RETASTE Conference Abstracts
Vol. 3 RETASTE-AFR-520-Oral
Athens, Greece, 27-29 September, 2023

rethink food resources, losses, and waste 2023

Unlocking the Potential of Agricultural Waste in Malaysia for Sustainable Applications as Thin Films

[1]N. Adrus, [1]C.K. Wong, [1]W.Q. See, [1]M.A. Mohd Farizal, [1]N.A.F. Mat Nasir, [2]A. Nasir, [1]J. Jamaluddin, [1]R. Hasham, [2]N. Basar and [2]S.P. Mohd Bohari

[1]*Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*
[2]*Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

Abstract

This comprehensive technical abstract provides an overview of fibre extraction from various agricultural waste sources. These abundant resources have gained significant attention as renewable sources for fibre extraction and subsequent utilization in film forming formulations, and electrospun mats. The study primarily focuses on pineapple leaf fibres (PALF), which are agricultural byproducts resulting from pineapple cultivation and are rich in cellulose. Similarly, rice straw (RS) and rice husk (RH), byproducts of rice cultivation and milling process, contain valuable fibres that can be extracted through alkaline treatments (Lai et al., 2022; Nasir et al., 2022). In Malaysia, palm oil empty fruit bunch (OPEFB) has also been identified as a plentiful and underutilized resource for extracting fibres that is rich in cellulose and lignin (Zainal Alam et al., 2020). Furthermore, herbal processing wastes, despite their potential as valuable sources of cellulose, are often overlooked in research and industrial applications (Kandemir et al., 2022). Hence, we also reported on cellulose extraction from herbal plants, specifically Tongkat Ali (TA) scientifically known as Eurycoma longifolia and Orthosiphon aristatus (OA) (Mohd Bohari et al., 2021) and compared with PALF extraction. The extraction of cellulose from PALF, RS, RH, OPEFB, TA and OA offer an environmentally friendly alternative to conventional fibres, as they contain a significant amount of cellulose. To fully exploit the potential of these lignocellulosic biomass, either the agricultural or post herbal processing wastes, our group has carried out a series of chemical treatments of these biopolymers. Through our investigation, we have recognized the importance of chemical pre-treatment as a vital step in the process. The effective removal of non-cellulosic components through chemical pre-treatment significantly enhances the suitability of cellulose for various applications, particularly in terms of its film forming properties. This process opens a wide range of possibilities, allowing cellulose to be utilized in diverse fields where film formation is crucial. Specifically, the alkaline treatment was carried out to PALF, OA and TA by using 10 % (w/v) of sodium hydroxide NaOH), followed by bleaching with 10% of sodium hypochlorite (NaClO). For RS, the

extraction of cellulose was conducted by varying concentrations of NaOH ranging from 2 to 12%, in order to determine the optimal condition that would give the highest yield (Lai et al. 2022). Some fibres, like RH required for acid pre-treatment also for complete removal of the amorphous region. Meanwhile, we also further delignified OPEFB by subjecting it to hydrolysis using hydrogen peroxide. Based on the FTIR analysis, the absorption bands at 1740 cm-1, represents C=O stretching of hemicellulose were absent in the spectra of TA, OA and PALF. Meanwhile, for the RH fibre, the absorption band of 1730 cm-1 associated with the presence of C=O carbonyl groups associated with hemicellulose and lignin was completely removed after treatment with 4, and 12 vol.% of NaOH (Nasir et al., 2023a). The FTIR spectrum also revealed that the peak assigned for C=O acetyl group of hemicellulose ester in the lignin unit, typically observed at 1735 cm-1, was not detected in the bleached OPEFB. We could further confirm that 6% of NaOH treatment was optimum for RS fibres for lignin removal base on FTIR analysis together with weight loss data (Lai et al. 2022). Moreover, the weight loss analysis demonstrated the effective removal of impurities on non-cellulosic component; whereby TA, OA and PALF exhibited a reduction of 31.52 %, 58.38%, and 42.90%, respectively after undergoing alkaline treatment and bleaching. It was also observed that the treated fibres exhibited a brighter appearance after the treatment process. This change in appearance suggests the removal of impurities and non-cellulosic components that may have contributed to a darker colour in the untreated samples. SEM analysis of the treated fibres revealed a strand-like morphology that is closely resembled commercially available cellulose. Transparent and flexible films were formed by dissolving cellulose valorised from various resources in a solvent mixture of dimethylacetamide/lithium chloride and then regenerating it via phase inversion. Despite having one of the lowest crystallinities, among other fibres, cellulose from OA still exhibits film-forming properties. This suggests that cellulose derived from herbaceous waste, such as OA, holds great potential for utilization in various applications (Mohd Bohari et al., 2021). The crystallinity analysis revealed that PALF had the highest crystallinity (76%), followed by TA (64%) and OA (57%), OPEFB (54%) and RH (51%). The film was also characterised by its gel content without and with the washing step to remove dissolvable shorter polymer chain prior to the measurement. For instance, the gel content of RS-film (98.7%) (Lai et al. 2022) obtained after washing was higher than the OPEFB-film (42.2%) obtained without the washing step. Additionally, we have successfully converted the extracted cellulose from RH into cellulose acetate and further processed it into nanofibrous mats using electrospinning techniques. We are also able to demonstrate that the RH-based nanofibrous mats possess high porosity (76-81%) and excellent water absorption capacity (maximum swelling ratio of 446) which are promising properties for potential wound dressing materials (Nasir et al., 2023b). In summary, these studies demonstrate the untapped potential of agricultural waste from pineapple leaf, rice straw, rice husk, and oil palm empty fruit bunch across different fields. The utilization of these fibres opens up new avenues for developing advanced materials with tailored properties, especially in film forming ability to form hydrogel and also nanofibrous electrospun mats for potential wound dressing application. Valorisation of agricultural waste offers sustainable solutions for waste management and contributes to a greener and more environmentally conscious future. These innovative approaches to utilize agricultural waste resources demonstrate the potential to revolutionize various fields, including biomedicine, agriculture, and environmental engineering, promoting SDG 3: Good Health and Well-

Being and SDG 12: Responsible Consumption and Production.

Keywords: Pineapple leaf fibre, Thin film hydrogel, Cellulose, Wound dressing, Electrospun

References

[1] Lai, V. W. X., Jamaluddin, J., Mat Nasir, N. A. F., Baharulrazi, N., Majid, R. A., Lai, J. C., Mohd Bohari, S. P., Chua, L. S., Hasham, R., Rahmat, Z., & Adrus, N. (2022). Extraction of cellulose from rice straw for regeneration of hydrogels. Environmental Quality Management, 32(1), 333–341. https://doi.org/https://doi.org/10.1002/tqem.21825 [2] Nasir, A., Adrus, N., & BOHARI, S. P. M. (2022). RICE HUSK AS POTENTIAL RESOURCE FOR BIOMEDICAL APPLICATIONS: A REVIEW. CELLULOSE CHEMISTRY AND TECHNOLOGY, 56(9-10), 911-928. [3] Kandemir, K., Piskin, E., Xiao, J., Tomas, M., Capanoglu, E. (2022). Fruit Juice Industry Wastes as a Source of Bioactives. J. Agric. Food Chem 70 (23). p.6805. https://doi.org/10.1021/acs.jafc.2c00756 [4] Zainal Alam, M. N. H., Adrus, N., Abdul Wahab, M. F., Kamaruddin, M. J., & Sani, M. H. (2020). Utilization of Agro-Waste as Carbon Source for Biohydrogen Production: Prospect and Challenges in Malaysia. In Z. A. Zakaria, R. Boopathy, & J. R. Dib (Eds.), Valorisation of Agro-industrial Residues – Volume I: Biological Approaches (pp. 131–147). Springer International Publishing. https://doi.org/10.1007/978-3-030-39137-9_6 [5] Mohd Bohari, S. P., Chua, L. S., Adrus, N., Rahmat, Z., & Abdullah Al-Moalemi, H. A. (2021). Biochemical Characterization of Orthosiphon Aristatus and Evaluation of Pharmacological Activities. Journal of Herbs, Spices & Medicinal Plants, 27(3), 305–321. https://doi.org/10.1080/10496475.2021.1911904 [6] Nasir, A., Adrus, N., & Bohari, S. P. M. (2023a). The Effect of Alkali Treatment on the Cellulose Extracted from Rice Husk as Potential Resources of Biomass. International Journal of Nanoscience, 22(02), 2350012. https://doi.org/10.1142/S0219581X23500126 [7] Nasir, A., Razak, S. I. A., Adrus, N., Suan, C. L., Rahmat, Z., & Bohari, S. P. M. (2023b). Fabrication and characterization of electrospun cellulose acetate nanofibers derived from rice husk for potential wound healing application. Cellulose, 30(5), 3153–3164. https://doi.org/10.1007/s10570-023-05083-1

Acknowledgments: The authors gratefully acknowledge the financial support of research funding from the Ministry of Higher Education Malaysia (MOHE): FRGS/1/2021/TK0/UTM/02/2, FRGS/1/2020/TK0/UTM /02/9 and The Universiti Teknologi Malaysia Grant (UTMFR) grant No: Q. J130000.3846.22H56. Q.J130000.2551.20H84, and TDR vot no. Q.J130000.3551.07G02