Careering towards the circular economy

MechChem Africa profiles plant and process innovator, John Bewsey, a Fellow of SAIChE and IChemE who, across his career, has been granted over 25 chemical technology patents covering an application range from fertiliser nutrient processing to industrial processes and waste recovery.

“I was born into a family that had absolutely no idea that water was H_2O, but I seem to have been given the gift of chemistry. Even at school I was part of a science society and was giving talks about how to make plastics and how to brew beer,” Bewsey begins.

Also good at fixing things, when it came to choosing a career chemical engineering made more sense to him than the pure chemistry options. So after matriculating from Bishops’ Diocesan College in Cape Town, Bewsey attended the University of Cape Town, from which he graduated in 1963 with a BSc in chemical engineering.

Seeking out the more practical side of the discipline, he went directly to work at the pharmaceutical manufacturer, Petersen (Pty) Ltd, in Epping, now called Fine Chemicals. “We made Codeine, Paracetamol and a host of other simple to make active pharmaceutical ingredients – which Fine Chemicals is still making these today,” he says.

“Within three months of graduating, I was promoted to manager of the plant, which I was running from 5:00 am to well past 7:00 pm. While my employer thought I was extraordinarily diligent, the real reason was that my wife, Jane, was a newly qualified doctor doing her housemanship at Groote Schuur, so she had to work all hours and I would get up early to take her in before going directly onto the factory. Then I would go back to collect her, sometimes at midnight. With this extra time, I was able to operate the plant for double shifts and increase production that was sadly behind, all with the help of a small dedicated staff who performed miracles,” Bewsey recalls.

Within two years he was promoted to general manager of the company’s larger plant in Alrode, Synchem, where he again set about revamping the process streams wherever he saw opportunities. “I spent two years there modernising the plant, which was originally designed by a chemist as a large scale up of laboratory equipment.

“While at Synchem I researched a method of milling one of the end products – phenothiazine – to below 3 microns, which would greatly reduce the cost of processing. The board was unwilling to invest in this new technology, however. Then I saw our fire-extinguishers being serviced and the powder poured out onto a plastic cloth to check if still inherent. The powder used in those days was sodium bicarbonate ($NaHCO_3$), and I rushed off to the library and read up on making this powder.

Agrofert Technologies’ factory where Bewsey began to manufacture nitrates before migrating to an organic granular product manufactured from reinforced chicken manure.

“Using the milling technique, I made a wonderful batch of fire extinguisher powder, which I took to the board as a new product option in an attempt to justify the mill investment. They were horrified: A pharmaceutical company cannot make fire extinguisher powder, was the thinking.

“I shared my frustration with a friend, Glenn Howard, who supplied our packaging materials at that time and who suggested going into business together to make this powder. He went ahead and registered a company called Glenjohn Chemicals, which eventually grew to be an avant-garde chemical business,” he says.

“Initially, we battled to break into the market, but a company called Mine Safety backed us and, from then on, our market share quickly grew until we were manufacturing some 80% of the powder required by the South African market,” Bewsey tells *MechChem Africa*.

Seeking new opportunities for Glenjohn during this period, Bewsey placed a small advert in a British Chemical Engineering journal inviting people to submit development ideas. “One idea struck home and it was for the manufacture of synthetic tartaric acid. I went to London to meet a true eccentric – Dr Michael Arnold – who introduced me to a process that had never been commercialised before. At that time, Beechams was using some 3 000 t/a of tartaric acid in its Eno’s Fruit Salts in South Africa.

“The initial trials in our pilot laboratory were a disaster. The first batch in the 5.0 ℓ reactor failed to stabilise at the 70 °C expected and as the reaction is violently exothermic, the temperature quickly went over 100 °C. I rushed around the corner and chased everyone out of the office alongside the lab just before the vessel erupted, spreading our first batch all over the ceiling and drizzling down onto the admin desks,” he relates.

After developing a way of controlling the reaction, Glenjohn applied for government funding to set up a production plant. “We had to locate the plant in one of the so-called homelands, though, so we built a plant in the Eastern Cape that employed some 100 people and became the first company in the world to make synthetic tartaric acid.

“We also made polyurethane through a partnership with Tebbe Polymers from Germany. The German operation went bust, though, leaving us owning the technology, which was eventually passed on to Industrial Urethanes, a significant supplier to this day,” Bewsey says.

He goes on to tell the story of his search for a way to make peroxide. “I met a Swedish gentleman who had used Russian technology in Sweden to build a peroxide plant and we built a similar plant at Chloorkop, which used the hydrogen gas from KOP, now NCP. I have always found it amusing that I could get Russian technology via Sweden at the peak of apartheid when both countries were sworn enemies of South Africa,” notes Bewsey.

“One day in our Chloorkop factory I saw a delivery vehicle loaded with magnesium nitrate labelled ‘made in Haifa, Israel’ and, with amazement, I realised that this valuable fertiliser was not manufactured in South Africa at all.”

Through a company called Agrofert Technologies, Bewsey entered the fertiliser industry, first via nitrates but the company quickly migrated towards manufacturing a host of other fertiliser raw materials. “We were early adopters of the organic route with a granular product manufactured from reinforced chicken manure and ended up as the seventh largest local fertiliser supplier in SA,” he recalls.

Having become increasingly aware of contaminated water problems, John Bewsey began to explore water treatment and waste recovery issues, more specifically, using his fertiliser experience to convert dissolved salts in wastewater into high-value fertilisers. This work resulted in the establishment of a new company called Trailblazer Technologies in 2006.

Explaining the problem with inorganically polluted water, he says that sodium is one of worst water pollutants. “When AMD is treated with lime, for example, the heavy metals are removed and the treated water emerges neither brown from the iron nor green from the chromium. So it appears to be safe. This is not the case, however. It still contains very high concentrations of sodium and other salts. The sodium salts are particularly hazardous, as is evident when seawater is used on arable land. It quickly causes the clay particles to absorb the sodium ions, which makes the soil impermeable. This causes the flora and the soil beneath it to die,” he notes.

He adds that more than 200 ppm of sodium in water is seriously damaging to agriculture and 63% of all river waters are used for irrigation. “Lots of our treated industrial mine water is running into our rivers at 800 to 1 000 ppm of dissolved sodium,” he points out.

Trailblazer Technologies’ recovery-based water treatment process uses a battery of continuously stirred tank reactors (CSTRs) and operates continuously and counter-current to produce demineralised water, with the contaminants being absorbed onto the ion-exchange resins for recovery upstream.

Bewsey has filed several award-winning patents, including the net-profitable KNeW, ZIX-Zak and No-Briner processes for treating all types of high salinity wastewater, while recovering the salts to manufacture potassium nitrate (KNO_3) and ammonium sulphate ($(NH_4)_2SO_4$).

Summarising the process, he says that Trailblazer Technologies’ recovery-based water treatment process starts after lime treatment in the case of AMD and underground saline water, and organic sewage treatment in the case of sewage. His process targets the removal of dissolved inorganics down to the level of potable water.

John Bewsey (centre) receives the 2013 IChemE Water Management and Supply award for innovation and excellence.

A battery of continuously stirred tank reactors (CSTRs) operates continuously and counter-current. This process produces demineralised water, with the contaminants being absorbed onto ion-exchange resins.

“The resins are then regenerated, using nitric acid for the catex resins to replace the cations with the H+ ion; and ammonia to place an OH- ion onto the anion exchange resin. The resulting product is a nitrate blend that is treated with sodium carbonate to cause all the multicharged cations to precipitate, enabling the precipitate to be filtered off and dried for use as a soil ameliorant.

“The residual sodium nitrate solution is then mixed with an equimolal amount of potassium chloride and evaporated, with the result that the least soluble salt, sodium chloride, which has an absolutely flat solubility curve, crystallises out for easy separation. This allows the residual liquor to be cooled to produce a pure crystalline potassium nitrate (KNO_3), which is dried for supply to horticulture as a primary and valuable fertiliser with global demand,” Bewsey explains.

An elegant solution that fits neatly into the ideas associated with the circular economy.

The sale of the nitrate-based fertilisers reduces the costs of treating wastewater to zero. In addition, there is the environmental advantage of reducing the amount of waste having to be dumped to an absolute minimum. “It is possible to make the process profitable, even after amortisation deductions,” he predicts.

A SAIChE IChemE member since the early 1970s and an Honorary Fellow since 1978, John Bewsey uses his experiences to inspire young engineers to appreciate the diversity offered by the chemical engineering profession.

“Many shy away from chemistry, but for those who love it, the opportunities are endless,” he concludes. ❑