A vital blow for chemistry

Chemistry may have become an increasingly high tech discipline, but it still relies on glassware – and the age-old skill of glassblowing – says Simon Hadlington.
If there is one material above all others that defines a chemistry laboratory, surely it is glass. Many aspiring young scientists have been drawn to chemistry by its astonishing range of glassware, in all its fabulous shapes – cones, spheres, coils, flasks squat and wide, flasks tall and thin. All impossibly fragile, yet robust enough to be heated directly on a flame and to carry boiling liquids. And, crucially, transparent, so that the chemist can observe what is happening as the reaction proceeds.

For centuries glass has been central to science. In their book The glass bathyscaphe: How glass changed the world, Alan McFarlane and Gerry Martin describe how they randomly selected twenty famous scientists. He worked as a scientific glassblowers servicing academic departments in universities by its technical back-up, and glassblowers abound.

Glasgow in the UK, notes. ‘For them would have been impossible without the use of glass tools. These included Lavoisier’s 1777 experiment to heat mercury in air, which would yield key evidence to support his oxygen theory, and Humphry Davy’s discovery of potassium in 1807.

For glass to have these multiple functions it needs to be shaped and worked into the myriad forms that the chemist needs. And it is here that an arcane but vital skill is needed: glassblowing.

In the early years of what we would recognise as modern science, glassware was often prepared by the scientist himself (in those days it invariably was a ‘he’). This state of affairs persisted until relatively recently, as William McCormack, honorary secretary of the British Society of Scientific Glassblowers (BSSG) and chief scientific glassblower at the University of York, UK, notes. ‘For hundreds of years there has been a need for some kind of glass apparatus and instrumentation. But glassblowing as a profession really took off after the second world war. Before then, glassblowing was often done by the scientist, but following [then-prime minister] Harold Wilson’s white heat of technology programme in the 1960s, accompanied by a large expansion in higher education, glassblowing came into its own.’

The burgeoning of science departments in universities around the UK required extensive technical back-up, and glassblowers abounded.

Steve Moehr was one of the glassblowers servicing academic scientists. He worked as a scientific glassblower in universities for 40 years until his retirement two years ago as chief glassblower at the University of York, UK. ‘I left school at 14 and because I was good with my hands I joined the glassblowing workshop at the University of Leeds for a five-year apprenticeship,’ Moehr recalls. ‘It was an interesting job. The glassware we would make could be highly complicated – tubes within tubes within tubes. You would get a drawing from an academic and you would say “I can’t possibly do that”; then of course I would do it. They would come back and say it doesn’t work, and it needs a tube in here and one out of there. Or they would drop it...’

Hopping the cracks
For Moehr one of the most complicated pieces of apparatus he was regularly required to make was a so-called three-stage mercury diffusion pump, a device for creating high vacuum and one that has largely now been superseded by mechanical vacuum pumps. These were highly elaborate pieces of equipment.

‘It was terrific fun making equipment like this,’ Moehr says. ‘You would spend maybe a couple of days preparing all the bits, adding different parts then finally fitting them all together. This is where the trouble could come – it could crack at this stage and it often did.’

Ingenuity and resourcefulness was also required. Moehr describes one memorable job. ‘I was commissioned by one professor to make a fused silica microbalance, which required a hydrogen and oxygen flame to melt the silica, and needed fibres of diameter in the region of only two or three microns. I had to do it under a microscope with a flame that I could hardly see. To make the fibres I took pieces of fused silica rod of one millimetre diameter and I hung a bulldog clip off the end. I held the rod up and melted it in the middle; it would drop, drawing the fibre out to the kind of tiny diameter I needed.’

Over the course of the four decades that Moehr spent in the trade, he did see changes. ‘I suppose one of the main things is that glassblowing has declined. Partly this is because glass does break easily and there had been a move to replace some of the equipment with metal and other materials. Also, 40 years ago there was a lot more innovation in equipment. Chemistry was a much younger science and one remembers laboratories full of chemicals in various wonderful vessels bubbling away – more so than these days perhaps.’

Moehr’s successor at York is Brian Smith, who has also been glassblowing for 40 years. ‘Glassblowing itself has probably changed little over the past 150 years,’ says Smith. ‘What does change is the type of equipment we make as new technology develops. We do make a lot of vacuum lines to order. A researcher will give me a drawing and we can work from that.’

Of course the flip side to the magic of glass, the transparent material that can be formed and manipulated into almost any shape, is that it is fiendishly fragile. ‘It can be extremely frustrating,’ Smith says. ‘A job will never go wrong at the beginning, only at the end as it gets more complicated. If you have spent two or three days building a component up, the last joint you put on will be the joint that cracks and writes the job off.’

Breakages are inevitable, Smith concedes, but not always. ‘Please, if joints won’t come apart, don’t try to force them – they will break. Bring them to the workshop!’ But despite these frustrations, the job remains, Smith says, highly fulfilling. ‘It is an unusual profession, and frankly not anyone can do it. And in this job you literally never know what is going to come through the door next.’

Lab glassware may have evolved, but many shapes have endured

In short

- Despite the rise of new technologies, chemistry research still relies heavily on glassware
- Designs for lab glassware have evolved over the years, but all rely on the glassblower’s ancient skills
- University glassblowing workshops may have become smaller, but specialist companies continue to thrive

Big projects
As well as academic research, glass is also key to the chemical and pharmaceutical industries, albeit on a larger scale.

Graham Reed is a past chairman of the BSSG who until recently had his own scientific glassblowing company servicing the commercial sector. ‘Glass has been absolutely
vital to science in the past, as it is now and will be in the future,’ he says. Reed confesses to having had an obsession with glass since seeing a craftsman fashioning novelty animals from glass in a department store when he was a child. He was offered a glassblowing apprenticeship with the then Mullard factory in Southampton in the 1960s making radio valves. ‘I eventually ended up at the University of Stirling in Scotland in the early 1980s where I took over the glass workshop. After a while I discovered a goldmine in central Scotland – there were no commercial glassblowing resources at all to service a rapidly growing chemical and biotechnological industry. ICI, Beechams, Glaxo and many start-up companies were based there, desperately trying to catch up with Japan and the US.’ The services of the university glassblowers are called upon to create a wide array of flasks and vessels.

It takes around five years to become a competent glassblower. Bob Hilliard of specialist glassblowing company Labglass says that while his trainees are expected to start making a contribution to their salary costs within 12 months, ‘we are looking at ten years before they would be fully competent to tackle everything which comes through the door.’

Unlike conventional glass blowing, where a mass of molten glass is inflated into a bubble through a blowpipe, a scientific glass blower is more of a ‘glass engineer’. For scientific glassblowing in a research laboratory, the main raw material is glass tubing, in diameters ranging from 2–3mm to 150mm. There are three types of glass: soda glass, which is typically used for items such as measuring cylinders that will not be heated appreciably; borosilicate glass, which is heat resistant (Pyrex is one of the best known manufacturers of borosilicate glass products), and quartz, which is for very high temperature, high purity work. Joints, taps and seals are bought in. The glassblower cuts the tubing to the required length and heats it in a flame of appropriate temperature to melt the glass to allow it to be formed and fused with other components. This requires considerable manual dexterity. Larger components can be mounted on a lathe. Once the piece of apparatus has been made it needs to be heated in an oven to remove internal strain, a process termed annealing.
local specialist sources such as
ourselves.
‘Most of what we do is big and
actually quite intimidating. We get
asked to do 20- or 30-litre reaction
vessels with a highly specific set of
parameters which are unusual. In
the past you had sprawling labs with
lots of twisty bits of glass with stuff
bubbling away, but now it is a bit more
sophisticated. People are saying, “we
want to make this type of drug: what
can we make it in?” We work closely
with the client to come up with the
final design.’

As for the future of scientific
glassblowing, opinions vary. Many
glassblowers are fearful for the future
of the craft. ‘There has been a collapse
in technician numbers over recent
years,’ McCormack says. ‘When I
started 30 years ago there were three
workshops and six glassblowers. Now
I am on my own.’

Steve Moehr says, ‘There are not
many people coming into the trade
nowadays; it is a dying craft.’

Mike Souza, a past president of the
American Scientific Glassblowers
Society and a glassblower with
35 years’ experience, says that the
decline in scientific glassblowing can
also be seen in the US. ‘Chemistry
has quickly evolved through
advances in analytical chemistry,
the impact of MRI, chromatography,
computer modelling software and
combinatorial techniques,’ he says.
‘All of these innovations have had an
adverse effect on the manufacturing
glass-blown instruments.’

Souza notes that his employer,
Princeton University, had as many
as five glassblowers 50 years ago,
whereas now he is the only one. ‘I
don’t think that there is another
university in this country that
employs more than one person,’ he
adds.

Bob Hilliard, director of Labglass,
a specialist glassblowing company in
the UK that employs six glassblowers,
is not so gloomy. ‘We are investing
at the moment so we see it as being a
fairly stable market. It is a matter of
supply and demand.’

Despite the drop in numbers of
technicians in the academic sector,
new recruits continue to enter the
profession. Abigail Storey is a trainee
glassblower at the University of
York. Having graduated in glass and
ceramics, Storey was no stranger to
working with glass. ‘The type of work
I do now is much more hands-on than
with the work I did on my course,’
she says. ‘Here you are much closer to
the flame, and every slight movement
with your fingers is translated to
the glass – it is very precise and you
are very much in control of what
happens. What is most satisfying to
me is that you change the glass from a
straight length of tubing which has no
real application into something which
is functional and which someone
will find useful. But it is incredibly
difficult to get the basic skills needed.
You have to develop a kind of sixth
sense, a feel for the glass and how
it interacts with the flame.
It might look easy but it isn’t!’

Simon Hadlington is a freelance
science writer based in York, UK

Further reading
Alan MacFarlane and Gerry Martin, The glass
bathyscaphe: How glass changed the world.
London: Profile Books, 2002

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commissions