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More Efficient Wastewater Treatment Looms

New technologies could lead to greener, less-expensive manufacturing processes

By Seán Ottewell, Editor at Large

TWO ADVANCES in wastewater treatment technology promise to save significant amounts of energy and improve processing efficiency.

The first, by scientists at Nanyang Technological University (NTU), Singapore, involves a new type of nanofilter that could reduce up to five times the energy needed to treat wastewater (Figure 1).

Typically in a wastewater treatment process, an ultrafiltration (UF) membrane removes small particles from the water before it goes to a reverse osmosis (RO) membrane for final purification. The high pressure needed for RO means the pumps require a lot of energy.

However, NTU's proprietary nanofiltration hollow-fiber membrane combines both processes into one step. It also requires only two bars of water pressure, yet produces water almost as pure as the RO process.

Researchers at NTU's Nanyang Environment and Water Research Institute (NEWRI) have spent two years developing the new membrane; it's now being commercialized by NTU spin-off company De.Mem, Singapore.

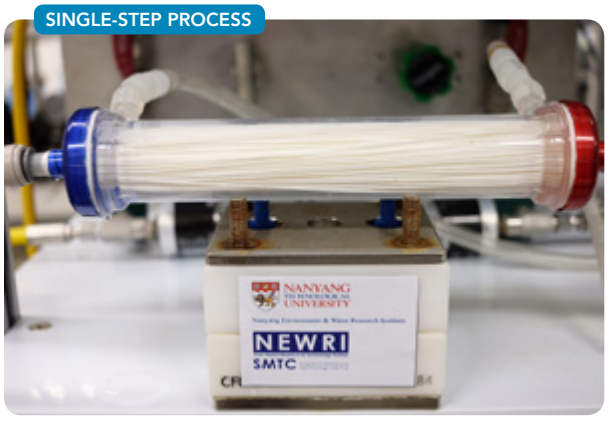

Figure 1. Nanyang Technological University's nanofiltration hollow fiber membrane combines both ultrafiltration and reverse processes into one step. *Source: NTU, Singapore.*

De.Mem, which owns more than a dozen water treatment plants in Vietnam and Singapore, will be building a pilot production plant in Singapore to manufacture the new membranes.

"With the increasing urbanization of cities and fast growing global population, more cities and communities will face an unprecedented challenge to meet growing demand for clean water and wastewater treatment," notes professor Ng Wun Jern, executive director of NEWRI.

NTU professor Wang Rong, director of NEWRI's Singapore Membrane Technology Centre, says his team designed the new membrane for commercial scale-up and production.

"Our new membrane is also easy to manufacture using low-cost chemicals that are 30 times cheaper than conventional chemicals, making it suitable for mass production," he adds.

Andreas Kroell, chief executive officer of De.Mem, says the new membrane fills a gap in the current market for water treatment: "Such an effective and efficient technology has significant market potential and can be used in many of De.Mem's projects that involve the treatment of industrial wastewater, too."

De.Mem's next step is to test the new membrane technology in a number of its treatment plants to verify its effectiveness and efficiency at an industrial scale. If this goes well, the company will then scale up its membrane production plant, too.

Meanwhile, researchers from the Universitat Autònoma de Barcelona (UAB), Barcelona, Spain, and technicians at water treatment company Depuración de Aguas del Mediterráneo (DAM), Valencia, Spain, will soon put

BIOGAS

Figure 2. Researchers in Barcelona are attempting to develop a wastewater treatment process that generates more energy than it consumes. *Source: UAB, Barcelona.*

into operation an experimental plant at the Rubí-Valldoreix wastewater treatment plant, with the objective of making the treatment process generate more energy than it consumes (Figure 2).

The technology has been developed as part of a project that focuses on the radical redesign of wastewater treatment plants to make them more efficient. Of the €1,169,068 budget, the European Union's LIFE Programme is funding 58%. This is the EU's only funding devoted exclusively to the environment; its general objective is to contribute to sustainable development and other important strategies related to climate and the environment.

UAB researchers say present-day wastewater treatment plants require a minimum energy consumption of 8–15 kWh/inhabitant/year to meet legal requirements on effluent discharge in terms of organic matter, nitrogen and phosphorus. This means considerable greenhouse gas emissions and high costs. Eliminating these costs could save €500 million to 1 billion (≈$550 million to $1.1 billion) per year in EU countries, they estimate.

This new treatment plant will use all organic matter in wastewater to produce biogas for heat and electricity. In addition, the nitrogen in the wastewater will be eliminated autotrophically, i.e., without the need for organic matter, by means of a new technology based on two biological stages: an aerobic partial-nitration reactor and an anaerobic ammonium oxidation (anammox) reactor.

The system has been laboratory tested; the pilot plant at Rubí-Valldoreix will treat 3 m^3/d of wastewater.

Compared with current urban wastewater treatment systems, UAB researchers predict the new process could consume 40% less energy, reduce nitrogen compound disposal by 10% and greenhouse gases emission by 20%, and increase biogas production 50%.

Pilot plant operation is expected to start in the first quarter of 2017, with the first experimental results due at the end of next year. Ongoing validation of the process will continue into 2018.

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Keep Calm and Save Water

Processors adopt diverse approaches to cut consumption

By Seán Ottewell, Editor at Large

MANY CHEMICAL makers now are focusing intently on water issues, prompted by concerns over water supply, quality and cost as well as by the quest for improved sustainability. As the experiences of Dow, Huntsman, Bayer and AkzoNobel show, optimizing water use requires careful analysis of all production processes involved.

"Changing water source is effectively a change in raw material and, therefore, numerous checks have to be carried out before it can happen," cautions Verónica García Molina, EMEA technical service and development manager, and global water technology center R&D manager, Dow Water and Process Solutions (DW&PS), Tarragona, Spain.

Huntsman Corp., The Woodlands, Texas, stresses that an accurate and comprehensive view of plant water use must underpin efforts. At its facilities in drought-stricken Texas, nothing has escaped attention: "To meet the water authority's call for conservation, operating personnel at the Port Neches plant, located 100 miles east of Houston, went through every unit to identify areas for reducing or eliminating water use, including replacing leaking valves," notes Mike Miller, senior manager, environmental, Huntsman Port Neches operations.

SPANISH SUCCESS

Dow's technology center in Tarragona (Figure 1) focuses both on development of technologies to improve water treatment and on process optimization and integration needed to implement them to the best effect. An ongoing water optimization project at the Camp de Tarragona chemical complex exemplifies a successful combination of the two.

The Tarragona region of Spain traditionally suffers rainfall shortages. The chemical complex takes water from the River Ebro, one of the most important rivers in Spain. The river also supplies the Camp de Tarragona municipality, which is popular with tourists; the local population of 200,000 can triple to 600,000 in a busy season. Unfortunately, drought and demand have caused a 25% fall in river volume over the last 60 years.

For its part, the chemical complex draws 19,000m^3/h of water from the Ebro. Home to almost 30 chemical companies — including a Dow facility that manufactures olefins, polyolefins, polyglycols, surfactants and performance fluids — and employing over 33,000 people, the site produces more than 21 million mt/y of products; it is the most important chemical complex in the Mediterranean region.

Backed by almost €6 million ($6.7 million) in funding from the DEMOWARE water reuse initiative of the European Union (EU), the complex in 2014 started a project aimed at replacing river water with treated wastewater from the municipality.

For Dow, this meant cutting back on the 6 million m^3/y of river water it alone used.

Today, Dow relies on a blend of 40% reclaimed water and 60% Ebro water. The plan eventually is to raise the level of reclaimed water in the blend to 90%.

"There were questions and concerns about the impact of the change in areas like corrosion, scaling and biofouling or bacteria growth phenomena. We reached a common agreement with the plant after about six months of a deep review process which included failure modes and effects analysis," says Molina.

Some surprises have occurred. For example, with the current 40% reclaimed water blending, DW&PS projected a 20–30% reduction in blowdown water production by the plant processes because of the better quality. In fact, the drop is nearly 50% now, which has cut the cost of treating the resulting wastewater, too.

The current 40% blending also has pared the volume of

Figure 1. Spanish site both develops water-treatment technologies and works to optimize and integrate them. *Source: Dow Water & Process Solutions.*

chemicals needed in cooling towers by about 23%, again because of the higher quality water. Dow expects to increase the amount of reclaimed water used in its ethylene-cracker cooling tower to 90% over the next 2–3 months.

"The expectation is that with better water quality we will also see additional benefits and savings due to less fouling buildup that, in turn, will lead to a decrease of cleaning operations in heat exchangers and other plant equipment," adds Molina.

One innovation stemming from this project is the idea of using DW&PS' minimal liquid discharge approach as part of the cost/benefit analysis. This enables an increase in the recovery of a system from 70% (achievable using a standard reverse-osmosis configuration) to as much as 95% at a 60% lower cost compared to alternative technologies such as zero liquid discharge, says Dow.

This month, the company is starting a new project at Tarragona, which initially will be funded by the EU as a demonstration unit, that will allow the site to treat and reuse its own wastewater rather than send it to the local wastewater treatment plant. DW&PS is partnering on the project with Veolia Spain — following good experiences with the company during DEMOWARE and other efforts, according to Molina. Startup is expected in January or February. Already settled is the ultrafiltration technology: Dow IntegraFlux, which allows up to 15% energy savings, while Dow's new Filmtec Fortilife membranes will handle reverse osmosis.

"The flow to be treated will be low, around 4 m^3/h, but this will be the first step. If the results are successful, we could expect total savings of up to 30–40%, including savings associated to the cost of treating the waste stream and the savings associated with the fresh water consumption decrease, but this is still a preliminary assumption," notes Molina.

DROUGHT-DRIVEN STEPS

The persistent drought in Texas has prompted Huntsman to implement measures to limit water use by as much as 30% at its plants in the state. The measures remain in effect; work to further reduce water use is ongoing.

The Port Neches facility started recycling its wastewater and changed routine firewater testing to avoid excessive use. Another saving came from the reverse osmosis unit used to produce high quality water for boiler feed. Originally 30% of this had been discharged. "Recycling this is saving us 600 gal/min of water," says Miller.

The company's specialty plant in Conroe, Texas, 30 miles north of Houston, (Figure 2) has focused its attention on the two onsite wells that supply groundwater for the production of amines, carbonates, urethane catalysts and surfactants. The plant had been withdrawing water at a set rate regardless of demand, sending excess water to the plant wastewater treatment system. It now has installed a variable-frequency-drive (VFD) motor so operations staff can adjust the pumping rate based on demand.

"The plant has also made improvements to increase condensate recovery, by collecting condensate produced during the process and putting it back into the system. As a result, site water usage has dropped by 7%," notes plant manager Walter Stamm.

Huntsman's Chocolate Bayou plant at Alvin, Texas, 40 miles south of Houston, which manufactures linear alkylbenzene, originally used 820,000 gal/d of water from the Brazos river for cooling tower evaporation and for steam boiler makeup. "As drought conditions worsened, the site was called on to reduce water supplied from the river. Today, we have reduced the amount of makeup water needed and also recycled water for other uses — reducing both intake and discharge by 15%," boasts plant, product and asset manager John Wiley.

Huntsman has shared the experiences of the Texas plants as best practices and implemented them elsewhere as needed, says Roy Conn, global sustainability coordinator. In Texas, one strategy the company is investigating is collecting storm water to provide emergency supplies in times of drought, he adds.

Meanwhile in the company's textile effects (TE) division, process modifications have made cleanout procedures more efficient, increasing output of the plants without the need for additional water supplies.

"Before the consolidation effort, TE discharged 12 tons of water per one ton of dye produced. Today, that number has been cut in half. The team also employed advanced technologies to improve effluent treatment at plants, removing hazardous chemicals to significantly improve the overall quality of water being discharged," explains Barry Griffin, vice president, operations.

In Finland, Huntsman's Pori pigments and additives plant uses 16 billion gal/y of river water. Now, the site returns 90% of this to the river. Moreover, it's cleaner than the water drawn from the river — thanks to treatment with a ferric sulfate coagulant that is a byproduct from Huntsman's own TiO_2 pro-

Figure 2. Specialties plant installed a variable frequency drive to allow adjusting water intake to demand. *Source: Huntsman Corp.*

cess. "Another ferric additive is also supplied from the nearby Kemira plant," adds Kati Ruusunen, Pori EHS manager.

In an interesting twist here, the water, which is potable, can be piped directly to the local town in an emergency, as happened three years ago when 47,550 gal/h of treated water was diverted following a rupture in the town's supply line.

LEVERAGING COOLING WATER

Bayer, Leverkusen, Germany, also is making concerted efforts to cut water usage. In 2015, total water consumption in the group fell by 1.1 % to around 346 million m^3.

Cooling water represents about 73% of all water used by the company. In cooling other streams, this water only is heated and doesn't come into contact with products. So, it can be returned to the water cycle without further treatment in line with the relevant official permits, says the company. The total volume of once-through cooling water was around 240 million m^3 in 2015. Water currently is recycled at 35 sites, for example, in closed cooling cycles, through the reuse of treated wastewater or the recirculation of steam condensates as process water. The company reused a total of 10.5 million m^3 of water in 2015.

Bayer is running numerous projects and initiatives at plants around the globe.

A number of sites have set themselves specific water-related goals as part of environmental management measures within their HSEQ [health, safety, environment and quality] management process, ISO 14001 certification, or the EU's EMAS [eco-management and audit scheme] validation services. For example, at Bayer's Antwerp complex, one initiative for increasing water efficiency is the development of a cost calculation for the re-engineering of wastewater streams in one plant to better separate the heavily contaminated streams from the less polluted ones.

The Bayer Integrated Site Shanghai in China, which produces polycarbonates, polyurethanes, coatings and raw materials for adhesives and is the largest and most important plant of Bayer Material Science (BMS) in the Asia Pacific region, has hit almost all of its targets for water use by better control and optimization of the production processes, says the company.

Meanwhile, a three-year project now is underway to reduce water use at the BMS (now Covestro) 250,000-mt/y polycarbonate production site in Map Ta Phut, Thailand. One of the main focuses here is on acid water recirculation.

In another three-year project, Bayer Technology Services' Belford Roxo, Brazil, site will add a water recycling system that will allow 90% of current wastewater from its polyurethane unit to be used as process water.

ECO-EFFICIENCY

AkzoNobel, Amersterdam, treats its water management efforts as an integral part of its ongoing operational eco-efficiency program.

A project at its Barcelona coatings facility exemplifies the approach. It centers on monitoring density in reused wash water to determine its solids' content. This information is used to balance the solids/water input for the batch and to better manage overall water consumption.

Such monitoring has reduced solid waste in the treatment plant and allowed reuse of wash water in the next batch. This has resulted in annual savings of almost €80,000 ($90,000), €46,000 ($52,000) from extra paint/yield increase and the rest from decreased water treatment.

A project at the Kristinehamn adhesives plant in Sweden involved installing a VFD system on cooling water pumps and automating the associated valves; this has allowed the plant to tailor fresh water intake to production rather than draw water at a constant rate. As at Huntsman's Conroe facility, this has stopped waste of unused fresh water.

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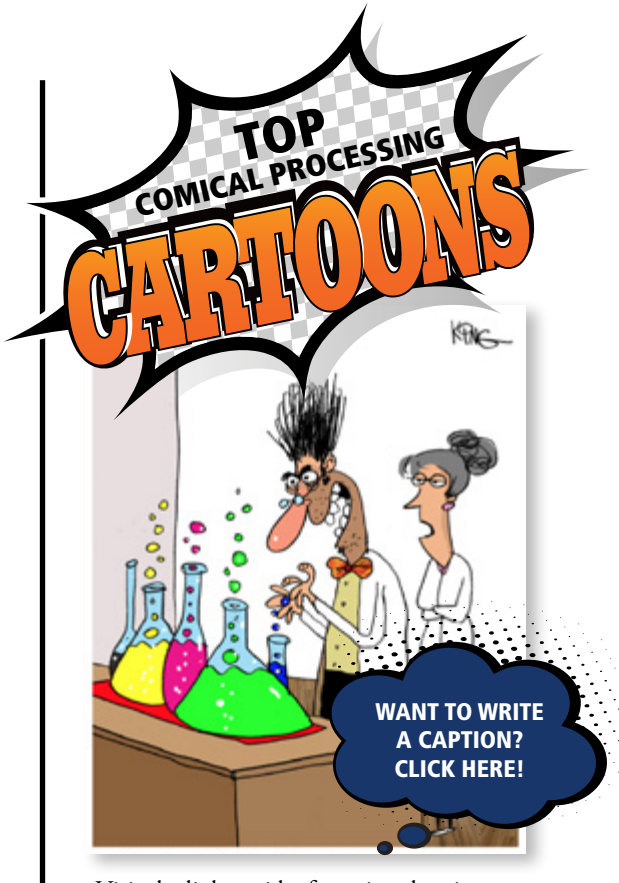

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