Popular Scientific Summary

Getting one step closer to global access to life-saving pharmaceuticals

Biopharmaceuticals are drugs that are produced using living organisms, and are used for the prevention of infectious diseases, as in the case of vaccines, and for the treatment of a broad range of diseases, such as cancer and hereditary disorders, having become an essential part of modern medicine. The drawback is that they are very expensive. For example, the cost of cancer treatment with a biopharmaceutical such as monoclonal antibodies is about $100,000 per patient per year. One way of reducing the cost is to increase the efficiency of the production process.

Speeding up the development of biopharmaceuticals

One of the things we have learnt from the COVID-19 pandemic is that reducing the development time of a biopharmaceutical can save many lives in the case of a global health emergency. In addition, it also reduces the price of the drug as the development of a biopharmaceutical is very costly, and accounts for a significant part of the total production cost. Therefore, developing new processes that allow rapid and straightforward scale-up should be a priority.

Integrated continuous processes for the purification of biopharmaceuticals

Integrated continuous biomanufacturing can be used to speed up the development of biopharmaceuticals and reduce costs, thus improving global access. In an integrated continuous process, all the operations are physically connected to achieve a single continuous flow, unlike the traditional batch processes, where there is no connection between the operations. This approach provides higher productivity, requires less equipment, and offers greater flexibility, and thus a lower production cost and a shorter development time. The purification of biopharmaceuticals is a very important part of the production process, but is very costly. For this reason, several methods of designing, controlling and optimizing integrated continuous processes for the purification of biopharmaceuticals are described in this thesis.

Process modelling, automation, design and optimization

Process modelling was used to predict the process performance based on factors affecting the process, and the information obtained was used to improve process control and design. A continuous process must be automated so that it can work without human intervention. Various methods of controlling and automating the process were thus investigated. The design of the unit operations in an integrated continuous purification process is complex and requires specific approaches that are presented in this thesis. Several examples of ways in which the optimization of

a process can be aided by modelling are also presented, as a means of increasing process efficiency.

These new techniques were successfully tested experimentally on laboratory and pilot scale for the integrated continuous purification of biopharmaceuticals. In all the cases studied, the unit operations in the purification processes were integrated with minimal use of equipment, and the processes were automated and controlled using Orbit, software created in my research group and further developed in this work to allow the application of the complex process sequences that are necessary in an integrated continuous process. The potential of integrated continuous biomanufacturing to reduce production costs and minimize the development time of a biopharmaceutical was demonstrated by the high productivity, high utilization of the equipment and increased automation, allowing the process time to be reduced from days to hours.