



# **Antimicrobial Activity of Nypa Fruticans (Nipa) Palm Starch and Zinc Oxide Nanoparticles (ZnONPs) in Textile: Solving the Scarcity Using Local Resources**

**Karina Milagros R. Cui-Lim<sup>1,2,3\*</sup>, Flyndon Mark S. Dagalea<sup>1,3</sup>,  
Nelia M. Adora<sup>3,4</sup> and Cherry I. Ultra<sup>3,5</sup>**

<sup>1</sup>Department of Physical Sciences, College of Science, University of Eastern Philippines, University Town, Northern Samar 6400, Philippines.

<sup>2</sup>Office of the Vice President for Research, Development and Extension, University of Eastern Philippines, University Town, Northern Samar 6400, Philippines.

<sup>3</sup>University Research and Development Services, University of Eastern Philippines, University Town, Northern Samar 6400, Philippines.

<sup>4</sup>Office of the Vice President for External Affairs, University of Eastern Philippines, University Town, Northern Samar 6400, Philippines.

<sup>5</sup>Office of the University President, University of Eastern Philippines, University Town, Northern Samar 6400, Philippines.

## **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors KMRCL and FMSD designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors NMA and CIU managed the distribution of the coated facemask with nipa biocomposite to the community. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/JPRI/2020/v32i3831016

### Editor(s):

(1) Dr. Mohamed Fathy, Assiut University, Egypt.

(2) Dr. Arun Singh, Rohilkhand Medical College & Hospital, India.

### Reviewers:

(1) H.S. Lalithamba, Siddaganga Institute of Technology, India.

(2) Areej Mostafa El- Mahdy, Mansoura University, Egypt.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/63519>

**Original Research Article**

**Received 29 September 2020**

**Accepted 04 December 2020**

**Published 04 January 2021**

## **ABSTRACT**

Nanotechnology is an emerging interdisciplinary technology that has been booming in many areas during the recent decade. The application of nanoscale materials and structures, usually ranging from 1 to 100 nanometers (nm), is an emerging area of nanoscience and nanotechnology. In this

\*Corresponding author: E-mail: karina\_cui@yahoo.com;

work, Zinc Oxide Nanoparticles were prepared by wet chemical method using zinc nitrate and sodium hydroxide as precursors and *Nypa fruticans* (Nipa) starch as stabilizing agent. The antimicrobial property was found effective against *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) bacteria. It has a clear zone of inhibition against *S. aureus* and *E. coli*. The scanning electron micrograph exhibited that after several washings the cloth facemask coated with nipa starch and zinc oxide still adheres to the cloth.

**Keywords:** Zinc oxide nanoparticles (ZnONps); *Nypa fruticans*; textile; antimicrobial property.

## 1. INTRODUCTION

Over the past months, the whole world has experienced the need for personal protective equipment (PPE), mostly this is the first time we experienced it in our lives. The need for gloves, sanitary items, social distancing, and especially face mask has been an important fixtures in our lives. Many of us have experienced shortage to no availability of PPE especially face masks, which lead to a numerous face masks which are ill-fitting and other unsanitary face gear.

All the leading textile industries are focusing on value added applications such as microbe resistance, electromagnetic protection and thermoregulatory fabrics [1]. Nanotechnology is an umbrella term covering a wide range of technologies concerned with structures and processes on the nanometer scale [2]. Because of its potential to change fundamentally whole fields of technology, nanotechnology is regarded as a key technology which will not only influence technological development in the near future, but will also have economic, social and ecological implications. For the past decade, nanoscale science and other related technologies has been the leading technology. Composite technologies have been merged with nanoscale science, leading to the development of nanocomposite science and technology. Incorporation of nanoparticles into composite materials has attracted a great deal of attention due to its ability to enhance properties such as thermal, mechanical and antibacterial properties [3].

The use of nanotechnology in the field of textiles has received much attention with the current broad interest in nanomaterials and nanotechnology [4]. According to the National Nanotechnology Initiative (NNI), nanotechnology is defined as utilization of structure with at least one dimension of nanometer size for the construction of materials, devices or systems

with novel or significantly improved properties due to their nano-size [5].

The wide range of applications is possible as ZnO has key advantages. It is bio-safe, biocompatible and can be used for biomedical applications without coating. With these unique characteristics, ZnO could be one of the most important nanomaterials in future research and applications [6].

The surface of Zinc oxide nanoparticles reacts with water to produce reactive oxygen species that destroy the bacteria cell membranes. And, if the nanoparticles are made small enough, the bacteria will actually internalize the nanoparticles, resulting in even higher killing efficiency as the cells are attacked from the inside too [7].

The people of Northern Samar, with a population of approximately 700,000 people, live in and subsist on the different island towns surrounded by species of palms like *Nypa fruticans* Wurmb. Until this day, Nipa is an underutilized plant resource since the only use of the nipa leaves are for roofing. The fruit of nipa is still of no economic use to the people of Northern Samar. Different palms were studied by the scientific community, in searching for new alternative sources like oil and starch, and the initial results proved their active properties of starch and that oil can be extracted from the palm of nipa. Nipa palm starch are rich sources of oil and the starch possess antibacterial properties. Antibacterial activity of Zinc Oxide Nanoparticles (ZnONps) has received significant interest worldwide particularly by the implementation of nanotechnology to synthesize particles in the nanometer region. Many microorganisms exist in the range from hundreds of nanometers to tens of micrometers. ZnONps exhibit attractive antibacterial properties due to increased specific surface area as the reduced particle size leading to enhanced particle surface reactivity. ZnO is a bio-safe material that possesses photo-oxidizing and photocatalysis impacts on chemical and

biological species [8]. In this work, the cloth facemask coated with nipa starch and zinc oxide nanoparticles will be studied.

## 2. MATERIALS AND METHODS

### 2.1 Isolation of Starch

The collected fresh fruits of *Nypa fruticans* were washed to remove the dirt and were dehulled manually to get the mature seeds. One kilogram up to more than five kilograms of fresh seeds were weighed and soaked in one liter (for every kilogram of the seeds) of 1% of Sodium Metabisulfate solution was added into it and was soaked for one hour. After an hour, the seeds were put in a juicer. It was juiced into paste and was filtered using cheesecloth. The filtrate was then soaked with 1% Sodium Metabisulfate and allowed to settle. Supernatant was discarded and then the starch mucilage was washed four times with 1% Sodium Metabisulfate and allowed to stand for 90 mins. After each wash, the starch mucilage was dried at 60°C in a drying oven for twelve hours. The dried starch was then pulverized and kept for analysis.

### 2.2 Preparation of Zinc Oxide from Zinc Nitrate

The preparation was done with the procedure of Subhankar Paul [2] with some modification made. Zinc oxide nanoparticles was prepared by using Zinc nitrate and sodium hydroxides precursors and starch as a stabilizing agent. Starch isolated from *Nypa fruticans* seeds, about 0.1g was dissolved in 500 mL of lukewarm distilled water. Grams of zinc nitrate was added in the nipa starch solution, and then followed by constant stirring for 1 hour using magnetic stirrer to completely dissolve the zinc nitrate. After complete dissolution of zinc nitrate, 0.2 M of NaOH solution was added drop by drop under constant stirring. The reaction was allowed to proceed for 2 hours. After the completion of reaction, the solution was kept overnight and the supernatant solution was kept overnight and the supernatant solution was discarded carefully. Rest of the solution was centrifuged at 10,000 g for 10 min and the supernatant was discarded. Thus, the nanoparticles were obtained and washed thrice using distilled water. Washing was carried out to remove the by-products and the excessive starch bound with the nanoparticles. After washing, the nanoparticles were dried at 80°C overnight.

### 2.3 The Antimicrobial Properties of Textile Treated with Zinc Oxide Nanoparticles

Antimicrobial analysis was carried out using the procedure used by Ariap (2017) but some modifications were made. All the equipment was placed in an autoclave for sterilization. Rajendran et al. [9] antimicrobial test was used to determine the antimicrobial activity of the treated textile against *E. coli* and *S. aureus*. Each of the subculture pure isolates of the bacteria were aseptically harvested into the surface of the cultured plates by using sterile cotton swab. A plain textile for the control was soaked with the solution of Chloramphenicol (1:10). The textiles and the soaked control were aseptically and carefully impregnated into the surface of nutrient agar using a sterile pick-up forceps. The disc was placed with a distance from each other. The inoculated plates were incubated at 37°C for 18-24 hours. After the inoculation, the plates were inspected for the presence of any clear zone of the inhibition around the sample discs.

### 2.4 Application of Nipa and ZnONps Biocomposite in Facemask

A procedure from the study conducted by S. Anita was adapted with a little modification. The zinc oxide nanoparticles were applied to the facemask cloth by pad-dry-cure method (with a little modification). The 2% zinc oxide nanoparticles were sprayed in a facemask cloth. A 100% wet-pick up was maintained for all the treatments. After spraying, the facemask was air-dried and then cured for 3 minutes at 140°C. The coated fabric was immersed for 5 mins in 2 g/L Sodium Lauryl Sulphate to remove any unbound nanoparticles. The fabric was next rinsed 10 times to completely remove any traces of soap. The facemask was finally dried in ambient air condition. The coated facemask was packaged properly and is ready for use.

## 3. RESULTS AND DISCUSSION

Nipa palm fruit starch is an interesting substrate for the production of cyclodextrin, an important polysaccharide due to its unique hydrophobic interior cavity and hydrophilic surface. It can encapsulate hydrophobic organic substances and aid its solubilization in water. This property is useful in food, pharmaceutical, cosmetic, agricultural, textile and packaging applications because of its economic and environmental

potentials. Modification is usually carried out to overcome the unstable properties of nipa palm fruit starch and improve its physical properties during processing. Incorporation of ZnO into biocomposite materials has attracted a great deal of attention due to its ability to enhance its properties. The combination of the unique properties of nipa palm starch and zinc oxide make it an interesting material for the development of practical applications as facemask coating with antimicrobial properties.

The result of the antimicrobial test for synthesized ZnONps against the bacteria *Staphylococcus aureus* and *Escherichia coli* is presented in Figs. 1 and 2.

As presented in the figures above, the result shows that ZnONps exhibits an antimicrobial activity against both *S. aureus* showing a clear zone of inhibition of 3.67 mm mean in all treatments and *E. coli* showing a zone of inhibition of 2.33 mm mean in all treatments, this implied that the sample have the potential in inhibiting the growth of *E. coli* and *S. aureus* bacteria, indicated by the presence of clear zone of inhibition. Absence of any clear zone suggest that the organisms were resistant to the chemical agent present in the disc. On the other hand, result of the positive control reconstituted powder of chloramphenicol was expected for a clear zone of inhibition. Once the ZnO kills/captures the cell membrane, the ZnONps presumably remain tightly adsorbed on the surface of the dead bacteria preventing further bacterial action [10]. However, ZnO nanoparticles continue to release peroxides into the medium even after the surface of the dead bacteria are completely

covered by ZnO nanoparticles, thereby showing high bactericidal efficacy [11].

A face mask is a loose-fitting device that creates a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment. Face masks may also help reduce exposure of one's saliva and respiratory secretions to others. While a face mask may be effective in blocking splashes and large-particle droplets, a face mask by design does not filter or block very small particles in the air that may be transmitted by cough, sneezes or certain medical procedures. In this study, the results exhibited that ZnONps as coating in reusable fabric facemasks showed an antimicrobial activity. The layers of the face mask are made of non-woven textile, which blocks dust and large particles and the outer layer of the facemask that was coated with ZnONps, exhibited an enhanced mechanical, thermal and antibacterial properties of the cloth facemask [12]. The scanning electron micrographs of the coated cloth facemask showed that after several washings the ZnONps still adheres to the cloth as presented in Fig. 3.

This research and development tapping the resources of Northern Samar will help in the extension and community work of the university, particularly to help the people in our province in this time of pandemic and other related application. This is a means of security to our fellowmen in this battle against COVID-19. After this pandemic, extension program could be seen to teach the LGUs in making antimicrobial cloth facemask from the local resources available in the Province.

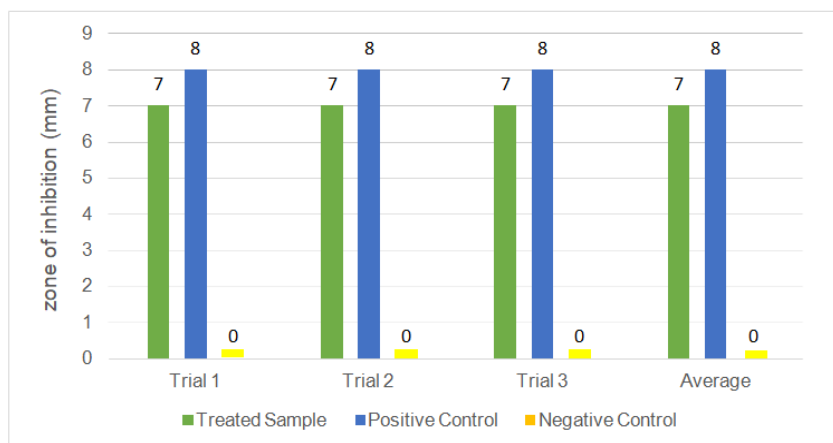


Fig. 1. Comparative chart on the zone of inhibition for *S. aureus*

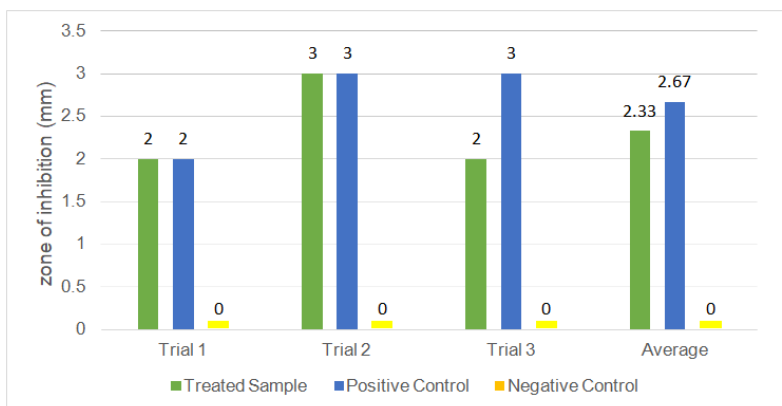


Fig. 2. Comparative Chart on the Zone of inhibition for *E. coli*

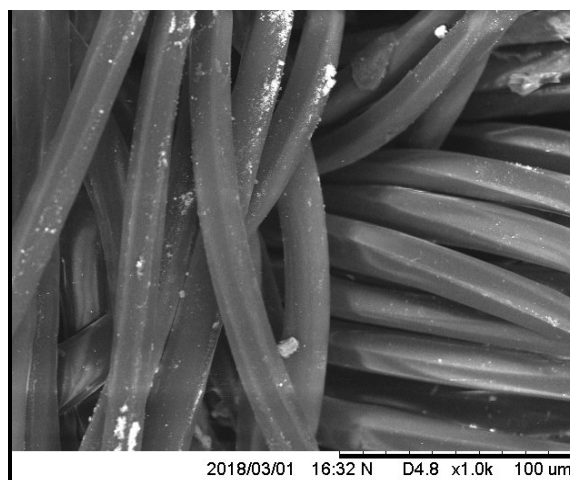


Fig. 3. Surface morphology of textile coated with ZnONPs

#### 4. CONCLUSION

The antimicrobial property of cloth facemask coated with ZnONPs against *Staphylococcus aureus* and *E. coli* can inhibit the bacterial growth. Thus, this research is a step forward for the textile industry.

#### CONSENT

It is not applicable.

#### ETHICAL APPROVAL

It is not applicable.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Shahidi, Sheila, Jakub Wiener. Antibacterial agents in textile industry. Department of Textile, Faculty of Engineering, Islamic Azad University, Arak Branch, Arak Iran and Department of Textile Chemistry, Faculty of Textile, Technical University of Liberec, Liberec, Czech Republic; 2007.
2. Paul S, Ban DK. Synthesis, characterization and the application of ZnO Nanoparticles in Biotechnology. International Journal of Advance in Chemical Engineering. 2014;1(1).
3. Nafchi AM, Alias AK, Mahmud S, Robal M. Antimicrobial, rheological, and physicochemical properties of sago starch films filled with nanord-rich zinc oxide. Journal of Food Engineering. 2012; 113:511-519.

4. Lee, Seungsin. Developing UV-protective textiles based on electrospun zinc oxide nanocomposite fibers. *Fibers and Polymers*. Department of Clothing and Textiles, Yansei University, Korea. 2009; 10(3):259–301.
5. Yadav A, Virendra Prasad, Kathe AA, Sheela Raj, Deepti Yadav, Sundaramoorthy C. Functional finishing in cotton fabrics using zinc oxide nanoparticles. *Bull. Mater. Sci. Nanotechnology Group, Central Institute*. 2006;29(6):641–645.
6. Kathirvelu S, D'Souza L, Dhurai B. UV protection finishing of textiles using ZnO nanoparticles. *Indian Journal of Fibre and Textile Research*. 2009;34:267-273.
7. Anita S, Ramachandran T. Preparation, Characterization and Functional Analysis of Zinc Oxide Nanoparticles Coated Single Jersey Cotton Fabric. *Textile Science and Engineering*. Tamil Nadu India; 2012.
8. Sirelkhatim, Amna, Shahrom Mahmud, Azman Seeni, Noor Haida, Mohamad Kaus. Review on Zinc Oxide Nanoparticles: Antibacterial Activity and Toxicity Mechanism; 2015.
9. Rajendran R, Balakumar C, Mohammed-Ahmed, Hasabo A, Jayakumar S, Videki K. Use of zinc oxide nano particles for production of antimicrobial textiles, *International Journal of Engineering, Science and Technology*. 2010;2(1):202-208.
10. Zhang L, Jiang Y, Daskalakis N, Jenken L, Povey M, O'Neil AJ. Mechanistic investigation into antibacterial behavior of suspension of ZnO nanoparticles against *E. coli*. *Journal of Nanoparticle Research*. 2009;12(5):1625-1636.
11. Padmavathy N, Vijayaraghavan R. Enhanced bioactivity of ZnO nanoparticles-an antimicrobial study, *Sci. Technol. Adv. Mater*. 2008;9:1-7.
12. Loghin Carmen, Luminta Ciobanu, Dorin Ionesi, Emil Loghin, Irina Cristian. Waterproof and water repellent textiles and clothing. *The Textile Institute Book Series*. 2018;3-24.

© 2020 Cui-Lim et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
The peer review history for this paper can be accessed here:  
<http://www.sdiarticle4.com/review-history/63519>