Fabrication of Polyurethane-Modified Concrete with Zinc Oxide Nanoparticles Using Cocopol Blend Polyols

Renzo Miguel R. Hisona[a]*, Arnold C. Alguno[ab], Arnold A. Lubguban[bc], Roberto M. Malaluan[bc], and Noel Lito B. Sayson[a]

[a]Department of Physics, Mindanao State University – Iligan Institute of Technology, A. Bonifacio Avenue, 9200 Iligan City, Philippines, [b]Center of Sustainable Polymers, Mindanao State University – Iligan Institute of Technology, A. Bonifacio Avenue, 9200 Iligan City, Philippines, [c]Department of Chemical Engineering and Technology, Mindanao State University – Iligan Institute of Technology, A. Bonifacio Avenue, 9200 Iligan City, Philippines

*E-mail: renzomiguel.hisona@g.msuiit.edu.ph

INTRODUCTION

- Polyurethane-modified concrete (PMC) offers significant advantages, such as excellent bonding ability, high workability, and high resistance to aggressive environments, making them applicable in areas like the rehabilitation of deteriorated bridge decks and industrial flooring overlays.
- However, in a specific application, there is a need to have better mechanical properties of the PMCs.
- To address this problem, integrating zinc oxide (ZnO) nanoparticles as filler in the PMC matrix is an excellent candidate to improve its mechanical properties.
- In this work, ZnO nanoparticles are introduced in the PMC matrix to enhance its mechanical properties in terms of maximum strain and stress of the composites.

Related studies: **concrete coatings and ZnO fillers**

- ✓ Polyurethane resin-modified concrete: concrete did not harden[1]
- ✓ Effects of ZnO on cement performance: increased mechanical strength[2]
- ✓ Solutions to blistering: usage of surfactant[3]

Present Study:

- ✓ ***Fabricate polyurethane-modified concrete with ZnO nanoparticles using cocopol blend polyols***

METHODOLOGY

Moringa Leaves Extract + **Zinc Sulphate**

Temperature is kept constant for 2 hours (w/ stirring)

Samples were placed in a Centrifuge machine and then washed with distilled water and ethanol multiple times

Samples were then dried overnight and then calcined

Characterization using **FTIR** and **UV-VIS**

Fabrication of PMC samples (Control, PMC, PMC w/ ZnO)

PMC was fabricated using Portland cement, isocyanate, glycerol, Rokopol, and water.

Introduction of ZnO in PMC sample fabrication (1, 2, 3%wt)

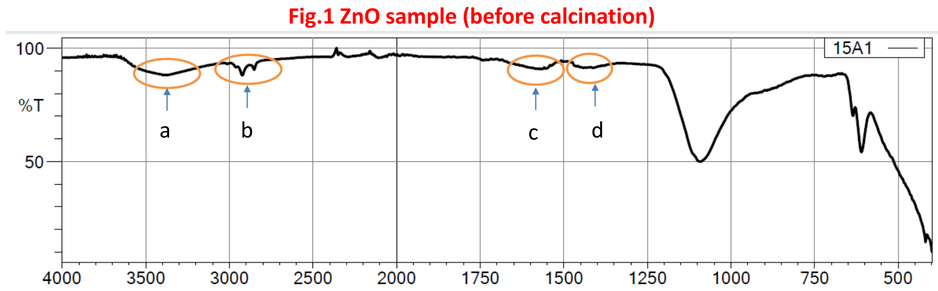
Characterization using **FTIR** and testing using UTM

Diagram of PMC and ZnO sample preparation, characterization and testing experiment

RESULTS *and* DISCUSSION

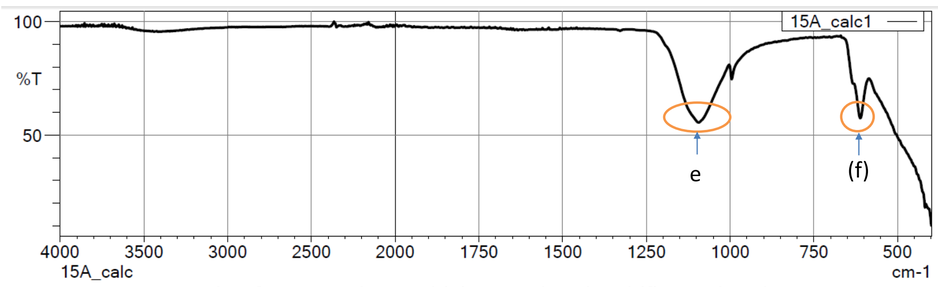
Fourier Transform Infrared (FTIR) spectroscopy (ZnO)

Fig.1 ZnO sample (before calcination)



Organic compounds present in sample before calcination (a), (b), (c), and (d)

Fig. 2 ZnO sample (after calcination)

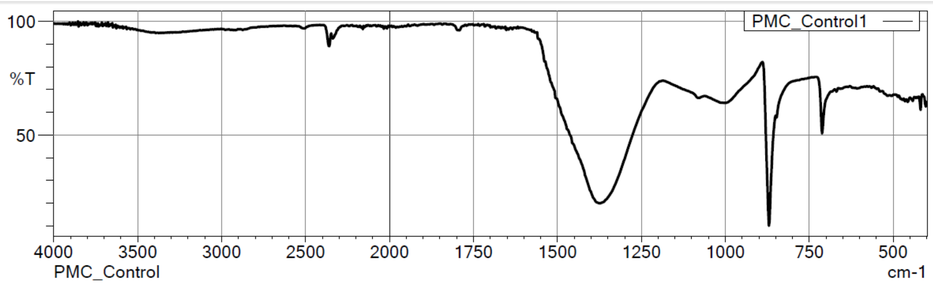


Peaks of interest observed (e) Zn-OH bond and (f) Zn-O bond

- Most of the organic compounds present in the sample were removed after calcination.
- Peaks corresponding to the (e) Zn-OH bond and (f) Zn-O bond were observed.

Fourier Transform Infrared (FTIR) spectroscopy (PMC)

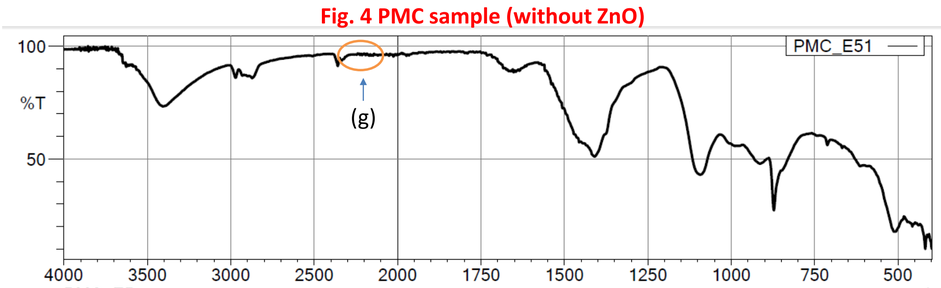
Fig. 3 Control Sample for PMC testing



- Control sample has no added PU, only Portland cement and water
- Used for comparison during PMC sample mechanical property testing

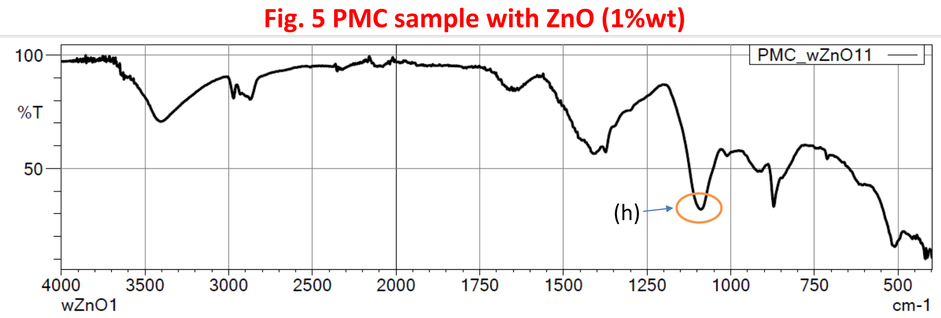
Fourier Transform Infrared (FTIR) spectroscopy (PMC)

Fig. 4 PMC sample (without ZnO)



(g) No peak at 2200 cm^{-1}

Fig. 5 PMC sample with ZnO (1%wt)



(h) Zn-OH peak in PMC sample with 1%wt ZnO

✓ **Formation of PMC**

- It is observed in Fig. 4 that there is no visible peak at around 2200 cm^{-1} (g), which is an indicator of the reaction between the polyols and isocyanate during polyurethane formation.

✓ **ZnO is incorporated in PMC**

- ZnO was integrated into the PMC during fabrication.
- In Fig. 5 a more pronounced peak (h) for the Zn-OH bond is observed, since ZnO equal to 1% of the total weight of the sample was introduced during PMC production.

UV-VIS (ZnO)

Fig. 6 Prelim ZnO sample (without annealing)

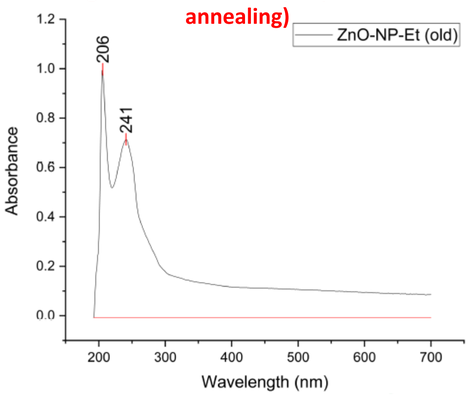
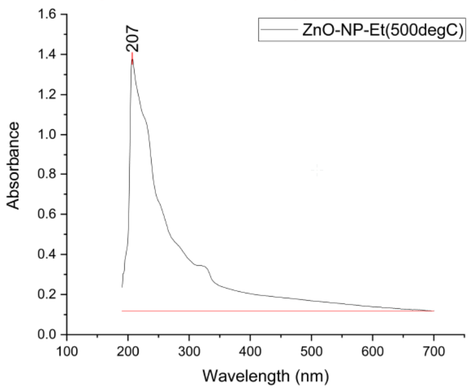


Fig. 7 Prelim ZnO sample (annealed)



UV-VIS results for Preliminary ZnO sample before and after annealing at 500°C

Pictures of Prototype PMC samples without ZnO

(a) PMC Prototype 1 (b) PMC Prototype 2 (c) PMC Prototype 3 (d) PMC P3 (back) (e) PMC P3 (top)

CONCLUSION

PMC was fabricated using Portland cement, isocyanate, glycerol, Rokopol, and water. Also, ZnO NPs were synthesized using the green synthesis method with Zinc sulfate, and moringa leaves extract as starting materials. Improvement in the mechanical properties of maximum strain and stress is very important in the application of industrial flooring overlays.

Acknowledgment:

The authors would like to acknowledge the **DEPARTMENT OF SCIENCE AND TECHNOLOGY (DOST)** through **DOST-NICER** and **DOST-PCIEERD** for the program funding and the **DOST-ASTHRD program** for the scholarship grant.

References:

1. Dhaliwal, G.S., Chandrashekhara, K., Volz, J., and Schuman, T.; "Nano-Engineered Polyurethane Resin-Modified Concrete"; Repository & Open Science Access Portal, 2014
2. Kumar, M., Bansal, M., Garg, R.; "An overview of beneficiary aspects of zinc oxide nanoparticles on the performance of cement composites"; Materials Today: Proceedings, Vol. 43, Part 2, pp. 892-898, 2021
3. Papadopoulos, E., "Solutions to Blistering: Modification of a Poly(urea-*co*-urethane) Coating Applied to Concrete Surfaces", 2009