Hydrophobically Modified Self-healable UV-resistant Smart Polymer/MOF Composite for Coating Application

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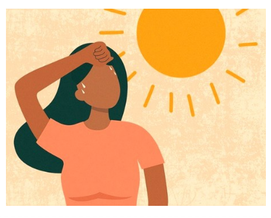
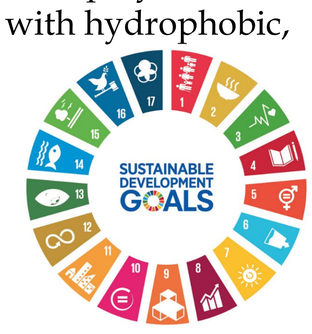
Abstract

This study introduces a novel hydrophobic, self-healing, UV-resistant smart polymer/metal-organic framework (MOF) composite designed for advanced coating applications. The copolymer, P(GMA-co-LMA), was synthesized to impart hydrophobicity, flexibility, self-cleaning, and heat-induced self-healing properties. Incorporating the MOF component enhanced the composite's antimicrobial and anti-UV capabilities. Characterization techniques such as 1H NMR, FTIR, and DSC were employed to analyze the copolymer. Further analysis of the composite was conducted using FTIR, XRD, SEM, UV-vis spectroscopy, water contact angle measurements, and antimicrobial tests. The resulting composite demonstrates significant improvements in surface roughness and water contact angle, indicating enhanced functionality. This innovative material holds promise for various applications requiring advanced durability and protection, including military textiles, passport covers, and high-performance coatings. The straightforward synthesis method also suggests potential for scalable production of multifunctional fabrics, aligning with current industrial demands for smart, robust materials with environmental resistance and self-repair capabilities.

Introduction

- ✓ Self-healing materials offer enhanced durability and sustainability.
- ✓ Focus on macromolecular chemistry to engineer functional polymers.
- ✓ This work presents a smart polymer/MOF composite with hydrophobic, UV-resistant, and antimicrobial properties.
- ✓ Environmental Consequences: Production & Disposal



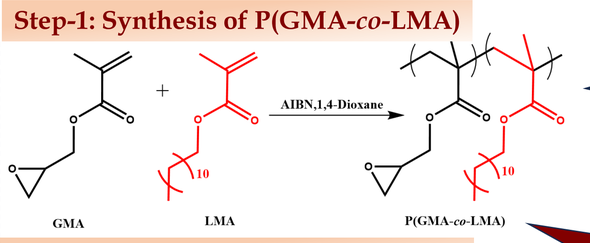
Research Gap

- ✓ Need for Long-lasting Advanced Coatings
- ✓ Challenges in Conventional Coatings, i.e. Environmental resistance
- ✓ Lack of Multifunctionality & Application Versatility
- ✓ Scalability and Ease of Synthesis



Methodology

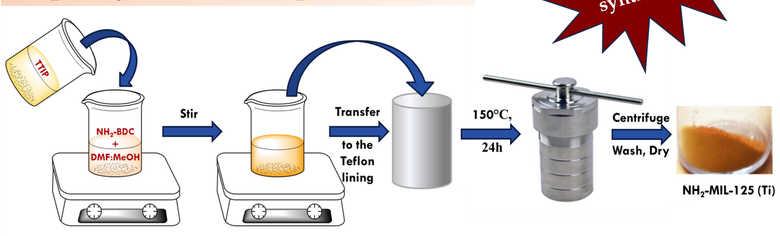
Step-1: Synthesis of P(GMA-*co*-LMA)



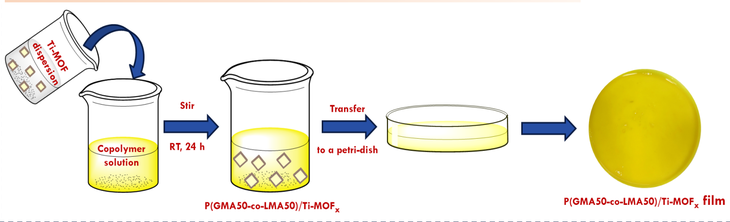
Mild reaction conditions

Easy to synthesise

Step-2: Synthesis of NH_2-MIL-125 (Ti)

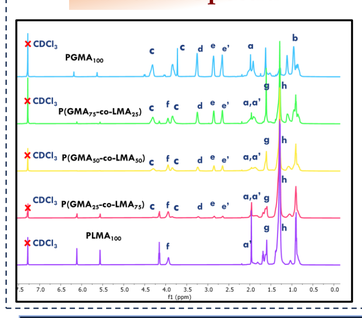


Step-3: Synthesis of P(GMA-*co*-LMA)/Ti-MOF

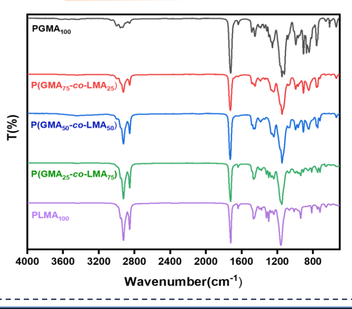


Characterisation of (GMA-*co*-LMA)

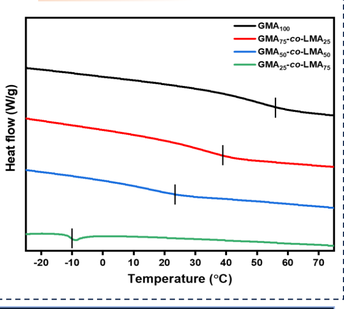
^{1}H-NMR Spectra



FT-IR Analysis

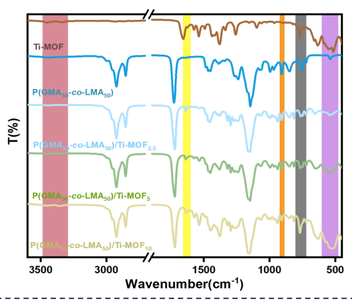


DSC Thermogram

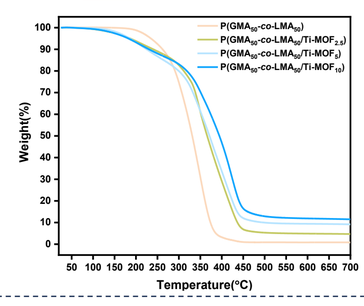


Characterisation of P(GMA-*co*-LMA)/Ti-MOF

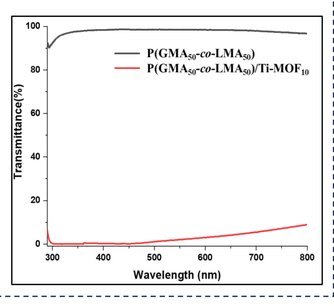
FT-IR Analysis



TGA Analysis



UV-vis Analysis



Results & Discussion

Hydrophobicity

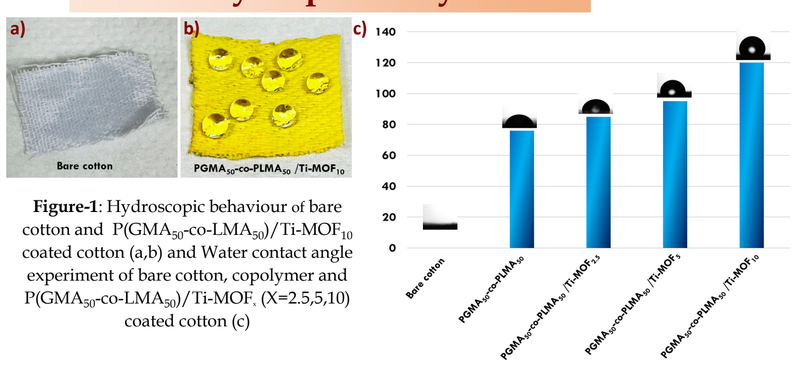


Figure-1: Hydroscopic behaviour of bare cotton and P(GMA_{50}-co-LMA_{50})/Ti-MOF_{10} coated cotton (a,b) and Water contact angle experiment of bare cotton, copolymer and P(GMA_{50}-co-LMA_{50})/Ti-MOF_x (X=2.5,5,10) coated cotton (c)

Self-healing Study

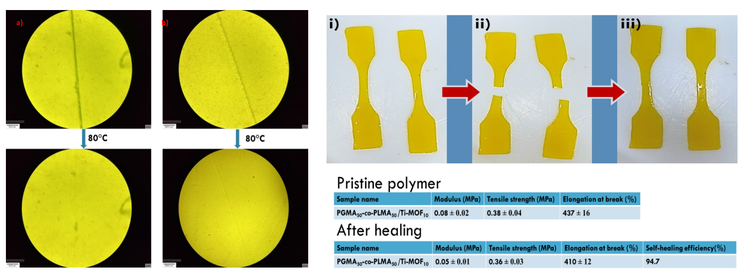
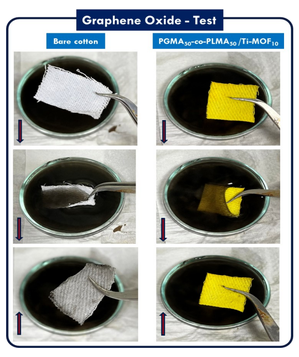


Figure-4: Optical images of P(GMA_{50}-co-LMA_{50})/Ti-MOF_{10} films before(a) and after(b) healing

Self-cleaning



UV-resistance

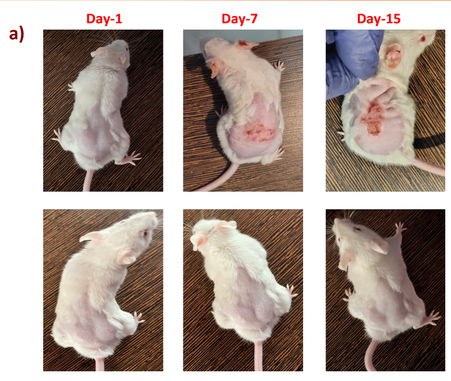


Figure-2: visual images at different days intervals of UVB exposure of mice covered with normal cotton and P(GMA_{50}-co-LMA_{50})/Ti-MOF_{10} coated cotton(a)

Smart Properties

Anti-bacterial Study

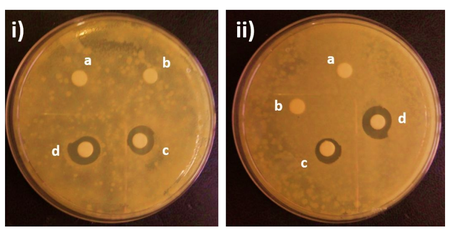


Figure-3: Zone of the inhibition test result in a culture lawn of i) E. coli and ii) S. aureus of a) uncoated cotton (controlled), b) coated with P(GMA_{50}-co-LMA_{50}), c) only NH_2-MIF-125(Ti) and d) P(GMA_{50}-co-LMA_{50})/Ti-MOF_{10}.

Durability Test

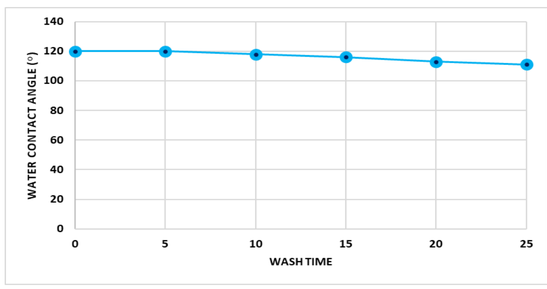


Figure-5: Water contact angle experiment of P(GMA_{50}-co-LMA_{50})/Ti-MOF_{10} coated cotton after 25 times washing for durability test

Conclusion

- ✓ Developed a hydrophobic, self-healing, UV-resistant smart polymer/MOF composite.
- ✓ Demonstrated enhanced properties: antimicrobial, anti-UV, self-cleaning.
- ✓ Potential applications in textiles, passport covers, and high-performance coatings.
- ✓ Scalable synthesis method aligns with industry needs for durable, smart materials.
- ✓ This work aligns with **SDG-9, 11, 12,** and **13**, emphasizing the need for advanced, sustainable materials for a better future.

Future perspectives

- ✓ To optimize composite properties for better performance.
- ✓ To scale up production methods for industrial use.
- ✓ To conduct long-term durability and real-world application tests.
- ✓ To customize materials for specific industries like aerospace and healthcare.
- ✓ To investigate eco-friendly alternatives and recycling methods.

Acknowledgement

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References

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Thank you