CHAPTER

5

Recent and advanced nano-technological strategies for COVID-19 vaccine development

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1 Introduction

The coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and is one of the most difficult health crises that humanity has faced in recent years. The pandemic has affected millions of people across the globe causing harm to humans as well as the economies of nations. Several public health strategies such as the use of masks, social distancing, regular washing of hands as well as contact tracing, have been employed since the beginning of the outbreak to curtail the spread of the virus. However, these practices have not been able to completely prevent the widespread of the pandemic (Young, Thone, & Jik, 2021). Despite the tireless efforts of researchers and scientists all over the world, there is as of now, still, no cure for COVID-19, although the United States Food and Drugs Administration (FDA) recently approved the use of remdesivir for treatment, especially in severe cases of viral infection (Campos et al., 2020). The outbreak of the pandemic has stretched the limits of healthcare systems and challenged the management of the situation using conventional tools in the development

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delivery vehicles have been modified to stabilize the vaccine antigens being delivered (Wang, Hu, et al., 2020; Wang, Peng, et al., 2020; Wang, Zhao, et al., 2020).

Despite the benefits that nanotechnology offers in vaccine development, there are also some issues of concern. One of the major problems of nano-based systems is the issue of toxicity. There are several molecular mechanisms of toxicity elicited by nanosystems. Some of these systems have been known to interact with cellular DNA, interrupting important enzyme functions and thus causing harm to the organism. There have also been some reports of these systems generating reactive oxygen species that eventually cause harm to genetic materials or disrupt vital enzyme functions (Pandey et al., 2021). Also, because the process of vaccine development testing and regulation is long, taking about 10–15 years, and the current COVID-19 vaccine candidates have been developed within a space of a year, there are concerns about the safety and long term effects of these formulations (Soleimanpour & Yaghoubi, 2021). The use of a multi-component nano-based vaccine, having complex structural make-up (Bonam et al., 2021) can bring about an increased cost of production as a result of a rigorous process of production. Some reports have also argued that since many nano-vaccines are usually produced in small batches for research, the scale-up of these systems might be challenging. This is because this process is largely plagued by variations in size, shapes as well as other properties (Kim et al., 2014). It is however advocated that self-assemble nano-based vaccine systems be developed to tackle the many challenges of large-scale production protocols. Also, the process of surface modification of nano-carriers for vaccines usually involves a time-consuming, costly and complicated process of purification (Kim et al., 2014).

8 Conclusion and future perspectives

In the absence of an approved cure for the COVID-19, vaccination remains the safest and most effective way of controlling the pandemic. The advent of nanotechnology in vaccine development has sought to ensure safe and effective delivery of antigens as well as improving the immune responses of antigens as suitable adjuvants. Nano-based systems have been known over the years for their uncanny ability to increase biocompatibility, exhibit controlled as well as targeted release profiles, ensure superior drug/antigen encapsulation to mention just a few. These desirable properties have been explored in the development of COVID-19 vaccines. Nano-based strategies have precipitated the development of vaccines at ultra-rapid rates which is of huge importance in a pandemic such as this. Owing to the delicate and ravaging nature of the COVID-19, various considerations are made in the development of suitable vaccines. The structural and sub-structural proteins from the coronavirus SARS-CoV-2 play diverse roles as target sites for vaccine development. Among the four structural proteins, spike protein (S protein) of the coronavirus SARS-CoV-2 is the primary target for most preclinical and clinical researches ongoing in the development of vaccines. Various components of the S protein are exploited as antigens and about 35 out of the 47 vaccine candidates undergoing clinical trials