Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

CHAPTER

8

Nanotechnology-based bio-tools and techniques for COVID-19 management

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8.1 Introduction to COVID-19

COVID-19, a most serious issue and the threat for the human life, has affected millions of people worldwide. It was observed as unknown cases of pneumonia in Wuhan, China and claimed unknown till January 10, 2020 and led to the corona virus disease 2019 (COVID-19) therefore worldwide pandemic. The Director-General-WHO declared the outbreak of COVID-19 and constituted a Public Health Emergency of International Concern (PHEIC) on January 30, 2020 with the recommendations of the Emergency Committee. This outbreak originated from Wuhan, China in 2019 named as COVID-19 approached 115 countries, with 119,239 cases of infection spread and 4287 deaths by March 11, 2020.

There were around 4,995,996 confirmed cases of SARS-CoV-2 including 327,821 deaths in 216 countries by May 22, 2020 [1]. Virus belongs to Coronaviridae family, Nidovirales order, and Cornidovirineae suborder. This

Sensing Tools and Techniques for COVID-19: Developments and Challenges in Analysis and Detection of Coronavirus
DOI: https://doi.org/10.1016/B978-0-323-90280-9.00008-0

Coronaviridae classified into Orthocoronavirinae and Letovirinae two subfamilies. Letovirinae have one genera named as Alphaletovirus whereas Coronaviridae have four genera named as αCoV (alpha-coronavirus), βCoV (beta-coronavirus), γCoV (gamma-coronavirus), and δCoV (delta-coronavirus).

COVID-19 virus belongs to the β coronaviridae family, seventh virus of its kind that infected the human being HKU1, 229E, OC43, and NL63 corona viruses mediates the slight cold or common cold. Whereas SARS-CoV, MERS-CoV, and SARS-CoV-2 are life-threatening viruses this may be the responsible cause of death [2]. Research shows coronavirus has 79.5% of its genome with SARS-CoV (severe acute respiratory syndrome coronavirus) 50% with MERS-CoV (Middle East respiratory syndrome coronavirus), and 96% with TG13 (bat coronavirus).

The International Virus Taxonomy Committee (IVTC) gave the formal name to a new coronavirus, SARS-CoV-2 on February 11, 2020 and named as COVID-19 [3]. The most general pathway of respiratory ailment diffusion is airborne droplets, physical contact, and fomites. The physical contact transmission refers to direct transmission and fomites transmission refers to the indirect transmission through intermediate objects. Fever, dry cough, and fatigue are the most generalized symptoms of COVID-19 patients.

Few patients reported conjunctivitis, loss of taste and smell, nasal blocking, pain in muscles and joint pain, painful throat, diarrhea, vomiting and queasiness, chills and dizziness, rashes on skin, and headache also. The severity of COVID-19 generally includes high temperature, constant pain and pressure in the chest, loss of hunger, breathlessness, and confusion in all ages' peoples. Few COVID-19 severe cases were found with nervousness, hopelessness, sleeping disorders, confusion, irritability, and reduced consciousness.

Neurological difficulties such as strokes, inflammation of brain, delirium, and damaging of nerve were present with the severe cases of COVID-19 [1]. COVID-19, a serious threat to life, has affected millions of propels worldwide. It was observed as unknown cases of pneumonia in Wuhan, China and claimed unknown till January 10, 2020 and led to the corona virus disease 2019 (COVID-19) therefore worldwide pandemic. The Director-General-WHO declared the outbreak of COVID-19 and constituted a Public Health Emergency of International Concern (PHEIC) on January 30, 2020 on the recommendations of the Emergency Committee. This outbreak originated from Wuhan, China in 2019 named as COVID-19 approached 115 countries, with 119,239 cases and 4287 deaths by March 11, 2020. There were around 4,995,996 confirmed cases of SARS-CoV-2 including 327,821 deaths in 216 countries by May 22, 2020 [4].

Virus belongs to Coronaviridae family, Nidovirales order, and Cornidovirineae suborder. This Coronaviridae family is further classified into the two subfamilies Letovirinae and Orthocoronavirinae. Letovirinae

have one genera named as Alphaletovirus and Coronaviridae consists of four genera αCoV (alpha-coronavirus), βCoV (beta-coronavirus), γCoV (gamma-coronavirus), and δCoV (delta-coronavirus). COVID-19 virus belongs to the β coronaviridae family, it is the seventh virus of its kind that infected the human HKU1, 229E, OC43 and NL63 corona viruses mediates the slight cold or common cold. Whereas SARS-CoV, MERS-CoV, and SARS-CoV-2 are life-threatening viruses and may cause death [2]. Research shows coronavirus has 79.5% of its genome with SARS-CoV (severe acute respiratory syndrome coronavirus), 50% with MERS-CoV (Middle East respiratory syndrome coronavirus), and 96% with TG13 (bat coronavirus). The International Virus Taxonomy Committee (IVTC) gave the formal name to a new coronavirus, SARS-CoV-2 that is severe acute respiratory syndrome coronavirus-2 on February 11, 2020 and was named as COVID-19 [3].

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8.2 Structure of COVID-19 virus

COVID-19 (SARS-CoV-2) virus structure shows it with single-stranded RNA, enveloped virus covered with high affinity protein glycosylated (S) for angiotensin-converting enzyme-2 receptor (ACE2). SARS-CoV-2 showed 10–20 times more likeness to receptor enzyme AEC-2 in comparison to SARS-CoV. It connects to protein receptor ACE2 of host cell membrane and supports the administration of the virus within the human cell [5]. SARS-CoV-2 composed of nearly 30,000 nucleotides forming a single stranded positive RNA contains 27 proteins, including four structural proteins named as spike and denoted by S, enveloped protein denoted as E, membrane protein denoted as M, and nucleocapsid protein denoted as N. The nucleocapsid protein clutches the RNA, whereas spike

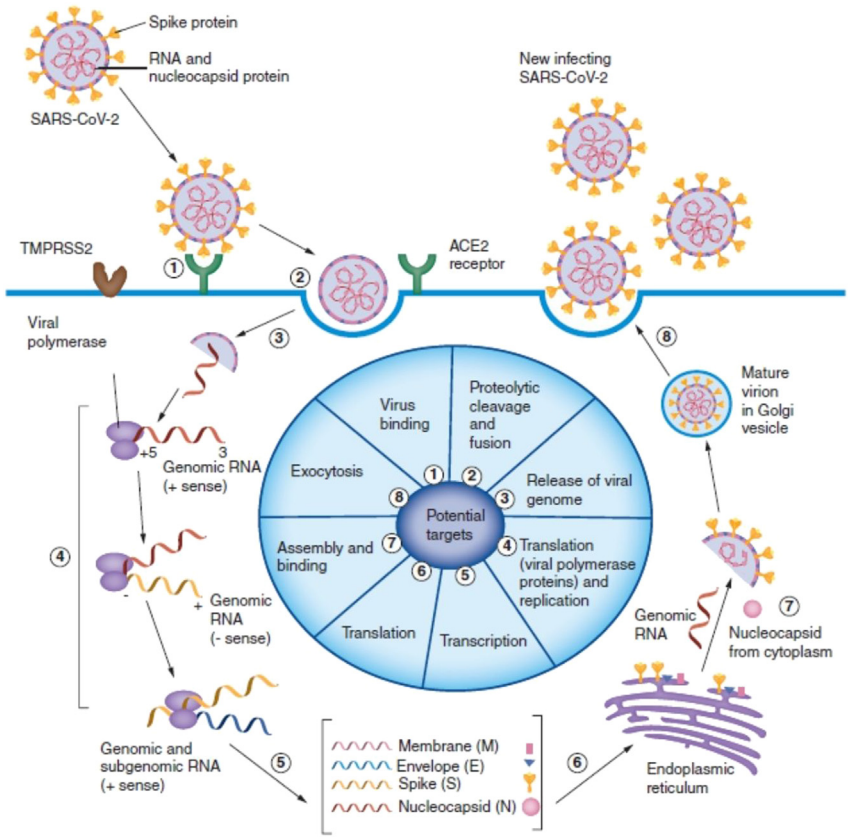

FIGURE 8.1 Targeting by SARS-CoV-2 COVID-19 to host cell Resource [69].

S. enveloped E, and the membrane M protein created the envelope for virus.

Previous studies indicate bat as the possible host for the SARS-CoV-2, and Malayan pangolin as the middle host [3,6–8]. Presence of the type-2 TM serineon on cell membrane promoted the administration of the COVID-19 virus into the host cell membrane with the activation of S protein. Upon entering from the membrane to host cell the virus released its genetic material RNA into the host cell. Further translation take place and translated the polyproteins with the help of genome RNA followed by replication and transcription. Thereafter, synthesis of structural protein, assembling, packaging taken place and particles of the viral released within the host cell [9] as the mechanism of the transmission indicated in Fig. 8.1. Moreover, the presence of ACE2 receptors at most of the organs and cells as endothelial cell, muscular cell and its maximum expression at renal,

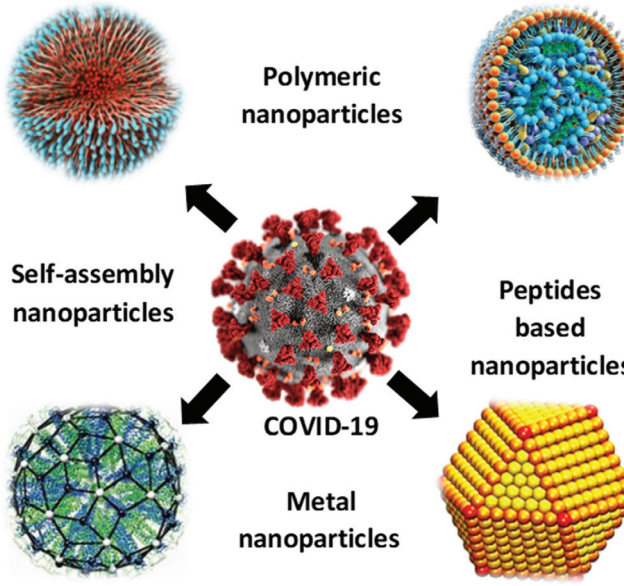

FIGURE 8.2 Nanotechnology as a diagnostic tool for COVID-19.

cardiovascular, and gastrointestinal tissues increases the survival domain and provides larger surface area for the interaction and transmission of SARS-CoV-2 through the membrane into host cell. Therefore, isolation of virus can be done through urine, blood samples, bronchoalveolar lavage fluid, cerebrospinal fluid, sputum, nasal swab, throat and anal swabs, and tracheal aspirates [10–12] (Fig. 8.2).

8.3 Management of COVID-19

The movement and transmission of COVID-19 can be constrained by making mindfulness and taking preventive measures, examples includes face covers, social separating, hand cleanliness, and isolating themselves from affected people [13]. Management strategies of SARS-CoV-2 COVID-19 also required an effective and precise diagnostic, identification, and separation method.

SARS-CoV-2 diagnosis is divided into four categories based on nucleic acid amplification, immunological assay and sequencing methods such as RT-PCR, immunoassay technique based on antibodies IgG or IgM, antigens, and other relevant diagnostic approaches. COVID-19 manifestation can also be verified using chest computed tomography (CT) and magnetic resonance imaging (MRI) [14–16]. There are four primary techniques

for nucleic acid-based diagnostic technologies: real-time RT-qPCR, Digital dPCR, multiplex mPCR, and loop-mediated isothermal amplification method (LAMP); each has advantages and limitations.

RT-qPCR offers a high sensitivity and the ability to quantify absolute and relative values with no communication error. It specifically targets RdRP, envelope, and nucleocapsid genes; the overall reaction time is around 80 minutes. The ORF1ab and nucleocapsid genes are targeted using digital PCR, and the entire reaction time is about 30–60 minutes. It is the most sensitive technique, capable of perfect identification. Multiplex PCR has the capacity to address several targets, primarily spike and nucleocapsid genes, with greater efficiency and takes around 2 hours to accomplish. The LAMP technique specifically targets the ORF1ab and nucleocapsid genes.

It does not require any extensive sample processing or thermal cycler. It takes around 30 minutes for complete analysis [17–23]). Immunological tests include the enzyme-linked immunosorbent assay (ELISA), the fluorescence-labeled immunochromatographic assay (FICA), the colloidal gold immunochromatographic assay (GLCA), and the chemiluminescence immunoassay (CMIA). The ELISA targets IgA, IgG, and IgM antibodies; it is a viable approach that requires no viral contact and produces findings in 1 hour.

GLCA is a quick and easy method that uses IgG and IgM antibodies to get results in 15 minutes. FICA is a very sensitive approach for detecting infection quickly and early. It specifically targets the nucleocapsid protein and produces effects in 10–30 minutes. CMIA is a highly sensitive and fully automated method that detects IgA, IgG, and IgM antibodies and produces findings in 15–40 minutes [24–27].

Sequencing-based detection technologies include the two most often used sequencing methods, mNGS (meta genomics next generation sequencing) and NTS (nonopore third generation sequencing). mNGS focuses on the whole gene sequence, whereas NTS focuses on specific genes such as ORF3a, ORF6, ORF7a, ORF8, ORF10, surface, envelope, and nucleocapsid genes. The study takes around 24 hours and is capable of detecting any portion of the genome as well as diagnosing viral mutations, making it a very sensitive and impartial testing tool [12,28–30].

Over the number of advantages, the high relativity of analysis in RT-qPCR gives false positive results. Efficiency of primers and reactions can also affect the testing outcomes. The expensiveness of dPCR limits its uses, mPCR requires multiple primers and optimization makes the process tedious, the complexity of the sample, primer design, and lack of data limits the usability of LAMP techniques. Moreover, all the above mentioned techniques take half an hour to 2 hours times for the analysis that also limits the uses and demands for high speed, sensitive, less complex, and accurate method [17–23].

Among the many benefits, the high relativity of analysis in RT-qPCR produces false positive findings. The efficiency of primers and reactions might also have an impact on test results. The cost of dPCR restricts its application; mPCR needs numerous primers and optimization, making the procedure time-consuming; and the complexity of the sample, primer design, and lack of data limit the applicability of LAMP methods. Furthermore, all of the above-mentioned approaches need a half-hour to 2-hour analysis time, which restricts the applications and demands for high-speed, sensitive, less complicated, and accurate methods [17–23].

Sequencing-based detection methods have drawbacks in terms of complexity, length of procedure, and length of time [12,28–30]. A few additional methods, such as chest computed tomography (CT) or magnetic resonance imaging, are also available for the diagnosis of COVID-19 (MRI). These imaging modalities are extremely expensive, and early diagnosis is not achievable with CT or MRI.

Overall, diagnostic and detection techniques play an essential role in controlling and managing COVID-19 and allowing health care specialists to focus resources to prevent the spread of infections and lower the death ratio due to COVID-19.

8.4 Nanotechnology: A diagnostic tool for COVID-19

A COVID-19 diagnostic instrument nanotechnology is the creation and deployment of nanoparticles that has enormous promise in many disciplines of research, including materials science, and biological science [31]. Nanotechnology is widely used in medical sciences due to its unique properties such as small size, large surface area, surface adaptability, and enhanced solubility, which aid in the development of safer and more efficient drug candidates, tissue-targeted therapies, personalized medicines, and early diagnostic devices. Despite the fact that nanomedicine techniques are being used to grow antibody transporters, nanotechnology approaches to dealing with generating vaccinations and therapy for the ongoing devastation remain missing. The COVID-19 pandemic necessitates an examination of current nanotechnologies [18,32].

COVID-19 instances are rising all the time, and millions of individuals are already infected, therefore it is critical to create specialized sensors to detect the infection for quick point-of-care (POC) diagnosis, observation, and monitoring of viral illness [33]. In the current situation, efficient, simple, and quick detection approaches for COVID-19 are required.

As a result, quick, sensitive, and exact diagnostic techniques, as well as point-of-care testing, are necessary to combat the COVID-19 epidemic. Nucleic acid-based testing was utilized as an effective detection technique for SARS-CoV-2, with nasal or oral swabs used to determine viral presence

using the real-time PCR method. This testing procedure was discovered to be costly, time-consuming, and labor-intensive.

Because of its tiny size, high surface to volume ratio, adsorption, and high reactivity, nanotechnology can greatly improve the sensitivity of detection methods such as real-time PCR and immunofluorescence tests. By using metal-based nanoparticles such as gold, copper, zinc, and others, nanoparticles can shorten detection time, improve selectivity and specificity, and aid in the detection of low-magnitude signals. Because of their excellent electric characteristics when coupled with antibodies, RNA aptamers, and single-stranded DNA, inorganic nanoparticles have been utilized in the development of a wide range of viral detection instruments [34].

Furthermore, nanoparticles can be utilized to prevent the transmission of viral illness, produce efficient sanitizers, and self-sterilizing personal protective equipment (PPE) such as masks and gloves [35].

The synthesis and separation of nanomaterials using bioengineering ideas in order to create nanoparticles/nano vaccines to combat COVID-19. In general, synthetic biology is involved in the creation of vaccines, the study of genetic sequences, and the development of antiviral medicines for detecting, treating, and preventing the spread of Coronavirus at the community levels [36].

Nanoparticles are also used in the development of Coronavirus detection devices that are supported by digital technologies and integrated with virus testing facilities for accurate and quick diagnosis. Coronaviruses are composed of RNA enclosed in proteins such as envelope proteins, nucleocapsid proteins, and glycoproteins. Nucleocapsid proteins are degraded by UV exposure, alcohol, and surfactant treatment. Nanoparticles, which are used as coatings and protective layers in nanodrugs and vaccines to combat viruses and break their DNA, will likewise degrade the outer layer of spike protein [37–39].

It has been suggested that monoclonal antibodies or vaccinations based on nanotechnology will be a potential technique for rapid diagnosis and successful therapy. Novel nanomaterials can boost the penetration of polymeric nanoparticles in the lung, increasing the efficacy of COVID-19 therapy. In addition, the researchers created stable, nontoxic, biodegradable nanoparticles that may be employed successfully in the lung.

Aside from that, nanotechnology may be utilized to create innovative antiviral medicines, promote the co-delivery of several treatments, lengthen the circulation duration, and release a consistent amount of pharmaceuticals (Figs. 8.3–8.5). Furthermore, it can be utilized for medication targeting and decreases drug-related adverse effects. Furthermore, by shielding mRNA and DNA vaccines from enzymatic breakdown, nanotechnology can be employed as an efficient delivery method [35,40].

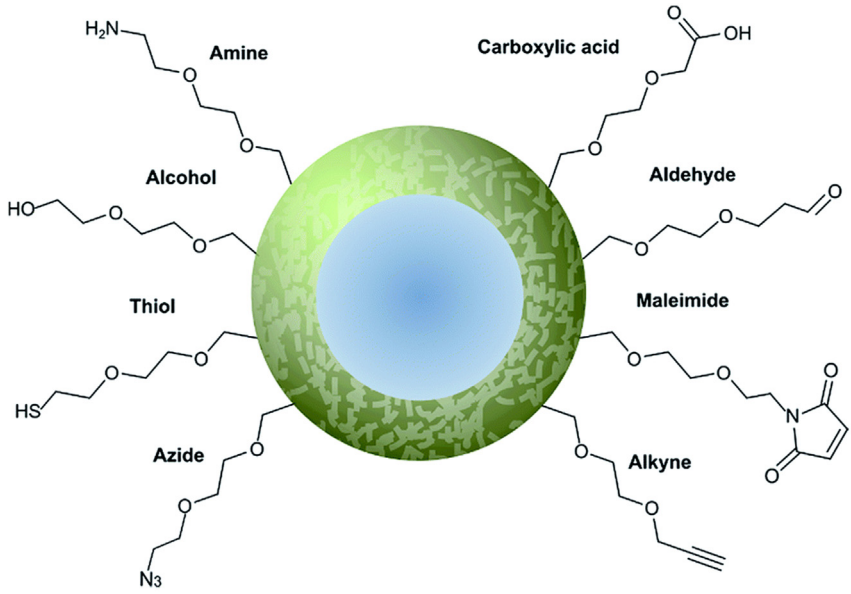

FIGURE 8.3 Representation of functional ligands (amine, carboxylic, aldehyde, maleimide, alkyne, azide, thiol, alcohol, and amine) attached to nanoparticle surfaces.

Anti-COVID-19 agents colloidal polymers composed of nanoparticles, with particle sizes ranging from 10 nm to 100 nm, are extremely efficient as gene carriers. Metal-based nanoparticles can impede viral attachment, replication, and deformation of viral walls and membranes.

Because of their unique characteristics, such as smaller particle sizes, higher surface-volume ratios, and surface charges, nanoparticles are effective tools in viral treatment. Antiviral effects of nanoparticles have been demonstrated against influenza, HIV, and rabies (Jiang et al., 2002). A more cost-effective, faster, and safer type of antiviral therapy has been developed using molecular imprinting with polymeric viral catchers.

Polymers, by sticking to infectious viruses and preventing them from entering cells, inhibit them from replicating and infecting cells. Natural (cyclodextrin, chitosan, and carrageenan) and synthetic polymers such as polyethyleneimine (PEI), poly (dl-lactide-co-glycolide) (PLGA), dendrimers, and metal and metal oxide NPs (silver, copper, titanium, zinc, and gold) have been introduced as effective antiviral agents due to their biodegradability, outstanding biocompatibility, and safety profiles in the human body [41–46]) (Table 8.1).

Cyclodextrins are nontoxic oligosaccharides with cyclic α-D-glucopyranose units of (α-1, 4)-linkage. It can help with formulation development by increasing the solubility of water-insoluble medicines

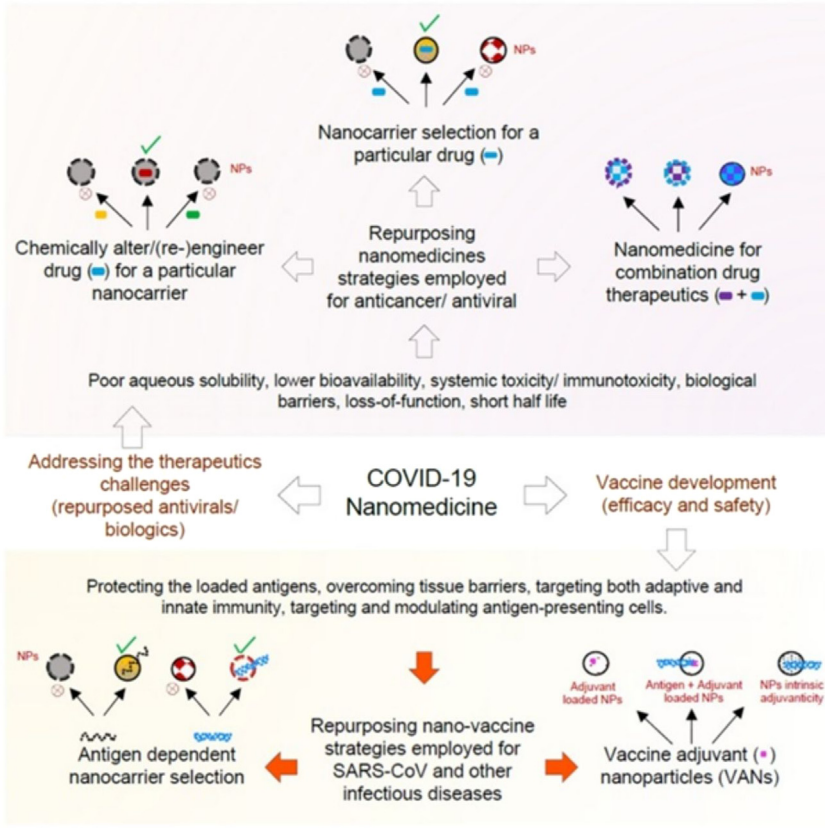

FIGURE 8.4 Nanomedicine approaches for production therapeutics of COVID-19 vaccines [18]. Polymeric-based nanoparticles against COVID-19.

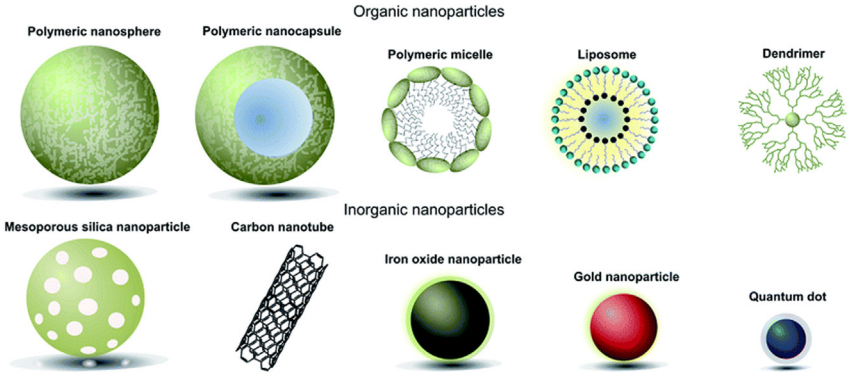

FIGURE 8.5 Representation of different types of nanoparticles used in several biomedical applications.

TABLE 8.1 Nanoparticle drug delivery systems with antiviral properties.

Nanocarriers	Composition	Size (nm)	Loaded molecules
Liposomes	Phospholipids	50–900	Hydrophilic, hydrophobic
Solid lipid nanoparticles	Solid lipid, surfactant	100–500	Hydrophobic
Nanostructured lipid carriers	Solid and liquid lipids, surfactant	100–500	Hydrophobic
Nanoemulsions	Liquid lipid, cosurfactant, surfactant	20–200	Hydrophilic, hydrophobic
Polymer nanoparticles	Polymer crosslinking agent	100–900	Hydrophilic
Cyclodextrins	Cyclic oligosaccharides	5–50	Hydrophilic, hydrophobic
Dendrimers	Oligosaccharides	3–20	Hydrophilic, hydrophobic

by inclusion complexation. The advantages of cyclodextrin complexed medicines include fewer adverse effects, more abundance, higher stability, a less volatile nature, and an enhanced drug release method. Chitosan is a common polysaccharide that is made up of randomly distributed deacetylated and acetylated units of D-glucosamine.

Chitosan, a deacetylated derivative of chitin, a natural polymer found in crab and shrimp shells, is utilized in a variety of our goods. Chitosan has gained popularity because to its antiviral, antibacterial, and anti-inflammatory properties, as well as its biocompatibility, biodegradability, nontoxicity, and high moldability. Researchers looked at the possible applications of chitosan in agriculture, biotechnology, cosmetics, environmental protection, gene therapy, materials science, the food industry, and wastewater treatment [47–49].

Carrageenans (CGNs), which are linear sulfated polysaccharides, are mostly found in marine seaweeds. Natural polymers have an ionic character and an ester sulfate concentration ranging from 15% to 40%. Various molecular weight CGNs polymers have been widely employed in drug discovery and development [50,51]. Dendrimers offer a greater biocompatibility, are less expensive, and provide a carefully regulated large macromolecular surface. One of the most distinctive properties of dendrimers is their ability to typify small size components such as medicines, metals, and imaging moieties that can fit inside their depressions and interact through charge connections, hydrogen holding, and lipophilicity [52].

Poly(lactic-co-glycolic corrosive) (PLGA) and polyethyl glycol (PEG) are FDA-approved polymers that can be used to combat COVID-19.

Furthermore, PLGA can be used in healthcare devices and other drug conveyance applications. A new nanovaccine based on PLGA and DEPE-PEG polymers can deliver subunit viral antigens, STING agonists, and an adjuvant in an infection-like fashion as a safe and effective anti-COVID strategy. The created capsid-like hollow nanostructured polymer exhibited a number of distinct and advantageous characteristics, including reduced systemic reactogenicity, a pH-responsive release profile, and substantial local immune activation. According to the study, this technique allowed the development of safe and efficient vaccinations for combating viral infections [53].

Polyethylenimine (PEI) is a kind of polycationic natural polyamine polymer. PEI is a water-soluble, fanned polymer that is frequently used in vitro and in vivo as a nonviral vector for DNA/RNA transfection and quality control. Covalent restriction of PEG or moieties with PEI was used to improve reliability and decrease poisonousness [54,55].

8.4.1 Self-assembling protein-based nanoparticles (SANPs) against COVID-19

SARS-CoV-2 RBD/spike antigens were developed and optimized for display on self-assembling protein nanoparticles (SApNPs) as possible COVID-19 vaccines. The creation of SApNPs have resulted in the production of a new nanoparticle by protein oligomerization (SANPs). In an animal model, nanoparticles made from protein monomers were able to give full protection against influenza [56].

SANPs have proven a variety of medicinal applications, and their size ranges in the viral size range (20–100 nm) making these particles effective and promising candidates for vaccine development against respiratory viruses such as COVID-19 [57,58]. In animal models, SANPS based on nucleoprotein from the respiratory syncytial virus (RSV) nucleocapsid were discovered to be a promising vaccine antigen, and vaccinated mice were reported to be protected against RSV replication and had reduced viral load in the lungs. Mucosal vaccination with nanovaccines induced both systemic and local immunity, with substantial levels of IgA anti-N, IgG2a and IgG1 antibodies, CD8+, and CD4+ T cells [59]. Furthermore, nanovaccines containing a palivizumab-targeted epitope to the N protein improved immune response against RSV [60].

Virus-like particles (VLPs) are spherical supramolecular assemblies produced by the self-assembly of viral capsid proteins with diameters ranging from 20 to 200 nm. VLPs are supramolecular assemblies with spherical shapes and dimensions ranging from 20 to 200 nm that are formed by the self-assembly of viral capsid proteins. VLPs are thought to be a promising method for vaccine development since they are capable of easily replicating antigenic epitopes despite the fact that they lack genetic components.

Intranasal administration of VLPs induced both humoral and cellular immune responses, and produced vaccines were found to be efficient in reducing viral loads [61–63].

8.4.2 Peptide-based nanoparticles against COVID-19

Peptide-based vaccinations contain peptides in addition to adjuvant mixes, or the peptides can be delivered by a nanocarrier or encoded by nucleic acid corrosive antibody designs. Nanoparticle antibody efficacies can be enhanced and their invulnerable profiles tailored to target specific infections by combining methods for concentrating on lymph hubs (LNs) or cell subsets and subcellular regions. Transformations in the amino corrosive and short peptide inhibitors are predicted to be anti-SARS-CoV apparatuses. Antibodies based on peptides express the C-terminal heptad rehash region, which is an excellent beneficial way for the treatment of SARS-CoV associated contaminations, and this technique is effectively used as peptide-based nanoparticles (PBNPs). Despite advancements in peptide-based COVID-19 vaccinations, industrial and academic initiatives impact expected B- and T-cell epitopes in their subunit antibodies against SARS-CoV-2 [64,65].

Peptide inhibitors derived from angiotensin-converting enzyme 2 (ACE2) are a potential technique for blocking COVID-19 receptor binding domains. For multivalent binding and inhibition of the COVID-19 receptors, peptides should be attached to the surfaces of nanostructured materials. It is possible by employing the PBNPs that have the capacity to neutralize COVID-19 infections. Furthermore, it was proven that by supplying numerous bindings of SPI onto the nanocarriers, the binding effectiveness may be increased [66,67].

8.4.3 Organic/inorganic and metal nanoparticles against COVID-19

Inorganic nanoparticles have a wide range of uses in medicine. Nanoparticles' appealing characteristics, including as biocompatibility, adjustable size, and unique physicochemical properties, make them appropriate for a variety of biomedical applications. The produced nanoparticle must be inert, stable under physiological circumstances, and have a surface that can be readily conjugated to the metal in order to travel freely through the body. The most efficient treatments technique is injecting nanoparticles with encapsulated cargo or magnetic capabilities, and surface targeting ligands assist nanoparticles in delivering to target locations without generating significant harm. Natural and inorganic NPs can be utilized to target the lung in order to counteract the side effects of conventional organization's high serum groupings. Carbon-based NPs, metal oxides

(Fe_2O_3, TiO_2, ZnO_2,) and transition metal NPs (Ag, Cu, Zn) exhibit inherent antipathogenic properties by interfering with at least one viral life-cycle phase.

Natural nanoparticles (NPs) such as liposomes, dendrimers, micelles, and polymers have also been demonstrated to be effective against SARS-CoV-2 (Table 8.2). These particles can be created on their own or in conjunction with inorganic NPs to create a target nanovaccine mixture. Because of their small molecular size, nanovaccine codelivery can also reduce health problems in the lung and respiratory systems ([68]; Shrivastava et al., 2021; [69]).

Nanolabeling can be accomplished by imbuing specific probes with metal nanoparticles such as silver (AgNPs) or gold nanoparticles (AuNPs) or quantum dots, resulting in signal amplification. Because of their regulated intracellular delivery, improved stability, and resistance to degradation, silver nanoparticles (AgNPs) are superior drug carriers for nucleic acid-based delivery. Among inorganic nanoparticles, gold nanoparticles (AuNPs) are suitable for vaccine production because they are easily absorbed by both dendritic cells and macrophages. AuNPs are polymeric NPs and vesicular nanocarriers that depending on their size, shape, and surface science, have the potential to activate cytokine and anti-inflammatory agent responses.

Because of the strong interaction between thiol groups and gold, large-scale synthesis of AuNPs is possible, and they can also be easily functionalized. In addition, because inert carriers, such as AuNPs, do not elicit an immune response, they have emerged as a platform for the development of nanovaccines via antigen fictionalization [15,63,70–73] (Fig. 8.5).

8.5 Conclusions and future perspective

Novel technologies and developments in nanoscience can be utilized to diagnose and cure viral respiratory infections. Because of their unique size, shape, surface area, and capacity to functionalize, nanoparticle therapeutic methods can overcome the limits of traditional vaccinations, resulting in immunogenicity and increased antigen presentation. Novel nanoparticles exhibited simple penetration, biodegradability, and toxicity. Furthermore, nanotechnology has enabled the creation of a number of biosensors, nanovaccines, and antiviral composites against SARS-CoV2.

Polymeric nanoparticles are safe to use, while inorganic nanoparticles based on gold, silver, copper, and zinc are among the finest prospects for use against viral illness and other medicinal uses. Furthermore, the protein-isolated peptide inhibitor inhibits SARS-CoV-2 because its binding effectiveness enhanced with repeated binding of nanocarrier linked peptides. However, the toxicity of Nanoparticles should be carefully studied

TABLE 8.2 Application of nanoparticles for prevention and detection COVID-19.

S.N.	Name of product/manufacturer	Type of nanoparticles	Function
1	Nano Silver sanitizer/SHEPROS	Silver nanoparticle	Hand sanitizer (kills 99% of germs and bacteria)
2	Silvo clean spray/Weinnovate biosolutions	Silver nanoparticle	Sanitizer and disinfectant
3	NanoSepti/NanoTouch Materials, LLC	Mineral nanocrystal	Surface disinfectant
4	TeqAir 200 air ionizer/TEQOYA	–	Air purifier
5	AAVI Leaf/AAVI Technologies Co.	–	Air purifier
6	Mack Antonoff HVAC/Mack Antonoff HVAC	–	Air purifier
7	Air Decontamination Units/Genano Ltd.	–	Air purifier
8	Graphene mask/Flextrapower, Inc.	Graphene nanomaterial	Virus protective respiratory mask
9	Guardian G-Volt (LIGC Applications Ltd)	Graphene nanomaterial	Virus protective respiratory mask
10	G + Fibrics/Directa Plus PLC	Graphene nanomaterial	Antiviral fabric is used in the production of masks, gloves and gowns
11	Antiviral fabrics/Promethean Particles Ltd	Copper nanoparticle	PPE (personal protective equipment)
12	MVX Nano Mask/MVX Prime Ltd.	–	Self-sanitizing surgical mask kills 99.9% of all viruses and bacteria
12	ReSpimask VK/RESPILON	Copper oxide nanoparticles	Face mask with a 99.9% filtration efficiency for viruses
13	Nanofiber mask/YAMASHIN-FILTER CORP.	Nanofibers made from synthetic polymers	Respiratory protective mask
14	NANOHACK (Copper 3D Antibacterial Innovations)	Copper oxide nanoparticles	Protective respiratory mask

(*continued on next page*)

TABLE 8.2 Application of nanoparticles for prevention and detection COVID-19—cont'd

S.N.	Name of product/manufacturer	Type of nanoparticles	Function
15	COVID-19 Rapid POC CE-IVD Test/NanoComposix	Gold nanoparticles	Detection kit used in point-of-care tests
16	COVID-19 Rapid Test Cassette/SureScreen Diagnostics Ltd	Gold nanoparticles	Detection kit
17	COVID-19 point-of-need diagnostic test/Mologic Ltd	Gold nanoparticles	Detection kit
18	SAFER-sample Kit/Lucence Diagnostics Pte Ltd	–	Sample collection kit (stabilizes viral RNA at room temperature for 1 week)
19	Lateral flow/Sona Nanotech, Inc.	Gold nanorod	Detection kit
20	mRNA-1273	Lipid nanoparticle	RNA vaccine; act as mRNA carrier for safe and efficient transport in vivo
21	NVX-CoV2373	Virus-like nanoparticle	Protein subunit vaccine; Thermostable and has a higher binding affinity for human ACE2 receptor and neutralizes virus infection
22	BNT162	Lipid nanoparticle	mRNA vaccine; acts as mRNA carrier for safe and efficient transport in vivo
23	ARCT-021	Lipid nanoparticle	RNA vaccine; acts as mRNA carrier for safe and efficient transport in vivo
24	ChulaCov19	Novel lipid nanoparticles	RNA vaccine; acts as mRNA carrier for safe and efficient transport in vivo
25	CVnCoV mRNA vaccine	Lipid nanoparticles	Acts as mRNA carrier for safe and efficient transport in vivo

and managed when creating Nanoparticle-based treatments for respiratory illnesses.

Furthermore, knowing the molecular processes of COVID-19, as well as a full understanding of viral transmission, is still necessary to deal with the COVID-19. Many nanovaccines have already been repurposed to treat the new SARS-CoV-2 disease, demonstrating the promise of nanotechnology. Furthermore, research should concentrate on the development of efficient models for assessing the toxicity profile of these nanovaccines, their in vitro and in vivo efficacy, and large-scale commercial production.

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Non-Print Items

Abstract

COVID-19, a most serious issue and the threat for the human life, has affected millions of people worldwide. It was observed as unknown cases of pneumonia in Wuhan, China and claimed unknown till January 10, 2020 and led to the corona virus disease 2019 (COVID-19) therefore worldwide pandemic. The Director-General-WHO declared the outbreak of COVID-19 and constituted a Public Health Emergency of International Concern (PHEIC) on January 30, 2020 with the recommendations of the Emergency Committee. This outbreak originated from Wuhan, China in 2019 named as COVID-19 approached 115 countries, with 119,239 cases of infection spread and 4287 deaths by March 11, 2020.

Keywords

COVID-19; SARS-CoV-2; Nanotechnology; Coronavirus