Biosurfactant Foam Separation

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Foam fractionation

Foam Fractionation is an adsorptive bubble separation method, which is used to enrich and partially separate solutions of surface active species. As the sparged gas bubbles rise through the liquid pool surface active molecules adsorb to the liquid gas interfaces. At the top surface of the liquid reservoir foam, which is richer in the adsorbed species than the liquid in the reservoir, is formed which constantly overflows from the top of the system. The overflowing foam is collapsed and enriched liquid known as foamate is obtained.

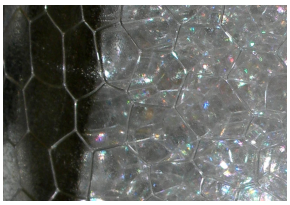


Figure: Foam

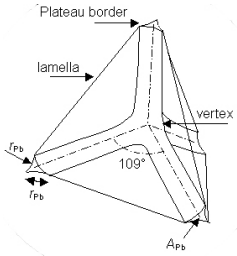


Figure: Structure of a polyhedral gas bubble within a foam

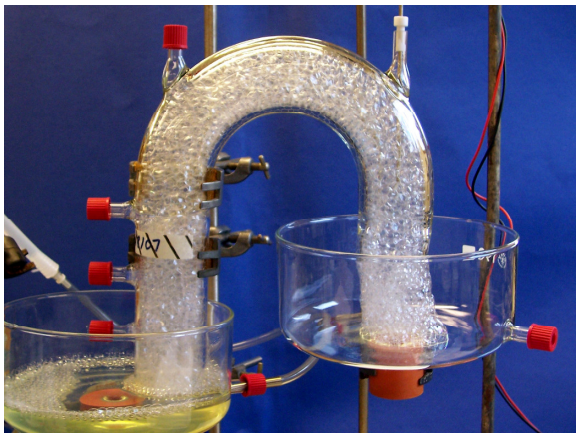


Figure: Experimental apparatus for continuous foam fractionation

Biosurfactant recovery

The use of foam fractionation for the primary recovery of biosurfactant product from cell culture broth can vastly reduce the cost of production as the volume of material requiring downstream separation, such as ultrafiltration, is reduced. The foam fractionation column can be directly integrated into a bioreactor, allowing for in-situ product recovery. This is advantageous as foaming which occurs during the fermentation doesn't have to be suppressed.

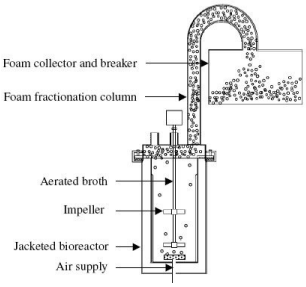


Figure: Direct integration of foam fractionation column and bioreactor

Foam fractionation experiments were carried out to separate the biosurfactant surfactin from cell culture broth. Surfactin is a secondary metabolite of *Bacillus subtilis*. The plot opposite shows that for a continuous process without reflux the concentration of surfactin in the foamate is increased by an order of magnitude.

The figure below shows spun down samples taken from the feed reservoir and the foamate, qualitatively it is observed that while some biomass carryover occurs the biomass concentration is reduced in the foamate. Understanding biomass carryover is critical to both the engineering aspects of the separation and the control of the biological process, avoiding washout of the reactor for instance.

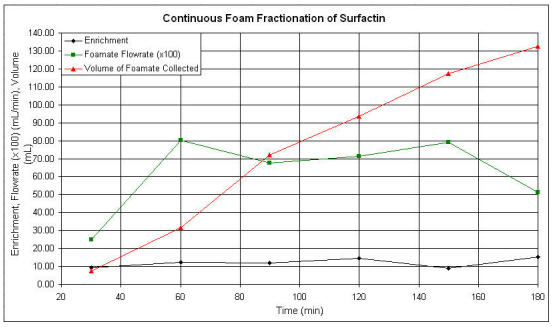


Figure: Variation of surfactin enrichment, foamate flowrate and volume of foamate collected with time

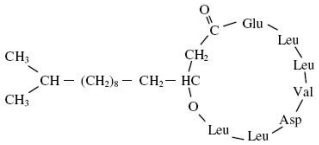
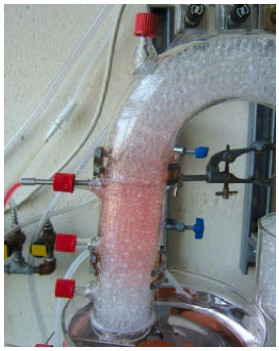


Figure: Primary structure of surfactin

Reflux

Incorporating reflux of foamate increases the enrichment that can be obtained. One important consideration is the transport and dispersion of reflux in the foam column. As the images of tracer injection below show the point at which reflux is introduced has an effect.



Figures: Dispersion of reflux (red tracer) in foam column

Foam breaking

Controlling and effectively collapsing the overflowing foam is a difficult practical task. Various mechanical and chemical methods exist such as rotary breakers and silicone antifoams. However, the use of non-invasive ultrasound foam breaking avoids creating large volumes of stable secondary foam and doesn't require the addition of contaminants to the system.

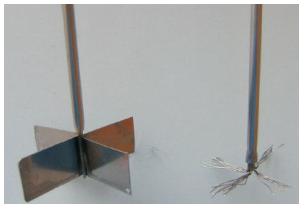


Figure: Rotary foam breakers

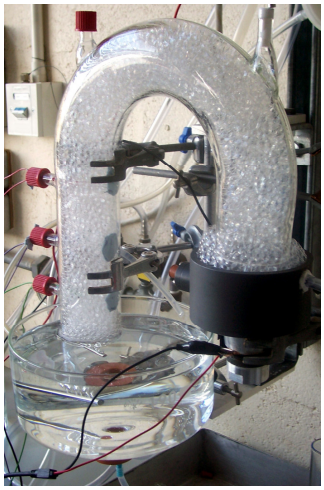


Figure: Ultrasonic foam breaking

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