Moisture-Activated Antiviral Coating based on Mussel Adhesive Chemistry

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Statement of purpose: Direct transmission of viruses through respiratory droplets endangers public health and is the main challenge in the current COVID-19 pandemic situation. There is an urgent need for developing self-disinfecting surfaces to mitigate viral transmission and health-threatening disinfectant products consumption. Here, we seek to develop a self-disinfecting polymer coating on the surface of a face mask fabric. Current existing self-disinfecting approaches require external factors such as heat [1] or light [2] to be activated which may not be available on demand. We aim to develop a catechol-based coating in which the moisture present in respiratory droplets can be utilized to activate the coating to generate a known disinfectant, hydrogen peroxide (H_2O_2). Catechol is the main adhesive molecule found in mussel adhesive proteins [3]. Autoxidation of catechol results in the generation of ROS such as H_2O_2. To further increase the rate of H_2O_2 generation, we prepared a polymer coating functionalized with 6-hydroxydopamine (6-OHDA), which contains a catechol modified with an electron donating –OH group with enhanced rate of oxidation. The feasibility of the polymer in functioning as a self-disinfecting coating on mask fabric was explored.

Methods: Acrylic acid *N*-hydroxysuccinimide (AA-NHS) and acrylamide (AAm) were copolymerized through free radical polymerization and further reacted with 6-OHDA to obtain 6-OHDA modified polymer. Polyacrylamide (pAAm) was synthesized and used as a control coating. Proton nuclear magnetic resonance (^{1}H NMR), and UV-Vis spectroscopies were used to characterize the composition of the polymer. Melt-blown polypropylene (PP) face mask fabric was soaked in 5 wt% polymer solution in dimethyl sulfoxide for 1 h. The volume of the polymer solution was adjusted to obtain 30 and 40 wt% polymer coatings on the fabric. The morphology of the polymer-coated PP fabric was determined using field emission scanning electron microscopy (FESEM). The porosity of the polymer-coated PP was evaluated using the *n*-butanol uptake method [4]. The H_2O_2 generation from the coatings on PP fabrics after the hydration by pH 7.4 phosphate-buffered saline (PBS) was determined by using quantitative Ferrous Oxidation-Xylenol orange (FOX) assay [5]. The antiviral activity of control-coated and polymer-coated PP fabrics was evaluated against human coronavirus (HCoV-229E) using human fetal lung fibroblast cells (MRC5) as the indicator cells.

Results: UV-Vis spectroscopy indicated that the polymer contained 27.8 mol% of 6-OHDA. FESEM and porosity measurements showed that the coating process did not significantly affect the porosity of PP fabric which was determined to be about 80%. When the polymer-coated PP fabrics was incubated in pH 7.4 PBS, nearly 4 mM of H_2O_2 was generated within 1 h (Figure 1). Both the 30 and 40 wt% polymer-coated PP fabrics reduced the infectivity of HCoV-229E virus by 1.7 and 2.5 log reduction values respectively, following hydration and incubation for 5 h (Figure 2). PP coated with control pAAm did not show any reduction in viral titer value.

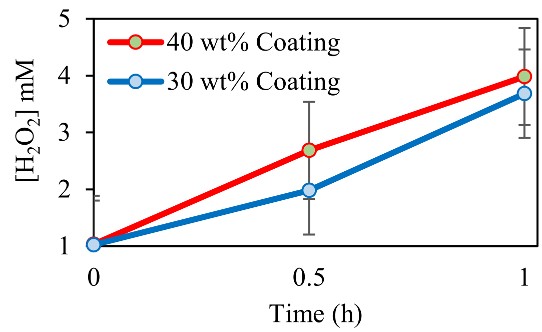

Figure 1: H_2O_2 generation from polymer-coated PP fabrics upon hydration by pH 7.4 PBS.

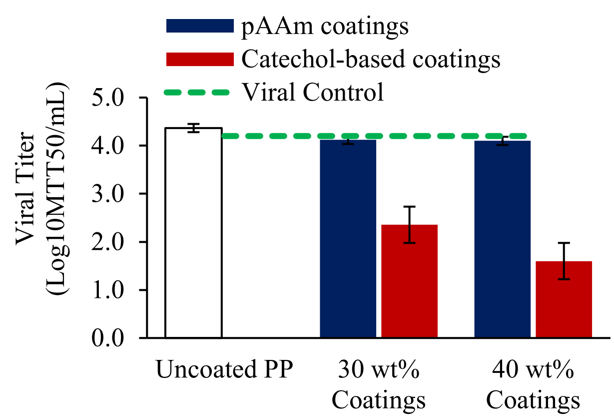

Figure 2: Inactivation of HCoV-229E by control (pAAm) and catechol-based polymer coatings on PP fabric upon hydration by pH 7.4 PBS.

Conclusion: Catechol-based polymer was successfully synthesized and coated onto PP fabric without affecting its porosity. The coating generated antiviral levels of H_2O_2 upon hydration and the generated H_2O_2 was found to be effective against a model coronavirus.

References:

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