Novel process reduces toxic chemical use

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A chemical engineer at The University of Auckland has used environmentally-friendly vegetable oils to replace toxic chemical solvents like kerosene in the extraction of a range of biomolecules, such as antibiotics and organic acids.

Dr Monwar Hossain in the Faculty of Engineering's Department of Chemical and Materials Engineering is conducting research into leading-edge extraction and separation processes which will lead to higher productivity in a wide range of sectors, including the pharmaceutical, food, dairy, biochemical and metals industries.

Dr Hossain's team has successfully extracted biomolecules, such as penicillin G and lactic acid with a process that utilises vegetable oils like sunflower oil to replace toxic and volatile solvents such as kerosene and toluene, the latter derived from coal and wood tar.

The antibiotic penicillin is widely used because of its lack of toxicity and irritancy. Penicillin G is the raw material of semi-synthetic penicillins, with more than 20 countries manufacturing over 11,000 tonnes of it a year.

Lactic acid has a wide range of industrial applications and present global demand is 70,000 tonnes. The demand is expected to shoot up 200,000 tonnes by 2011 because of its recent use as a raw material for ploy lactic acid, a biodegradable and biocompatible polymer.

Dr Hossain says there are some disadvantages with current methods of manufacturing antibiotics like penicillin, and the extraction of other biomolecules, which his process is expected to overcome.

Penicillin is commonly produced by submerged aerobic fermentation and physically extracted at low pH (measure of acidity) from the fermentation broth using butyl acetate or kerosene. Because of the instability of penicillin at low pH, extraction has to be done at low temperatures, but there is still a 10-15 percent loss of product using the current industrial process.

Coupled with relatively low yield, traditional manufacturing methods are costly involving high consumption of butyl acetate and high energy consumption to recover butyl acetate residues from the target substance - a process which requires many stages.

Dr Hossain says although the end product is safe using current technology, after production solvents like toluene and butyl acetate disperse into the atmosphere.

"These solvent vapours are not only bad for the environment, they pose occupational health and safety problems."

Combining the chemical engineering techniques of separation and reaction, Dr. Hossain has developed a process which better selects the target substance and has greater yield, compared to conventional techniques and can be operated semi-continuously.

Dr Hossain's process uses molecules which react with the target substance, binding to them, and uses a membrane to separate them from the feed solution.

"Insertion of a hollow fibre membrane between the host solution and the solvent allows only the target substance to pass through and stops impurities but it slows down the process. To make it faster, we've added 'carrier' molecules to the solvent, which react with the target substance and 'drag' them more quickly across the membrane.

"The carrier molecule can selectively and reversibly react with the solute which increases both the speed of extraction and the selectivity towards the target substance. The result is that we can do this at a desired pH level, and so greatly reduce our decomposition losses."

Dr Hossain is also investigating the use of a natural polymer to encapsulate and preserve the activity of bioactive catalysts, such as enzyme or yeasts, for their long-term use in the processes.

"The advantage of this is that the process using the encapsulated biocatalysts would be rapid compared to fermentation and can be eventually integrated with the hollow-fibre extraction process. This combinational technology is expected to provide an efficient, effective, economic process which is environmentally and operator-friendly."

Source: University of Auckland

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