Molecular Sciences

Short Communication

Advanced Nanomaterials and Nano-Optics Based Platform to Expose The Interaction Between Coronavirus and Living Cell: Molecular Phenomenon of Physiology Alterations

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Abstract

Advanced nanomaterials and nano-optics-based platforms can perform at the nanoscale and have already been applied as a promising strategy in various investigations. At the nanoscale, these cutting-edge nanotechnologies, devices, and nanotools have already been applied for trapping, tracking, and tackling individual particles of viruses similar to severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) accurately. Moreover, the nano-optics-based platform and nano-tweezers can be applied for exposing the interaction between coronavirus and living cells and the characterization of various materials in three dimensions with high flexibility, precision, and integration. Perfectly focused lasers act as "optical tweezers" and can be used to elucidate the interaction between coronaviruses and living cells and study the properties of individual viruses and cells in real-time for diagnosis and treatment.

Introduction

Advanced nanomaterials and nano-optics-based platform technologies can be applied to detect the changes (mechanical, chemical, and physiological) that occurred during the aforesaid interaction [1]. Hence, nano-optics-based platforms and nano-optical tweezers can elucidate virus-bio interface, chemical transformations, and molecular phenomena of physiology alterations and, therefore, can be applied for detecting cellular perturbations, modeling of mechanical forces, cell shrinkage, and cytoskeletal pathologies, and interpretation and exploration of conformational changes and biotic-abiotic interfaces [2]. A nano-optics-based platform can grab single molecules and measure events that are occurring, employed for measuring forces and measuring distances with high resolution by forwarding scattered light. The other important aspects of the grabbing phenomenon are that it displaces or releases a particle that can be controlled and governed according to needs. A miniature and modular system is applied for optical grabbing by generating a force that depends on the light intensity gradient in nano-optics-based platforms and nano-optical tweezers [3]. Overall, these nanotools and devices can detect the forces that initiate the interface and can be used for a proper illustration of cell and virus interaction [4]. The nanotechnology-derived tools will suitably assimilate multimodal exploration with high throughput [5]. Here, a dual-mode electrical and optical single-nanoparticle sensing device has the capabilities and techniques that can be applied individually for detecting changes that occurred during the contact between the SARS-CoV-2 and living cells. Optical tweezers and nano-optics-based platforms can be directly applied to detect these nanoscale changes and alterations when SARS-CoV-2 touches the cell membrane and disturbs its normal functioning [6]. For example, optical tweezers can perform without overheating or damaging the specimen, which is why they are useful in biology and quantum optics.

Materials and Methods, Results, Discussion

FNano-optics-based platforms and optical trapping-based technologies are utilized for trapping, tracking, and tackling particles, molecules, and biological identities, i.e., viruses, living cells, and cell organelles [7]. Here, optical forces will be applied to control the overall phenomenon of the virus being grabbed by the beam. Advanced nanomaterials and nano-optics-based platforms can isolate viruses at the single-molecule level and detect molecular events, cellular perturbations, modeling of mechanical forces, cell shrinkage, and cytoskeletal pathologies that are going on at the virus-bio interface [8]. The nano-

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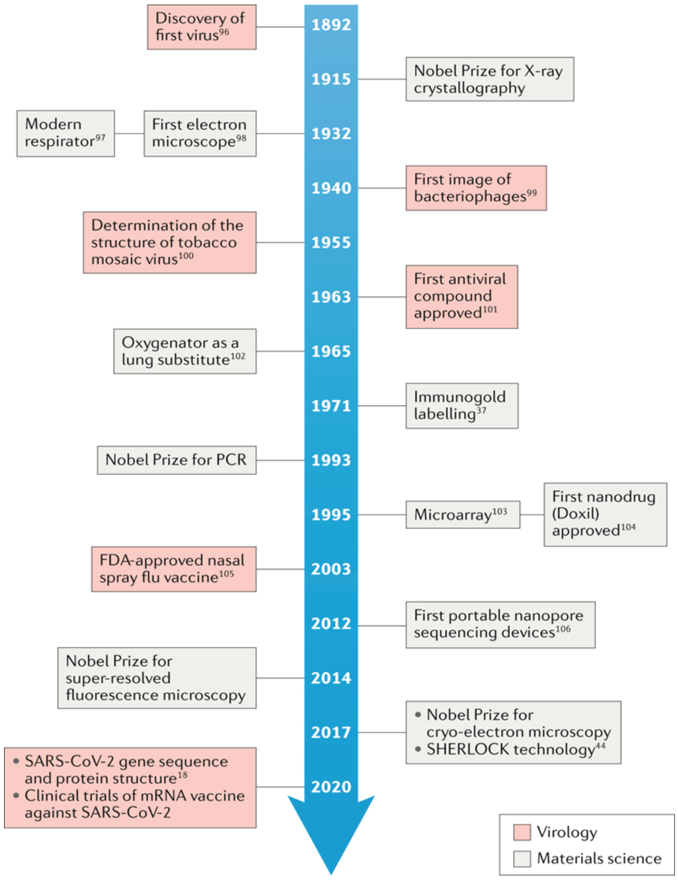

Figure 1. Timeline of the major contributions made by materials science to the field of virology. Reprinted with permission from reference. [29]

optics-based platform can identify chemical transformations and molecular phenomena of physiology alterations. Advanced nanomaterials and nano-optics-based tools can detect conformational changes occurring at biotic-abiotic interfaces [9]. The advanced nanotechnology, nano-optics-based platform, and optical tweezers can measure the space- and time-dependent rheological features and microrheology dimensions of single molecules (Figure 1). The nano-optics-based platform and optical trapping technologies can probe the nonlinear viscoelastic response related to heterogeneous, nonequilibrium materials, non-continuum mechanics, force relaxation dynamics, nonlinear strain-field heterogeneities, mechanical responses, stress propagation, and time-dependent mechanics of active nanomaterials [7]. In this research proposal, the authors will expose the role of advanced nanomaterials and nano-optics-based platforms and explain the basic principles underlying optical tweezers microrheology and how these aforementioned can be applied as a key tool to elucidate the interaction between coronavirus and living cells, as they have already been successfully applied for trapping, tracking, and tackling SARS-CoV-2 [10]. Moreover, the computational tool will be applied for measuring the signal-persisted virus in the particle tracking route with a sensor-engaged nano-optics-based platform [11]. These calculations will display the path of the tracking signals observed for different particles and consider a shot-noise limit for highlighting the position of the sensitivity as a function. The displacement of particles from the trap center will be measured in proportion to the applied force. Hence, the quantum-enhanced particle tracking will be done to overcome the fixed limit, and therefore, it will likely play a key role in these biophysical try-outs [12]. An optical arrangement is proficient for engendering stereoscopic imaginings to trap nanoscale particles in three dimensions. Our research team will apply quantum-enriched sensitivity to upgrade the phenomenon of nano-optic platforms and advanced materials for better particle and viral grabbing, and the same will be revealed during the investigation of this proposal.

In detail, the biophysical experiments are interrelated with optical power limitations, which, therefore, edge the out-and-out sensitivity, which is characteristically feasible. This technique fructifies into wider applicability in the study of Brownian motion in optomechanics; besides that, it also has a solid and significant footing in sub-cellular biology. The illustration of biophysics will reveal the dynamics and magnitude of the forces applied by biological motors and the flexible properties of DNA and RNA through nano-optics-based platforms and optical detection tools [13]. The dynamics of virus-host coupling will be exposed by reviewing the intrinsic mechanical activity directly. A strong research impetus will support the techniques for the elucidation of the interaction between coronavirus and living cells, and therefore, the researchers of our team will tackle the matter at the nanoscale for innovating chip-scale devices. By this way, we can generate energy-efficient nano-optic platforms and optical grabbing technologies compared to contemporary microscope-based optical tweezers. Earlier, it was examined that these approaches were applied to entrap particles on the micron scale (i.e., bacteria and cells) [14]. The onus is now to work on sub-micron and nanoscale objects such as nanobeads and DNA strands, which require tethering them to larger beads and high values of input power, which can damage the surface properties and the activity of the grabbed objects [15]. The research thrust of our team is, therefore, focused on the development of detecting devices, nano-optics-based platforms, and other optical grabbing technologies that can overcome these limitations and do living matter manipulation with high efficiency. These nanoscale tools and devices will function at low power levels to enable the trapping and manipulation of nanoparticles smaller than 100 nm, which is essential for life science research. For example, nano-optics-based platforms and nanophotonic tweezers will be applied to detect various molecular interactions [1], cellular perturbations, modeling of mechanical forces, cell shrinkage, and cytoskeletal pathologies because they can handle molecules from tens to thousands of nanometers in diameter [16]. The detection of individual nanoscale particles and SARS-CoV-2 for the analysis of interaction between coronavirus and living cells has significantly enhanced the possibilities for understanding fundamental biological components, such as molecular diagnostics, that are rapidly becoming relevant to various applications in the emerging field of biological and chemical characterization [17]. The nanotools and nano-optics-based platform will have an optofluidic chip that will provide space for entry to control the delivery of individual nanoparticles and a virus in an optical excitation region for ensemble-free optical analysis rapidly [18]. The tactics of detecting virus-bio interfaces, nanoinformatics strategies, chemical transformations, molecular phenomena of physiology alterations, interpretation, exploration of conformational changes, biotic-abiotic interfaces, and tackling the manipulation of individual nanoscale particles and SARS-CoV-2 are in demand and can also be applied for the architecture of varieties of materials and geometries. A virus propagates by channelling genetic material that may vary from cell to cell during thermal excitement at the nanoscale. Viruses displayed resourceful passive and active approaches during the release of nucleic acids and affected the dynamic behavior of viruses. Advanced nanomaterials and nano-optics-based platforms can detect different types of biostructures, such as viruses and bacteria [19]. These targeted detection methodologies can detect biostructures, nanoscale objects, chemical surface modification of nanoplatforms, and tuning of nano-optical properties. Moreover, the nano-optics-based platform and nano-optical tweezers can be used to discover biological variability and bio-detections [20]. Furthermore, an analytic expression can be used to quantitatively define the phenomenon that occurred during the interaction of the particles. The nano-optics-based platform and optical trapping-based technologies can detect virus-specific RNA sequences by attaching the virus' RNA to a fluorescent molecule. Antibody-antigen interactions involved in coronavirus (COVID-19) detection will also be tested. Simultaneously, a scientific approach for detecting non-covalent interactions for higher-sized biostructure exposure can be implemented based on bioimaging generation and optical signaling modifications [16].

Lab-on-particles and functional nanoparticles were revealed and can be tuned as a technology for bio-detection (apoptosis, cell cleaning, proteostasis, proteolysis, signaling pathways of cell machinery, cellular perturbations, modeling of mechanical forces, cell shrinkage, and cytoskeletal pathologies) [10]. These innovative tactics may be applied to develop targeted nanoplatforms that can be used for light delivery applications. A fine analysis of the assembly pathways of the viruses will lead to the success of the theme. The undiscovered pathways and processes of particle nucleation, particle growth, and the mode of genome compaction will be exposed by the use of nano-optics-based platforms and optical tweezers [21]. The discovery of real-time assembly through nano-optics-based platforms and optical tweezers by tracing the processes of elucidation of viral nucleation and growth principles will open new ventures for a fundamental understanding of assembly pathways naturally evolved in viruses. A precise optical wavelength can tackle individual viruses, and the same was witnessed by observing the changes in volumes of a few cubic micrometers. Nano-optics-based platforms and nanotweezers can orient arrays of viruses optically by restricting noticeable damage. These manipulations were performed with a high level of precision [22]. Not only were these techniques applied for grabbing a single vision, but also the received outputs were further used to calculate the refractive index of the virion. With the help of the aforementioned tools, the three-dimensional optical illustration method generates multiple beams to facilitate advanced, altered geometries. These tactics are highlighted as an efficient method that is capable of doing multiple grabs by enabling fast and accurate 3D force. The nano-optics-based platform and plasmonic optical tweezers can grab microscopic objects without tempting, without making undesired changes, or without initiating any cellular perturbations, cell shrinkage, or cytoskeletal pathologies in the assembly [3]. Therefore, three-dimensional (3D) micro/nano-manipulation is a significant innovation and has recently been applied in biology and nanotechnology [23]. These advanced tools are also used for revealing the distance of multiple objects simultaneously and have technology like multiple-beam optical tweezers that can manipulate objects [24]. These innovative methods are implemented in many fields of physics and biology for the manipulation and grabbing of the structure and dynamics of nano- and mesoscale objects by exerting micro-scale force on biological samples in three dimensions. Three-dimensional scattering and interferometric imaging were used to measure the spatial interaction potentials of nanoobjects. This proof of concept demonstrates the mechanism and empowers users to do 3D manipulation according to their applications [25].

Conclusions

Nano-optics-based platforms and optical trapping-based technologies will be applied in the fields of biology, nanotechnology, chemistry, biochemistry, and physics for various investigations and will play a major role in innovation [26]. These discoveries will have an impact on bioengineering and nanoscience, for example, by making attempts to control the organization of cells during the interaction between coronavirus and living cells and by exploring molecular phenomena of physiology alterations [7]. Moreover, the nano-optics-based platform and optical trapping tools are used for grabbing large numbers of particles, holding particles, atoms, molecules, and even bacteria and other living cells too. Optical lasers deal with these complicated tasks without damaging nanoscale objects, so they can be recommended in pharmaceutical research. The experimental configurations and derived physical parameters concerned with nano-optics-based platforms and optical tweezers that are based on powerful lasers will be employed soon while dealing with a single molecule for generating small forces that are pulling and holding nano- and microscale objects such as strands of DNA, viruses, and enzymes at the time of investigations [27]. These tackling strategies will nourish the phenomenon that will be applied for the exploration and grabbing of a virus to explore its significance in the fields of nanotechnology, biophysics, and biomechanics [28]. The researcher of the team hopes that this international collaborative project will add novel findings and new innovations in the fields of virus-bio interface, computational nanotechnologies-interface, nanoinformatics strategies, nanotopographical tools, and nanodevices; chemical transformations; molecular phenomenon of physiology alterations; interpretation and exploration of conformational changes; and biotic-abiotic interfaces that occurred during the interaction of coronavirus with cells. The elucidation of coronavirus impact on a single cell is an emergency requirement in the current pandemic, particularly due to the unavailability of suitable therapeutic drugs for COVID-19. These combined efforts will add new discoveries to science and will be applied to different applications in the medical field and other areas worldwide. Therefore, the authors proposed this project by covering recent advances in research on the interaction of the virus with single cells using nano-optical tweezers to expose mechanical, chemical, and physiological alterations.

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Author contributions

Rajiv Kumar supervised and wrote this review article. Prof. Svetlana von Gratowski suggested the revisions in the manuscript, updated the required corrections, and in the end, approved the manuscript.

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Conflict of interest

The authors declare no conflict of interest, financial or otherwise.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

Due to the nature of the research, [ethical, legal/commercial] supporting data is not applicable and thus not available.

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