# Press Release

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**7th International Exhibition-Congress on Chemical Engineering and Biotechnology**

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Trend Report No. 12: Water Technologies

## Wide diversity of water treatment technologies

- **Hybrid processes often the method of choice**
- **There's no such thing as an 'off-the-shelf' plant – systems have to be customized to the task in hand – German technology in global demand**
- **Water technology: a key theme at AchemAsia**

*Water is indispensable to industry, its availability in suitable quality and quantity is an important factor for investment decisions. Its responsible use is the basis for sustainable global development and stable economic growth. The need for enhanced production process efficiency and advanced product quality standards requires innovative, optimized water treatment technologies. Their integration is a challenge to process engineering.*

*Water management and water recycling in industry are also key themes at AchemAsia 2007, which will take place from 14 to 18 May in Beijing, PR China. As the biggest international forum for the process industry in Asia, AchemAsia 2007 will highlight the optimum solutions. The event is expected to draw a total of 500 exhibitors and 20,000 attendees from all over the world.*

### Water is big business in China – municipal and industrial demand soaring

With an annual growth rate of around 15% the Chinese market for water treatment is second only to the USA. Moreover this development is given added impetus by the 2008 Olympic Games in Beijing and Expo 2010 in Shanghai.

In China wastewater treatment continues to be a problem. Statistics indicate that China's wastewater treatment rate is currently about 50 %. There is a lack of adequate sewage collection systems and existing systems frequently fail to function satisfactorily. According to data from the China Sewage Treatment Industry Report 2006 (www.researchandmarkets.com/reports), 278 of China's 600 historical grown cities do not have any, or do not have sufficient, wastewater treatment facilities. The goals set in the 11th Five-Year Plan (2006-2010) envisage an investment of 330 billion RMB for this sector. This is also a promising market for foreign companies. To date the share of foreign capital is less than 10%.

Siemens is one of the global players on the Chinese water market, particularly for industrial water treatment. With its recent acquisition of 70% of CNC Water Technology Inc., Beijing, a successful Chinese system integrator of water treatment and seawater desalination plants, Siemens is expanding its industrial water treatment business in China, the bias being on filtration applications. Founded in 2002, CNC was the first company on the Chinese market to use membrane filtration in water treatment and seawater desalination. CNC has successfully carried out a number of the biggest Chinese projects for seawater desalination and for industrial and municipal water treatment and covers sectors, such as petrochemistry, refineries, steel and energy production.

Germany is the world's leading exporter in the area of plant, components and systems for water and industrial wastewater treatment. According to data from VDMA, in 2005 Germany's exports in this sector rose by around 30%. Germany's share of 564 million euros (20.2%) catapulted her to the top of the league, followed by the USA with 557 million euros and France with 200 million euros. In the first half-year of 2006 Germany's production volume again increased by 8%, and the branch anticipates a new production record of 675 million euros for the whole of that year.

## Other treatment methods

Besides innovations in membrane technology (see also Trend Report No.11) other water treatment technologies have pushed numerous new developments that supplement or improve conventional processes. They include not only mechanical treatment methods for industrial applications, but also biological, chemical and, not infrequently, hybrid processes.

## Biological treatment methods for industrial applications

There are three types of biological-treatment technologies: aerobic, anaerobic and anoxic. Normally, aerobic and anaerobic steps are incompatible, but a process from BASF AG enables nitrification and denitrification of wastewater within a single tank – a technology known as timeswitching. In late 2004, BASF donated its U.S. Patent 6 426 004, entitled Continuous Flow Completely Mixed Wastewater Treatment Method, to the Water Environmental Research Foundation. The timeswitch method requires additional controls and mixers, but eliminates the need to invest in additional tanks.

Meanwhile, a new process that uses anaerobic microbes to decolorize wastewater from dye-production plants has been commercialized by Nippon Kayaku Ltd. The company has implemented the technology in a two-reactor facility that treats 240 $m^3$/d of wastewater containing azo, formazane, and copper-containing dyes.

Conventional chemical methods, using sodium hypochlorite, achieve only a 70 % decolorization, while risking the release of chlorinated organic compounds, says the firm. Three kinds of anaerobic bacteria, of the species *Enterococcus* MH-3, have been discovered by Nippon Kayaku for performing the decolorizing process. The company is planning to implement the technology at its other dye-manufacturing plants, and is considering the possibility of including the bioreactor system as a new environmental business in future.

Enviro-Chemie GmbH has developed a range of Biomar® anaerobic reactor systems for industrial applications. For example, fixed film reactors Biomar® AFB are used in the dairy and food industry whereas anaerobic sludge bed (ASB) technology serves the beverage industry. In cooperation with the Technical University of Hamburg, Germany, a new type of anaerobic high performance reactor has been developed for use in the treatment of highly loaded industrial wastewaters. Anaerobic reactors are becoming increasingly popular as part of multi-stage processes in order to achieve minimum effluent concentrations and enable re-use of treated water at a reasonable cost.

With over 100 references in different industrial applications worldwide, Wehrle Umwelt GmbH ranks among the market leaders in membrane bioreactor technology. As this process is used to treat especially high loaded industrial wastewater, Wehrle uses external membranes

capable of being heavily loaded, which can be adapted to different types of wastewater. The patented low energy membrane process Biomembrat-LE is the best technology to treat medium loaded industrial wastewater with a high filtration capacity, combining stable membrane performance and low energy use as well as low membrane replacement costs. The simple chemical cross flow cleaning of the membranes ensures a long term membrane performance.

Break-through in anaerobic digestion was the granular sludge based UASB technology. New developments with expanded granular sludge bed (EGSB) offer high concentrations of biocatalysts (easily settable organic sludge) together with high loading rates (20-40 kg COD/($m^3$·d)) and methane byproduct for energy recovery. Anaerobic reactors offer great advantages for closing industrial water loops. Applying thermophilic treatment conditions moreover enables additional savings of energy costs. Application covers a wide range of industrial sectors: all kinds of food industry, pulp and paper, pharmaceutical and chemical industry etc.

Ondeo Hager + Elsässer supplies wastewater treatment solutions for the food and beverage Industry as well as for the pulp and paper Industry. The targets to minimize energy demand and sludge production for the treatment of high loaded wastewater sidestreams are realized by the use of different anaerobic reactor systems, like Analift, Anaflux and an EGSB type reactor. Based on the wide range of experience different system designs adapted to the specific needs of these industries are available. An additional benefit is obtained by the use of biogas as energy source. The total wastewater treatment is completed by final aerobic treatment and water reuse options.

**Methods for removing arsenic and other heavy metals**

Adsorbents for the removal of arsenic and other heavy metals from water are available from a number of companies. Under a new agreement with Lanxess AG (formerly the chemical arm of Bayer AG), Severn Trent Services offers an adsorption system for removing metals from industrial wastewater that uses a fixed bed of Lanxess's synthetic alpha iron hydroxide-oxide (Fe[OH]O) granules.

GEH Wasserchemie offers the GEH-Process using granular ferric hydroxide with extremely high adsorption capacities for efficient removal of arsenic and phosphates from water in fixed bed reactors (treatment capacities 5 to 60 $m^3$/h).

Graver Technologies has acquired HydroGlobe which has a process that uses titanium dioxide granules to adsorb arsenic, lead and other heavy metals. However, the principal market for these processes is the removal of arsenic from drinking water, which is particularly relevant right now in the U.S., where the standard for arsenic in drinking water just dropped from 50 ppb to 10 ppb effective January 2006.

Enviro-Chemie GmbH has introduced an Envochem® process with a selective ion-exchange resin for the removal of molybdenum, which serves as catalyst in chemical production. Molybdenum is recycled at the production facilities as a concentrated solution of $Na_2MoO_4$. Residual heavy metals are removed from the wastewater by applying a second type of resin.

**Recycling deionized water**

Exergy Technologies Corp. has commercialized EthorCel, a new process-water recycling technology for industrial and high-tech applications that use deionized (DI) water. The cost of ownership of EthorCel is less than a third of conventional water-purification operations, such as ion exchange or reverse osmosis, says the firm.

The EthorCel system is based on the principals of electrodeionization, which consists of an electrodialysis cell with its membrane compartments packed with a with mixed-bed (cationic and anionic) ion-exchange resin. Feedwater is pumped into the central compartment at ambient temperature and a pressure of 40–60 psi. In a single pass, the system is said to

achieve a 99 % reduction of total dissolved solids (TDS). The quality of the water produced by EthorCel depends on the feed concentration. For example, purified water with a specific resistivity of 18.2 MΩ · cm is produced from feedwater with < 12 ppm TDS.

Ondeo Hager + Elsässer has experiences in the handling and treatment of complex recycling water compositions. The treatment line includes detection and segregation of troublesome ingredients and units for TOC and ion removal. The latest development is the TOC reduction unit BioSorb.

**Reducing corrosion in process water and boiler feedwater systems**

Liqui-Cel® membrane contactors manufactured by Membrana have proven beneficial in many process water loops for simultaneous $O_2$/$CO_2$ removal and corrosion control. For example, $O_2$ negatively impacts many processes; it is corrosive and can oxidize materials. In the power and industrial sectors, piping and equipment are susceptible to corrosion. Additionally, $CO_2$ negatively impacts the performance of EDI and ion exchange. Liqui-Cel contactors offer a modular solution for $O_2$/$CO_2$ removal without chemicals. Membrana has developed new large capacity contactors suited to process larger flow rates.

**Separating oil from water**

A system that achieves greater than 97 % efficiency for separating oil and water has been developed by Nu-Corp International Technologies, Inc.. The high efficiency of NuCorp's XpaK system, measured by researchers at Mississippi State University's Diagnostic Instrumentation and Analysis Laboratory (DIAL, www.msstate.edu), is significantly higher than the 75 % efficiency typically achieved by conventional gravity separators, says the firm.

XpaK takes advantage of the difference in densities of immiscible fluids. As such, it can be applied to any mixture of immiscible liquids of different buoyancy. In the separation process, solids are first screened and recovered in an induced-vortex, suspended-solids unit. The oil-water mix is then pumped to a high-rate separator. The high-rate separator is a curvilinear compound separator made up of XpaK internals. The mixture circulates through this column, from bottom to top, along a controlled flow pathway (multiple channels), under controlled temperature and pressure. The combination of the fluid's kinetic energy, thermal gradient and nucleation causes the oil and water particles to separate – the oil moving towards the walls and the water towards the center, of the column.

Nu-Corp states that the capital cost for the system is about one-quarter that required for conventional equipment. The operating costs are also lower because no chemicals are required to enhance the separation; the return on investment can be weeks to months, depending on the application. A large-scale demonstration is being planned, pending federal funding, at an oilfield site in Mississippi.

**Using hydrogen peroxide**

Hydrogen peroxide has become the "green solution" for bleaching, cleaning and disinfecting in a wide range of industries, including textile, pulp, paper, food preparation and food packaging. And through a recent discovery by scientists at the Idaho National Laboratory for subsequent removal of the hydrogen peroxide from downstream wastewater, the method is even greener. With the use of *Thermus brockianus* catalase, a naturally occurring bacterium in the hot springs of Yellowstone National Park, hydrogen peroxide decomposes safely and wastewater needs no extra pretreatment. *T. brockianus* produces an enzyme that can endure harsh industrial conditions like high temperatures and high pH's, and lasts thousands of times longer than alternative catalases. And, unlike other enzymatic treatment methods, the enzyme created through this method lasts long enough to treat multiple batches of wastewater.

**Ozone – on top to remove endocrine disruptors and pharmaceuticals**

Different studies in Germany and Europe, presently also in the US, show that many harmful chemicals present in wastewater or even in drinking water can be efficiently oxidized by ozone. The European studies focus on the treatment of the effluent of municipal wastewater treatment plants as one main pathway for the distribution of persistent substances in the aquatic environment. The final report from the EU research project POSEIDON (www.eu-poseidon.com) summarizes the results.

Wedeco as a supplier of ozone and UV system solutions supported pilot trials to treat the effluent of wastewater treatment plants in the cities of Braunschweig, Berlin and Zurich. In these effluents more than 30 compounds could be detected, including pharmaceuticals, natural estrogens, musk fragrances and iodinated contrast media (the water was tested for 53 different compounds). The concentration of the detected substances was from 0.01 µg/L to 10 µg/L in the effluent of the municipal wastewater treatment plants.

The applied ozone doses during the pilot trials varied between 1 mg/L and 15 mg/L. The results showed a very positive treatment effect by ozonation for most of the compounds with oxidation efficiencies of higher than 90 % in most cases. One highlight of the ozonation was the effective oxidation/degradation of the three major endocrine disrupters (17α-ethinylestradiol, 17β-estradiol and estrone), which probably lost most of their estrogenic potency. Thus, ozonation might drastically reduce estrogenic effects on fish, frogs, birds etc. caused by discharging treated municipal wastewater into rivers and streams.

Furthermore, it can be assumed that the potential for the formation of resistant bacterial strains is lowered significantly because antibiotics were no longer detected in the ozonated wastewater.

**Ozone and UV – two complimentary tools for "multi-barrier concepts" in drinking water treatment**

In today's drinking water market, there are more technologies available than ever that promise complete disinfection (i.e. for providing a barrier for human pathogens). Prior to selecting the project-specific technology or solution, the following challenges have to be understood and evaluated:

- The group of human pathogens contain very different species from viruses via bacteria to parasites. Their sensitivity towards specific disinfection technologies varies greatly.
- Some disinfection technologies will impact the water quality. The impact can be positive (e.g. reduction in color, taste, odor, etc) or negative (e.g. pH, taste, etc.).
- Some disinfection technologies can produce disinfection by-products (DBPs) such as THM's, HAA's, Bromate, etc, which are considered carcinogenic and mandated by the EPA.
- Some disinfection technologies do not actually oxidize or inactive the organisms. The organisms are removed through fine filtration, where the back wash water must then be treated as a recycle or discharge stream.

The complimentary combination of ozone as pre-oxidant and UV light as primary disinfectant has shown to be of high benefit to the utility and end-customer, becoming a "multi-barrier-concept" of growing strength. The US Environmental Protection Agency (USEPA) has just recently classified UV disinfection as a "critical compliance technology" in the treatment of drinking water, to protect the public against harmful micro-organisms. The disinfection effectiveness of UV is further enhanced by using ozone as a pre-oxidant, providing a water of a high and consistent quality. Examples of large sized plants using the $O_3$/UV combination as multi-barrier include:

- Helsinki drinking water plants Vanhakaupunki and Pitkäkoski (design flows: 5,000 m³/h and 7,000 m³/h respectively)
- Mühlheim drinking water plant (Germany) Styrum-Ost (design flow: 8,000 m³/h)
- Drinking water plant Weber Basin III in Utah (USA) (design flow: 7,254 m³/h)
- Drinking water plant Lake Pleasant in Arizona (USA) (design flow: 12,931 m³/h)

**Ozone and $H_2O_2$ – a tool for the degradation of none biodegradable COD**

In case that an advanced COD reduction is required and an existing biological treatment does not achieve the limits given by existing or new regulations, several options are available to achieve lower COD levels.

Either an additional oxidation step or the combination of oxidation and biology can be applied. The following processes are established by references in the field:

- Biology – Ozonation – Biology
- Biology – Ozonation
- Biology – Ozone / $H_2O_2$

Especially the combination of membrane biology systems with an oxidation step can support and strengthen the overall treatment capabilities of these systems. This can be the oxidation of organic substances to prevent an increase of organic load in the system or could be the final oxidation of residual organic substances in the outlet of the system.

As advanced treatment of municipal and industrial wastewaters the use of ozone and probably Advanced Oxidation Processes (AOP) enables to meet future water clarification and recycling standards in an economic feasible way. Especially the existing regulations for COD, color and the possible future regulations for different kind of persistent substances, e.g. industrial chemicals, hormones and pharmaceuticals can be achieved by oxidation with ozone or combinations e.g. ozone / $H_2O_2$.

**Ozone – disinfection of cooling water**

Usually cooling water is treated by adding biocide in order to minimize biological growth. Nevertheless, more and more wet cooling towers have been identified as a source of legionella or Legionnaires' disease. If the additional problems relating to the discharge of biocides together with spray losses from cooling towers are considered, it is imperative to change one's views regarding the treatment of water from cooling towers. Treatment technologies are called for that are environmentally friendly, non-toxic and are not hazardous to persons in the vicinity of a cooling tower. One alternative to biocides is BWT's Coolzon process which continually supplies ozone to the cooling water. The highly reactive ozone is produced directly at the place of use, being fed automatically, depending on the demand, into the cooling water. Practical experience shows that bacterial counts in cooling systems are thus reduced significantly.

**Heat pump based vacuum distillation for wastewater treatment**

Vacuum distillation from Aqua-Society based on a highly efficient heat pump unit can be used for the recovery of recycable material from liquids by separating most of the water, or for the evaporation of most of the water contained in hazardous liquid waste thus reducing the volume dramatically before further cost intensive treatment. After compressing and thereby heating the vapor, the vapor can transfer its heat by condensation to the boiling liquid. Thus the condensation energy can be used for heating the distillation process itself. No need for cooling water, much lower energy demand compared to conventional distillation by using the heat pump heating, fully automatic operation of units from 30 to 2,000 L/h and

the ability to be powered by solar energy due to low energy demand are some of the benefits of this technology.

### Upgrading of existing wastewater treatment plants

Linde-KCA-Dresden GmbH supplies treatment plants for both municipal and industrial wastewaters. The proprietary Linpor Systems offers attractive solutions for upgrading existing biological treatment facilities. By application of a mobile carrier material, existing activated sludge tanks can be adjusted to handle increased pollution loads and/or achieve nutrient removal and elimination of hard-to-degrade pollutants, often without additional tankage. The system is also attractive for new plants, particularly in case of reduced land availability or foundation problems. Use of pure oxygen instead of air makes the proprietary Lindox system an odor nuisance free alternative in residential areas.

### Water technology at the AchemAsia Exhibition - Congress 2007

Numerous exhibitors and contributors to the congress program will pinpoint the latest trends and technologies in the area of water and wastewater treatment technologies for industrial application. The themes span the whole range from the reduction of process water by innovative process techniques to the most diverse water recycling processes. The key topics of the congress are: sustainable water management for industries and municipalities, biological wastewater treatment, advanced oxidation technologies, membrane technologies, and water resources for industrial processes.

**www.achemasia.de; www.achemasia.net**

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