We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,300

Open access books available

172,000

International authors and editors

190M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Separation of Bovine Serum Albumin (BSA) Protein by Foam Fractionation Technique

Avishek Mandal

Abstract

Foam fractionation is an effective, low-cost, and environmentally friendly method for water treatment that is widely applied to the removal of hazardous materials, organic materials, and metal ions from the wastewater by using the surfactant as a collector. This type of process known as the adsorption bubble separation technique. It uses bubbles as a separation medium and concentrates the surfactant from its aqueous solution by the difference of adsorption properties of the surfactant on gas-liquid interfaces. During the process of foam fractionation, it sparged gas through the bottom of the column to create dispersed rising bubbles. They adsorbed the surfactant onto gas-liquid interfaces of the rising bubbles. We discuss here separate Bovine Serum Albumin from aqueous solution with haemoglobin by foam fraction method. To investigate the effect of the following variables on the enrichment ratio of total protein, the separation process like concentration of feed, the effect of pH, and the Effect of gas flow rate.

Keywords: Concentration of collector, BOVINE SERUM ALBUMIN (BSA), Foam height, Foam density, Foam drainage

1. Introduction

Foam separation, which uses adsorptive bubbles to separate particles, has developed as a viable alternative to conventional separation approaches with ion exchange, chromatography, and precipitation. Foam fractionation is a fast, easy, and efficient method for separating chemical compounds and recovering waste products from aqueous solutions, and it can be used as a pre-concentration method in their analytical determination [1]. The authority takes the waste materials required for reuse in the food industry because of the recycling strategy of various aqueous products. The recovery of whey protein from aqueous products in the food industry is very successful when whey waste is treated as Bovine serum albumin using the foam fractionation technique in batch mode [2]. Its role of pH-induced structural change in interface-induced protein aggregation was investigated using bovine serum albumin (BSA) as a model protein to reduce protein aggregation in foam fractionation. Foam fractionation is a well-known protein purification method that may be useful in the early stages of recombinant and other proteins' downstream production. The process has many benefits, including ease of use, technical simplicity, and hence low cost as opposed to other purification processes. While

much research has been done on particular protein solutions, there's been less done on protein mixtures in order to purify one protein ingredient from a mixture of proteins [1]. In mineral flotation, foam fractionation or adsorptive bubble separation methods have been commonly used. The methods were focused on the surface tension differences between the products to be isolated [3]. This method is also used in the discharge of wastewater. Since organic compounds have a low surface tension and can be enriched at the air-water interface, it is possible to recycle or remove dilute organic compounds found in industrial waste water. Despite the fact that this method has been around since the beginning of the century, more research is needed to further understand the conditioning and viability of proteins and single protein fractions using foam fractionation by concentrating on the most critical process parameters [2]. Solvent sublation is a non-foaming adsorptive bubble procedure that can remove trace amounts of non-volatile and unstable organic materials from wastewater [4]. This approach is also useful for waste water recovery and the elimination of hazardous materials. Solvent sublation has the benefit of achieving better removal efficiencies than bubble fractionation or air stripping. Since the disposal of pharmaceutical unit effluent is a required operation, this method may be used to isolate drugs from waste water released by pharmaceutical industries, thereby reducing harmful pollution.

2. Adsorption bubble separation technique

The term “adsorptive bubble separation technique” was developed by Lemlick et al. who called it the “Adsorption bubble technique.” The disparity in surface behaviour is the basis for this technique [5]. The disparity in surface behaviour is the basis for this technique. Material of various sizes, including molecular, colloidal, and macro particulates, is selectively adsorbed or added at the surface of growing bubbles in the liquid, and thereby accumulated or isolated. A material that is not surface-active will often be rendered surface-active by combining with or adhering to a surface-active collector. Colligend is the name for the material that has been extracted. Foamate is a small amount of collapsed foam that is used to concentrate or separate the material [6]. This makes the adsorption bubble isolation approach applicable to a broader variety of compounds, such as ions, molecules, precipitate, active carbon, nano particle, proteins, and bacteria [6].

3. Characteristics of an adsorptive bubble column

Porous frit creates bubbles on a continuous basis, providing a broad surface region for substance movement from the bulk solution. The bubble diameter is observed to be a high function of the orifice diameter and a weak function of the gas velocity in the orifice at low gas velocity (0.5 cm/sec) [7]. The diameter of a bubble at high gas velocity is determined by the gas flow rate. It's important to note that the presence of an electrolyte in a solution has an effect on the bubble scale. In the presence of electrolytes in the water, smaller bubbles form due to surface tension and the electrostatic potential of the resulting ions at the gas-liquid interface. The size of the bubble is determined by the electrolyte concentration and form. Foam Separation and Non-Foaming Separation are the two major types of adsorptive bubble separation methods. To take away liquid, foam separation necessitates the development of a foam or froth. The separating of products using a non-foaming

process would not necessitate the use of foam [7]. Bubble fractionation and solvent sublation are two subsets of the Non foaming Adsorptive Bubble Separation Process. The movement of fluid inside a liquid by adsorption or addition on the bubble surface, accompanied by deposition of material at the top of the liquid as the bubbles leave, is known as bubble fractionation. Solvent sublation refers to the transition of substance from one miscible liquid to another, or from one miscible liquid to an immiscible liquid mounted on top of the main liquid. Foam fractionation and froth flotation are two different types of foam separation. The foaming off of dissolved content from a solution through adsorption at the bubble surfaces is known as foam fractionation. The removal of particulate material by frothing is known as froth flotation. Based on the material, which can be molecular, colloidal, or microparticulate, froth flotation can be separated into many branches. Mineral extraction from ores using froth flotation in a special situation. Macroscopic particles are separated using macro flotation. The separation of microscopic particles, especially colloid or microorganisms, by foaming is known as micro flotation. Precipitate flotation is the practise of removing a precipitate using a surfactant that is not the precipitating agent. Ion flotation is the isolation of surface inactive ions by foaming with a catcher, which produces an unsolvable liquid, especially whenever the substance is extracted as scum. Molecular flotation, on the other hand, is the isolation of surface inactive molecules by foaming with collectors and resulting in an insoluble substance. Finally, adsorbing colloid flotation is the separation of a solute through adsorption on colloid particles followed by flotation. The following methods can be used to operate the Adsorptive Bubble Separation Process [8]. (a) Simple continuous flow, (b). Simple Batch, (c) Combined enriching and stripping, (d) Continuous flow stripping, (e) Continuous flow enriching by reflux, (f) Staged operation [8].

4. Classification of adsorptive bubble separation method and classification

4.1 Collectors and mechanism of action

When the particles of interest (colligend) do not have surface active properties of their own, they are made effective surface active or collected by adding to the collectors in an adsorptive bubble separation process. Ionic surfactant travels to the surface of gas bubbles increasing through the liquid during ion flotation, and the surface becomes charged [8]. The oppositely charged substance of interest (Colligend) adsorbs to the bubble interface as a counter ion, forming an electrical double layer. Because of the foam's high surface area to liquid volume ratio, the liquid that emerges from its breakdown is much more concentrated in the ion than the original solution. The colligend should be specific for the interface of a charged surfactant. Surfactant molecules have two parts: one is hydrophobic, while the other is hydrophilic. The hydrophilic portion comes outside, while the hydrophobic part stays within. The hydrophilic component was applied to the substance of interest and taken away at the foam bubble interface (**Figure 1**).

Enantiomeric mixtures are separated using chiral collectors. These chiral molecules are known to interact with analytes in a variety of ways, including ligand exchanged interactions, hydrophobic inclusion complexation, and hydrogen-bonding interactions. Colligend must be used as a foaming agent so chiral collectors are not foaming agents. Enantioselectivity can be caused by a disparity in the chiral collector's and two enantiomers' reaction mechanism.

Figure 1.
Classification of adsorptive bubble separation method classification.

5. pH’s impact

Ion flotation is especially vulnerable to some of these parameters because variations in pH have a significant impact on the nature and charge of both collector and colligend. Several researchers mention some part of this dependence; the following are the consequences that can be observed when the pH is changed. Hydrolysis or the forming of other complexes can cause a change in the charge on the colligends. Ionisation of the collector can change; acids and amines, for example, can lose their charge at low and high pH values, respectively. They either stop being collectors or change their collecting mode. If ion flotation is preferred, the colligend can be precipitated as a hydroxide and then extracted by precipitate flotation instead of ion flotation. If ion flotation is desired, a difference in the pH can result in a change in the design of the method. The enhanced ionic strength that occurs when the pH is adjusted to extreme values will suppress flotation. The consistency of the foam that supports the sublata could deteriorate, resulting in re-dispersion.

6. Temperature

When the foam durability of surface-active materials varies with temperature, temperature has been proposed as an operating variable. If the binding of the collector to the mineral surface is due to physical adsorption, surfactant adsorption and hence flotation could be assumed to decrease with an increase in temperature in the case of froth flotation of minerals. If somehow the adsorption is caused by chemical forces between the surfactant and the mineral particles, the result could be the reverse. Temperature, on the other hand, was observed to have no impact in the ion flotation and foam fractionation processes in many cases.

7. Gas flow rate

The removal of dissolved compounds is heavily influenced by the gas flow rate, although steady state removals are unaffected. The distribution or division of

dissolved substances between the gaseous and aqueous phases is needed for their removal. The volume and size of gas bubbles, which increase interfacial space, cause an increase in removal at any given moment, depending on the gas flow rate. Low enrichment, on the other hand, increases as the loss of solution increases with a high gas flow volume. Of course, there must be enough gas flow to sustain the foam height, which is necessary for effective separation. The maximum flow rate, on the other hand, is calculated by the surfactant concentration and the foam's nature.

8. Other auxiliary reagents are present

For better separation, many reagents are successfully used in foam separation techniques. In some situations, the results are due to particulate flocculation or collector activation for increased adsorption. Alum, ferric salts, and organic poly-electrolytes are the most widely used flocculation agents in foam separation. Using these flocculating reagents, for example, improved the removal of phosphate and suspended solids from waste water. Activators that facilitate preferential adsorption of the collector on a specific material are often used in the foam separation process.

9. Surface area of bubbles

Spargo and Pinfold made an assumption, which Lemlich et al. addressed. In the flotation cell, they used a pore diameter of 10 μ for the frit. The smallest diameter of this method was 10 μ diameter, and the overall size was about 40 μ . As the flow rate grew, these values increased as well.

10. Foam height

The isolation of albumin is influenced by the foam height, with the effect being more noticeable near the foam liquid interfaces. The foam stream changed dramatically as the foam height was increased from 3 to 17cms. The amount of the solution taken away in the shape of foam was 24 ml/min at a foam height of 30cms, and 10 ml/min at a foam height of 17cms. Furthermore, it was discovered that increasing the foam height resulted in a slight reduction in the process' productivity. At good operating conditions, the height of the transfer unit (HTU) varies slightly with column length for counter current lengths of 10 to 28cms.

11. Foam density

The density of the foam is critical to the operation's progress. When the foam concentration is too high, the bubbles cannot rise to the surface as a result of the pressure, resulting in no separation. High densities of bubbles are seen when there is a large concentration of molecules in solution as well as a large concentration of collections.

12. Foam drainage

While doing a foam separation, the extract must be condensed to a minimum amount as necessary. Foam drainage is usually accomplished by forcing foam upward across a stretch of extended column diameter. Sweitzer P.A. et al. designed

a foam separating mechanism that allows the foams to migrate almost horizontally. He discussed about how this system is better than the vertical system. To begin with, the vertical portion of gas velocity is reduced to 0, and the distance from which the liquid must drain can be rendered uniform and set at any desired value. Second, laboratory experiments with static foams will estimate the drainage that occurs.

13. Equipment design

One of the most important aspects of this method's performance is its equipment configuration. As currently mentioned, there should be enough foam height to provide dry foam, the width and height of the column should be in a specific proportion for liquid delivery, and the frit pour size should be kept to a minimum to ensure enough bubble surface space.

14. Area of potential use in the pharmaceutical field

Purification of products from a combination of ingredients or isolation of drug components. This process isolation of pharmacological activities from plant sources, such as alkaloid mixture salts, separation from soap, and extraction of active components using the foam fractionation process. Enrichment of plant proteins and foam fractionation of fruit juice enzymes, such as **Bromelain** from pineapple, using an adsorptive foam separation process. Finally, pharmaceutical products are removed from waste water.

15. Experimental procedure

The target concentration range of 3 mg/ml was obtained by weighing and dissolving the necessary amount of crystal BSA in double distilled water and then diluting it properly. The optical density (OD) was then measured with a UV-spectrophotometer at a wavelength of 280 nm. A regular curve was created by plotting the resulting value against concentration. The SDS-PAGE system was used to quantitatively estimate individual components in a protein mixture.

16. Determination of critical micelle concentration (CMC) of BSA

Required quantity of powdered BSA was weighed and dissolved in double distilled water and then suitably diluted to obtain a desired concentration range of 100–800 mcg/ml. The surface tension of those samples was measured by using drop count method, and a plot of Concentration VS Surface tension was constructed (**Figure 2**).

17. Measurement of the gas percentage hold up

Different concentrations of feed are prepared for deciding percentage gas holdup while keeping the same Protein surfactant ratio. As gas went through the column, the percentage gas hold up was determined in a batch of oil. The liquid pool's height was assessed. After turning off the gas supply, the height of the liquid

Figure 2.
Surface tension vs. concentration of bovine serum albumin (BSA).

Figure 3.
Percentage of gas hold up at defferent ci and fixed PSR.

pool was measured once more. The percentage of entrapped gas bubbles in the liquid column was measured and tabulated as percent gas hold up. The percentage gas hold up was plotted against the gas flow rate (GFR). The temperature in the lab was held at 25°C (**Figure 3**).

18. Foam fractionation (batch process)

Initially, feed at a certain concentration was made by diluting stock whey with water to the desired concentration. To achieve the correct Protein Surfactant Ratio (PSR), the necessary amount of Sodium Lauryl Sulphate (SLS) was applied to the feed, which was then allowed to mix evenly with the help of an ultrasonic cleaner. The pH of the feed was then calculated and modified as required by adding

concentrated HCl or concentrated NaOH solution. After that, one liter of feed solution was added to the foam fractionation column, and nitrogen gas was moved through the feed at the required gas flow rate (GFR). An analysis of the percentage of gas hold up' The GFR was held between (100 to 200) cc/min. The frit first creates bubbles, which then rise through the liquid column. When bubbles leave a material, they form foam. Foam was absorbed constantly through the top outlet into a receiver as it moved up the column due to gas velocity. A foam breaker was added to the receiver. For the necessary amount of time, the foam was continuously extracted. The foam was then able to collapse using a stirrer until it broke down into foamate (collapsed foam). The total amount of foamate was weighed, diluted appropriately, and absorbance was recorded. The gas was turned off after the procedure was completed, and the residual liquid in the column was extracted. The volume of the residual liquid was calculated, as well as its concentration. The mass flow rate (MFR) was then calculated using a regression equation derived from a plot of protein volume versus time. Enrichment ratio (ER), separation ratio (SR), and recovery percent (percent RP) were all measured as performance parameters for foam fractionation.

19. Foam fractionation (continuous process)

Feed was prepared by suitable dilution of Bovine Serum Albumin (BSA) to get the desired feed concentration. Required quantity of Sodium Lauryl Sulphate (SLS) was added to the feed to get the desired PSR, it was then allowed to mix uniformly with the help of an ultrasonic cleaner. Then the pH of the feed was measured and adjusted as per requirement. The foam fractionation column was then filled with 1 lit. of feed solution and Nitrogen gas was passed through the feed at desired gas flow rate (GFR). Feed was introduced from outside through an inlet into the column with the help of a peristaltic pump to maintain a constant volumetric flow rate (VFR), and the flowing effluent is constantly collected at intervals through a outlet from other side, the flow rate of the outgoing effluent is same as the incoming feed. Bubbles are formed initially which then rises to the top of the column leading to formation of foam. The foam is continuously collected for required period of time. Foam was then allowed to stir using a stirrer until the foam breaks down to form foam. The effluent was collected in a reservoir, the residual was also collected, then the collected material (effluent) was pumped into the second column, where it acts as feed for the second column. When the work with the first column is finished the gas flow into the first column was stopped and the valve is opened so that the gas now flows into the second column and samples were withdrawn at regular intervals assessed. After steady state was achieved, the effluent showed constant concentration. Whole procedure is repeated again as mentioned above. The volume of foam is measured, sample was suitably diluted and absorbance is noted. The total effluent and residual were collected and absorbance was noted, the total input amount, output amount, loss amount, recovery %, enrichment ratio was also calculated.

20. Results and discussion

Binary protein mixtures were used in batch foam fractionation experiments to assess the enrichment ratio and percentage recovery for various feed concentrations at varying pH of the solutions, liquid pool heights, and air circulation rates. The obtained findings are discussed elaborately. The ratio of the concentration of the

foam (Cp) to the concentration of the feed liquid (Cf) from which the foam was produced is known as the enrichment ratio or separation factor (E).

$$\text{Enrichment ratio (E)} = \frac{\text{Concentration of Foam (Cp)}}{\text{Concentration of the feed solution (Cf)}} \quad (1)$$

$$\text{Percentage removal (P.R\%)} = \frac{\text{Amount of recovered (Cf-Cb)} \times 100}{\text{Amount of metal ions in feed solution (Cf)}}, \quad (2)$$

where Cb is the concentration of metal ion in residual solution.

20.1 Statistical analysis

Each experiment was at least three times repeated. Graph Pad prism 5 was used to do an analysis of variance on the data. The t-test with ($P < 0.05$) was used to determine the difference between mean values.

20.2 The impact of airflow rate

Experiments were carried out with different air flow concentrations at fixed other conditions such as a 30 cm liquid pool height, a feed concentration of 3 mg/mL of Bovine Serum Albumin (BSA) and 2 mg/mL of Haemoglobin, a feed pH of 5.0, a drainage time of 4 minutes, and a foam height of 35 cm. The findings for the impact of air flow rate on enrichment ratio are as follows: The separation factor or enrichment ratio decreased from 2 to 0.568 as the air flow rate rose from 0.3 to 0.8 lpm. Brown et al. verified these findings. The enrichment ratio and percentage elimination increase as the air flow rate is increased from 0.4 to 0.6 lpm at first. However, as the air flow rate increased, the enrichment ratio and percentage elimination decreased. This is because, at low flow speeds, the bubble sizes are greater at first, resulting in more coalescence and drainage. As a result, the enrichment ratio and percentage elimination initially improved. As the air flow rate was increased higher, the foam bubble size declined, and coalescence and drainage reduced. As a result, both the enrichment level and the amount removed decrease.

20.3 Height of the liquid pool impact

Figure 4 shows the effect of liquid pool height on foam concentration and protein enrichment ratio at set other conditions of 0.2 Lpm air flow volume, 3 mg/mL Bovine Serum Albumin (BSA) and 2.0 mg/mL haemoglobin, 5.0 pH of feed, 4 min drainage time, and 35 cm foam height. The enrichment ratio of metal ions improved as the height of the liquid pool increased from 5 to 25 cm, as seen in the **Figure 4**. When the liquid pool's height is greater, the residence time of bubbles in the liquid pool is longer. This results in a higher enrichment of metal ions on the bubble surface, and it may reach a point where enrichment cannot increase much more. This equilibrium is achieved in the current analysis at a pool height of 25 cm.

20.4 Effect of foam height

Figure 5 shows the experimental findings for the effect of foam height on foamate concentration and enrichment ratio. When the foam height is raised from 35 cm, the foam residence time increases, allowing for more liquid draining in the films. As a result, the foam is drier and the enrichment level is higher. The bubble

Figure 4.
Schematic diagram of foam fractionation apparatus operating (batch process).

Figure 5.
Schematic diagram a foam fractionation apparatus operating in continuous mode.

scale was found to be larger at the liquid-foam interface, indicating that the drainage is greater. Dry foams appear at the tip of the foam as the height is raised, indicating that optimum draining has already occurred. As a response, no substantial difference in enrichment ratio was observed above a certain foam height (Figures 6–8).

Figure 6.
Effect of air flow rate on foam concentration and enrichment ratio [liquid pool height = 30 cm, feed concentration = 3 mg/mL of BSA and 2 mg/mL of haemoglobin, pH of the feed 5, drainage time = 4 min, foam height = 35 cm]. Compared to the enrichment ratio of total protein with concentration of BSA in foam concentration, the p-value significantly changed (** $p < 0.05$). As we air flow rate increases so the foam bubble size reaches big resulting in the waste product produce so significantly change observe 0.1 lpm to 0.8 lpm (litre per minute) height increase.

Figure 7.
Effect of liquid pool height on foam concentration and enrichment ratio [air flow rate = 0.2 lpm, feed concentration = 3 mg/mL of BSA and 2 mg/mL of haemoglobin, pH of the feed 5.0, drainage time = 4 min, foam height = 35 cm]. Compared to the enrichment ratio of total protein with concentration of BSA in foam concentration, the p-value significantly changed ($p < 0.05$). As we foam height increase so the foam reaches dry so significantly change observe a 20 cm to 35 cm height increase.

Figure 8. Effect of foam height on foam concentration and enrichment ratio of total proteins [air flow rate = 0.2 Lpm, liquid pool height = 30 cm, feed concentration = 3 mg/mL of BSA and 2 mg/mL of haemoglobin, pH of the feed = 5.0, drainage time = 4 min]. Compared to the enrichment ratio of total protein with concentration of BSA in foam concentration, the *p*-value significantly changed (***p* < 0.05). As we liquid pool height increase so the foam reaches dry so significantly change observe a 5 cm to 30 cm height increase.

20.5 Effect of pH of feed

In **Figure 5** the impact of feed pH on formats concentration and protein enrichment ratio is seen. It can be shown that the highest enrichment ratio is obtained at a pH of 5.0. These were induced by the protein’s increased hydrophobicity at its isoelectric point. Between proteins adsorbed on the air-liquid interface, an electrostatic repulsive force and the Vander Waals attractive force act. The dissociation of amino acid residues causes the surface charge on the protein molecule. Because this electrostatic repulsion between protein molecules adsorbed on the bubble surface is thought to be lowest at the isoelectric point, proteins should be adsorbed more compactly on the bubble surface at that point (**Figure 9**).

20.6 Effect of feed concentration

Impact of haemoglobin and BSA concentrations in feed on foamate concentration and enrichment ratio seen changes. The concentration of haemoglobin in the feed solution was increased from 0.6 to 1.6 mg/L by maintaining the BSA concentration at 3 mg/L, and it was discovered that as the concentration of haemoglobin in the feed solution was increased, its adsorption decreased, but BSA adsorption increased. That’s because the inclusion of haemoglobin in the bulk solution facilitates the adsorption of BSA on the bubble surface. In the presence of haemoglobin, the BSA concentration in the foam is clearly increased. As the feed haemoglobin concentration exceeds 1.5 mg/mL, it ceases adsorbing on the bubble surface entirely. The enrichment ratio and the foam concentration of BSA decrease as the feed concentration of BSA is increased from 2 to 2.9 mg/mL at fixed other conditions of 2 mg/mL of haemoglobin in feed, 0.2 lpm of air flow volume, 30 cm of liquid pool height, 5.0 pH of feed, drainage time of 4 min., and 35 cm of foam height. This may be because the surface tension reduces as the feed concentration

Figure 9.
Effect of pH of feed on foam concentration and enrichment ratio of total protein [air flow rate = 0.2 Lpm, liquid pool height = 30 cm, feed concentration = 3 mg/mL of BSA and 2 mg/mL of haemoglobin, drainage time = 4 min, foam height = 35 cm]. Compared to the enrichment ratio of total protein with concentration of BSA in foam concentration, the *p*-value significantly changed ($***p < 0.05$) from pH 4 to pH 8.

increases. As a result, more stable bubbles form with less coalescence, resulting in decreased drainage. As a result, the wetness of the foam is greater, lowering the enrichment ratio and percentage reduction.

21. Conclusion

The effects of parameters like air flow rate, liquid pool height, feed concentration, pH of the feed, and foam height on the foam concentration and enrichment ratio were studied in experimental studies on batch foam separation of binary proteins such as Bovine serum albumin (BSA) and haemoglobin. The perfect pH for maximal separation was discovered to be 5, perhaps owing to enhanced hydrophobicity of proteins. The amount of BSA adsorbed on the foam increases as the concentration of haemoglobin in the feed increases. This is because the inclusion of haemoglobin in the feed liquid enhances the adsorption of BSA on the bubble surface. At the optimal operating conditions of 0.2 Lpm air flow rate, 30 cm liquid pool height, feed concentration of 3 mg/ml BSA and 2 mg/mL haemoglobin, 5.0 pH of feed, and 35 cm foam height, an enrichment ratio was achieved. As a result, the foam separation technique of pure BSA focused on the foam will successfully separate binary proteins Bovine serum albumin (BSA) and haemoglobin.

IntechOpen

IntechOpen

Author details

Avishek Mandal

Department of Pharmaceutical Technology, Jadavpur University, India

*Address all correspondence to: avishek7477@gmail.com

IntechOpen

© 2021 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

References

- [1] Suzuki. A., Yasuhara. K., Selective Foam Separation of Binary Protein Solution by SDS complexation Method. *Journal of Colloid And Interface Science*, Vol. 253, 2002, P 402-408.
- [2] Martinez Aragon M., Burghoff. S., Goetheer E.L.V., Haan De. A.B., *Separation and Purification Technology* Vol. 65, 2009, P 65-72.
- [3] Zhaoliang Wu, Bo Liang, Bin Hu, Huijie Zheng, Separation of l-lysine by solvent sublation, *Separation and Purification Technology*, Vol. 66, 2009, P 237-241.
- [4] Schugrel K, Recovery of proteins and microorganisms from cultivation media by foam floatation method. *Advanced in Biochemical Engineering/ Biotechnology*, Vol. 68, 2000, P 191-233.
- [5] Wilson, D.J., Clarke, A.N., *Topics in foam flotation: Theory and application*, 1st edition, Dekker: New York, 1983.
- [6] Lemlich, R., *Adsorptive Bubble Separation Technique* Academic Press, New York, 1972.
- [7] J.K. Gehlawat, Design of bubble column reactors, *Indian Chem. Engr. Section A*, Vol. 39, No.1, Jan-Mar, 1997, 3-8.
- [8] The following methods can be used to operate the Adsorptive Bubble Separation Process. Borje Sellergren, Direct drug determination by selective sample enrichment on an imprinted polymer, *Anal. Chem.* 1994, 66, 1578-1582.