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Textile Coated with Mercaptoethane Sulfonate-functionalized Silver Nanoparticles with Virucidal Activity against SARS-CoV-2

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Extended Abstract

Recent SARS-CoV-2 pandemic emphasized the need for broad-spectrum intervention before virus-specific vaccination and antiviral drugs are readily available. One of such intervention is blocking of a common step in the virus life cycle such as the attachment to the cells. Viruses frequently attach to an abundant adhesion molecules before attachment to a specific receptor. Next to sialic acids, the most common is heparan sulfate proteoglycans (HSPG) [1]. The role of HSPG during virus entry was shown for many viruses such as HSV-1, dengue virus, HBV, human papillomavirus, HIV-1 [2], and recently also for SARS-CoV-2 [3]. Mimicking heparan sulfate by silver and gold nanoparticles (NPs) capped with mercaptoethane (AgMES) and mercaptoundecane sulfonate (AuMUS) molecules, was successfully used in the past to inhibit viruses including HSV-1, HSV-2, human papillomavirus, dengue virus and others [4, 5]. Interestingly, AuMUS nanoparticles were shown previously to irreversibly block these viruses, but the inhibition of SARS-CoV-2 was reversible [6]. Here, we present optimized process of sonochemical coating of fabrics with AgMES NPs that possess very good virucidal activity against SARS-CoV-2 and common human coronavirus HCoV-OC43.

AgMES NPs and AgMES-coated cotton fabrics were prepared by one-step ultrasound assisted procedure using different molar ratios of $AgNO_3$ and sodium 2-mercaptoetahnesulfonate. AgMES NPs were characterized by X-ray diffraction analysis and the coated fabrics were further evaluated by additional physico-chemical methods: ICP, FTIR and HRSEM. Cytotoxicity, antiviral and virucidal activity of powders and coated fabrics were performed against SARS-CoV-2 and HCoV-OC43 in Vero E6 cells.

The AgMES NPs showed only moderate cytotoxicity in Vero E6 cells at a concentration 0.5 mg/ml, while they inhibited SARS-CoV-2 with EC_{50} of 60 µg/ml and HCoV-OC43 with EC_{50} of 1.3 µg/ml. The 46 times better anti-HCoV-OC43 activity than anti-SARS-CoV-2 activity was also translated in a different antiviral activity of coated fabrics. The AgMES-coated fabrics containing 0.2 wt% of Ag^+ were able to eliminate up to 99% of HCoV-OC43 after 60 min contact time, while, by contrast, the same fabrics did not reduce SARS-CoV-2 titer at all. Using different fabrics, in situ vs throwing stones sonochemical technique, changing time, temperature and sonication power improved the anti-SARS-CoV-2 activity only marginally. Finally, after increasing the Ag^+ initial concentration in the synthesis by factor of five and testing different molar ratios of Ag/MES from 1/2.5 to 1/0.5, we were able to improve the virucidal activity of fabrics against SARS-CoV-2. Fabrics coated with Ag-MES NPs, which were synthesized from 1/0.5 ratio of Ag/MES, eradicated 97-100% of SARS-CoV-2 after 60 minutes contact time. To verify the stability of the AgMES NPs coating on the fabrics, a leaching procedure in water was performed. The analysis of the leaching solution showed less than 0.02 mg/l after 2 as well as 7 days of leaching. Moreover, such treated fabrics still eradicated 100% of SARS-CoV-2. Finally, the rich pattern of NPs in XRD analysis together with HRSEM of fabrics show very uniform AgMES NPs about 500-600 nm in size explained the improved anti-SARS-CoV-2 effectiveness.

In summary, the improved sonochemical method to deposit AgMES NPs onto fabrics, which lead to quick eradication of SARS-CoV-2 upon contact, provides another step towards better preparedness in the case of future pandemics.

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