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Valorization of residual Empty Palm Fruit Bunch Fibers (EPFBF) by microfluidization: Production of nanofibrillated cellulose and EPFBF nanopaper

Ana Ferrer [a], Ilari Filpponen [b], Alejandro Rodríguez [a], Janne Laine [b], Orlando J. Rojas [b,c,*]

[a] Department of Chemical Engineering, University of Cordoba, Spain
[b] School of Science and Technology, Department of Forest Products Technology, Aalto University, 00076 Aalto, Finland
[c] Department of Forest Biomaterials, North Carolina State University, Raleigh, NC 27695-8005, USA

HIGHLIGHTS

- Empty Palm Fruit Bunch Fibers (EPFBF) were subject to sulfur-free chemical treatments.
- Microfluidization of EPFBF yields nanofibrils comparable to those from wood fibers.
- Nanopaper with excellent properties was manufactured from nanofibrillar EPFBF.
- Valorization of EPFBF is attractive due its higher yields and lower costs.

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ABSTRACT

Different cellulose pulps were produced from sulfur-free chemical treatments of Empty Palm Fruit Bunch Fibers (EPFBF), a by-product from palm oil processing. The pulps were microfluidized for deconstruction into nanofibrillated cellulose (NFC) and nanopaper was manufactured by using an overpressure device. The morphological and structural features of the obtained NFCs were characterized via atomic force and scanning electron microscopies. The physical properties as well as the interactions with water of sheets from three different pulps were compared with those of nanopaper obtained from the corresponding NFC. Distinctive chemical and morphological characteristics and ensuing nanopaper properties were generated by the EPFBF fibers. The NFC grades obtained compared favorably with associated materials typically produced from bleached wood fibers. Lower water absorption, higher tensile strengths (107–137 MPa) and elastic modulus (12–18 GPa) were measured, which opens the possibility for valorization of such widely available bioresource.

1. Introduction

The marked increase in the use of alternative, non-wood fibers results from the need to cut costs and avoid negative environmental effects. In fact, non-wood raw materials constitute the sole useful source of cellulose fiber in some regions of the world (Rodríguez et al., 2008) and provide several interesting advantages (Rodríguez et al., 2008): (a) allows wood raw materials to be spared for uses where they are most required; (b) reduces wood and cellulose fiber imports in countries with a shortage of wood and, (c) satisfies the increasing demands for paper-grade fibers from green processes.

The use of Empty Palm Fruit Bunch Fibers (EPFBF), bagasse and rice straw for papermaking and production of composite panels is a common practice in several countries without large supplies of wood resources (English et al., 1997; Young, 1997). EPFBF, in particular, comprises residual fibers from the palm (*Elaeis guineensis*) oil processing. Malaysia is the largest palm oil producer (51% of the worldwide production), and constitutes an important economic resource for this country. Cultures are also extending to countries in Western Africa (Nigeria, Guinea, Ghana, etc.), South America (Ecuador, Colombia, Honduras, etc.) and Asia (Thailand). The global production of oil palm has risen from 16 million tons in 2007 to almost 21 million tons in 2010 (FAO, 2010). Palm plants start fruiting 4–5 years after planting. Fruit bunches usually weigh 15–25 kg and contain 1000–4000 oval-shaped, 3–5 cm long fruits. Fruit production peaks at 20–30 years, after which they decline and become unprofitable (especially because their fruits are too high to collect). Each hectare of oil palm produces an average of 10 tons fruits per year, which give about 3000 kg of palm oil as the main product (Malaysian Palm Oil Council, 2010). A significant amount of residual EPFBF can be used as a source of cellulosic fibers if separated by pulping processes. In this regard and owing

* Corresponding author at: Department of Forest Biomaterials, North Carolina State University, Raleigh, NC 27695-8005, USA. Tel.: +1 919 5137494.
E-mail address: ojrojas@ncsu.edu (O.J. Rojas).

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