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Stimuli-responsive face mask-based on electrospun nanofibers

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INTRODUCTION

Environmental pollutants and pathogens have been made issues for human health, especially in the recent pandemic situation.[1] Filtering facepieces are the most common way to protect inhalation from ambient pollutants. Available protective devices have some issues that can be solved to present a higher shield against harmful matters and provide smart features.[2]

The main problem of surgical masks is the low efficiency of filtration. Furthermore, reusability and disinfection properties can also be achieved by proposing stimuli-responsive capability, like the photothermal antimicrobial surface.

EXPERIMENTAL METHODS

Electrospray of Au nanorods

The electro-spraying technique deposited Au nanorods (NRs) over the face masks. The alcosols of Au NRs were prepared in different concentrations. The ratio of gold NRs colloid in the utilized solutions varied from 1:5 to 1:50 volume ratio. Optimization of the Au NRs concentrations was carried out by employing laser irradiation and studying the effect of the laser.

Fabrication of Electrospun face mask

To create a nanofibrous layer over the commercial surgical face mask, a solution of 12% (v/v) of polyacrylonitrile (PAN) in N, N-dimethylformamide was electrospun. The thickness of the electrospun layer is optimized by implementing a filtration efficiency test and scanning electron microscope to achieve the desired structure. PAN 10 and PAN 20 refer to 10 and 20 minutes of electrospinning over the face mask.

RESULTS AND DISCUSSION

Filtration Efficiency

The filtration efficiency of the filtering facepieces was performed by the use of NaCl aerosols (0.3 am). This analysis was conducted to compare the commercial face masks filtration with the modified masks (Figure 1a). Electrospun PAN nanofibers layer leads to a decrease in the pore sizes of the mask compared to the commercial masks (Figure 1b). The proposed structure of the masks showed an impressive enhancement in the performance of the protective devices.

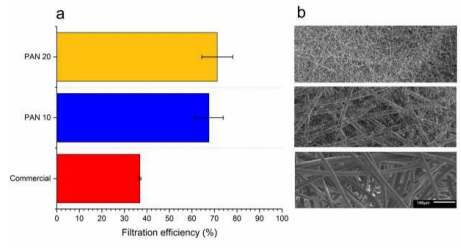

Figure 1. Distinctive features and structures of the produced face masks. a) Filtration efficiency test of the electrospun face masks shows two times increase in the efficiency. b) SEM images of the different obtained masks` structures (microscope images located in front of the corresponding diagram).

Photothermal Activity

Stimuli-responsivity of fabricated electrospun gold treated face masks investigated by a thermo-optical setup (Figure 2a). After electro-spraying Au NRs over the mask, upon laser exposure, the plasmonic photo-responsivity drives to increase the outer layer's temperature (ΔT=20°C; Final T: 45°C - Figure 2b). The analysis of the response of the smart masks to the laser beam was conducted over the different concentrations of the Au NRs (Figure 2c).

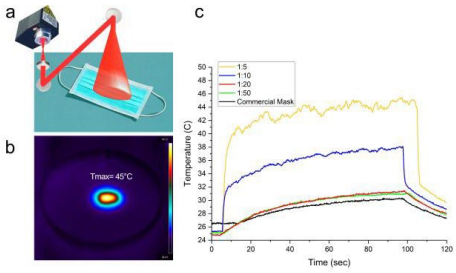

Figure 2. Photo-responsive electrospun masks, a) Schematic of triggering laser to the sample. b) Thermographic image of the heat generation of the mask. c) Monitoring the temperature of the face masks with the different concentrations of the Au NRs by triggering the laser.

CONCLUSION

The study demonstrated that electrospun nanofibers could double the filtration efficiency over the commercial face mask. Also, by employing Au NRs, it made out that the electrospun mask will turn into a smart photo-responsive protective equipment that can potentially eliminate the pathogens. This new characteristic may lead to on-demand sterilizable masks that can be fruitful in the pandemic situation.

REFERENCES

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ACKNOWLEDGMENTS

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