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Research Article

Melanin Adhesivity for Possible Trapping of SARS-CoV-2 on Chin Straps: A Proof-of-concept Assay Using Model Nanoparticles †

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Abstract

In the frame of COVID-19 pandemic, improved chin straps are obviously necessary to better prevent aerial infection by SARS-CoV-2. Adhesivity of melanins could be applied for trapping virus, but due to present limitations to work with infective agents, we have performed a proof-on-concept assay using zinc oxide (ZnO) nanoparticles with similar size (about 100 nm) as a virus model. Cotton fabrics were impregnated with allomelanin isolated from black beans, and ZnO solutions filtered through melanin-containing filters. Results and controls showed that these filters retained efficiently the nanoparticles, suggesting that melanin-treated chin straps could be a valuable and effective protection resource to trap virus and avoid infection. .

Keywords: Aerial Infection; Chin Strap; COVID-19; Melanin Adhesivity; Melanin Coating; SARS-CoV-2; Virus Trapping

† Dedicated to Oscar A. Alberti, *in memoriam.*

Introduction

In the present scenario of coronavirus disease 2019 (COVID-19) pandemic, SARS-CoV-2 places us in the urgent challenge of reducing morbidity, mortality, and disease infection. In addition to possible treatments [1], it is very important to prevent progression of the disease using protocols based on the reduction of aerial infection by simple chin straps, either alone or impregnated with hypertonic NaCl solution [2]. The design and use of highly efficient chin straps is strongly recommended, and thus coating and adhesive properties of melanin is coming to this specific purpose.

Melanins (e.g., eu-, pheo-, allomelanin) are polymeric indole or catechol pigments [3], with high light absorption, and wide applications in dermocosmetics, tissue engineering, regenerative medicine [4-6], opto-electronic and photo-acoustic devices [7], antitumoral photothermal therapy [8], and multifunctional platforms in biotechnology [9]. Surface coating and high adhesivity are important properties of melanins [7,10,11]. Bearing in mind the rhinopharyngeal access of SARS-CoV-2, it is tempting to speculate that the adhesivity of melanin-impregnated chin straps could retain the virus and then avoid the aerial infection. Due to fashion or esthetic reasons, commercial publicity offers several melanin-named black chin straps, but no scientific evidence supports improved protection for these products.

On the other hand, for the possibility that viral particles could be replaced by model nanoparticles, a simple proof-of-concept was designed using zinc oxide (ZnO) nanoparticles to be trapped on melanin-impregnated fabrics. ZnO nanoparticles are well known compounds with biomedical applications and useful properties as model nanomaterials [12,13]. Since ZnO nanoparticles and SARS-CoV-2 virions have very similar size and are delivered in aqueous media, it would be expected that this model system represents a valid assumption for extrapolating results to the case of viral particles.

Materials and Methods

ZnO nanoparticles (Sigma-Aldrich 544906, 99% purity, particle size <100 nm) were used as an inorganic model of the SARS-CoV-2 (virion size between 60 and 140 nm; average size: 100 nm). The white ZnO powder is dissolved in tap water (0.5 mg/mL), forming a milky colloidal solution.

A dark brown-black solution of melanin (allomelanin, plant catechol-melanin [10]) is obtained from 200 g of black beans (*Phaseolus vulgaris*), soaked in 300 mL of tap water for 24 h at room temperature (RT), then boiled for 30 min, and cooled to RT. To be used as model filters, small pieces of common cotton fabrics were impregnated with the allomelanin solution at 100 ºC for 5 min, left to cool and air-dried. Commercial chin straps were also soaked with allomelanin. Next, some filters were treated with 4% formaldehyde in tap water for 30 min to improve the pigment fixation and to retain the weakly bound fraction.

Ten mL of the ZnO solution were placed on dried fabric filters with melanin (a), and without melanin (b), after which the corresponding filtrates were collected. Two types of controls were performed: (1) Once dried, unfixed and formaldehyde-fixed filters were soaked in tap water from 1 to 6 h to test color fading. (2) Filters without melanin were used to filter ZnO solutions, to compare the filtrate with that obtained through filters with melanin.

Results and Discussion

Following melanin impregnation, the rough surface of filters, either fabrics or chin straps, appears stained dark brown-black (Figure 1 A, B). Unfixed filters lose some color by water washing (probably due to pigment excess), whereas those fixed with formaldehyde do not discolor at all (Figure 1 C).

After filtering ZnO solutions, melanin filters clearly show the white deposits of retained ZnO in the center of filters (Figure 2 A). ZnO deposits resist the water washing of filters for several hours, and they remain stuck to the melanin surface. The filtered solutions appear transparent and contrasting with the milky aspect of ZnO solutions before filtering (Figure 2 B, C).

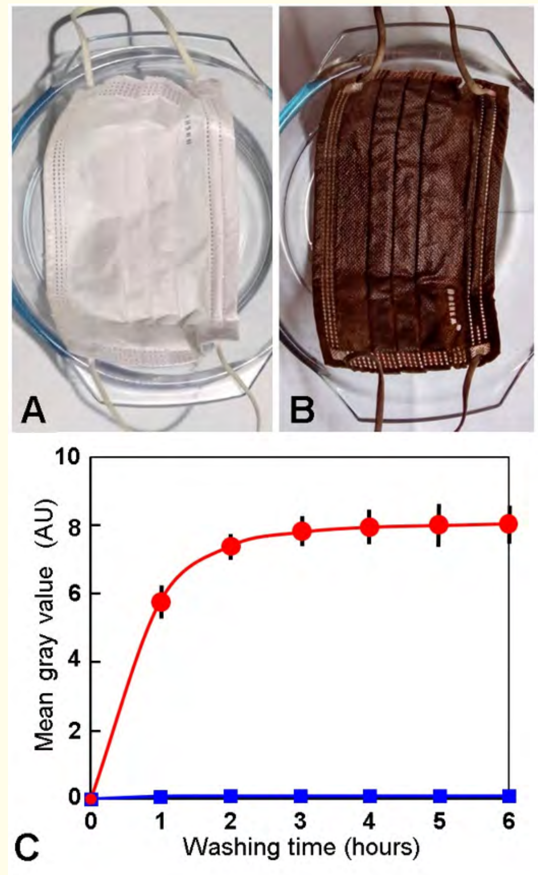

Figure 1: A, B: Commercial chin straps before (A), and after impregnation with allomelanin (B). C: Kinetics of the color removal of allomelanin-impregnated fabrics by water washing. The light brown color of 30 mL of washing media at increasing times (mean gray values in arbitrary units (AU), and standard deviation when pertinent) were measured by densitometry of photographs using ImageJ 1.52v software.

On the contrary, ZnO solutions filtered through filters without melanin are identical to the original unfiltered solution, which indicates that melanin is the specific adhesive component that retain the nanoparticles. In this case, no deposits are found on the melanin-free filters.

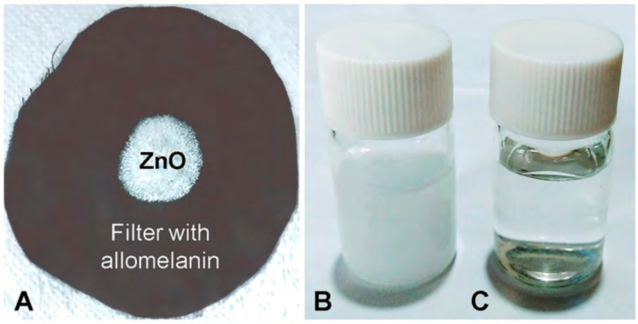

Figure 2: A: Allomelanin-impregnated fabric after filtering of the ZnO solution. Observe the white deposit of ZnO retained on the filter. B, C: Comparison between the aspect of 5 mL of milky ZnO solution before filtering (B), and clear solution filtered through the allomelanin-treated fabric (C).

As far as we know, no references have been quoted on the proposal of using melanin chin straps to improve virus trapping, and thus this possibility is suggested here. Unfortunately, in the frame of the present-day pandemic and disruptive laboratory work, we could not use infecting virus but only a proof-of-concept approach applying ZnO nanoparticles. The average size of ZnO and SARS-CoV-2 particles are equivalent, both are surrounded by hydration layers, immersed in aqueous media, and delivered to the filter surface in water. Therefore, it is logical to assume that ZnO nanoparticles are suitable models of virions.

Adhesivity probably depends on the formation of reactive radicals in quinone, catechol, and phenol components of melanin [14,15], as well as on the negatively charged melanin surface, and easy chelation with di-and trivalent inorganic cations [10]. In addition, polydopamine [16], and synthetic allomelanin [15] would be also useful to replace natural allomelanin. Furthermore, melanin filters could be used to retain other viruses, and also bacteria, aerial xenobiotics and pollutant materials.

Conclusions

Common cotton fabrics and chin straps impregnated with allomelanin act as filters that retain ZnO nanoparticles, and therefore they could represent a suitable tool for trapping infective aerial virus as well as other nanomaterials. Relevant advantages of melanin-treated chin straps would be the very low cost, and easy preparation and use even under adverse economic and social conditions.

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Conflict of Interest

The authors declare no conflict of interest.

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