# Charles Sell

At school it became clear that chemistry was the subject that suited me best especially when I encountered organic chemistry during A level work. On leaving school, I decided to study chemistry at the Queen's University of Belfast. There, I was introduced to the subject of biochemistry and saw how organic chemistry related to biology and the medical sciences, other subjects that had attracted me during my schooldays. After graduating, I applied for and was fortunate enough to gain, a scholarship to work for a PhD with the late Professor Arthur Birch at the Australian National University. One of Professor Birch's research interests was terpenoid chemistry and I chose this as the subject of my doctoral thesis. After three great years in Canberra, I took postdoctoral positions in ETH Zurich and then the University of Warwick. In both of these, I worked on topics of potential pharmaceutical interest and was thinking of a career in either academia or the pharmaceutical industry.

While working at Warwick, my attention was drawn to an advertisement for a position in terpenoid chemistry. The description of the job vacancy fitted very well with my experience at ANU and so I travelled down to Kent to a company I had not heard of before, Proprietary Perfumes Limited (PPL), although I certainly knew of Unilever who owned PPL at the time. I formed an immediate rapport with the people I met there and so began my career in the fragrance business.

I am by nature a researcher and so my entire career has been in research. My initial work was on improving synthetic routes for production of chemical species used in perfumery and in making novel molecules that might have use in perfumes. Not long into my career, Unilever merged PPL with several other subsidiaries to form PPF and this gave me opportunities to learn about and carry out research in the flavour industry and the essential oils industry. Unilever then acquired Naarden International and merged PPF and Naarden to form Quest. This merger added to my experience of working across cultures, though the English and Dutch cultures are not that dissimilar. I spent several years working partly in England and partly in the Netherlands and still have many strong friendships forged with Dutch colleagues at that time. Eventually Quest was bought by Givaudan and that gave me many new colleagues and new friendships. My time at ETH Zurich had introduced me to Swiss culture and I readily took to working with the teams in Zurich and the increased opportunities for research that Givaudan offered.

My early years in PPL and PPF taught me much about the business of perfumery. Although fragrance companies operate in competition with each other, they also depend on each other since they buy ingredients from competitors and sell their ingredients to competitors. One point to learn was the life cycle of a typical fragrance ingredient. Initially it is held captive and only the company that developed it can use it. Slowly it is released into the market, at a higher price than the internal price of course, and so the company can earn income from sales of the ingredient as well as using it to sell perfumes. Eventually, the ingredient might grow to larger tonnage and, when patents expire, other companies begin to produce it. If the sales volume is high enough, large chemical companies are attracted to enter the market and use their economies of scale to manufacture it at a lower cost. In which case, the company that introduced the ingredient is often forced out of production.

Another key learning point was the need for a fragrance ingredient to perform in the consumer goods to which it is added. The chemical environment in consumer goods can be quite harsh; high or low pH or the presence of strong oxidants such as hypochlorite bleach for example. Consumers want cleaning products with the efficacy of hypochlorite but they also like a lemon scent for these since lemon is perceived as a "clean" smell. This presents the chemist with a big problem since ingredients eliciting a lemon scent are mostly aldehydes and these are rapidly destroyed by hypochlorite.

No responsible company would wish its products to harm either the consumer or the environment. Safety to both humans and the environment have become dominant factors in the ingredients market. Contrary to lay opinion, many of the natural components in essential oils are unsafe on toxicological or environmental grounds. Clove, saffron, fennel, for example are all restricted in use because of adverse biological properties and many of the odorants produced from woods fail the OECD ready biodegradability test. We need to find ways of reducing the impact of such materials or to develop new ingredients to replace those that are lost for such reasons.

The search for new ingredients appealed to me and so that became the main focus of my work. Predicting chemical interactions in products is relatively straightforward for a chemist. Predicting safety and biodegradability is more difficult and there my interest in the chemical processes in living organisms came into play. For example, looking at the structures of substances found to be strong skin sensitisers indicated that soft electrophiles are likely to lead to problems on skin and complex polycyclic hydrocarbon structures lacking readily available centres for enzymic action are likely to be slow to biodegrade.

The largest research challenge is to design molecules with attractive odours and that blend well with other odorants. Theories about how the nose and brain detect and recognise odorants abound but none are satisfactory. Proponents of each theory could easily find examples to support their ideas but there are always other examples that disprove the theory. Thanks to modern methods of biochemistry and molecular biology, we now understand the first stage of the recognition process, how the odorant molecules interact with the receptor proteins in the nose. My last and most interesting research project with Givaudan was in that area of science and in collaboration with a research team in Brussels in addition to my colleagues in Zurich. Odorant molecules interact, through stereoelectronic recognition, with a large number of receptor types in the nose generating a complex signal pattern. There is no simple code since each odorant reacts to varying degrees with a range of those receptor types. Therefore, the signals generated in the olfactory epithelium in the nose, are much more complex than any of the theories of the last century would suggest. But that is only the beginning of the process. Neuroscience is just beginning to show how complex is the process of converting the signals coming from the nose into the mental image that we call an odour percept. We now also know that, because of genetic diversity, no two people will have the same percept, even from a simple pure chemical such as 2-phenylethanol. Involvement in these areas was the highlight of my research career and I am grateful to Givaudan for allowing me to be part of an international multi-disciplinary research team.

Prediction of biological properties is a challenging field of research. Because of the nature of olfaction as described above, odour prediction will always be a statistical process rather than a consistently accurate and precise one. Prediction of skin safety, toxicity and biodegradability are probably more important skills to develop. Perfumers can use many different odorants of many different odour types but all new perfume ingredients must be safe in use and in the environment after use.

The challenges facing the fragrance industry today are more significant than ever. To secure its future, any fragrance company must engage with the latest research to provide the ingredients and perfumery techniques that will enable the creation of safe and effective perfumes in an ever more challenging environment. To any students thinking of a career in fragrance chemistry I would say that it is a fascinating and intellectually rewarding career. Modern scientific research is multi-national and multi-disciplinary. The excitement of the research is added to the rewards of working in teams spanning different countries and cultures and different branches of science. It offers great scope for broadening one's view of life and the universe.

Charles Sell has published a number of books in addition to patents, reviews and research publications. *Fundamentals of Fragrance Chemistry*, (2019, Wiley-VCH, Weinheim, ISBN 978-3-527-34577-9) provides an introduction to fragrance chemistry and *Chemistry and the Sense of Smell* (2014, John Wiley & Sons Inc., Hoboken New Jersey, ISBN 978-0-470-55130-1) takes the subject to a deeper level. Charles edited, and contributed several chapters to *The Chemistry of Fragrance* (2nd Edition, 2006, Royal Society of Chemistry, Cambridge, ISBN 10: 0-85404-824-3; 13: 978-0-85404-824-3) which provides a view of fragrance science from the perspectives of experts in different aspects of the subject.