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New Techniques Tame Biofouling

Biofouling plagues many plants in the chemical process industries. Unchecked, such fouling can lead to inadequate performance and even outright failure of equipment, as well as contamination of process streams and products. That is why ongoing research, here and abroad, is focusing on ways to control a range of bioorganisms, ranging from fungi to zebra mussels, that can cause these problems.

(An article about biofouling, "Control Biofouling in Evaporative Cooling Systems," appeared in *Chemical Engineering Progress*, Sept. 1998, pp. 45–50.)

Chlorine pulsing

Frequently, biofouling has been controlled by adding large amounts of chlorine in the form of sodium hypochlorite to the plant cooling water. Now, KEMA, an international energy company based in Arnhem, The Netherlands, has a new approach to using chlorine — pulsing it.

Dr. Henk Jenner, one of the developers says, "Sodium hypochlorite remains an excellent anti-biofouling agent for cooling water systems, but by using our Pulse-Chlorination systems, zebra mussel colonization can be controlled using a fraction of the chlorine that the conventional approach requires. As well as saving our clients money, less chlorine means less impact on the aquatic environment."

He adds: "Pulse-Chlorination is based on what we know about the time it takes for mussels to recover after chlorination. If chlorine is added in short bursts with pauses in between, the effect on the mussels is much the same as if the water is permanently chlorinated." KEMA and two other Dutch companies have developed MusselMonitor, a device that records the mussel activity. "By attaching sensors to the mussels, we can keep a record of their behavior and determine how they respond to the chlorination," Jenner says. It is believed these mollusks can sense oxidizers even at low levels. They protect themselves by closing their shells. (The MusselMonitor can also be used for monitoring the intake of drinking water from a river or lake system, and the quality of industrial waste water.)

Jenner stresses, however, that there is "no interval that is right in all cases, as the recovery period varies, not only from species to species, but also from site to site, depending on the water chemistry."

To date, the Pulse-Chlorination system has been installed at four Dutch sites: two power stations (one that uses seawater and one that uses brackish water), at a petrochemical plant using seawater, and at a waste incinerator using brackish water. Dr. Harry Polman, another developer of the system, says custom plant trials, which usually last between three and four weeks, are critical to the success of Pulse-Chlorination.

Filters for pretreatment

TNO, The Dutch National Research Laboratory based in Delft, is developing filters for the pre-treatment of process water to curb the opportunity for biofouling.

These filters, which could be commercialized within the next 18 months, are designed to remove nutrients from the water that encourage biofouling. Ir. Koen Meesters, a TNO project manager, says his group is concentrating on recirculating-cooling-water systems and reverse-osmosis membrane filtration systems. Two types of filters will be tested later this year, a biofilter and a physical/chemical filter. With the former, biomass accumulates in the filter and not in the process equipment. With the physical/chemical filter, nutrients are removed by adsorption.

Electronic rods

Instead of using biocides or special filtration systems, engineers at Zeta Corp., Tuscon, AZ, have designed electrodes that electrostatically disperse mineral and organic colloids to control microorganisms. According to Rodrigo F. V. Romo, a chemical engineer and vice president of the firm, this can be a major cost savings over more traditional chemical biocide treatments.

(Romo is the author of an article, "Application of Electrotechnology for Removal and Prevention of Reverse Osmosis Biofouling" that appeared in AIChE's *Environmental Progress*, Summer 1999, pp. 107–112.)

For biofouling to occur, there has to be an initial adhesion stage when the microorganisms and colloidal particles stick to the membrane or other surface. It is at this stage that biofouling prevention should be targeted, Romo says.

The electrode forms the cathode

of a capacitor and a grounded metal pipe or vessel the anode. The electrode prevents scaling by elevating the naturally occurring surface charges of colloidal particles, preventing their nucleation or attachment to wetted surfaces.

The rods expose waterborne particles to an intense electrostatic field. As a result, the particles develop a high surface charge that prevents them from combining to form biofilm or scale and attaching to equipment or piping surfaces. The electrodes can also be used to dislodge existing biofilm and scale, he adds.

Romo says that when membranes are involved, the electrodes can be used in the feed line on the suction side of the high-pressure pumps. In larger capacity systems, additional electrodes are placed between filters. "By reducing cleaning frequency, the rods help extend membrane life, and permit longer production runs."

Applications have included pasteurization equipment and membranes in the processing of beverages. The electrodes also have been used as a pre-treatment to prevent membrane fouling and for cleaning-in-place applications.

In coolants, Romo notes, the electrodes keep bacteria and fungi in a free-floating, exposed state so a lower quantity of biocides is needed. "In cooling towers, evaporative coolers, and evaporative condensing systems," he says, "maintaining total aerobic counts three to four orders of magnitude lower than a system treated with conventional chemical biocides is regularly achieved."

Antimicrobial coating

A new system, developed at Oregon State University, Corvallis, relies on a coating to control biofouling in food processing. It treats the surfaces of process vessels with Nisin, an antimicrobial. According to Dr. Joe McGuire, a chemical engineer and professor of bioengineering at the university, the antimicrobial can be sprayed or dip-coated on surfaces of food processing equipment, including stainless-steel heat-exchanger plates. "The ability of pathogenic and food spoilage microorganisms to adhere to surfaces is widely recognized as as serious problem for food processors. There is a need for antimicrobial surfaces that do not add ingestive toxicity or altered favors to foods contacting them. Nisin reduces microbial attachments and could be used as a preventative measure, after cleaning-in-place is performed in the processing equipment."

The research was funded by the National Research Initiative grants program sponsored by the U.S. Department of Agriculture, and the technology now is said to be ready for transfer to industry.

— Claudia M. Caruana, associate editor

Corn-Based Polymers to Debut

Cargill Dow Polymers, LLC, (CDP) based in Minnetonka, MN, a joint venture of Cargill Inc., Minnetonka, and The Dow Chemical Co., Midland, MI, are commercializing a new family of polymers, tradenamed NatureWorks, that it claims can compete in price and performance with conventional plastics and be used for fibers and plastic packaging. Corn will be used as the initial feedstock because of its low-cost and abundance although research is underway to use other renewable crops such as wheat, sugar beets, and rice, as well as agricultural wastes.

The NatureWorks process allows the company to harvest the carbon that plants remove from air during photosynthesis. The carbon and other elements in these natural sugars are then used to make polylactide (PLA). In the process, dextrose from milled corn is fermented to produce lactic acid, and converted to lactide, which is then polymerized to PLA. Control of the ratio of the lactide's optical isomers allows tailoring of PLA's properties. The resulting PLA is melt-processable and combines the performance advantages of both natural and synthetic materials, claims the firm.

CDP president and CEO Jim Stoppert says, "The process allows us to tap into the natural raw materials contained within plants and create plastic with performance that is equal to or better than those made from non-renewable sources. The polymers can compete head-to-head with traditional fibers." He adds that PLA is a major step toward the development of sustainable products. Waste created from the process is fully compostable in municipal/industrial facilities.

Many attributes

The resins produced from the process can be run on existing fiber spinning and downstream textile fabrication equipment. Processing advantages include high extrusion/spin speeds, reduced processing temperatures, and lower energy consumption. The fibers exhibit a number of attributes that make them competitive for use in industrial and institutional fabrics, including excellent UV resistance and elastic recovery, says the company. The fibers also offer resiliency, reduced flammability with low smoke and heat generation, as well as good soil and stain resistance.

In the packaging and film markets, the polymers have performance characteristics that are similar to, or better than, materials currently available, the company notes. In packaging, the combination of properties, such as high-clarity, stiffness, twist retention, and sealability, creates unique product opportunities, it says.

CDP will spend more than $300 million on the construction of a PLA manufacturing plant in Blair, NE, which is scheduled to go on-stream in late 2001 with an anticipated capacity of 140,000 metric ton/yr. An additional plant is planned for Europe two years later, with other plants likely every 18 months.