Δπ=0 REVERSE OSMOSIS ENRICHES A HIGH OSMOTIC PRESSURE SOLUTION FROM A LOW-TITER FERMENTATION BROTH TO A SATURATED SOLUTION OR SALT FORM USING RO AND NF MEMBRANES

Ho Nam Chang, Chemical and Biomolecular Engineering, KAIST, Daejeon 34141, Lab to Market, Seoul 03925, Korea
hnchang@kaist.edu
Kyeong Rok Choi, Chemical and Biomolecular Engineering, KAIST, Daejeon 34141, Korea
Mi Hyang Sun, Lab to Market, Seoul 03925, Korea

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Diverse biotechnology products are produced by microbial or eukaryotic cell fermentations in aqueous solutions. Removal of water is inevitable to enrich the product into a concentrated solution or into solid forms (such as crystals). The theoretical minimum energy required to remove 1 m3 of water is 716 kWh for thermal methods and 1 kWh for reverse osmosis (RO). In practice, the thermal methods equipped with heat energy recycling needs about 25 kWh to remove 1 m3 of water, and the RO methods needs about 4 kWh since extra energy (3 kWh) is required to operate pumps and other facilities in a plant. In general, membrane processes need less energy than thermal processes since there is no phase change in the separation processes and do not damage heat-sensitive biotechnology products. While both RO and NF membranes are permeable to water, RO membrane retains NaCl molecules and NF membrane is permeable to NaCl molecules, which is useful to remove inorganic salts from the products. Unlike thermal processes, the application of the membrane processes is limited by high osmotic pressure as the product solution is enriched by removing water. Chang et al. (2013) proposed a concept of osmotic pressure-free reverse osmosis (Δπ=0 RO) that overcomes this limitation and allows concentration of any solution with high osmotic pressure to its saturation point and further to crystal form. Δπ=0 RO, a two-component system, is distinct from 3-component forward osmosis and does not require the third component (draw component or extraction solvent) that must be separated from the aqueous solution at the end. This presentation will compare (1) ways of Δπ=0 RO technologies in desalination, and, furthermore (2) dewatering and desalination of high osmotic solutions of NaCl (343 bar), volatile fatty acids (400 – 600 bar), and fuel ethanol (6000 bar) with thermal separation methods in terms of energy consumption and potential of Δπ=0 RO technology.

1. Chang et al. (2017), US patent 14,764,975(2015, 07,30), registration in progress