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Editorial: Covid-19: Materials Science and Engineering Challenges

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Editorial on the Research Topic

Covid-19: Materials Science and Engineering Challenges

On March 11, 2020, the World Health Organization (WHO) declared that the coronavirus COVID-19, the respiratory disease caused by the novel coronavirus SARS-CoV-2, had become a pandemic. It was first reported in China in late 2019 by the WHO. At the time of proposing this Research Topic on June 4, 2020 the WHO indicated that 213 countries and territories were affected, as well as two international conveyances, with over 388,600 deaths worldwide. Now more than ever, it is evident that the scientific community must come together in search of solutions. With the lives of millions of people worldwide disrupted by this infectious disease outbreak, Frontiers in Materials joined the global scientific community in the response to the challenges of COVID-19 by proposing this Research Topic—"*Covid-19: Materials Science and Engineering Challenges.*" This Research Topic thus aimed to highlight a few examples of significant contributions that materials scientists can bring to this global crisis, and we particularly welcomed contributions that include, but were not limited to, the following topics and their applications for addressing COVID-19 challenges:

- Mechanics of virus materials
- Materials for biosensors, such as chemical and electrochemical biosensors
- Materials for destroying COVID-19, such as catalysts and photocatalysts
- Materials for purifying air and efficient COVID-19 removal
- Rational materials design, characterization, and design of novel biomaterials for applications such as controlled release and drug delivery systems, for biomaterials-based imaging and probes
- Manufacturing technologies for biomaterials, such as 3D printing. Accordingly, this brief themed article collection features four key contributions, as briefly summarized below, reporting nearly verbatim the respective abstracts.

Harrison Lourenço Corrêa and Daniela Gallon Corrêa focused on "*Polymer Applications for Medical Care in the COVID-19 Pandemic Crisis: Will We Still Speak Ill of These Materials?*". As consumption and use increased, the accumulation of urban waste of polymeric origin drew the attention of several sectors, especially that of the organized civil society. Through mobilization and activism, environmental legislation became more restrictive regarding the use and disposal of polymer materials. Plastic bags, tires, disposable cups, plastic straws, and PET bottles are some examples of how polymers have had a negative impact on the environment, generating pressures around the world to rethink their uses. However, the pandemic crisis that emerged in January 2020 has reinforced the importance of polymers for contemporary society. If, in the past, consumerism was the driving force behind the application of polymers, nowadays health and medical emergencies are the new forces. The reduction in stocks of medical-hospital supplies and personal protective equipment for health professionals and the general public caused by the pandemic led to the emergence of alternative production movements based on polymers. Those alternatives have helped a lot to save and preserve lives; the discussed work aims to highlight the types of polymers most used during this pandemic period, such as polycarbonate (PC), poly(ethylene terephthalate) (PET) and polypropylene (PP). For this purpose, scientific articles related to the production of masks and other devices having some types of polymers as raw materials were analyzed. The research was based on the first half of 2020, highlighting the countries, the polymer used, and the final product for which it is intended.

Samar Shurbaji et al. focused on "*Nitric Oxide Releasing Hydrogel Nanoparticles Decreases Epithelial Cell Injuries Associated With Airway Reopening*." Acute respiratory distress syndrome (ARDS) is an acute inflammatory lung condition. It is characterized by disruption of gas exchange inside the alveoli, accumulation of protein edema, and an increase in lung stiffness. One major cause of ARDS is a lung infection, such as SARS-COV-2 infection. Lungs of ARDS patients need to be mechanically ventilated for airway reopening. Consequently, ventilation might damage delicate lung tissue leading to excess edema, known as ventilator-induced lung injury (VILI). Mortality of COVID-19 patients under VILI seems to be higher than non-COVID patients, necessitating effective preventative therapies. VILI occurs when small air bubbles form in the alveoli, injuring epithelial cells (EPC) due to shear stress. Nitric oxide (NO) inhalation was suggested as a therapy for ARDS, however, it was shown that it is not effective because of the extremely short half-life of NO. In this study, NO-releasing nanoparticles were produced and tested in an *in vitro* model, representing airways in the deep lung. Cellular injuries were quantified *via* fluorescent live/dead assay. Atomic force microscopy (AFM) was used to assess cell morphology. qRT-PCR was performed to assess the expression of inflammatory markers, specifically IL6 and CCL2. ELISA was performed to assess IL6 and confirm qRT-PCR results at the protein level. Finally, ROS levels were assessed in all groups. Here, the authors show that NO delivery *via* nanoparticles enhanced EPC survival and recovery, AFM measurements revealed that NO exposure affects cell morphology, while qRT-PCR demonstrated a significant downregulation in IL6 and CCL2 expression when treating the cells to NO both before and after shear exposure. ELISA results for IL6 confirmed qRT-PCR data. ROS experiment results support the authors' findings from previous experiments. These findings demonstrate that NO-releasing nanoparticles can be used as an effective delivery approach of NO to deep lung to prevent/reduce ARDS associated inflammation and cell injuries. This information is particularly useful to treat severe ARDS due to COVID-19 infection. These nanoparticles will be useful when clinically administrated to COVID-19 patients to reduce the symptoms originating from lung distress.

Nathan Lawko et al. focused on "*3D Tissue Models as an Effective Tool for Studying Viruses and Vaccine Development*." The recent SARS-CoV-2 outbreak has researchers working tirelessly to understand the virus' pathogenesis and develop an effective vaccine. The urgent need for rapid development and deployment of such a vaccine has illustrated the limitations of current practices, and it has highlighted the need for alternative models for early screening of such technologies. Traditional 2D cell culture does not accurately capture the effects of a physiologically relevant environment as they fail to promote appropriate cell-cell and cell-environment interactions. This inability to capture the intricacies of the *in vivo* microenvironment prevents 2D cell cultures from demonstrating the necessary properties of native tissues required for the standard infection mechanisms of the virus, thus contributing the high failure rate of drug discovery and vaccine development. 3D cell culture models can bridge the gap between conventional cell culture and *in vivo* models. Methods such as 3D bioprinting, spheroids, organoids, organ-on-chip platform, and rotating wall vessel bioreactors offer ways to produce physiologically relevant models by mimicking *in vivo* microarchitecture, chemical gradients, cell–cell interactions and cell–environment interactions. The field of viral biology currently uses 3D cell culture models to understand the interactions between viruses and host cells, which is crucial knowledge for vaccine development. In this review, the authors discuss how 3D cell culture models have been used to investigate disease pathologies for coronaviruses and other viruses such as Zika Virus, Hepatitis, and Influenza, and how they may apply to drug discovery and vaccine development.

Finally, Di Novo et al. focused on "*Modeling of Virus Survival Time in Respiratory Droplets on Surfaces: A New Rational Approach for Antivirus Strategies*." The modeling of the viability decay of viruses in sessile droplets is addressed considering a droplet sitting on a smooth surface characterized by a specific contact angle. To investigate, at prescribed temperature, how surface energy of the material and ambient humidity cooperate to determine the virus viability, the authors propose a model which involves the minimum number of thermodynamically relevant parameters. In particular, by considering a saline water droplet (one salt) as the simplest approximation of real solutions (medium and natural/artificial saliva), the evaporation is described by a first-order time-dependent nonlinear differential equation properly rearranged to obtain the contact angle evolution as the sole unknown function. The analyses were performed for several contact angles and two typical droplet sizes of interest in real situations by assuming constant ambient temperature and relative humidity in the range 0–100%. The results of the simulations, given in terms of time evolution of salt concentration, vapor pressure, and droplet volume, elucidate some previously not yet well-understood dynamics, demonstrating how three main regimes—directly implicated in nontrivial trends of virus viability and to date only highlighted experimentally—can be recognized as the function of relative humidity. By recalling the concept of cumulative dose of salts (CD), to account for the effect of the exposition of viruses to salt concentration on virus viability, the authors show how the proposed approach could suggest a chart of a virus fate by predicting its survival time at a given temperature as a function of the relative humidity and contact angle. They found a good agreement with experimental data for various enveloped viruses and predicted in particular for the Phi6 virus, a surrogate of coronavirus, the characteristic U-shaped dependence of viability on relative humidity. Given the generality of the model and once experimental data are available that link the vulnerability of a certain virus, such as SARS-CoV-2, to the concentrations of salts or other substances in terms of CD, it is felt that this approach could be employed for antivirus strategies and protocols for the prediction/reduction of human health risks associated with SARS-CoV-2 and other viruses.

The pandemic is not yet over but there is hope today, thanks to the solidarity between people and also to the new frontiers of Science and Technology.

AUTHOR CONTRIBUTIONS

NP wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.