Mini Review

Pharmaceutical BIOPROCESSING

The Production of Polysaccharide Nanoparticles Using Microfluidics

Abstract

In the current study, silver nanoparticles that have been proved to be effective antibacterial agents against Escherichia coli are continuously produced using microfluidic reactors and environmentally friendly substances like glucose and flour. Even after 48 months of unprotected storage at 24 °C, the silver nanoparticles created under continuous flow maintained their stability in terms of optical response, shape, and size distribution. When the continuous flow arrangement was employed to complete the reaction in less than 9 minutes, the greatest results in terms of colloidal stability were achieved after synthesising those nanoparticles at 70oC in the presence of an excess of glucose. Comparatively, identical studies conducted under batch settings took a lot longer to complete and produced findings that were significantly less stable and more polydisperse, especially in the range for long-term preservation.

Keywords: Microfluidic • Nanoparticle Production • Polysaccharide Nanoparticles • Hyaluronic Acid • Chitosan • Alginate

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Introduction

The microfluidic technology has emerged as a promising tool to hasten the clinical translation of nanoparticles, and its application impacts a number of factors, including the manufacture of nanoparticles and the in vitro characterization in the microenvironment, simulating in vivo circumstances. This overview addresses the fundamentals of the microfluidic method and how it is used in a variety of contexts, including the production, recovery, and analysis of nanoparticle samples, as well as their in vitro characterization and in vivo use. These include benefits in producing polymeric nanoparticles in a well-controlled, repeatable, and high-throughput way, as well as in-depth explanations of microfluidic technologies frequently utilised for the synthesis of polysaccharide nanoparticles. Although these Nano-particulate systems have garnered interest as drug delivery systems for many years, nothing is known about how to create them using the microfluidic method. This paper analyses the characteristics of the most researched polysaccharide drug carriers, including chitosan, hyaluronic acid, and alginate polymers, and discusses the application of the microfluidic approach for the manufacture of polysaccharide nanoparticles. The evaluation of the most recent studies that have been written about critically enables us to predict that microfluidics will be crucial to the development and application of nanoplatform in clinical settings [1-5].

Microfluidics describes a system that works with tiny channels with sizes ranging from ten to hundreds of micrometres to manipulate small amounts of fluids (10-9 to 10-18 litres). It is an interdisciplinary field that integrates molecular biology, molecular defence, microelectronics, and molecular analysis. It is useful for the design of tiny volume fluid processing systems that enable multiplexing, automation, and high-throughput screening. Beginning in the 1980s, microfluidics was developed and is now employed in the creation of inkjet print heads, DNA chips, lab-on-a-chip technology, micro-thermal technology, and micro-propulsion technology.

Micro often refers to one of the following characteristics:

- Miniature volumes (L, nL, pL, and fL)
- Little size

- a minimal energy footprint
- micro-domain outcomes

Microfluidic systems often move, mix, separate, or process fluids in some other way. Many applications rely on passive fluid control using capillary forces in the form of flow resistors and accelerators that modulate capillary flow. For a directed conveyance of the medium, external actuation methods are also utilised in some applications. Examples include the use of rotary motors to move fluid on passive chips by applying centrifugal forces. Active (micro) components like micro-pumps or micro-valves are used to specifically manipulate the working fluid in active microfluidics. Micro-pumps are used for dosing or to continuously provide fluids. The flow direction or mode of movement of pumped liquids is controlled by micro-valves. On a single chip, procedures typically performed in a lab are frequently miniaturised [5-8].

Discussion

Both the science and the technique of creating microminiaturized devices with chambers and tunnels through which fluids flow or are constrained are known as microfluidics. Microfluidics investigates the behaviour of fluids through micro-channels. In microfluidics, fluid volumes as tiny as femtoliters (fL), or one quadrillionth of a litre, are dealt with. On a micrometric scale, fluids behave quite differently from how they do in daily life; these distinctive characteristics are crucial for new scientific research and inventions. A microfluidic chip is a pattern of moulded or engraved micro-channels. Several holes of various sizes hollowed out through the microfluidic chip connect this network of micro-channels built into it to the macro-environment. Fluids are introduced into and removed from the microfluidic chip via these routes. To achieve multiplexing, automation, and high-throughput systems, fluids are directed, mixed, segregated, or otherwise modified. To achieve the necessary functionalities (lab-on-a-chip, pathogen detection, electrophoresis, DNA analysis, etc.), the micro-channels network design must be carefully elaborated.

The science and technology field of microfluidics focuses on miniature devices that process or manipulate small volumes of fluids (10–9 to 10–18 L) through channels that have sizes between a few tens and hundreds of micrometres. This then-emerging approach could be beneficial in a number of fields, including molecular biology, molecular analysis, biodefence, and microelectronics, according to an intriguing research that was published in Nature in 2006. After twelve years, microfluidics is successfully used in a variety of fields. The laws and procedures that control mixing in a constrained environment serve as the fundamental tenets of the microfluidic technology. As the few examples provided herein demonstrate, they have been researched and commented on by several authors throughout the years. A new work by Capretto and colleagues analyses the method and outlines its tenets. The primary strength of this method is its capacity to convert conventional bulk methods into a 100-m-wide microchannel. For the objectives of synthesis and separation analysis, chemicals are mixed using a pumping technique in this channel. When discussing this method, it should be noted that microfluidic mixing is not subject to the same laws that apply at the macroscale, and that microfluidic devices are not macroscale ones that have been scaled down. From macroscale to microscale, physical properties and diffusion-based mass transport cannot be linearly scaled. The laminar flow that can only be achieved by microfluidic devices is its key characteristic. Viscous forces have a significant part in this phenomenon, which makes it irreversible. In other words, a microfluidic mixer should be made to take advantage of the physical properties of mass and fluid transfer in the micro-confined domain rather than just being a miniature replica of a macro scale mixing device [8-10].

Conclusion

The use of the microfluidic technology to create polysaccharide nanoparticles is currently a hot topic in the field of drug delivery. The synthesis of polysaccharide NPs using the microfluidic technique has not yet received as much attention, despite the fact that many research publications have previously been published on the use of the technique for the manufacture of NPs based on synthetic polymers. After closely analysing the research articles that were presented, it can be concluded that all of the authors concur that microfluidic devices are preferable to conventional procedures in that they provide for better control over the polysaccharide NP synthesis process. As a result, the procedure is more repeatable than the bulk mixing method. Transferring this method to the industrial scale may be hampered by the significant setup costs for microfluidic devices that need to be GMP

approved for commercial scale-up. In terms of the pharmaceutical industry, the microfluidic industrial setup could be utilised for high-value drug products, such as Nano-sized drug delivery systems utilising monoclonal antibodies, or for the repurposing of existing medications with advantageous properties (e.g., cytotoxic medications like doxorubicin, methotrexate, etc.).

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