

CHAPTER

2

CHEMICAL COMPOSITIONS OF OPEFB NANOCELLULOSE IN COMPOSITES

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2.1 POTENTIAL OF OIL PALM BIOMASS AS GREEN NANOFILLERS IN COMPOSITES

Oil palm biomass can be converted into cellulose nanoparticles (CNPs) to meet the increasing demand for advanced nanomaterials (Yang et al., 2021). CNPs are generally classified into two types: nanocrystalline cellulose (NCC) and nanofibrillated cellulose (NFC). The primary distinction lies in their extraction methods, NCC is obtained through chemical treatment, while NFC is isolated via mechanical treatment (Norizan et al., 2022).

The NCC derived from oil palm empty fruit bunch (OPEFB) has appeared as an emerging nanofiller in science and nanotechnology. This is due to its large specific surface area, excellent aspect ratio, light weight, high concentration of hydroxyl groups, biocompatibility, and outstanding mechanical properties. These attributes have attracted attention from various industries, particularly in the development of natural fibre-reinforced polymer composites, which are used in a broad range of polymer science applications. Composites made from such

materials are lightweight, cost-effective, and environmentally friendly, while offering specific properties comparable to those of conventional synthetic fibre composites (Mahjoub et al., 2013).

One of the major limitations is moisture absorption, which can negatively affect the performance of polymer composite materials (Manimaran et al., 2025). To address this issue, fibre modifications, such as chemical treatment, can be employed to improve compatibility and enhance the physical and mechanical properties of biocomposites (Hassan et al., 2010). These treatments significantly affect physico-mechanical characteristics of the final composite materials.

In this study, OPEFB was selected as the raw material for NCC extraction using a series of chemical treatments. The process involved bleaching, followed by alkaline treatment, acid hydrolysis, ultrasonication, and freeze-drying. Finally, the chemical and morphological properties of NCC derived from OPEFB for use in polymer composites are discussed.

2.2 OIL PALM EMPTY FRUIT BUNCH

Oil palm biomass includes OPEFB, oil palm fronds (OPF), mesocarp fibre (MF), palm kernel shells (PKS) and oil palm trunks (OPT) (Septevani et al., 2020), as shown in Figure 2.1. OPEFB, MF, and PKS are formed during the process of milling, while OPT and OPF are produced during replanting activities (Manimaran et al., 2025).

OPEFB is widely recognised as the most utilised agro-waste for nanocellulose production, mainly due to its high cellulose content compared with other oil palm-based biomass sources (Fatah et al., 2014), as shown in Table 2.1. Its abundance as a by-product of the palm oil industry further enhances its potential as a sustainable and low-cost raw material. In addition, OPEFB exhibits favourable mechanical properties, making it suitable as a reinforcing material in polymer composites (Fahma et al., 2010), as presented in Table 2.2.

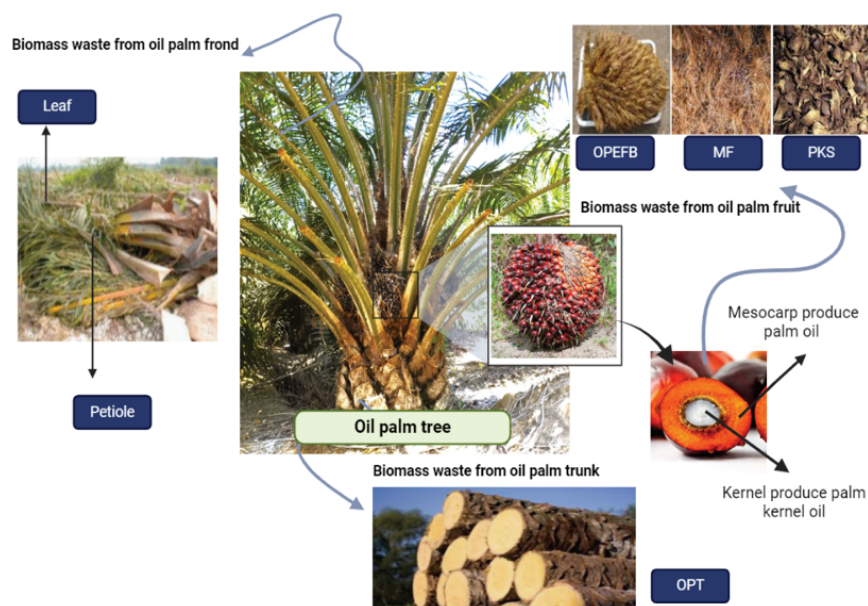


Figure 2.1 The oil palm lignocellulose biomass

Table 2.1 Chemical compositions of various oil palm biomass

Type of Oil Palm Biomass	Lignin (%)	Hemicellulose (%)	Cellulose (%)
OPF	21–22	40–41	30–31
OPEFB	22–23	35–36	38–39
OPT	25–26	31–32	34–35
MF	27–28	26–27	33–34
PKS	50–51	22–23	20–21

Table 2.2 Properties of the oil palm empty fruit bunches

Property	Value
Density (g/cm ³)	0.7–1.55
Tensile Strength (MPa)	50–550
Young's Modulus (GPa)	1.7–3.2
Elongation at break (%)	4–18