IOCN 2025 Conference
The 5th International Online Conference on Nanomaterials
22–24 September 2025 | Online
MDPI

Fabrication and characterization of cross-linked PDMAEMA/PEGMA membranes incorporating ZnO nanoparticles

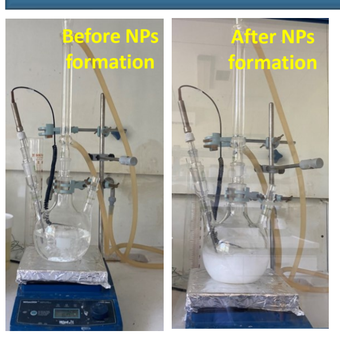
Ioanna Tzoumani[1], Ioannis Smpoukis[2], Zacharoula Iatridi[2], Georgios Bokias[1,3], Nikolaos Bouropoulos[2,3]

[1] Department of Chemistry, University of Patras, Patras GR-26504, Greece
[2] Department of Materials Science, University of Patras, Patras GR-26504, Greece
[3] Foundation for Research and Technology Hellas, Institute of Chemical Engineering and High Temperature Chemical Processes, Patras GR-26504, Greece

INTRODUCTION & AIM

The unique properties of materials at the nanoscale have attracted the interest of scientists in recent years for use in electronics, photonics, biomedicine, etc. Zinc oxide (ZnO) is a multifunctional material. Some of the main applications of ZnO include cosmetics and protective products [1]. Also, it is widely used in antibacterial applications due to its excellent physicochemical properties and bioactivities [2]. The incorporation of ZnO nanoparticles (NPs) into polymers leads to nanocomposites with improved properties (e.g. optical, thermal, biomedical) [3]. The aim of this work was to prepare and explore the properties of hybrid polymer/ZnO membranes. For this, two water-soluble copolymers, were combined to form cross-linked membranes in which ZnO nanoparticles (~7nm in size) were incorporated. The presence of ZnO in the membranes was confirmed by several methods. Properties like surface wettability, surface morphology and thermal stability were also examined.

EXPERIMENTAL



Preparation of ZnO NPs in boiled MeOH solution

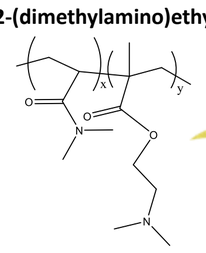
Concentrations and amounts of reagents used and the amount of ZnO formed.

Sample	Zinc Acetate Dihydrate (M)	KOH (M)	ZAD (g)	KOH (g)	H_2O (ml)	ZnO (g)
IS4	0,05	0,10	5,4844	2,8048	-	1,6902

Preparation of cross-linked membranes

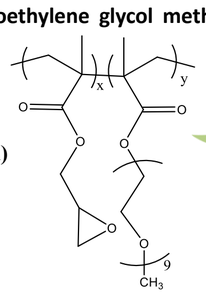
poly(*N*,*N*-dimethylacrylamide-co-2-(dimethylamino)ethyl methacrylate)

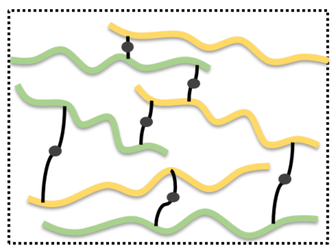
P(DMAM-co-DMAEMA)

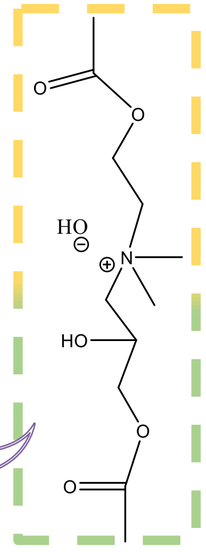


poly(glycidyl methacrylate-co-oligoethylene glycol methyl ether methacrylate)

P(GMA-co-PEGMA)







cross-linking through the reaction between the amine and epoxy groups derived from DMAEMA and GMA units

Amounts of reagents used and experiment condotions for the preparation of cross-linked polymer/ZnO membranes

Sample	Complementary Copolymers (g)		EtOH (ml)	ZnO (IS4) (mg)	Curing temperature and curing time
	P(DMAM-co-DMAEMA)	P(GMA-co-PEGMA)			
Pol	0.3	0.3	12	0	120°C/12h
Pol/ZnO7.5	0.3	0.3	12	7.5	120°C/12h
Pol/ZnO15	0.3	0.3	12	15	120°C/12h
Pol/ZnO30	0.3	0.3	12	30	120°C/12h

Pure Polymer membrane **Pol/ZnO7.5 membrane**

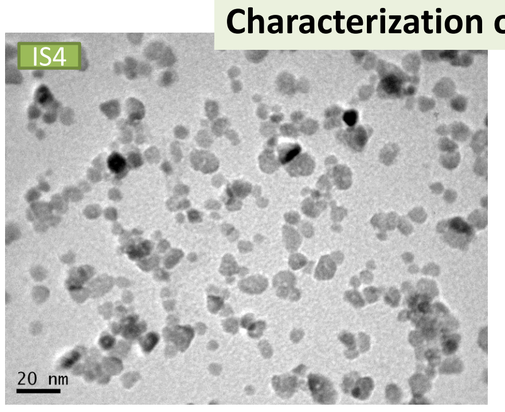
Characterization of Polymer/ZnO membranes:

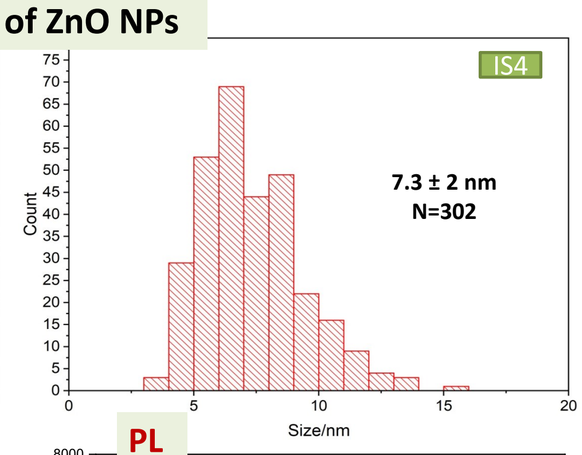
- ✓ Scanning Electron Microscopy/Elemental Analysis (SEM/EDS)
- ✓ Thermogravimetric Analysis (TGA)
- ✓ Water Contact Angle measurements (WCA)
- ✓ Antimicrobial Activity tests

RESULTS & DISCUSSION

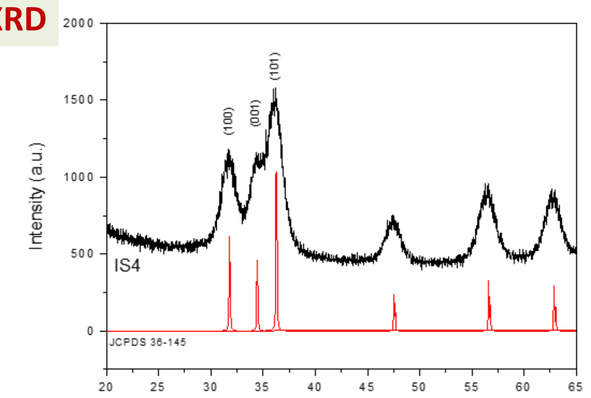
Characterization of ZnO NPs

TEM

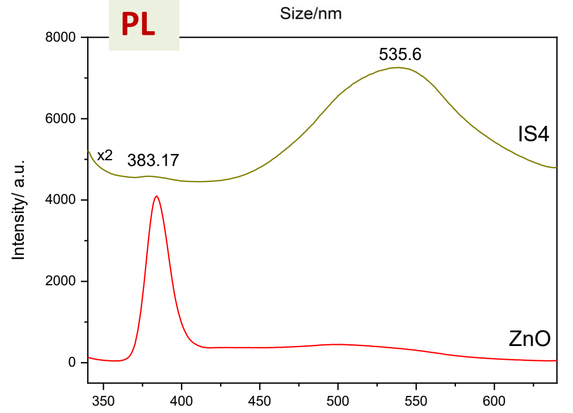




XRD

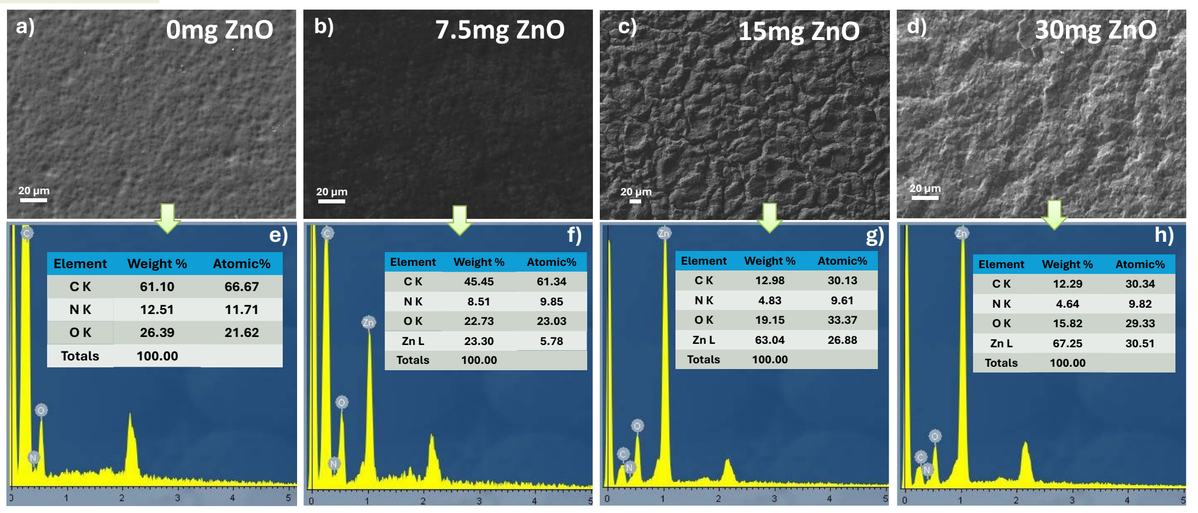


PL

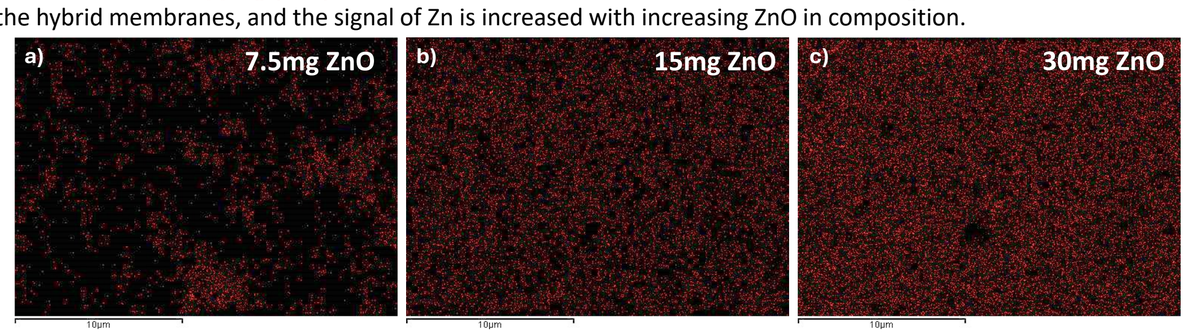


Characterization of Polymer/ZnO membranes

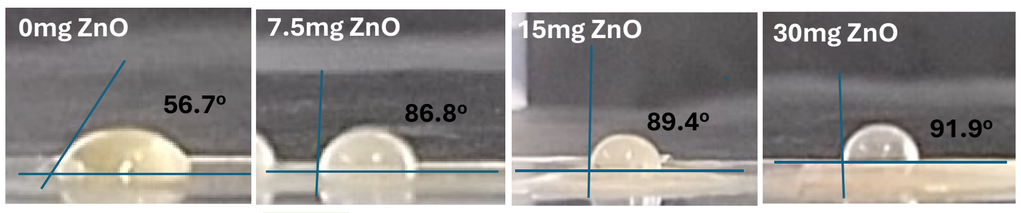
SEM/EDS



From **Elemental mapping (EDS)** of Zn in Pol/ZnO membranes it is seen that: there is good distribution of ZnO in the hybrid membranes, and the signal of Zn is increased with increasing ZnO in composition.

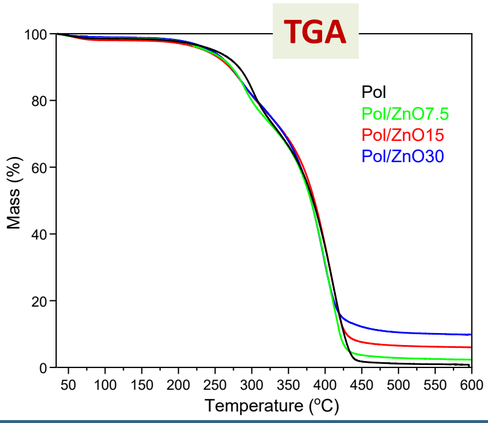


Water Contact Angle

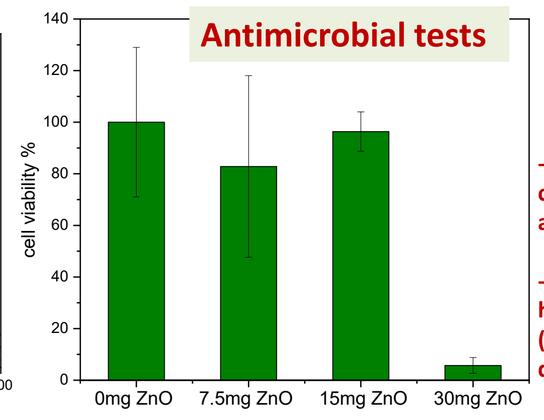


- **Pure polymer membrane exhibited the most hydrophilic behavior.**
- **Hydrophobic behavior increases with the increase of ZnO NPs in the polymer/ZnO membranes.**

TGA



Antimicrobial tests



Effect of ZnO-NPs on S.aureus

- **The membranes exhibit a concentration-dependent antimicrobial effect.**
- **The membrane with highest concentration (30mg ZnO) leads to decreased cell viability.**

CONCLUSION

- ❖ Successful synthesis and characterization of ZnO NPs in boiled methanolic solution.
- ❖ Crosslinked materials were successfully synthesized via reactive blending of random copolymers with complementary active groups.
- ❖ The hybrid Polymer/ZnO membranes were successfully characterized by SEM/EDS, TGA and WCA measurement. We found good distribution of ZnO in the hybrid membranes, and the signal of Zn is increased with increasing ZnO in composition. The increase of ZnO NPs in the polymer/ZnO membranes enhances hydrophobic behavior.
- ❖ Preliminary antimicrobial tests indicate a concentration-dependent activity: the membrane with highest concentration in ZnO leads to the most decreased S. aureus cell viability.

REFERENCES

[1] S. Raha, Md. Ahmaruzzaman, *Nanoscale Adv.*, **2022**, *4*, 1868-1925.
[2] V. Puspasari, A. Ridhova, A. Hermawan, M.I. Amal, M.M. Khan. *Bioprocess Biosyst Eng*. **2022**, *45(9)*, 1421.
[3] D. Ponnamma, J.-J. Cabibihan, M. Rajan, et al. Mat. Sci. Eng.C, 2019, 98, 1210

Acknowledgements: The antimicrobial tests were performed by Assoc. Prof. Alexios Vlamis-Gardikas from the Department of Chemistry, University of Patras, Greece