Polydopamine Coating for Effective Photothermal Killing of Microbe upon Near-Infrared Irradiation

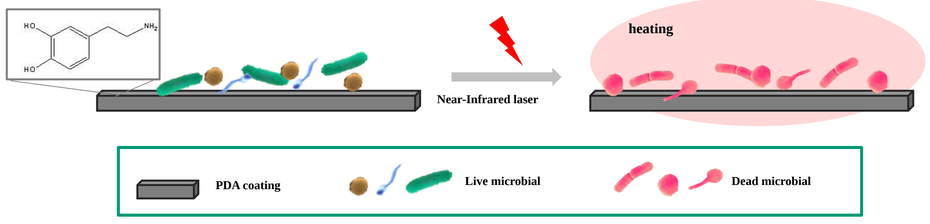
Wen-xi Lei, Ting-ting Chen, Xia-chao Chen, Bo-chao Li,Ke-feng Ren*, Jian Ji*

MOE Key Laboratory of Macromolecular Synthesis and Functionalization, Department of Polymer Science and Engineering, Zhejiang University, Hangzhou 310027, China

*Contact to; Jian Ji, E-mailjijian@zju.edu.cn, Tel/Fax: +86-571-87953729

Abstract

Polydopamine (PDA) has been widely known for its material-independent surface modification capacity , however, the photothermal property of PDA, which contributes to the antibacterial effect has not yet been demonstrated. In this study, PDA coating was prepared under alkaline conditions. Upon near-infrared (NIR) irradiation, the resulting PDA coating efficiently generated rapid localized heating which was able to kill bacteria and fungus on it. What's more, PDA coating was easily polymerized on the surface of PVC and rubber tube, which are commonly utilized in the medical field. Due to the PDA coating, S.aureus, E.coli and C.albicans were killed more than 95% on the tubes under the NIR irradiation, indicating the PDA coating is a potential NIR-light-activated material to design bactericidal biomedical implants surface.



Scheme 1. Schematic illustration of killing effect of PDA coating due to the photothermal property.

Method

1 PDA coating on glass was fabricated by self-polymerization. Dopamine solution (2mg/mL Tris buffer pH 8.5) was prepared and the polymerization processed for different time with the glass slides in it. Tubes with PDA coating were obtained in the same way.

2 The heat was generated through a NIR laser (808 nm and 0.9 W/cm^2)

Results and Discussion

1. PDA coating characterizations

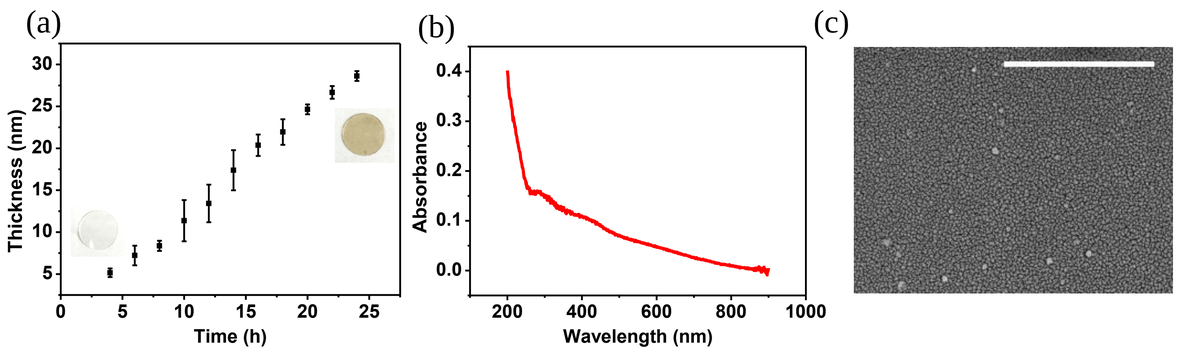


Figure 1. (a) Thickness of polydopamine coating as a function of polymerization time, Insets show appearances of glass slides with dopamine coating polymerized for 0 h (transparent) and 24 h (light brown color). (b) UV−vis−NIR absorption and (c) SEM image of polydopamine coating polymerized for 24 h. The scale bar is 1 μm.

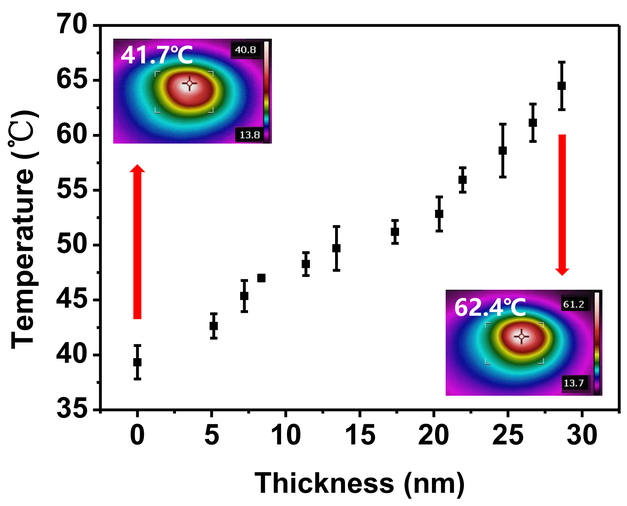


Figure 2. Temperature evolution curve of polydopamine coating with different thickness under the infrared irridiation, Insets show the image of near-infrared (NIR)-irradiated photothermal image of polydopamine coating polymerized for 0 h and 24h.

2. Antibacterial and antifungal activity

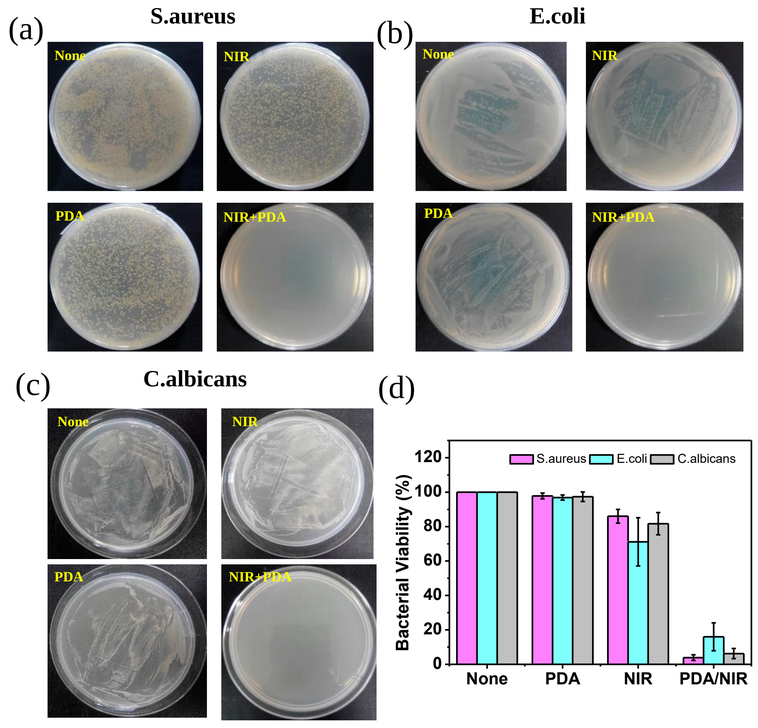


Figure 3. Photographs of (a) S. aureus, (b) E. coli and (c) C.albicans colonies grown on plates after different treatments. (d)The killing efficiency of polydopamine under NIR irradiation (0.9 W/cm^2) on bacteria and fungus.

3. PDA coatings on PVC and rubber tubes

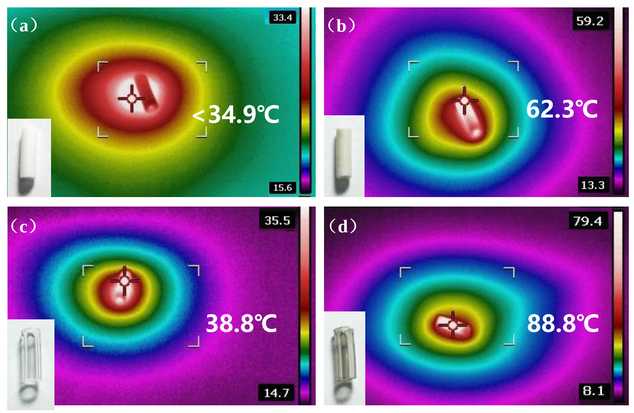


Figure 4. Thermal images of PVC and rubber tubes with or without polydopamine coating.

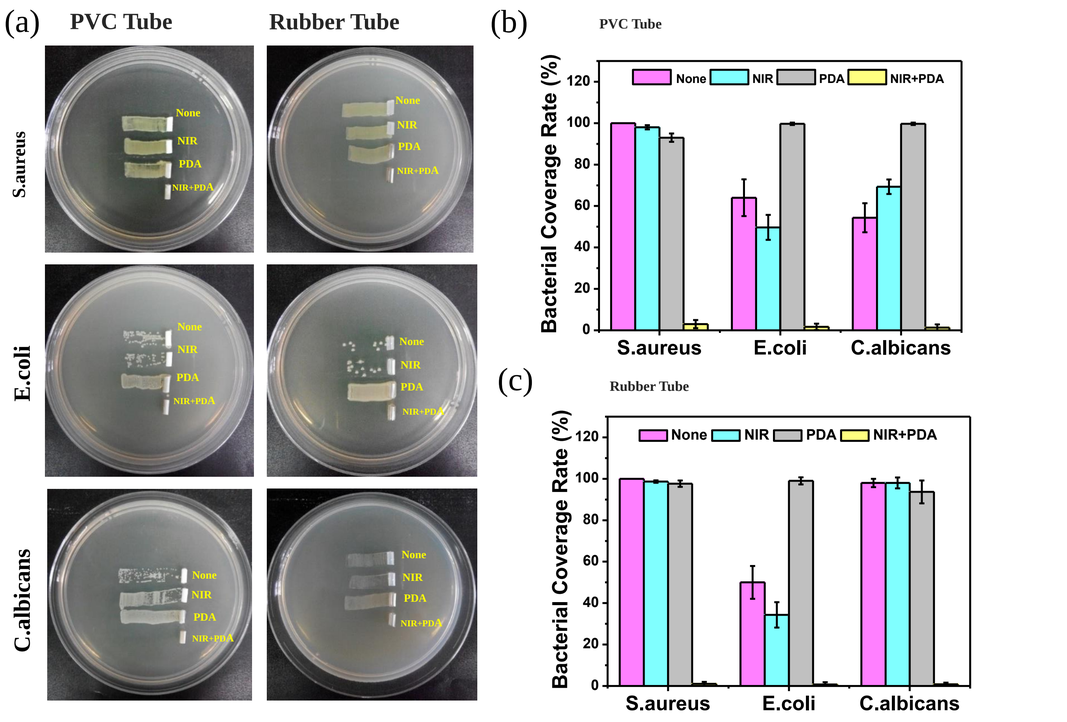


Figure 5. Antibacterial and antifungal effect of PVC and rubber tube with polydopamine coating.

Conclusions

PDA coating was fabricated easily under alkaline conditions. Sufficient heat was obtained with the NIR irradiation from the coating , which was able to kill the bacteria and fungus on the coating surface. PVC and rubber tubes with PDA coating also had the antibacterial and antifungal property, providing a novel way to protect the medical device surface.

Acknowledgements

This research was supported by Zhejiang Provincial Natural Science Foundation of China under Grant No. LR15E030002, the National Natural Science Foundation of China (51333005, 21374095, 51573162), Research Fund for the Doctoral Program of Higher Education of China (20120101130013), and International Science & Technology Cooperation Program of China (2014DFG52320).