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Development of integrated microfluidic platform coupled with Surface-enhanced Raman Spectroscopy for diagnosis of COVID-19

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Abstract

Corona Virus Disease 19 (COVID-19) pandemic has created an alarming situation across the globe. Varieties of diagnostic protocols are being developed for the diagnosis of COVID-19. Many of these diagnostic protocols however, have limitations such as for example unacceptable no of false-positive and false-negative cases, particularly during the early stages of infection. At present, the real-time (quantitative) reverse transcriptase-polymerase chain reaction (RT-PCR) is considered the gold standard for COVID-19 diagnosis. However, RT-PCR based tests are complex, expensive, time consuming and involve pre-processing of samples. A swift, sensitive, inexpensive protocol for mass screening is urgently needed to contain this pandemic. There is urgent need to harness new powerful technologies for accurate detection not only of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) but also combating the emergence of pandemics of new viruses as well. To overcome the current challenges, the authors propose a diagnostic protocol based on Surface-enhanced Raman Spectroscopy (SERS) coupled with microfluidic devices containing integrated microchannels functionalized either with vertically aligned Au/Ag coated carbon nanotubes or with disposable electrospun micro/nano-filter membranes. These devices have the potential to successfully trap viruses from diverse biological fluids/secretions including saliva, nasopharyngeal, tear etc. These can thus enrich the viral titre and enable accurate identification of the viruses from their respective Raman signatures. If the device is successfully developed and proven to detect target viruses, it would facilitate rapid screening of symptomatic as well as asymptomatic individuals of COVID-19. This would be a valuable diagnostic tool not only for mass screening of current COVID-19 pandemic but also in viral pandemic outbreaks of future.

Section snippets

Background of hypothesis

Rapid spread of the COVID-19 pandemic has created alarming situation all over the world. Originating in China, it has rapidly spread like a wild fire all over the world, thus ravaging the healthcare systems and economies of several countries. This pandemic has far reaching consequences even beyond its physical spread as it has severely dented global economic structure. This unprecedented situation underscores the urgent need for novel rapid diagnostic protocols that could be used to screen…

Statement to hypothesis

The authors of the collaborative study propose a diagnostic tool based on SERS coupled with microfluidic devices containing integrated microchannels functionalized either with disposable electrospun micro/nano-filter membranes or with vertically aligned Au/Ag coated carbon nanotubes for the detection of SARS-CoV-2.

SERS is a very selective and highly sensitive technique which can be employed in pathogen identification. SERS enhances the Raman effect, using plasmonic properties of metallic…

Proposed prototype

The two following proposed models are based on the unique concept of SERS coupled with microfluidic device for the detection of COVID-19 from biological fluids.…

Application of Raman spectroscopy for the detection of SARS-CoV-2

The Ag/Au nanoparticles present in the detection well will enhance the Raman signal. Raman signal will be analyzed via machine learning algorithms that can be trained on the signals of known virus molecules. Spectrum of test sample will be matched with previously recorded standard reference spectrum of SARS-CoV-2.

The device essentially traps viruses in nanotubes. Au/Ag-VACNTs not only help to segregate but also concentrate the viruses from samples (on repeated applications). This localized…

Conclusion

It is believed that this technique would provide a viable, long term alternative for reliable diagnosis of SARS-CoV-2 detection. Importantly, positive outcome of any of these two prototypes will facilitate the design and manufacture of versatile, portable platforms to contain future outbreaks of viral epidemics with steep reduction in the response time.…

Limitations of concept

Validation of the prototypes is needed in the initial stage in determining the specificity and sensitivity of the proposed prototypes as against gold standard methods such as RT-PCR.…

Conflict of interest

All authors declare no conflict of interest…

Funding sources

No funding was availed to disclose…

Author contribution

The authors of the study jointly proposed this diagnostic tool for the detection of SARS-CoV, and are planning to submit this concept as a multicentric proposal for seeking research grant to Indian Government funding agencies. Instead of individual authors, the role of each organization is listed as follows;

1. **Aditya Jyot Foundation For Twinkling Little Eyes**
    - Conceptualization of prototype…
    - Literature survey…
    - Preparation of manuscript…