Fluorescent Carbon Nanodots/Poly(acrylic acid) Self-Healing Nanocomposite Hydrogels for Antibacterial Application

螢光碳奈米點/聚丙烯酸水膠作為自我癒合與抗菌之應用之研究

南臺科技大學
Southern Taiwan University of Science and Technology

En-Yu Zhou†, Hui-Shan Chang, Yu-Tung Liu, Wei-Yu Chen*, and Hong-Ru Lin*

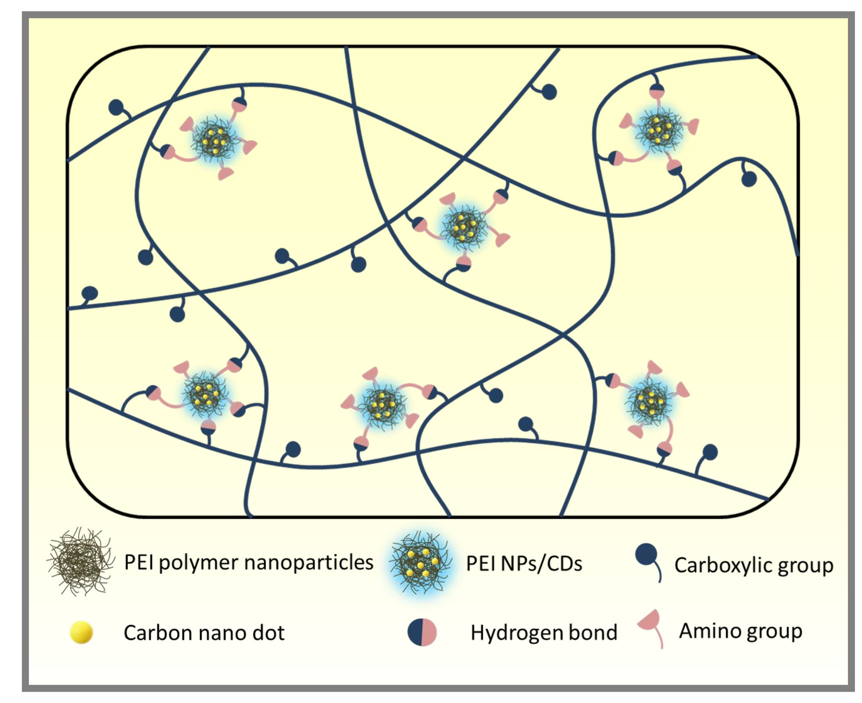
Department of Chemical and Materials Engineering,
Southern Taiwan University of Science and Technology, Tainan, Taiwan

微奈米生醫技術實驗室
Mirco & Nano-Biomedical Technology Lab

ABSTRACT

Carbon dots (CDs) have attracted significant interest in recent years due to their fluorescence and optical properties, biocompatibility, and simple synthetic routes from readily available substances. Herein, we report a facile strategy to fabricate self-healing nanocomposite hydrogels. Fluorescent CDs were synthesized from polyethylenimine (PEI) aqueous solution assistance by hydrothermal reaction at 220°C for 8 h. Poly(acrylic acid) hydrogels (PAA hydrogels) incorporated with fluorescent PEI-CDs have exhibited excellent self-healing properties as well as high mechanical reprocessability. The self-healing gels were formed through dynamic covalent bonds between the quaternary ammonium ions displayed upon the carbon dots' surface and carboxylic acids residues within the PAA network, generating interaction. Moreover, the viscoelastic properties of the gels could be intimately modulated by controlling the ratio between the carbon dots and polymer. We demonstrate that PEI-CDs obtained from PEI polymers possess effective antibacterial activities against *Escherichia coli*, and *Staphylococcus aureus* bacteria.

Keywords: carbon dots, hydrogels, self-healing, antibacterial



Scheme

METHODS

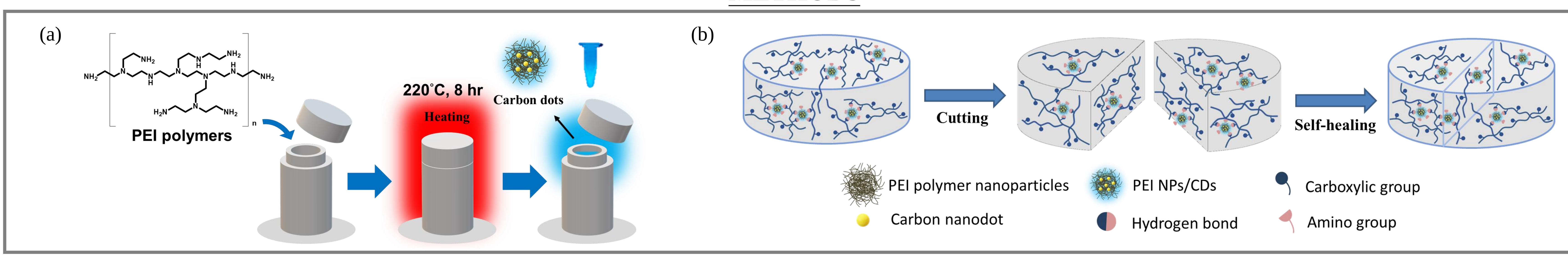


Figure 1. (a) Bottom-up methods. (b) Self-healing hydrogels.

RESUSTS AND DISCUSSION

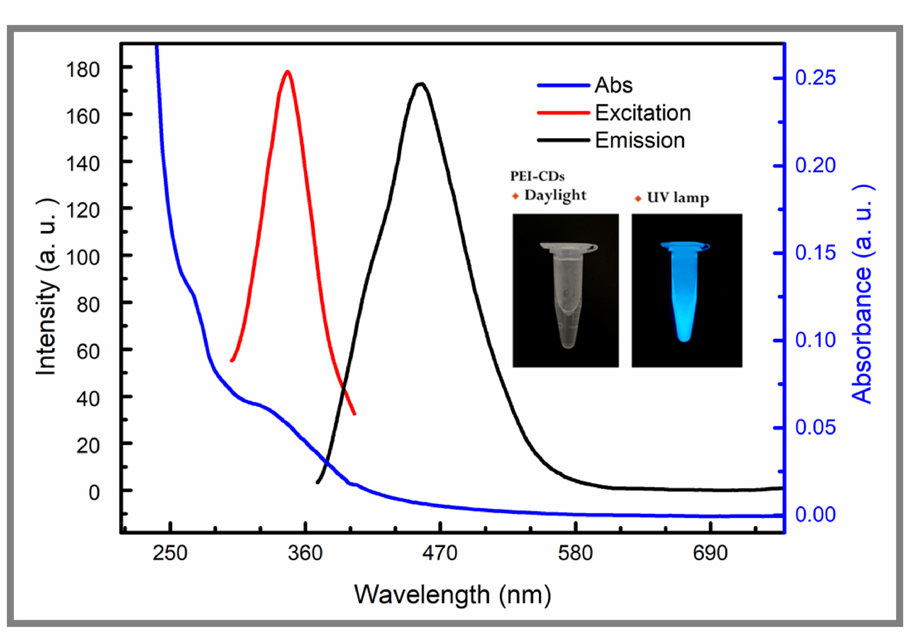


Figure 2. UV-vis and PL spectra of PEI-CDs. Inset shows photograph of the fluorescence of solutions under visible light and upon excitation a hand-held UV lamp.

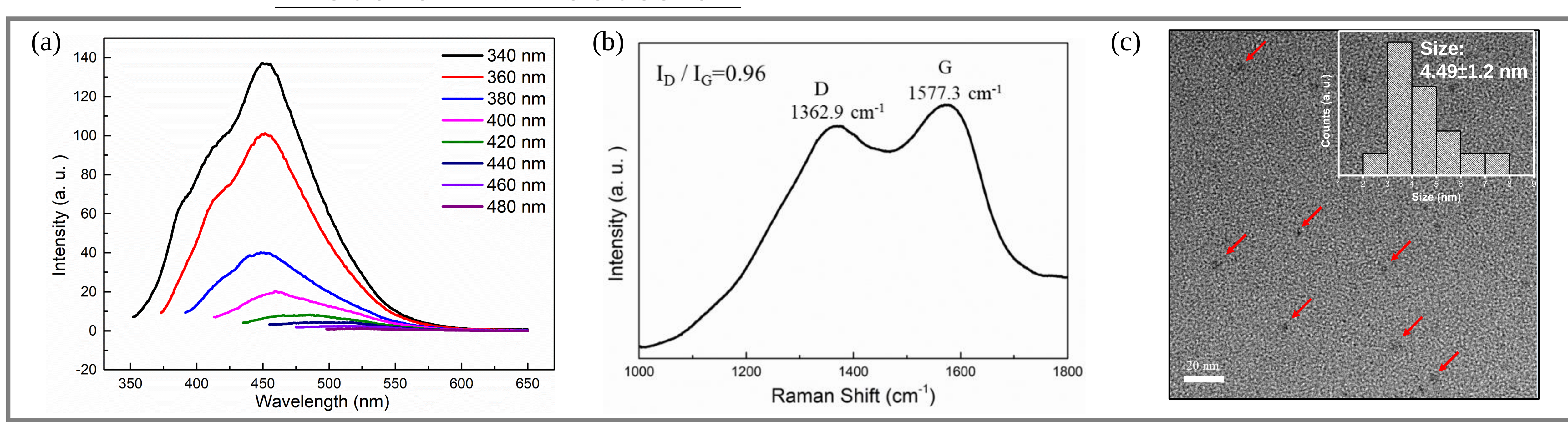


Figure 3. (a) Wavelength dependence of aqueous solutions of PEI-CDs solution at excitation wavelengths between 340 and 480 nm at pH 7. (b) TEM image analysis of PEI-CDs. (c) Raman spectrum of PEI-CDs.

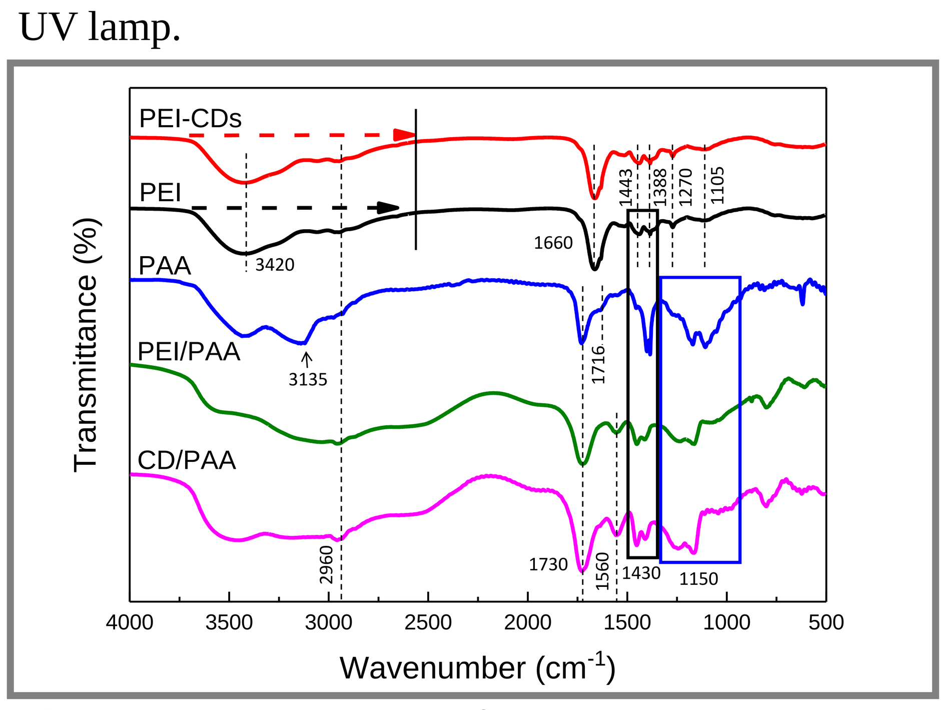


Figure 4. FTIR spectrum of PEI, PEI-CDs, PAA hydrogel, PEI/PAA hydrogel and PEI-CDs/PAA hydrogel.

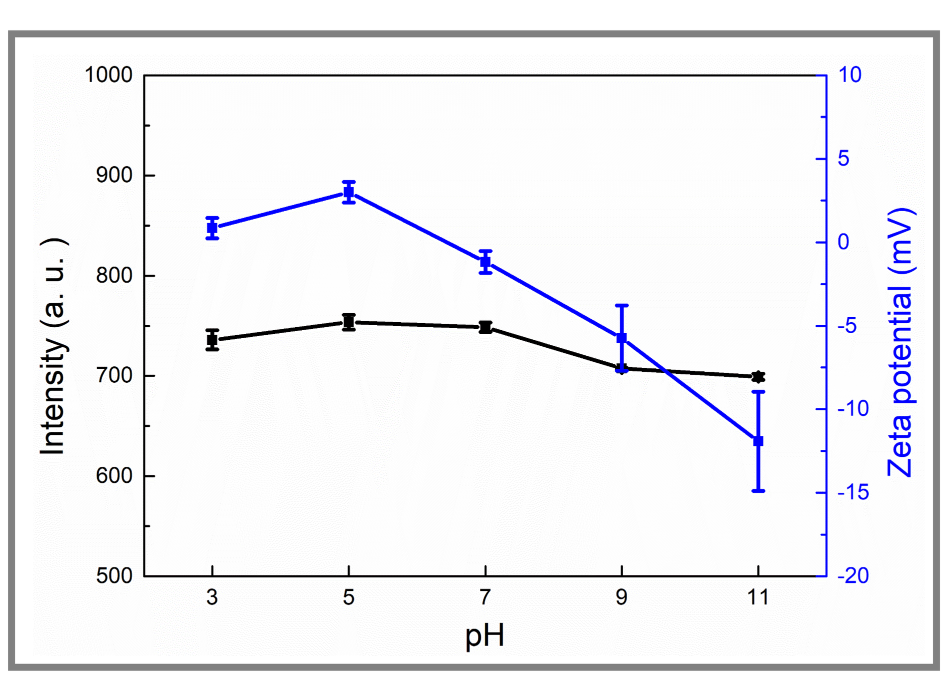


Figure 5. Effect of PEI-CDs at different pH.

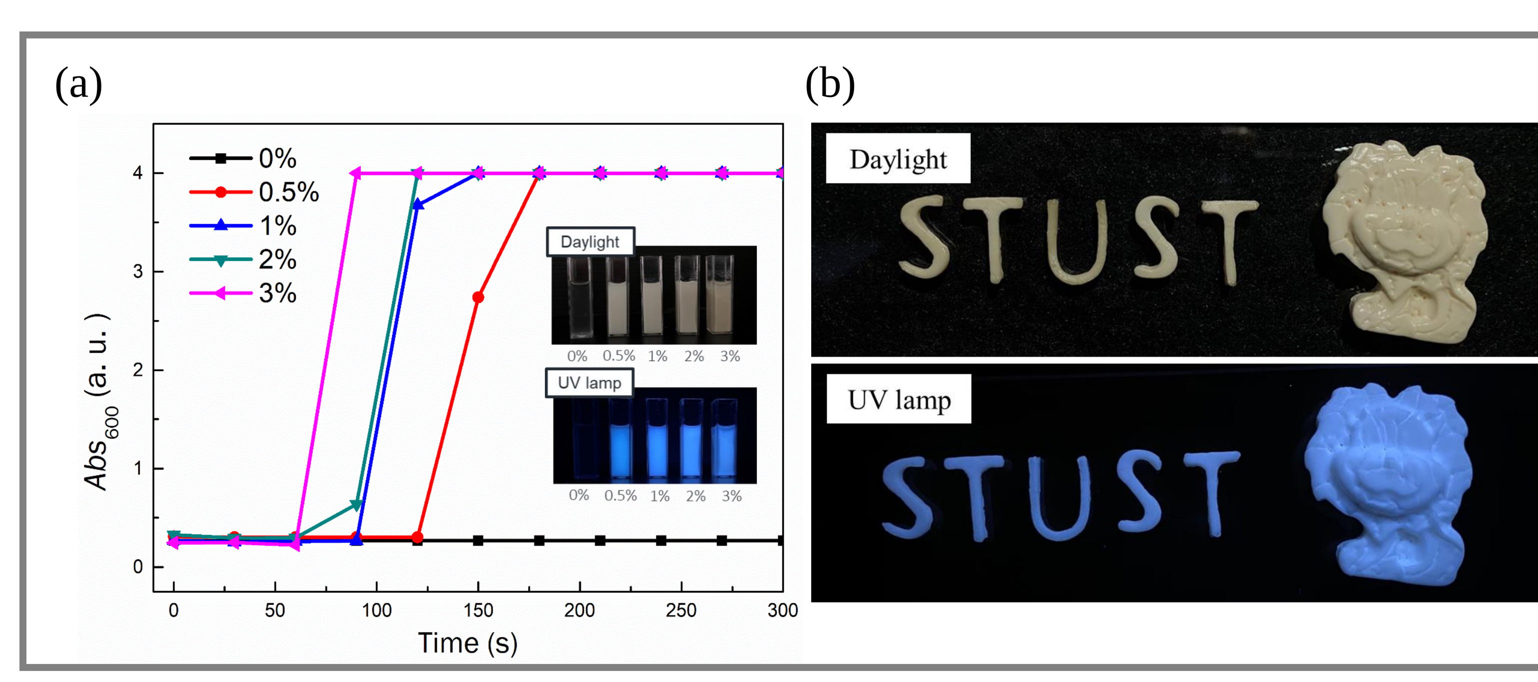


Figure 6. (a) Gel time (at 37 °C). (b) Patterning and programmable deformation of the PEI-CD/PAA hydrogels by using a silhouetted mask.

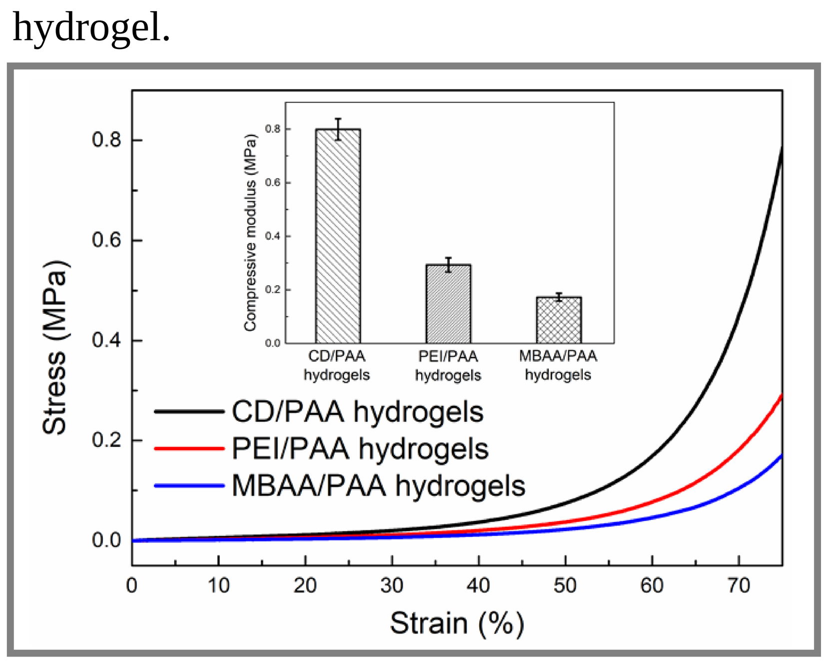


Figure 7. The compressive stress-strain curve of various hydrogels and the maximum compressive strength of various hydrogels.

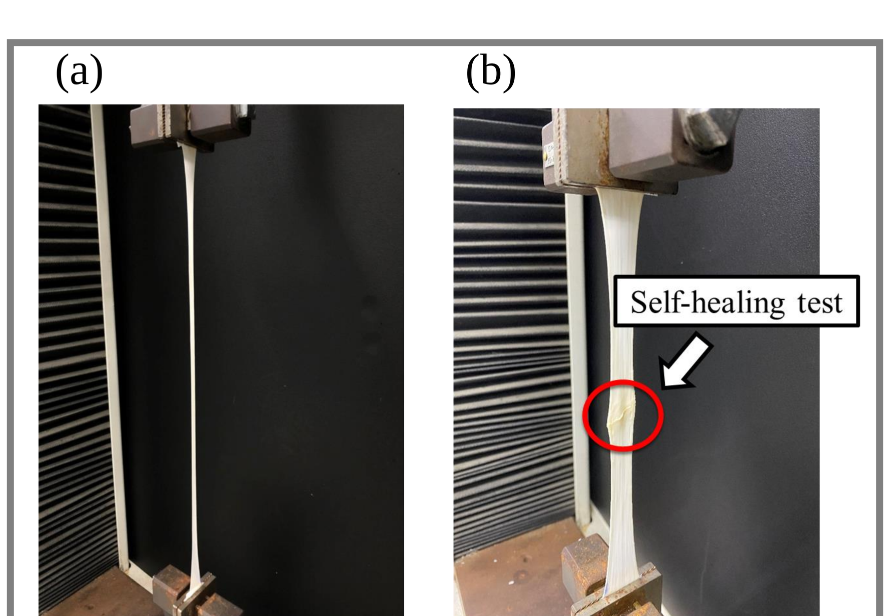


Figure 8. Photographs of the self-healing property of PEI-CDs/PAA hydrogels.

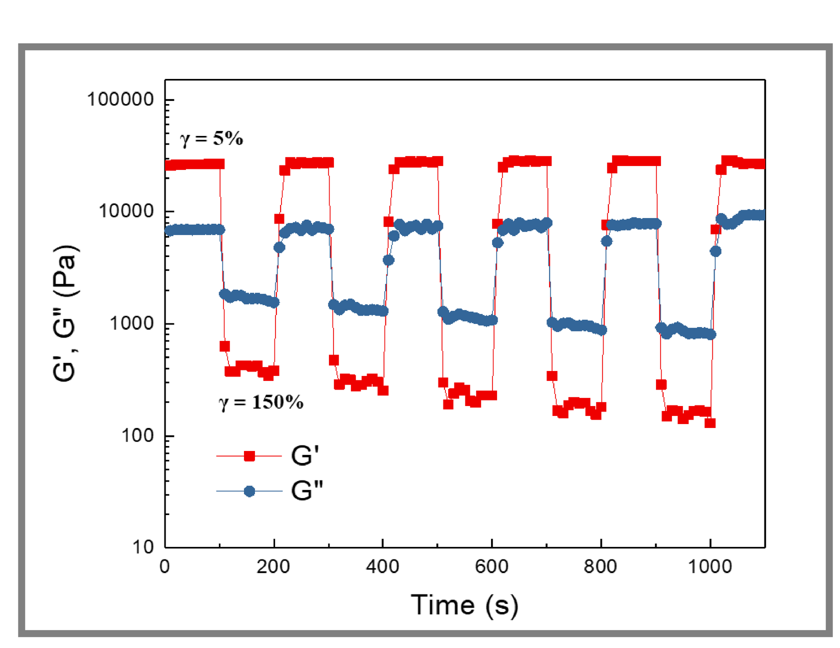


Figure 9. PEI-CDs/ PAA hydrogels rheological test.

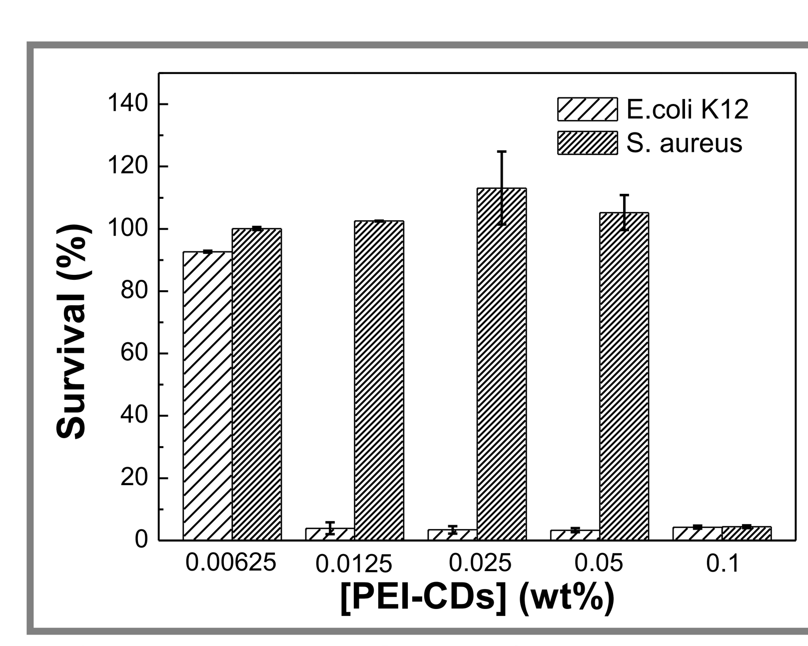


Figure 10. Survival rate of PEI-CDs against *Escherichia coli* and *Staphylococcus aureus* at various concentrations.

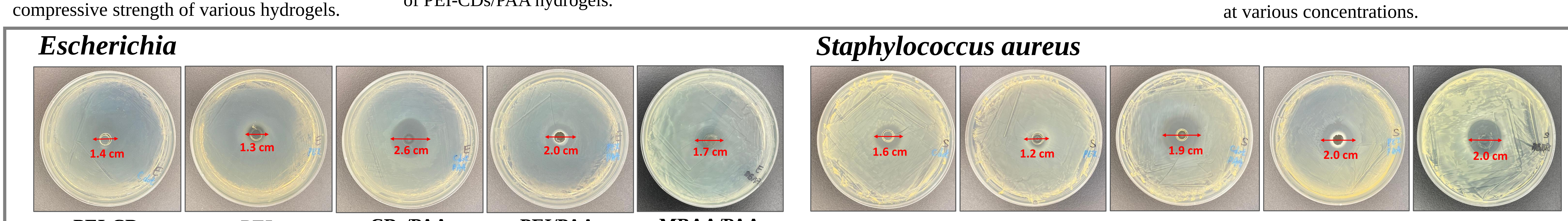


Figure 11. A zone of inhibition test using sterile discs dipped in *E.coli* K12 and *S. aureus*.

SUMMARY

1. We synthesized fluorescent self-healing PEI-CD/PAA hydrogels through reacting quaternary ammonium group-PEI-CDs and PAA hydrogel system.
2. The PEI-CD/PAA hydrogels exhibited fluorescence, high mechanical strength, self-healing and antibacterial properties.

REFERENCES

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