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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4.4 Virus-like particle vaccines

Hepatitis B and human papillomavirus vaccines are based on this platform. Virus-like vaccines are subunit vaccines that are designed to closely resemble the structure of a virus and can induce robust immune responses to the antigen(s) expressed on their surface; they have good safety profiles since they do not contain the pathogen's genetic material. Virus-like particle (VLP) vaccines make use of the immunogenic and safety property of empty virus particles with multiple copies of the same antigen on their surface. The presence of multiple copies of antigen induces a stronger immune response than a single copy. Virus-like particles are formed when proteins S, M, and E of enveloped coronaviruses, with or without N, are co-expressed in eukaryotic cells (Lokugamage et al., 2008). The viral particle detaches from the eukaryotic producer cells through budding. The VLPs produced are identical in structure to the pathogenic virus but lack a viral genome and are thus non-infectious. When VLPs are administered, they bind to ACE2+ cells through their surface S protein in the same manner as the parent virus (Naskalska et al., 2018). The complexity of the production process of VLPs is a challenge in their development. Also, VLPs require an adjuvant and repeated administration just like subunit and inactivated viral vaccines. Nevertheless, the technology used in the production of VLPs is well established, the biology and safety profile of coronavirus VLPs are understood. Five virus-like particle candidates for SARS-CoV-2 produced are currently in clinical trials as shown in Table 1 (WHO, 2020).

4.5 Vectored vaccines

Vectored vaccines are one of the newer platforms for vaccine development. Vectored vaccines are designed using harmless viruses to deliver the pathogen's genetic materials to recipient host cells to produce antigenic proteins to stimulate immune responses. They are modified versions of different viruses with reduced virulence and replication potential but maintain their capacity to infect human cells. Commonly used vectors which are effective in eliciting strong immune response are adenovirus, measles, and vesicular stomatitis virus (VSV) vectors. Recombinant viral-vectored vaccines are developed as either replicating viral vectored vaccines or non-replicating viral vectored vaccines (Jeyanathan et al., 2020). The non-replicating type is incapable of self-propagation but has the advantage of reduced adverse effects. The replicating type, though attenuated, retains its ability to make new viral particles. Hence they can provide vaccine antigen for a longer time. Consequently, a lower dose of the vaccine may be enough to generate a robust immune response. Conversely, non-replicating vectors should be administered in higher dosages since they are incapable of forming new antigens (Jeyanathan et al., 2020). The replication-deficit viral platforms are mostly based on adenovirus or MVA, and most of these vaccine candidates express the S protein or RBD of SARS-CoV-2. Replication- competent viral vectors are mainly based on VSV. The presence of existing antibodies against the viral backbone in people previously exposed to the