Photo-induced crosslinking for green electrospinning processes

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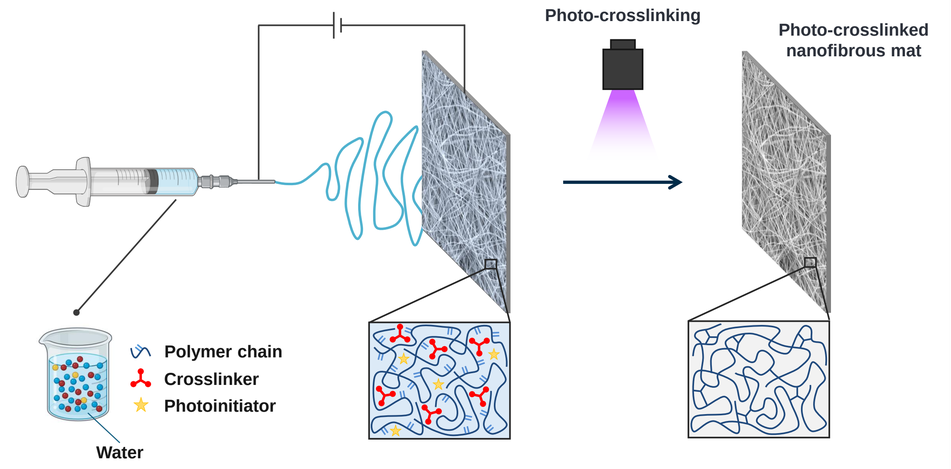
Introduction

Electrospinning is a versatile and **promising technology** for the mass production of nonwoven nanofibrous materials: polymer fibres are produced by an electrostatically driven jet of a polymer solution formed by the application of a high voltage. Due to its unique properties, it has a **wide application potential in several areas**, such as filtration, environmental and energy, and chemical and biological sensing.

Photopolymerization and **photo-induced processes** are efficient, eco-friendly and energy-saving processes due to reduced reaction time, high reactivity and low VOC emissions.

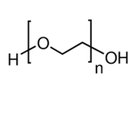
Herein, we report two examples of the use of photo-induced crosslinking on two different electrospun membranes, namely PEO-based and polybutadiene-based, to increase their thermal, chemical, and morphological stability.

Process



PEO-based

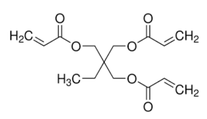
Polymer



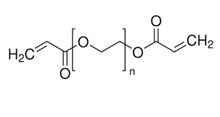
Polyethylene oxide (PEO)

- **Sustainable**
- **Biocompatible**
- **Water soluble**

Crosslinkers

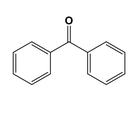


Trimethylolpropane triacrylate (TMPTA)



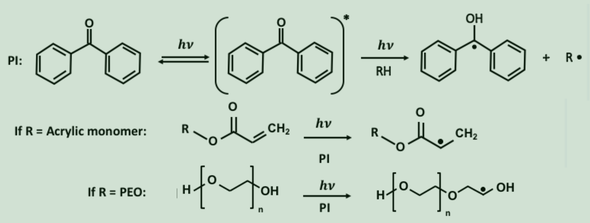
Polyethylene glycol diacrylate (PEGDA)

Photoinitiator



Benzophenone

Radical photo-crosslinking reaction:



Samples tested

TMPTA — PEGDA

Crosslinker

C=C/EO ratio: L — M — H

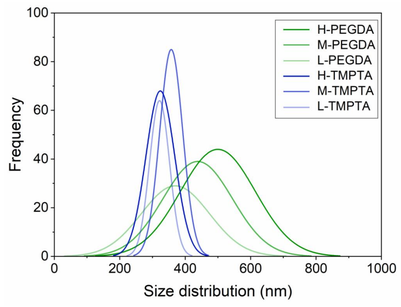
- **PEO/TMPTA:** uniform and thinner fibers, with narrower size distribution

Optimal system:

M-TMPTA

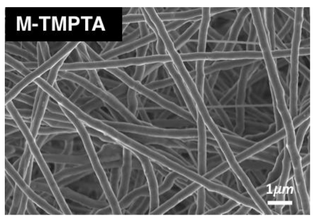
M-TMPTA	[%]
C=C conversion	42 ± 5
Insoluble fraction (water)	76

Size distribution

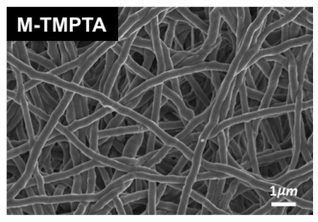


- **Relatively low C=C conversion** due to low spatial availability
- **High insoluble fraction**

Shape stability

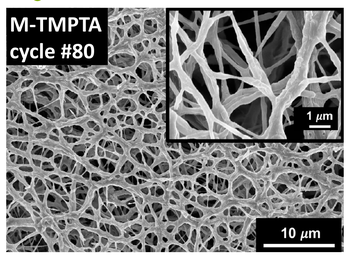


After electrospinning



After water treatment

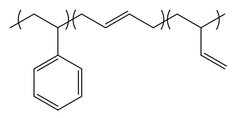
Thermal stability



- **Excellent shape stability** after water treatment and **thermal stability** up to 100°C due to photocrosslinking of TMPTA

Polybutadiene - based

Polymer

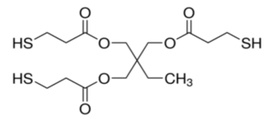


Styrene-butadiene copolymer (SBR)

- High flexibility
- Good mechanical properties

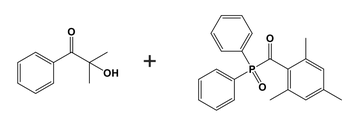
- Not easily electrospinnable
- Soluble in toxic solvents

Crosslinker



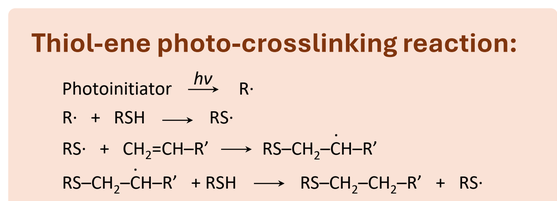
Trimethylolpropane tris(3-mercaptopropionate) (TRIS)

Photoinitiators (PI)

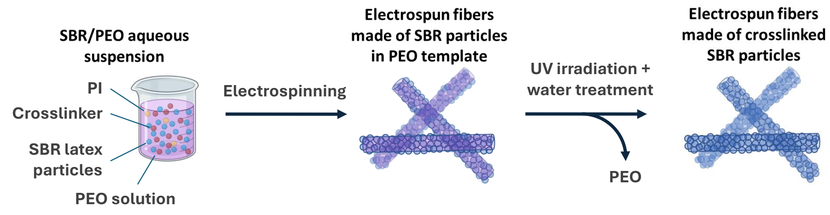


Darocur® 1173 + TPO

Thiol-ene photo-crosslinking reaction:



PEO was used as **electrospinnable templating agent**



Samples tested

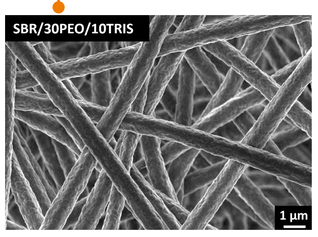
TRIS (phr): 3 — 10 — 50

PEO (phr): 7.5 — 15 — 30

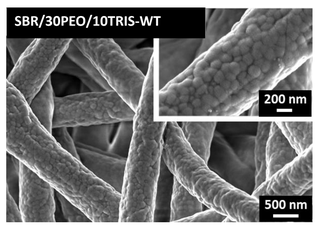
Optimal system: **SBR/30PEO/10TRIS**

- **Excellent shape stability** after water treatment
- **No cold-flow** of SBR at RT after photo-crosslinking

Fibers morphology

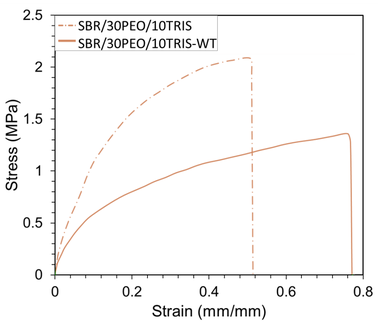


After electrospinning

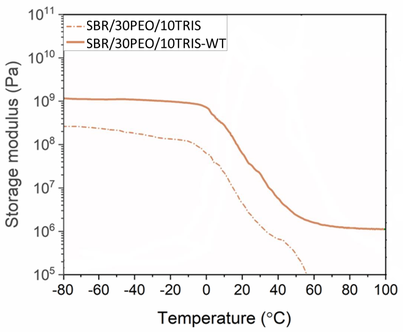


After UV irradiation + water treatment

Tensile test



DMTA



Conclusions

- **Coupling electrospinning and photo-crosslinking** is an efficient method to produce nanofibrous coatings with enhanced properties and well-controlled morphology and functionality

- **Green and sustainable fabrication of stable nanofibers** based on PEO and polybutadiene, **working at RT** and **using water-based solutions**
- **Enhancement of resistance of PEO and polybutadiene nanofibers to solvents, heat and storage time** thanks to photo-induced crosslinking

To know more about it

Thi Nhung Vu's poster:

"Innovative electrospun nanofibrous membrane by coupling electrospinning and photoinduced processes"

References

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Acknowledgements

This work was partially supported by the Italian Ministry of Foreign Affairs and International Cooperation (Grant number EG24GR02).

Ministry of Foreign Affairs and International Cooperation