim to provide. The Dearing Report "emphasised the need for students and employers to be well-informed about what higher education offers. They need clear statements about the intended outcomes of higher education programmes…"

Moreover, the report (paragraph 38) stated[2] that "There is much evidence of support for the further development of a range of skills during higher education, including what we term the key skills of communication, both oral and written, numeracy, the use of communications and information technology and learning how to learn. We see these as necessary outcomes of all higher education programmes."

Underpinning this is recommendation 21, which requires all degrees to have a "programme specification", which "gives the intended outcomes of the programme in terms of"

Knowledge/understanding of subject (syllabus)
Special subject skills (e.g. lab work)
Cognitive skills (methodology, critical analysis)
Key skills:

- Communication
- Numeracy
- Use of IT
- Learning how to learn

The chemistry degrees in most departments meet the first three criteria, although the balance and quality of this education might vary widely. The debate continues to rage about the size of the syllabus, the importance and nature of lab work, and the extent to which students carry out what can justly be called critical analysis. But it is the area of key skills that is probably covered least adequately by chemistry departments in the UK.

Quality Assurance Agency

Although the Teaching Quality Assessments had been going on for some years, the Dearing Report certainly influenced the way that the QAA modified its assessment procedures subsequently. In particular, Chemistry, History and Law underwent trial TQAs in 1998, in which the programme specification was a major feature. In order to provide some sort of national framework for the core requirements of degrees in particular subjects, the benchmark documents were produced by appropriate bodies; for Chemistry, this was the RSC.[3] Their programme specification for chemistry mirrored Dearing's, with four main headings as summarised below:

Programme specification – Chemistry benchmark:

Subject knowledge (syllabus)
Chemistry-related cognitive abilities and skills
Chemistry-related practical skills
Transferable skills

'Transferable skills' correlates to Dearing's key skills, and had the following sub-headings:

- Communication (written and oral)
- Problem-solving (and critical thinking)
- Numeracy and computing
- Information retrieval
- IT skills
- Interpersonal skills
- Organisational skills (including time management)
- Skills for continuing professional development

The programme specification was sensible and wide-ranging, but the Chemistry benchmarking panel (uniquely amongst the subjects in the TQA trial) specified levels of proficiency that were expected for various standards of degree, and the transferable skills were embedded within these criteria. So transferable skills are a requirement for professionally accredited degrees in chemistry, and proving that they are indeed delivered by us will be one aspect of all future TQA exercises.

Employers.

In 1999, Duckett, Garratt and Lowe published the results of an extensive survey of recent chemistry graduates.[4] The types of employment were wide-ranging, and about a quarter were in non-chemistry jobs. Summarising the results of the survey, the following seven areas are those that were identified as very important, and for which graduates felt that their university training had been inadequate (roughly in this order):

- Time management
- Updating one's skills/knowledge *by oneself*
- Contributing to discussions
- Presenting information using computer software
- Self-appraisal
- Understanding/evaluating the views of others
- Talking/writing persuasively to non-specialists

Notable from various analyses of employee shortcomings is that the chemistry *syllabus* does not feature, and yet this is probably the issue that is debated most heatedly in departments (e.g. "How could we consider graduating someone who doesn't know…?"). All the concerns that do feature might be considered as aspects of transferable skills, and most could be regarded as communication skills. In the same paper, Duckett et al. reported the following top seven areas of deficiency of recent graduates, as perceived by chemical company employers:

- Awareness of intellectual property
- Communication/presentation skills
- Ability to relate to all levels
- Innovative thinking
- Leadership qualities
- Commercial awareness
- Practical skills

This view of recent graduates was reinforced in the Mason Report (1998);[5] of major issues identified by employers, "…concern was expressed about weakness in interpersonal and communication skills, accuracy in documentation and practical laboratory skills."

In conclusion, there is an overwhelming case for our courses to support the development of communication skills by our students, both because of external assessment of us, and because our students need these skills. But should this be our job?

Why WE shouldn't teach communication skills

Of course communication skills feature as part of chemistry degree courses now. All departments require students to carry out literature searches, give oral presentations, prepare reports and (often) posters, as part of their chemistry degree programmes. But these integrated parts are (almost always) too insubstantial on their own, although they allow reinforcement of skills the students already possess. The problems are that

- Students don't learn how to give talks by doing it once or twice.
- They don't have much incentive to do it well if it counts nothing towards their degree.
- Despite the apparent emphasis by TQA and chemistry departments, not many departments allocate more than 100 hours of dedicated work to these skills and this amounts to only about 2% of student time in a degree course.

So, assuming that a couple of talks, two team exercises and a literature search don't constitute enough, where should the extra tuition come from? There is a strong case for teaching communication skills centrally, and arguments that have been put forward in support of this include the following:

- Special expertise is needed to teach communication skills at an appropriate level. If most of us are untrained as teachers, at least we have specialist knowledge that we can impart to others within our discipline. For a topic such as communication skills, we are ill prepared as tutors.
- The skills are generic, and thus there are advantages in teaching the skills using general examples and exercises, rather than within a subject specific context.
- Centralised teaching of these skills can be a more efficient use of both resources and time, than if it is done in departments. Resources include reference materials (books, CD-ROMs, Web information), computing facilities (hardware and software), videoing capabilities, team exercise material, and dedicated rooms. Concerning time, both central timetabling and the use of experts to teach large(ish) groups might help to make efficient use of time by both students and tutors.
- If there is a special university course, it is easier to identify the content of the programme, and to monitor the topic; this issue should not be underestimated, particularly if one is to prove to external assessors that one is teaching 'communication skills' adequately.
- There is already insufficient time to teach the students all the chemistry they need to know! At least an intensive central course would provide the teaching they need with minimum disruption of delivering the all-important syllabus.

Although one may have reservations about most of these statements, there is a valid argument for the centralised teaching of generic communication skills at university. Yet it is often observed that students disengage from activities that seem irrelevant to them, and they perceive centralised teaching to be so for two reasons:

Students believe that the skills needed to communicate effectively in chemistry are subject specific. Our students come to university to study chemistry, and that is what we should teach them – they simply don't believe that being taught generic transferable skills is relevant to them, and to the subject they have chosen.

It is very hard to build in a marks scheme that gives appropriate weighting to communication skills. If many marks are assigned to these, then departments argue that the subject-specific degree is undervalued; but if the weighting is low, students perceive the course teaching such skills as low priority, and are likely to be content with a modest performance (e.g. getting a minimum pass mark if it is a course requirement).

So, despite the strong case for the centralised tuition of communication skills, I think it extremely difficult to make these relevant enough for students, if they are taught generically.

Teaching communication skills within a chemistry context

As an example of an exercise requiring communications skills in chemistry, imagine being asked to write a short news article about some new discovery or development in chemistry. As usual, something like this actually requires several skills:
Comprehension

Writing a clear, concise report
Computer keyboard skills
Creating visual impact

A cursory analysis of how such articles are constructed in *New Scientist* shows that its half-page news items usually have roughly the following structure:
A catchy title (6 word maximum)
A catchy graphic
One sentence summary (20 words)
One paragraph summary (80 words)
Four paragraph summary (320 words)

There is also a strong human angle, in two ways:
Articles must be relevant to the reader – typical items cover medicine, new devices (e.g. gadgets that we might use), helping others (dealing with problems like earthquakes, health issues), our origins (particle physics, the Big Bang, evolution).
The articles always talk about the scientists, as well as the science, often including a few quotes from the researchers and other leading experts.

Most trained chemists ought to be able to construct such articles from papers in any issue of *Chemical Communications*. As examples, key parts of two articles from *Chemical Communications*, 2000, issues 16 and 17 are in Appendix 1; the first section of each paper (title, authors, abstract), their graphical abstracts, their introductory paragraphs and their final conclusions or summaries. You might like to choose one of the articles, and try to produce a catchy title, and the first sentence (20 word summary … don't forget the human angle).[6]

I hope that you have taken up my challenge (and done better then me).[6] If you did, it may have been because, like chemistry undergraduates, you could imagine being in a position where you might wish to do this, and you have the technical skill to understand (and, hopefully, to explain) the science. Had you been asked to prepare something similar in a non-scientific (or even just non-chemical) area, it might have seemed irrelevant and inappropriate, even if the material had been quite easy to understand. However, and this is a key point, the skills required for this exercise are primarily generic ones.

This type of exercise quickly engages the interest of students. They can gain the satisfaction of using the specialist knowledge they have acquired in chemistry, yet they need to use much more wide-ranging generic skills to produce a good article. Two examples produced by students at Heriot-Watt are in Appendix 2.

What communications skills should we teach?

Although there is a case for teaching key skills centrally, it is my firmly held view that these should be part of the teaching and learning of chemistry degrees within our departments; the reason for this is simply relevance. There are three other important aspects of communication skills:

Firstly, learning key skills isn't about having a couple of away-days solving business games in teams, and a final-year literature review and oral presentation. If 5% of a degree course is intended to cover this topic, this requires about 200-300 hours of work from the students. So it requires lots of time, and that has to be rigorously built into the degree programme.

Secondly, the skills are almost unteachable but they are learnable. This means giving students the chance to try things several times, with effective feedback and review mechanisms to help them identify how to improve.

Thirdly, there must be pressure on the students to do the tasks well. Peer pressure is very effective, but it is essential that their work must actually count towards their degree.

Like most departments, we at Heriot-Watt embed aspects of communication skills in our course, but (unlike most places) there is also a big component in a specific module that is a chemistry degree requirement. All chemistry students must take (and pass) a module called 'Communicating Chemistry' in their penultimate honours year. This is at the heart of the key skills parts of our chemistry degrees, and requires about 100 hours of work from each student (most of it as private study). Although the content of the module varies from year to year, the list below shows a typical module content of 10 typical exercises, with the approximate amount of time required of the students indicated:

Week 1 Fluorofen problem (industrial, team exercise; 1h)
Scientific paper (comprehension; 3h)
Week 2 Keyboard skills (using software to prepare material; 10h)
New Chemist assignment (as described above; 18h)
Week 3 Information retrieval (*Chemical Abstracts* and *Web of Science*; 8h)
Week 4 Dictionary of Interesting Chemistry (20h)
Week 5 Chubli Fruit project (multi-part team exercise; 8h)

Week 6 Annual review (individual oral presentations; 12h)
Week 7 Interviews (they attend and conduct interviews; 8h)
Week 8 Team project (research plan, presented as a poster; 12h)

More information on the module can be found in references 9 and 10.

Here are some of the features that help such a module to run successfully.
Each exercise starts 'cold', so the students are caught up in the scenario from the start of the exercise.
There are time pressures to submit work within tight deadlines.
The students must pass all exercises to pass the module, and the module itself is a prerequisite for our chemistry degrees.
They work singly, in pairs or in teams (depending on the exercise).
There is strong peer pressure created by teamwork and peer judgement.
Prizes are awarded, and this adds a bit of fun and incentive at certain points in the module.

Three of these points are worthy of elaboration:

Setting the scene and requiring tight deadlines is important. If students are asked to prepare for an exercise by carrying out some background reading, not all of them will do it. However, there is an excitement and involvement from being suddenly required to tackle an urgent problem, which is simply lost if material is distributed beforehand. A sense of immediacy and realism can be achieved by setting a plausible scenario (e.g. an urgent problem that a manufacturing company must solve; an article that must reach an editor by a deadline; a presentation that has been requested at short notice). The scenario can be set using a role-play, a short explanation, or simply by handing out an 'urgent memo'.

Peer pressure is a huge incentive, and requiring their work and presentations to be seen (and hence judged) by their peers is one of the strongest incentives for students to produce high quality work. However, it does not follow that students are good at actually awarding marks to the work of others. To state an obvious problem, a weak student will often regard a poor piece of work as quite good, whereas very able students are usually harsh in their marking. One useful compromise is to discuss and agree a marking scheme with the class for some of the exercises. Nevertheless, students are good at perceiving high quality work, and there is always strong agreement between students about the best pieces of work from an exercise, which usually matches the tutor's views. The peer selection process can usefully be used in the allocation of modest prizes. Using peer judgement has the added advantage that some students might not be clear what was wrong with their piece of C-rated work, but they can clearly see that someone else's was worth an A.

Feedback and assessment are essential components of any programme that aims to develop communication skills.[7] Whilst peer pressure is hugely effective in encouraging high quality work, we at Heriot-Watt also require students to pass every component of our 'Communicating Chemistry' module; they can't get away without having had a valid attempt at everything, and everything they attempt is given a letter grade. They also get extensive feedback, although just as important is providing them with copies of the best work from their colleagues, so that they can see high quality examples. Their feedback can be collated into a final feedback sheet, and it is worthwhile to require them to use this to help them produce a summary of their strengths and weaknesses. Finally, we produce an average letter grade (including judgement of the amount of work they did, and team input), which is entered into the University system as a mark:

A*	outstanding	=80%
A	excellent	75%
B	very good	65%
C	good	55%
D	OK	45%
E	minimally acceptable	40%
F	unacceptable	0%

Students seem completely happy with this marking scheme, which is explained at the outset of the module. Moreover, it helps to emphasise that this is not a linear marking system. Once students are producing really good work, smallish improvements in style and presentation are potentially worth a lot of marks; outstanding work can receive 90%, but it must be precisely that – work that stands out from the rest.

Our module at Heriot-Watt gives students the chance to tackle a wide range of exercises in communication skills, requiring them to access and deliver information in a variety of interesting chemical scenarios. They have a substantial time allocation for 'Communicating Chemistry' within their degree programme, for which they work singly, in pairs, or in groups. They judge each other's work, and receive feedback and assessment for all aspects of the module. Our emphasis is not so much on the teaching of communication skills as on enabling the students to start learning these skills, and helping them to realise some of their own strengths and weaknesses. Most importantly, although they probably do not realise it at the time, they are developing generic skills that will be of value to them in whatever career they subsequently follow.

There are many ways in which communication skills can be taught within chemistry degree programmes, but we must always try to identify how our students can best acquire the skills we would like them to have, an issue that Johnstone has addressed in this issue of *U.Chem.Ed.*, and elsewhere.[8] All of us ought to have a commitment to help our students develop communication skills, and this is best achieved within our subject. That means having a clearly defined programme of such skills, so that we really can see that our students get the chance to try, to criticise, and to develop the full range of communication skills that will underpin their careers. And what would have been Nyholm's view of this? As he famously said, "You don't learn from chemistry. You learn through chemistry."
I totally agree.

Acknowledgements
I chose my co-presenters at the Nyholm Symposium (York, 21 February 2001) with great care, as I wished us to produce some answers to the question "Do we teach our students the skills they need?" The symposium contributions from David Phillips, Tina Overton, Alex Johnstone and John Garratt are presented in the accompanying articles in this issue of *University Chemistry Education.* I would like to thank them for their inspiration as colleagues, and for their practical contributions to the Symposium. I would also like to thank colleagues and students from the Universities of York and Heriot-Watt (especially Sara Shinton and John Garratt) who have helped me develop materials and ideas for teaching, and the RSC for its support via the Cutter Bequest, HE Teaching Award, and Nyholm Lectureship.

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2) P. Coldstream, *U. Chem. Ed.*, 1997, **1**, 15 (in which Coldstream looks at the skills that employers need, and picks four key areas of communication, numeracy, teamwork, lifelong learning; this was pre-Dearing!).
3) a) *The Bulletin of the Quality Assurance Agency for Higher Education*, **1(3)**, March 1998; b) *General Guidelines for the Academic Review of Bachelors Honours Degree Courses in Chemistry*, Quality Assurance Agency for Higher Education, 1998.
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6) Although you can probably do better, I suggest: a) *Cheaper, safer fertilisers* – "Chemists from Greece have now found how to make ammonia, the main component of many fertilisers, using mild reaction conditions"; b) *Watch-sized computers* – "Impregnating special clays with tellurium compounds generates tiny semiconductors, which could be used to make mini-computers, according to Canadian chemists".
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Some teaching materials and advice:
Courses in communication skills – refs. 9, 10.
Team exercises (multiple skills) – refs. 11, 12, 13.
Oral presentations – refs. 14, 15.
Critical thinking – refs. 16, 17, 18.
Searching/using chemical literature – refs. 19, 20.
Professional development and IP skills – ref. 21.
Student quick reference guide – ref. 22.
Chemical Web sites to search – refs. 23, 24.

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24) http://www.physsci.ltsn.ac.uk/

Electrochemical synthesis of ammonia at atmospheric pressure and low temperature in a solid polymer electrolyte cell

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The heterogeneous electrocatalytic synthesis of ammonia from nitrogen and water is carried out at Ru cathodes, using a Solid Polymer Electrolyte Cell (SPE), at atmospheric pressure and low temperature; the reduction rate increases with increase of temperature up to 100 °C, while with the increase of the negative potential a maximum is observed at −1.02 V *vs.* Ag/AgCl and gradually decreases in the hydrogen discharge region.

Industrially the synthesis of ammonia takes place by passing N_2 and H_2 over Fe or Ru surfaces at about 430–480 °C and 100 atm.[1] The synthesis of ammonia over these catalysts at ambient temperatures is a very difficult process because of the high energy barrier for the breaking of the N≡N bond which is about 1000 kJ mol^{-1} at 25 °C.

Numerous efforts have been reported so far on the conversion of nitrogen to ammonia at room temperature and atmospheric pressure using, photocatalytic,[2,3] electrochemical[4–11] or catalytic methods.[12] Recently, Marnellos and Stoukides studied the electrochemical synthesis of ammonia at Pd cathodes using a solid proton conductor at 570 °C and atmospheric pressure and pointed out that the thermodynamic demand for high pressure can be compensated by the use of an electrochemical reactor.[13] However, the operation temperature of that cell is high and ammonia undergoes decomposition at this temperature.

$$N_2 \longrightarrow NH_3$$

This is the first report regarding ammonia production at atmospheric pressure and low temperature. The main problems that exist at the present are the low rate of ammonia formation and the hydrogen evolution at the cathode. Further work to optimize these factors is in progress.

Preparation, characterization and condensation of novel metal chalcogenide/MCM-41 complexes

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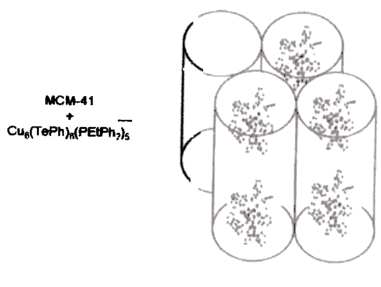
Hexagonally ordered mesoporous MCM-41 with 3 nm pores has been impregnated with the metal chalcogenolate $Cu_6(TePh)_6(PPh_2Et)_5$ 1: the analysis and condensation of this material is a step toward the synthesis of semiconducting nanowires.

The ability of mesoporous materials to act as hosts for quantum structures has been the focus of numerous research efforts as exemplified with reports on the absorption and subsequent polymerization of analine,[1] the encapsulation of semiconducting Ge filaments,[2] the preparation of ferrocenophane polymer[3] and the fabrication of nanostructured Pt clusters and wires.[4]

The independent development of the chemistry of mesoporous materials and metal chalcogenide clusters over the past decade have seen dramatic growth.[5–7] The union of these two fields, the encapsulation of metal chalcogenide clusters and their subsequent condensation into size limited semiconductor particles, should provide novel one-directional nanostructures.



Thermally activated condensation of 1 inside the pores of MCM-41 is also possible with complete loss of $TePh_2$ and PPh_2Et moieties with only copper telluride remaining as characterized by PXRD. We are currently perusing the characterization of the condensed materials and the general applicability of this method to metal chalcogenolate complexes.

Helping holes make computer screens better!

Neil Polwart and **Martin Mella**

COMPUTER screens on laptop computers may soon be able to have full colour displays if work done at Toyota's Research and Development Labs makes it to the production line.

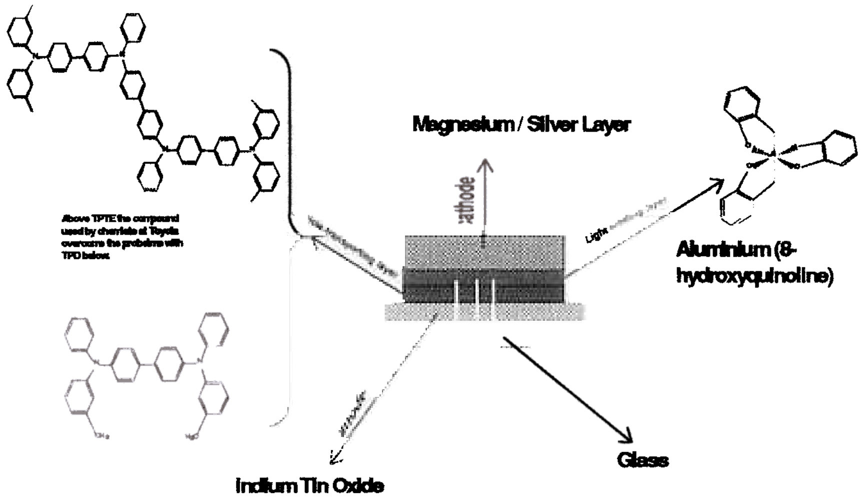
Scientists believe that electroluminescent (EL) devices made from layers of polymer are likely to hold the future for full colour flat panel display systems. Such displays would not only offer the full range of colours detectable to the human eye but would also need to use only low voltages, and be able to operate highly efficiently. Techniques are available to produce such devices, however they degrade very quickly. This instability, which results in a reduction in luminescence and an increase in drive voltage, is believed to be the result of changes in the arrangement of molecules in a thin film which carries electronic holes - vital to the properties of these devices.

Typically such devices use *N,N'-Diphenyl-N,N'-(m-tolyl)benzidene* (TPD) as the hole carrier. As the device is used it heats up and reaches temperatures close to a critical point known as its glass transition temperature, here molecules move around in the thin film and this is believed to cause changes in their electrical properties.

Recently another group of scientists fabricated devices with long life times - using a starburst shaped molecule (called TCTA), unfortunately the devices require almost three times as much energy to emit light that standard TPD devices.

TPD is made up from two smaller units called TPA, the team at Toyota's lab have managed to produce a series of compounds made from two to five of these units with increasing glass transition temperatures. EL devices have been fabricated with optical and electrical properties similar to those made from TPD. The difference being that with these devices they could operate at 100 °C for 100 hours without serious damage, whilst the TPD device broke down after a few seconds at those temperatures. Toyota's team says in *Chemical Communication (21/09/96, 18. p2175)* this is directly linked to the glass transition temperatures.

Obviously some work still needs to be done before we see full colour EL devices in mass production , but perhaps in a few years time you will be reading an on-line version of New Scientist on a full colour laptop computer.

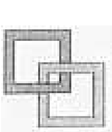


Organic Chemists Redundant ?

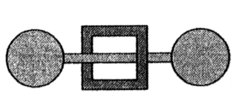
Dawn Robinson and Trish Drennan

MOLECULES that build themselves could lead to a new generation of molecular electronic devices and antibiotics. Such complicated systems could be constructed from molecules which could uniquely identify each other and self-assemble in a "jigsaw" like fashion.

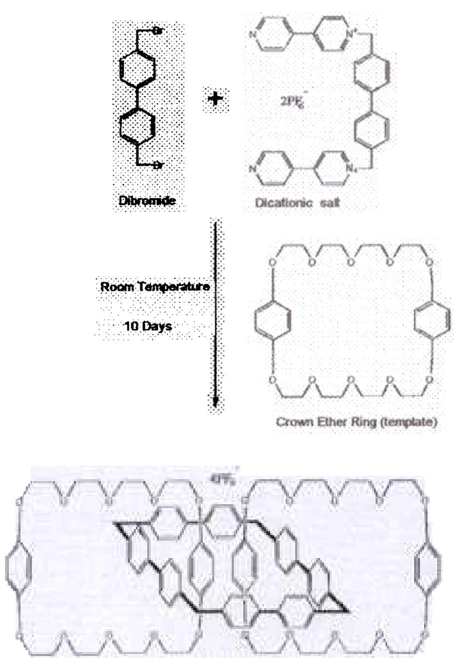
Currently two classes of molecular building blocks are being used to construct primitive molecular switching devices and large molecular assemblies. These are namely the catenanes and rotaxanes, the former being two or more interlocking rings giving rise to a "chain" like structure and the latter being one or more rings threaded onto a dumbbell shaped molecule where multiple threading gives rise to an "abacus" type molecule.



Catenane



Rotaxane



Synthesis of the "chain" type compounds is trivial with the [3] catenane, self-assembled in 25% yield by reacting a simple dibromide with a dicationic salt, in the presence of a templating agent, such as a crown ether ring. The reaction occurs at room temperature over a period of ten days (*Journal of the Chemical Society, Chemical Communications* 1996, No. 4, p 487).

Rotaxanes can be synthesised in a similar manner where a ring is unravelled to give a linear molecule with large bulky groups at either end acting as stoppers, to retain the threaded ring(s).

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Structural recognition, self-organisation and self-replication are known to be key elements in nature. These features are inherent in this chemistry, and subsequently could be used, with a bit of imagination, to mimic biological processes.

So perhaps the organic chemist is not quite redundant yet ?!

Electrochemical synthesis of ammonia at atmospheric pressure and low temperature in a solid polymer electrolyte cell

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$$N_2 \longrightarrow NH_3$$

This is the first report regarding ammonia production at atmospheric pressure and low temperature. The main problems that exist at the present are the low rate of ammonia formation and the hydrogen evolution at the cathode. Further work to optimize these factors is in progress.

The heterogeneous electrocatalytic synthesis of ammonia from nitrogen and water is carried out at Ru cathodes, using a Solid Polymer Electrolyte Cell (SPE), at atmospheric pressure and low temperature; the reduction rate increases with increase of temperature up to 100 °C, while with the increase of the negative potential a maximum is observed at −1.02 V *vs.* Ag/AgCl and gradually decreases in the hydrogen discharge region.

Industrially the synthesis of ammonia takes place by passing N_2 and H_2 over Fe or Ru surfaces at about 430–480 °C and 100 atm.[1] The synthesis of ammonia over these catalysts at ambient temperatures is a very difficult process because of the high energy barrier for the breaking of the N≡N bond which is about 1000 kJ mol^{-1} at 25 °C.

Numerous efforts have been reported so far on the conversion of nitrogen to ammonia at room temperature and atmospheric pressure using, photocatalytic,[2,3] electrochemical[4–11] or catalytic methods.[12] Recently, Marnellos and Stoukides studied the electrochemical synthesis of ammonia at Pd cathodes using a solid proton conductor at 570 °C and atmospheric pressure and pointed out that the thermodynamic demand for high pressure can be compensated by the use of an electrochemical reactor.[13] However, the operation temperature of that cell is high and ammonia undergoes decomposition at this temperature.

Preparation, characterization and condensation of novel metal chalcogenide/MCM-41 complexes

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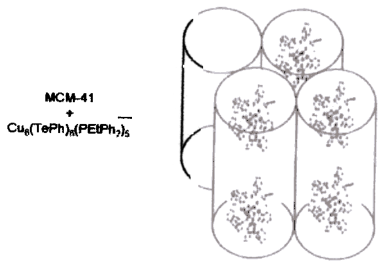


Thermally activated condensation of **1** inside the pores of MCM-41 is also possible with complete loss of $TePh_2$ and PPh_2Et moieties with only copper telluride remaining as characterized by PXRD. We are currently perusing the characterization of the condensed materials and the general applicability of this method to metal chalcogenolate complexes.

Hexagonally ordered mesoporous MCM-41 with 3 nm pores has been impregnated with the metal chalcogenolate $Cu_6(TePh)_6(PPh_2Et)_5$ 1: the analysis and condensation of this material is a step toward the synthesis of semiconducting nanowires.

The ability of mesoporous materials to act as hosts for quantum structures has been the focus of numerous research efforts as exemplified with reports on the absorption and subsequent polymerization of analine,[1] the encapsulation of semiconducting Ge filaments,[2] the preparation of ferrocenophane polymer[3] and the fabrication of nanostructured Pt clusters and wires.[4]

The independent development of the chemistry of mesoporous materials and metal chalcogenide clusters over the past decade have seen dramatic growth.[5–7] The union of these two fields, the encapsulation of metal chalcogenide clusters and their subsequent condensation into size limited semiconductor particles, should provide novel one-directional nanostructures.

Helping holes make computer screens better!

Neil Polwart and **Martin Mella**

COMPUTER screens on laptop computers may soon be able to have full colour displays if work done at Toyota's Research and Development Labs makes it to the production line.

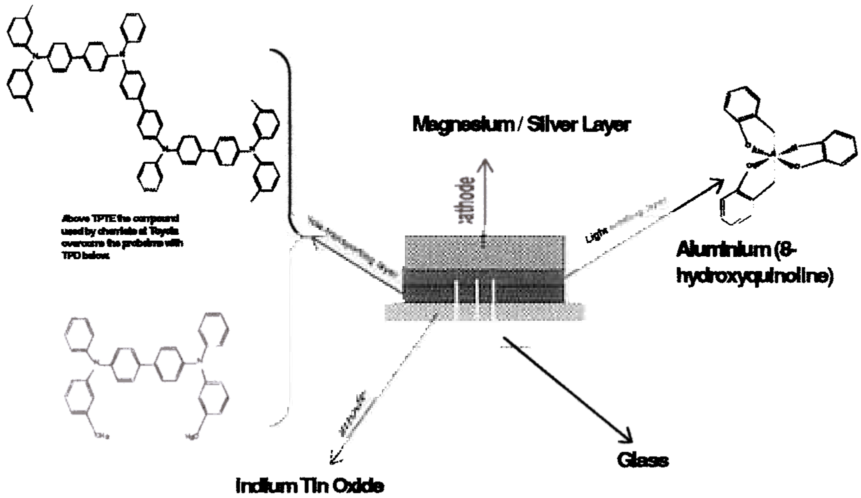
Scientists believe that electroluminescent (EL) devices made from layers of polymer are likely to hold the future for full colour flat panel display systems. Such displays would not only offer the full range of colours detectable to the human eye but would also need to use only low voltages, and be able to operate highly efficiently. Techniques are available to produce such devices, however they degrade very quickly. This instability, which results in a reduction in luminescence and an increase in drive voltage, is believed to be the result of changes in the arrangement of molecules in a thin film which carries electronic holes - vital to the properties of these devices.

Typically such devices use *N,N'-Diphenyl-N,N'-(m-tolyl)benzidene* (TPD) as the hole carrier. As the device is used it heats up and reaches temperatures close to a critical point known as its glass transition temperature, here molecules move around in the thin film and this is believed to cause changes in their electrical properties.

Recently another group of scientists fabricated devices with long life times - using a starburst shaped molecule (called TCTA), unfortunately the devices require almost three times as much energy to emit light that standard TPD devices.

TPD is made up from two smaller units called TPA, the team at Toyota's lab have managed to produce a series of compounds made from two to five of these units with increasing glass transition temperatures. EL devices have been fabricated with optical and electrical properties similar to those made from TPD. The difference being that with these devices they could operate at 100 °C for 100 hours without serious damage, whilst the TPD device broke down after a few seconds at those temperatures. Toyota's team says in *Chemical Communication (21/09/96, 18. p2175)* this is directly linked to the glass transition temperatures.

Obviously some work still needs to be done before we see full colour EL devices in mass production , but perhaps in a few years time you will be reading an on-line version of New Scientist on a full colour laptop computer.

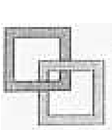


Organic Chemists Redundant ?

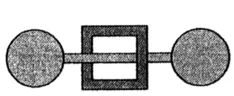
Dawn Robinson and Trish Drennan

MOLECULES that build themselves could lead to a new generation of molecular electronic devices and antibiotics. Such complicated systems could be constructed from molecules which could uniquely identify each other and self-assemble in a "jigsaw" like fashion.

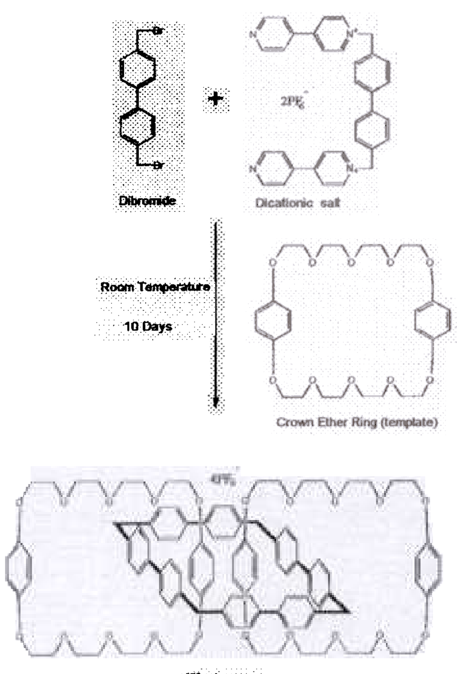
Currently two classes of molecular building blocks are being used to construct primitive molecular switching devices and large molecular assemblies. These are namely the catenanes and rotaxanes, the former being two or more interlocking rings giving rise to a "chain" like structure and the latter being one or more rings threaded onto a dumbbell shaped molecule where multiple threading gives rise to an "abacus" type molecule.



Catenane



Rotaxane



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