WHD

Grass waste derived cellulose nanocrystals as nanofiller in polyvinyl alcohol composite film for packaging application

Wan Hazman Danial[1], Raihan Mohd Taib[1], Mohd Armi Abu Samah[1], and Zaiton Abdul Majid[2]

[1]Department of Chemistry, Kulliyyah of Science, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

[2]Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

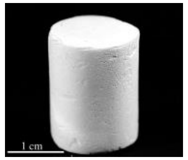
INTRODUCTION

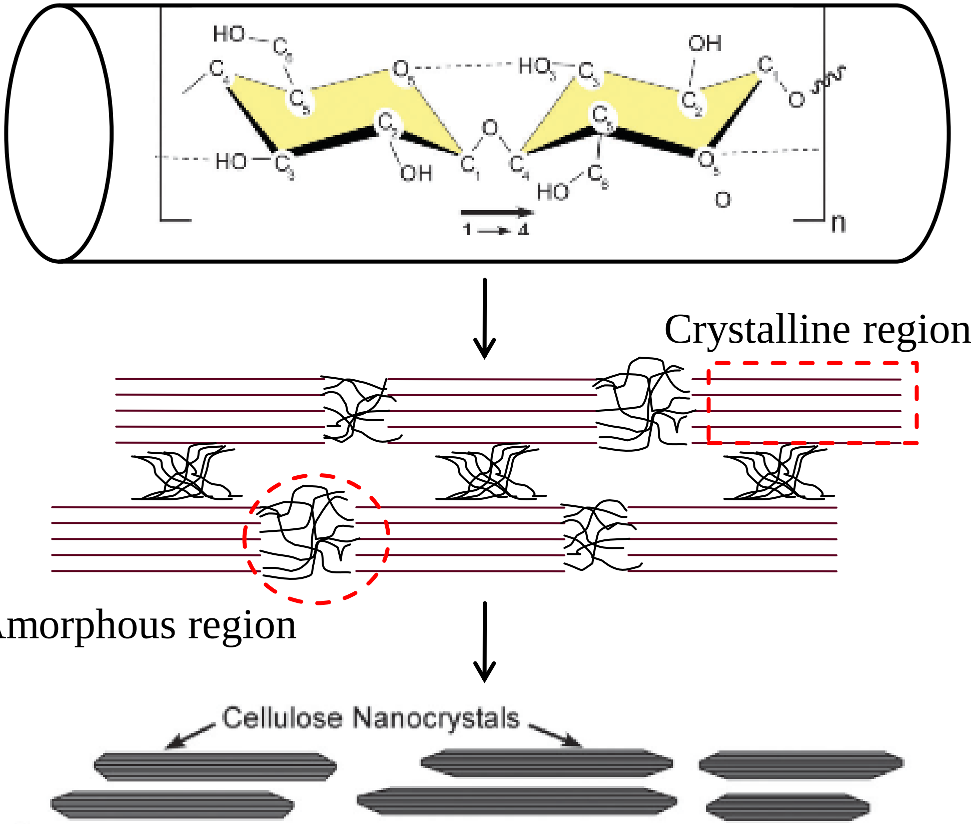
- Highly ordered (crystalline) structure of cellulose
- Rod-like (l ~ 50 – 500 nm, ø ~ 3 – 5 nm,
- High aspect ratio
- High degree of hydroxyl side groups

Cellulose Nanocrystals (CNCs)

Applications

- Biomedical
- aerogel
- membrane
- nanofiller
- nanocomposite

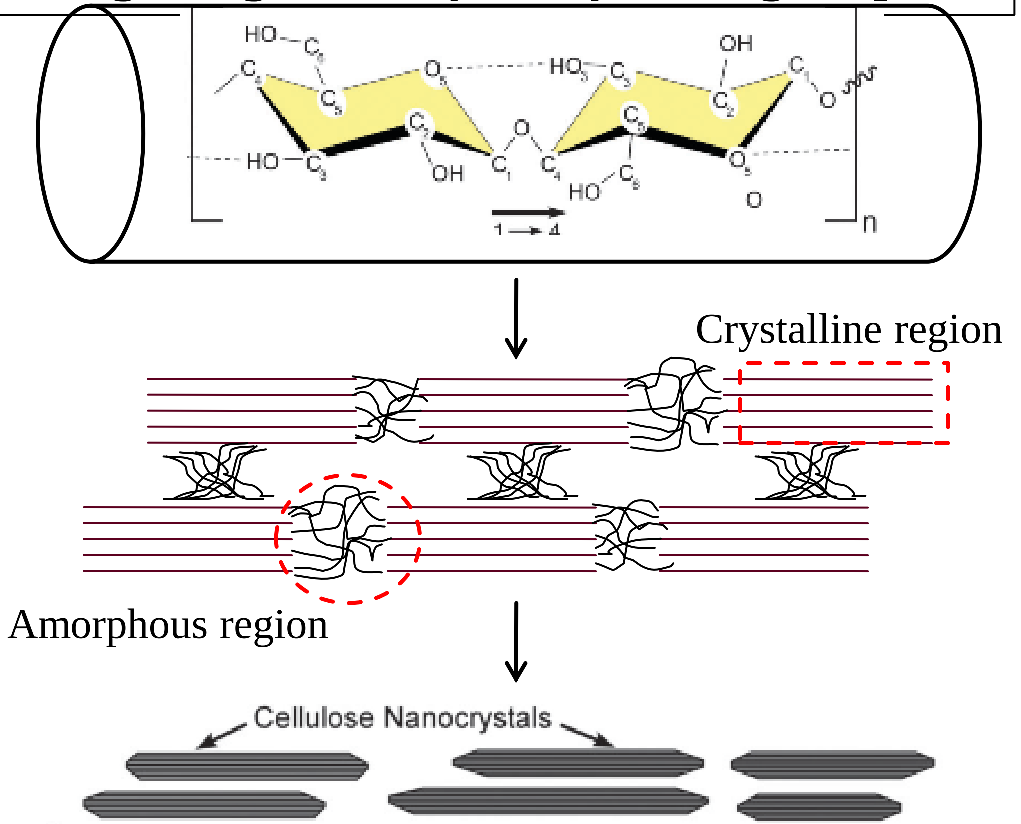




INTRODUCTION

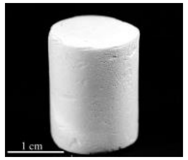
Cellulose Nanocrystals (CNCs)

- **Highly ordered (crystalline) structure of cellulose**
- **Rod-like (l ~ 50 – 500 nm, ø ~ 3 – 5 nm**
- **High aspect ratio**
- **High degree of hydroxyl side groups**



Applications

- Biomedical
- aerogel
- membrane
- nanofiller
- nanocomposite



INTRODUCTION

Cellulose Nanocrystals (CNCs)

Sources

Wood pulps

cotton

hemp

sisal

wastepaper

Cellulose powder

INTRODUCTION

Cellulose Nanocrystals (CNCs)

Sources

Wood pulps

cotton

hemp

sisal

wastepaper

Cellulose powder

These cellulose sources already have their significant function for cellulose manufacturing or recycling industries

INTRODUCTION

Cellulose Nanocrystals (CNCs)

Sources


Wood pulps


cotton


hemp


sisal


wastepaper

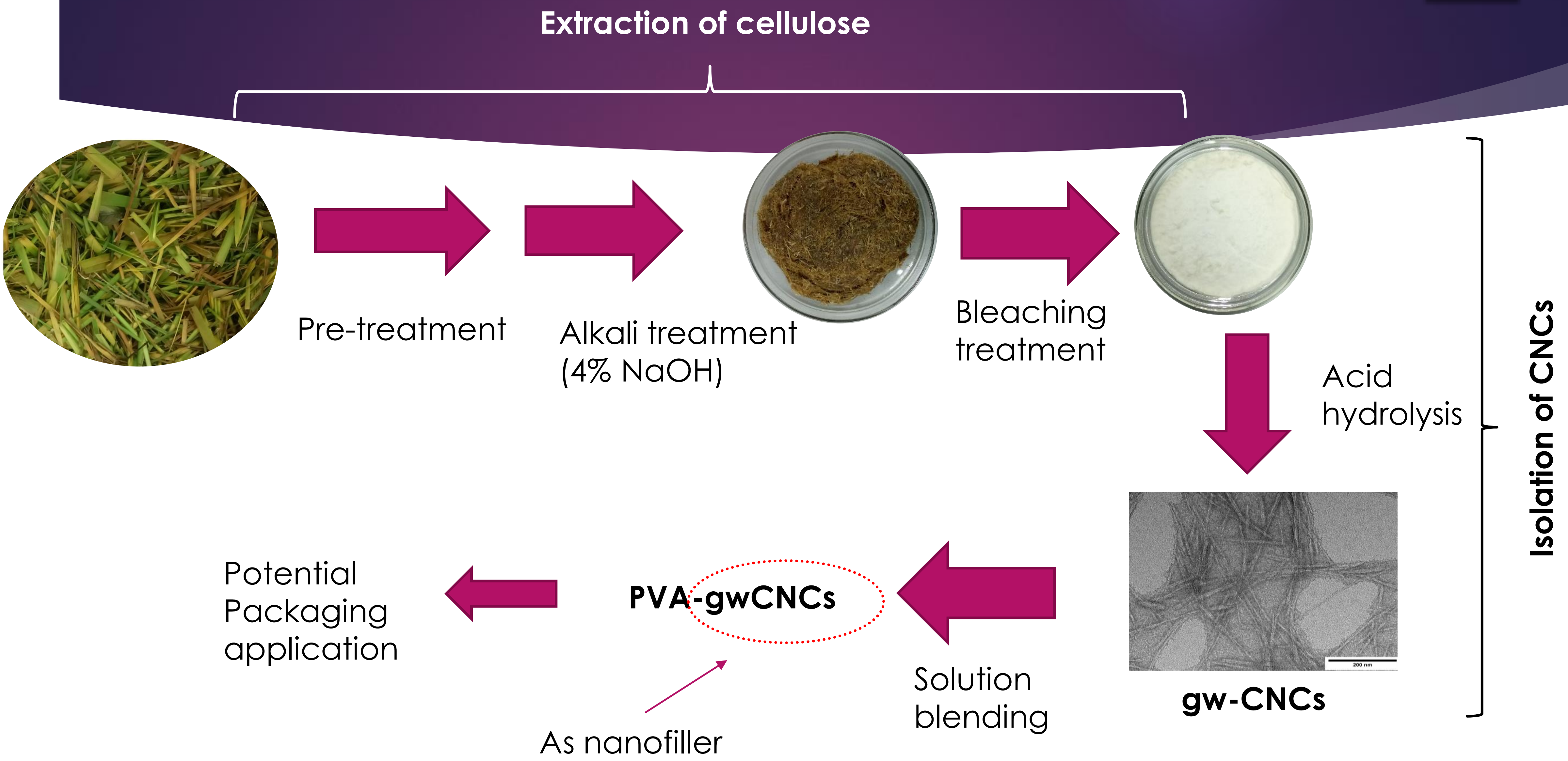

Cellulose powder

These cellulose sources already have their significant function for cellulose manufacturing or recycling industries

INTRODUCTION

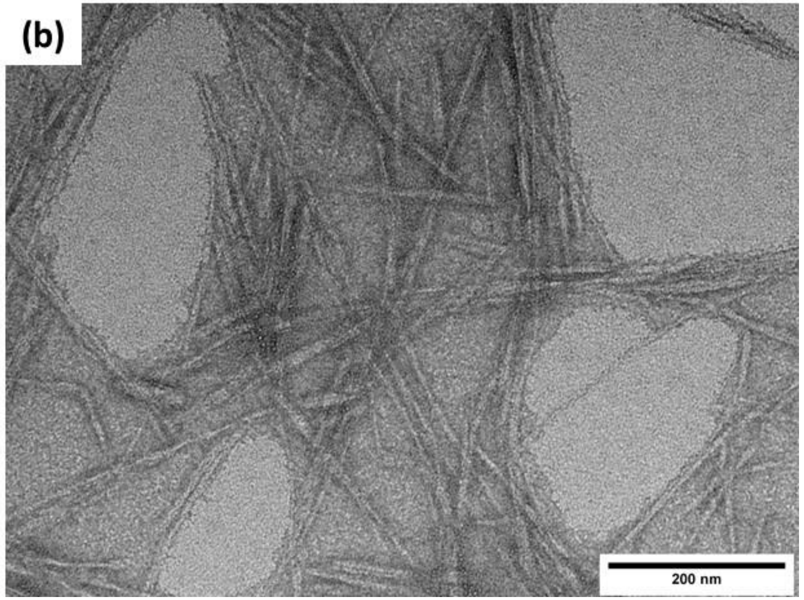
- Therefore, an unused or underutilized precursor such as **agricultural waste** should be explored to allow sustainable cellulose nanomaterial production; adapting waste to wealth initiative.
- Recently, the first attempt for the isolation of CNCs from grass waste material has been reported (*RSC Advances, 2020 10, 42400-42407*).
- As an eco-friendly and promising low-cost precursor.
- The application of grass clippings for the CNCs production can be a significant alternative as environmentally friendly approach to mitigate the impact of waste generation

EXPERIMENTAL



RESULTS (TEM ANALYSIS)

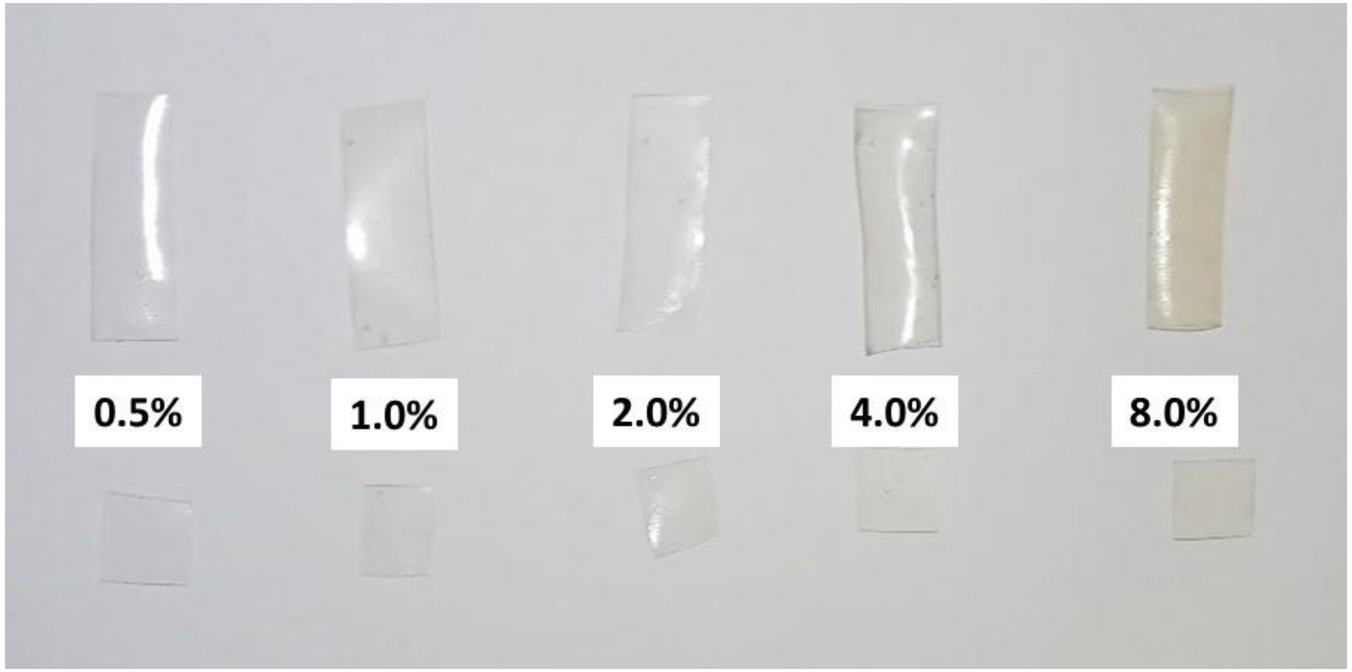
Grass waste



gw - CNCs

- ✓ The TEM image indicate rod-like or **needle-like structures** of CNCs was obtained.
- ✓ Some of the individual CNCs are arranged longitudinally due to hydrogen bonding interaction.
- ✓ The size of the CNCs produced from the grass waste was reported to be ranged around **100 – 500 nm** and **5 – 15 nm** for length and diameter, respectively.
- ✓ The percentage yield of the CNCs obtained from the grass waste was calculated in this study to be around **23.3%**.

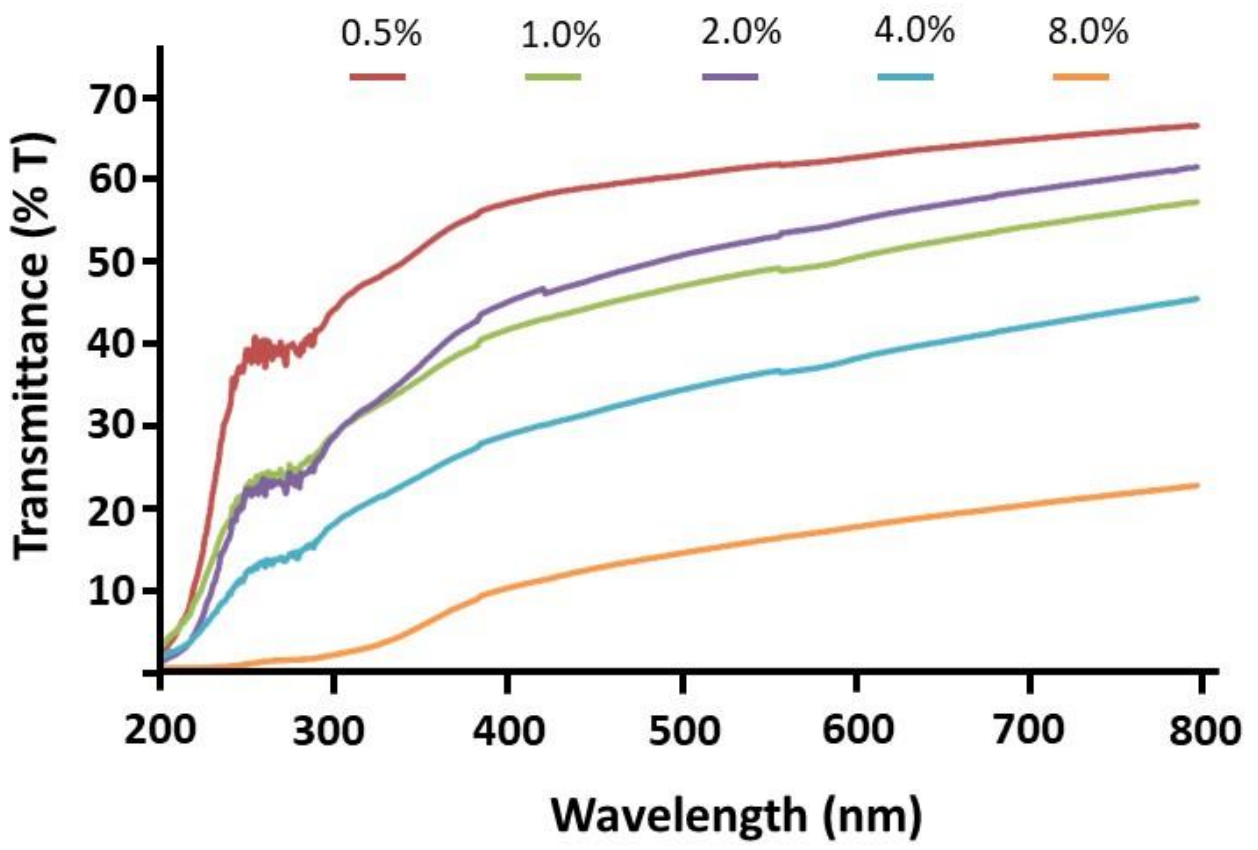
PVA/gw-CNCs nanocomposite films



Digital image of PVA nanocomposite films with 0.5, 1.0, 2.0, 4.0, and 8.0% of gw-CNCs.

- ✓ Solution casting with various percentage of gw-CNCs.
- ✓ The higher the amount of gw-CNCs in the nanocomposite, the transparency of the composite film was reduced.
- ✓ A good transparency can still be obtained for PVA nanocomposite films with below 4% of gw-CNCs.
- ✓ Induce a **soft-touch effect**.

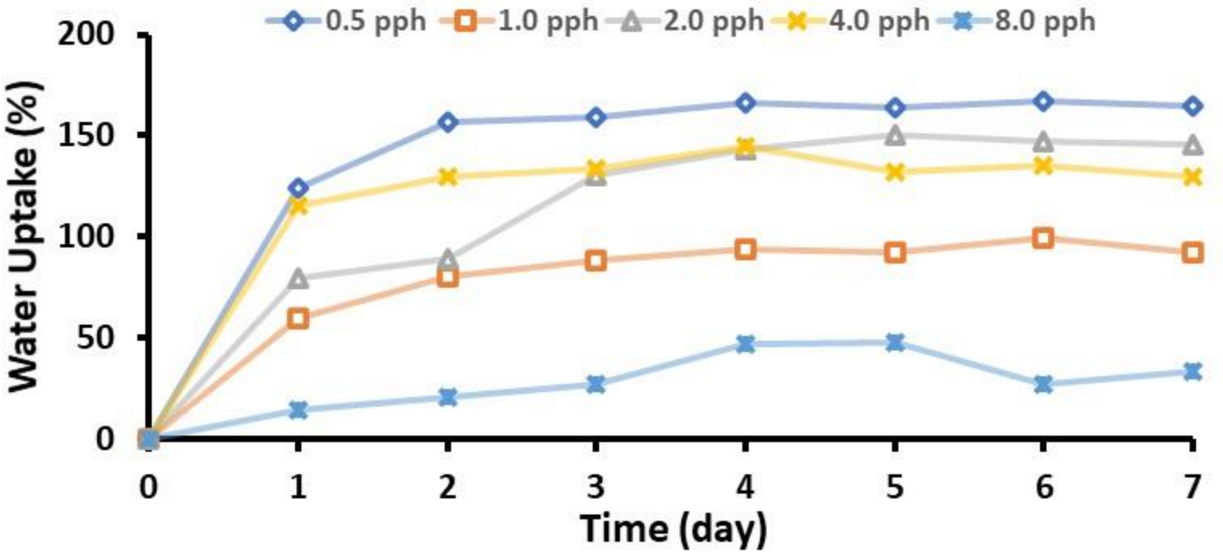
UV Transmittance of PVA/gw-CNCs nanocomposite films



Optical transmittance of PVA nanocomposite films

- ✓ The UV transmittance of the nanocomposite films decreases with increasing amount of gw-CNCs.
- ✓ Films that prevent from UV radiation while maintaining a good transparency can be considered as a **good quality packaging**.
- ✓ The higher gw-CNCs content enhanced the **UV shielding.**

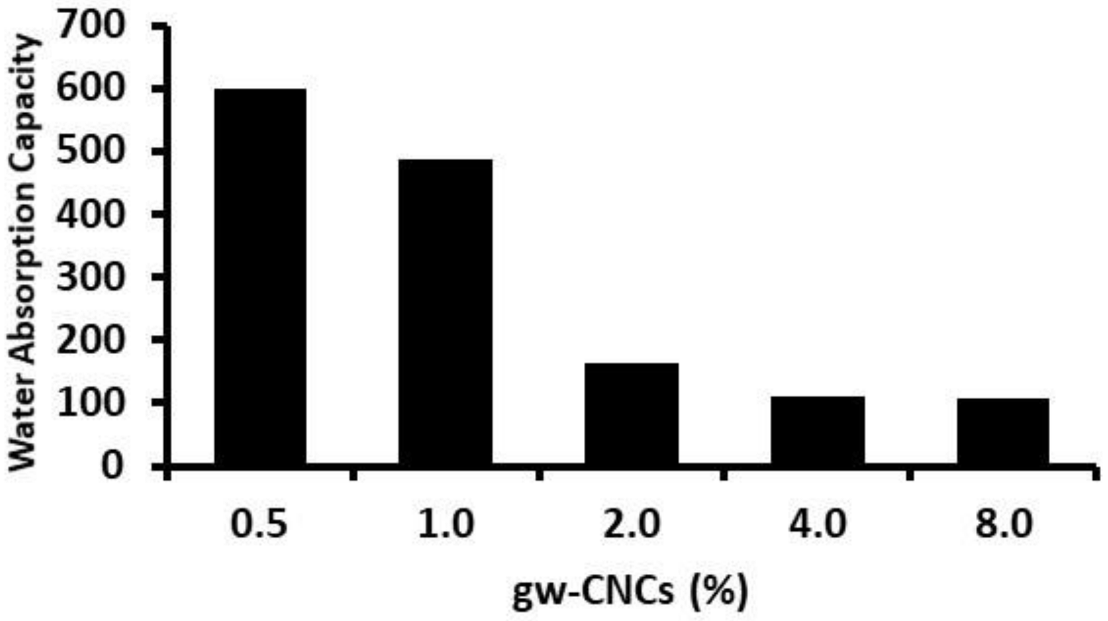
Water Uptake



Water uptake

- ✓ The Figure shows the effects of the gw-CNCs on the water uptake of the PVA nanocomposite films in the aqueous solution.
- ✓ As compared to PVA film with 0.5% gw-CNCs, the percentage of water uptake was significantly lower for PVA film with 8.0% of gw-CNCs.
- ✓ The water uptake was also reduced by incorporating 1.0% and 2.0% of gw-CNCs.
- ✓ It can be generally observed that the water uptake was decreases with increasing content of gw-CNCs.
- ✓ Such inhibition of water uptake might be dictated by the presence of C-H grouped from the cellulose anhydro-glucose unit backbone, and the interference of substantial filler-matrix interaction and filler–filler network.

Water Absorption Capacity



water absorption capacity

- ✓ The results showed that the water absorption capacity was reduced with increasing gw-CNCs content.
- ✓ The influence of CNCs towards the water uptake and absorption capacity can be explained based on the occupancy of the available hydrogen bond site and the "Lindman effect".
- ✓ Although PVA and CNCs both have available hydrogen bond sites, the CNCs have the unique characteristic of having hydrophobic site, defined by the structure of cellulose consisting both polar (OH) and nonpolar (CH) regions, making cellulose or CNCs, render an amphiphilic behaviour.

CONCLUSIONS

- This study reveals the feasibility of producing CNCs from grass waste and thus possible application of the grass waste derived CNCs as nanofiller in composite or packaging materials.
- The CNCs prepared showed the usual whisker- or rod-like feature, with nano-scale dimensions as clearly observed by TEM analysis.
- Given the constant generation and abundance of the grass waste, this work revealed the significant potential and alternative of the waste valorization and nanomaterial production.
- Incorporation of the grass waste derived CNCs on PVA nanocomposite films influences the optical transmittance, whereby the UV shielding effect was enhanced while reducing the water uptake and absorption capacity with increasing of CNCs content.
- The enhanced properties of the PVA/gw-CNCs nanocomposite films may unlock the potential of gw-CNCs as nanofiller for packaging applications; adapting waste to wealth initiative.

ACKNOWLEDGEMENT

- Fundamental Research Grant Scheme (**FRGS19-015-0623**), Ministry of Higher Education (MOHE), Malaysia

- Department of Chemistry, Kulliyyah of Science, International Islamic University Malaysia.


감사합니다
Natick
Grazie
Danke
Ευχαριστίες
Dalu
Obrigado
Thank You
Köszönöm
Tack
Спасибо
Dank
Gracias
谢谢
Merci
Seé
ありがとう