MORPHOLOGY OF MECHANICALLY REFINED AND CHEMICALLY-TREATED OIL PALM FRUIT BUNCH FIBRES

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MORPHOLOGY OF MECHANICALLY REFINED AND CHEMICALLY-TREATED OIL PALM FRUIT BUNCH FIBRES

By

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The study of surface characterisation of oil palm empty fruit bunch (EFB) fibre before and after physical and chemical treatments was carried out by using light microscopy, Scanning Electron Microscopy (SEM) and Fourier Transform Infrared (FTIR) techniques. One of the objectives of the study was to evaluate fibre microphological characteristics of different parts of oil palm empty fruit bunch. This study was also conducted to examine the effects of chemical pre-treatment and mechanical refining on the morphological characteristics of EFB fibres and to evaluate the surface characteristics of chemically modified EFB fibre after being treated with succinic anhydride. For comparison, samples from fresh fruit bunches were also examined. The mechanical refining process employs pre-treatment with water and sodium hydroxide (1%). Chemical modification on EFB fibres with succinic anhydride was carried out for 1, 2, 3, 4, 5 and 6 hour each at 80°C, 100°C and 120°C. The objective of this study was to examine the effects of succinic anhydride modification on the morphology of EFB fibres, as well as the extent of cell wall bulking.
Oil palm EFB differs from wood fibres since it does not possess structures such as cambium, ray cells, sapwood or heartwood portion. These differences are highlighted in this study. EFB is formed from structures of vascular bundles which consist of xylem cells, phloem cells, vessels and fibrous sheath and embedded within soft ground parenchymatous tissue. The examination on the surface morphology of the fibre vascular bundle suggested that this material may require pretreatment and chemical modification to enhance surface quality within a fibre/matrix composite due to its waxy surface nature. Light and SEM micrographs revealed on the presence of cell inclusions such as stigmata which marked it’s presence through the globular protrusion on the surface of fibre. Silica bodies are found abundantly embedded within the stigmata cells which are detachable upon processing.

This study also clarified on the differences in properties of fibres according to different parts of a single fruit bunch. The study on the properties of individual fibre from different section of EFB (core, stalk and spikelets) concluded that fibre properties within the fruit bunch are not homogenous. The stalk portion of the fruit bunch has short fibre lengths (\( \mu \text{m} \)) and high tendency to collapse. Compare to the core of the fruit bunch, the fibre length from this part is longer. Being compared to wood fibre properties, the core of EFB exhibit quiet a comparable properties especially referring to its Runkel ratio, coefficient of suppleness and felting power.

The results also indicate that mechanical refining significantly changed the morphology of EFB fibre structure. The untreated and unrefined EFB fibre is still in it’s original cylindrical shape suggesting the presence of lignin which holds up the cell wall. The
Special thanks to the lecturers and staffs of Faculty of Forestry especially to fellow colleagues: Sapari Mat, Frisco Nobilly, Norzanalia, Mastura, Rasmina, Nurulhuda and Dr. Manohar for being such a good listener and source of encouragements. Heartfelt gratitude to her fellow postgraduates, especially to FORGRAD members, and to her other numerous friends for their inspirations and guidance. Much appreciation also goes to Hazeline Aasyiqeen, Rohaida, Ann and friends for continuous support and helping hands.

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surface of the fibres with is covered mainly by thick waxy cuticle layer with occurrences of globular protrusion indicating the presence of silica bodies. The effect of water soaking and sodium hydroxide has extensively removed the waxy cuticle layer and most silicate structures from the fibre surface. Refined fibres appeared defiberized and fibrillated especially on sodium hydroxide (NaOH) pre-treated fibres. Internal and external fibrillation which relates to shearing in fibre wall and peeling of super-facial layer was extensively observed. Longitudinal compression of disintegrated fibre was observed extensively especially on sodium hydroxide treated fibres. Most of the silica bodies have been detached from fibre surface, creating a porous look. Swelling of cellulose, hemicellulose and lignin contributes to the efficiency of the refining process. This occurrence also attributed to the delignification and dissolution of non-cellulosic substance (i.e hemicellulose).

The chemical modification treatment succinic anhydried on EFB fibres has resulted for morphological changes such as swelling and surface smoothing. Through SEM examination, swelling of cell wall was clearly observed on individual fibre cell wall, areas surrounding the voids and also stegmata cells although it was less obvious on metaxylem vessel, protoxylem, protophloem, pits and perforation plates. Surface cracks and degradation due to the cell wall bulking and swelling effect was not visible on any the cells. Introduction of foreign moieties on to the surface hydroxyl group has made the appearance smoother due to removal of waxy layer which also reveals the stegmata cells and voids area. The extent of esterification was examined through the Weight Percent Gain (WPG) value. WPG subsequently increases as reaction time prolonged and with higher reaction temperature. The swelling of fibre, measured through cell diameter to
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Oleh

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permukaan kutikel berlilin yang mendedahkan sel-sel stegmata dan lompangan kosong. Tahap esterifikasi telah dinilai melalui Peratus Berat Perolehan (PBP). Nilai PBP meningkat dengan pertambahan masa tindakbalas dan kenaikan suhu tindakbalas. Tahap pengembangan gentian yang dinilai menerusi nisbah diameter sel kepada diameter lumen sel juga bertambah secara langsung dengan nilai PBP. Corak spectrum yang diperoleh menerusi ujian FTIR telah menunjukkan beberapa kawasan yang aktif seperti di 1705 – 1750 cm⁻¹ 1230 – 1282 cm⁻¹ dan 3200 – 3600 cm⁻¹. Puncak-puncak spectrum ini dipengaruhi oleh kumpulan berfungsi dan juga tahap esterifikasi (nilai PBP).
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cell lumen diameter ratio, also increase proportionally with the value of WPG. The spectrum obtained through examination with FT-IR has depicted several active regions such as 1705 – 1750 cm\(^{-1}\), 1230 – 1282 cm\(^{-1}\), and 3200 – 3600 cm\(^{-1}\) which corresponds to the concentration of a functional group that strongly affects the intensity of the peaks which also corresponds to the extent of esterification (WPG values).
I certify that the Examination Committee met on 12th of September 2007 to conduct the final examination of Adlin Sabrina Muhammad Roseley on her Master of Science thesis entitled “Morphology of Mechanically Refined and Chemically-Treated Oil Palm Empty Fruit Bunch Fibres” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the degree of Master of Science.

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I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

________________________________________

ADLIN SABRINA MUHAMMAD ROSELEY

Date : 1 February 2008
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5.15 Longitudinal section of modified fibre indicates (a) fibre cell wall swelling (b) effects of swelling on pitting on fibres and metaxylem vessel

5.16 Metaxylem vessels of an esterified EFB vascular bundles with distinctive vessel pitting

5.17 Metaxylem vessel pitting on the (a) outer side and (b) inside of an esterified EFB

5.18 SEM micrograph of longitudinal section of (a) metaxylem vessels (encircled) and (b) perforation plates (encircled)
5.19 Cell diameter to cell lumen diameter ratio and WPG value of succinic anhydride treated oil palm empty fruit bunch fibre at 1 to 6 hour of reaction time