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Dipeptide mediated biosynthesis of zinc (hydro)oxide nanoparticles on biohybrid nanofibers; a wound healing material

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Abstract

Introduction

Biosynthesis of nanohybrid materials assures low cost, eco-friendly preparation of biomaterials for various biomedical applications including wound healing. In this study, L-carnosine (CAR), a dipeptide of β-alanyl-L-histidine, was loaded on hydrolysed polyacrylonitrile (PAN) nanofibers (NFs) to act as a mediator for biosynthesis of ZnO and/or $Zn(OH)_2$ nanoparticles (NPs) on the NFs surface. CAR per se can offer a wound healing effect thanks to its promising antioxidant, anti-inflammatory, and anti-neoplastic properties. On the other hand, due to its immunomodulatory activity, the release of Zn^{2+} ions from ZnO NPs contributes to wound healing. **Results and discussion** Thanks to homogenous loading of CAR ligands, the biosynthesized ZnO/$Zn(OH)_2$ NPs (23 ± 7 nm) were uniformly distributed on the surface of CAR/PAN NFs (Fig. 1a&b). EDX (Fig. 1c) and XRD analysis (Fig. 2a) validated that the NPs were composed of ZnO and/or $Zn(OH)_2$ (possibly as a core-shell NP). The co-existence of CAR and ZnO NPs led to a superhydrophilicity effect and promoted the elastic modulus and tensile strength of ZnO-CAR/PAN NFs (Fig. 2b-d). The PAN NFs become stiffer and stronger after hydrolysis, due to intermolecular bonding between the PAN chains functionalized with oxygen bearing functional groups. This effect is intensified after biofunctionalization of PAN NFs with CAR. The CAR ligands act as the cross-linkers connecting the NFs, thereby raising stiffness and strength of the mat comprising thereof. As a result, inter/intrafiber bonding brings about a considerably higher elastic modulus/tensile strength as 462%/44% (cPAN), 1036%/315% (CAR/PAN), and 314%/118% (Zn-CAR/PAN) increase, when comparing with that of PAN NFs.

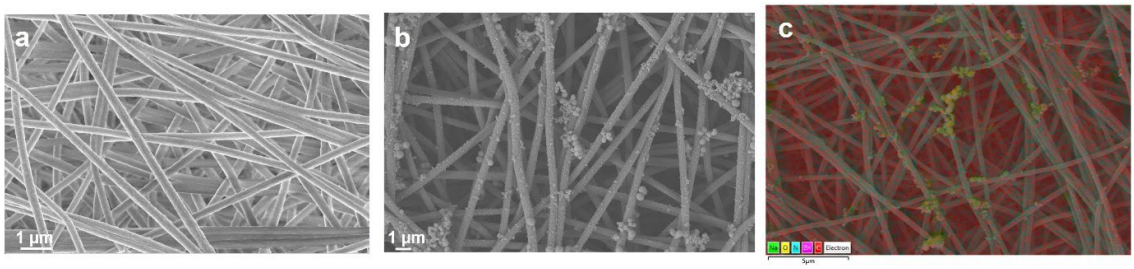

Figure 1. SEM images of CAR/PAN (a) and ZnO-CAR/PAN NFs (b). The uniform distribution of biosynthesized ZnO NPs across the NF mat is evident. C) EDX elemental map confirms the formation of Zn rich NPs.

Conclusion

The ZnO-CAR/PAN bionanohybrid NFs were produced through biosynthesis of ZnO NPs in the presence of CAR. The release of Zn^{2+} ion, an essential trace element involved in the chemistry of different transcription factors or enzymes, can potentially enhance wound healing effect.

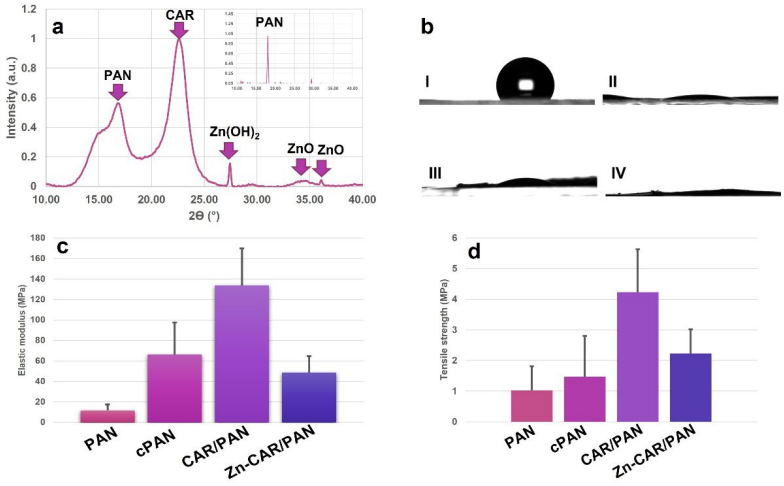

Figure 2. a) XRD analysis verifies the formation of ZnO/Zn(OH)$_2$ NPs on the NFs surface, b) Superhydrophilicity effect induced by CAR ligands and ZnO/Zn(OH)$_2$ NPs (I-IV: PAN, hydrolysed PAN, CAR/PAN, and ZnO-CAR/PAN NFs, respectively), c) Elastic modulus, and d) Tensile strength of ZnO-CAR/PAN NFs.