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Fourier Transform Infrared Spectroscopy of the Wood Composite from Neolamarckia Cadamba and Endospermum Diadenum for Particleboard Application

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Abstract This research is to characterize the potentials wood species for particleboard alternative materials. The wood species are Neolamarckia Cadamba sp. (NC) and Endospermum Diadenum sp. (ED), which were selected forest plantations in Malaysia due to rapid growing species. Indeed, also known as lesser-known commercial timbers species. The NC and ED functional group analysis chemistry were examined using the Fourier transform infrared spectroscopy analysis (FT-IR). The significant bands emerged at 3600 to 3050 cm^{-1} , which ascribed to Amines' stretching (N-H groups). The intense peak at 2850 cm^{-1} is related to chains of C-H bonding.

1. Introduction

The wood industry is currently trendy in Malaysia, especially in fulfilling the furniture sector demand, starting from sketching, designing, assembling, discovering new materials species, and packaging of the products [1, 2]. Designers will create new products based on customer needs and requirements. The critical part is making the product with green characteristics such as recycled wood waste, substituting the primary materials, and producing work and furniture [3-7]. Furthermore, furniture production is related to creating furniture's primary material, while the composite materials have also been developed [5, 8-11].



Most of the leading materials used in producing furniture are from engineered wood or known as wood composite. The wood composite is defined as combining one or more elements glued together. Besides, the wood composite is very popular because it is easy to apply in any product and be optimized in the wood sector due to a large amount of demand in the wood industry. Thus, the production of the wood composite is increasing to be supplied regarding the unstoppable demand.

Particleboard is one of the famous wood composite industry in the world, especially in Malaysia. The alternative method is applying the new wood species as the main materials to produce the product based on the suitability and availability of its applications. Hence, to conserve and sustain nature, manufacturers need to find the new materials of wood species as primary materials. Among these wood products, the typical applications of the wood composite are to be used as furniture, wall, and paneling.

Neolamarckia Cadamba sp. (NC) or its standard Malaysian name is Laran also known as Kelempayan in Peninsular Malaysia. This tree belongs to the Rubiaceae family. Kelempayan is recommended as a plantation tree due to its characteristics such as fast growth rate. This plant grows very well and denuded areas especially in logged-over areas. Other plantations of Kelempayan can be found in Sabah and Sarawak [12].

While *Endospermum Diadenum* sp. (ED) or Sesenduk belongs to the Euphorbiaceae family. This tree has been proposed for plantation in Peninsular Malaysia. Sesenduk is an excellent alternative timber for the furniture industry due to a cheaper price, compares to rubberwood price [13]. Sesenduk is easy to be treated with chemicals and has excellent working and nailing properties. Sesenduk plantation was also established in Sungai Buloh Forest Reserve, Selangor.

In this research, FT-IR was used to identify the functional group inside a small amount of sample. The chemical structure changes could be determined from the spectra. The resulting spectrum represents the molecular absorption and transmission, creating a molecular fingerprint of the sample.

2. Methodology

The preparation of the particleboard with the ratio NC: ED was as the state in the previous study [5]. Fourier-transform Infrared Spectroscopy, also known as FT-IR analysis, is an infrared spectroscopy method used to identify organic, polymeric, and in some cases for inorganic materials. The specimens were placed into the sample platform. Then the sample was closed under a pressure tower and compression. After that, the software analyzed the specimens by showing the graph includes the molecular structure, peaks representing the components with different types of bonds, and the other functional groups. The model machine was used is Thermo Scientific Nicolet iS10 FT-IR Spectrometer. Scanning ranges between 4000-500 cm^{-1} .

3. Results and Discussion

The particleboard's surface functional group analysis chemistry examined using the Fourier transform infrared spectroscopy analysis and presented by the FT-IR spectrums. The FT-IR study provided information about the molecular structure of the functional group present on the samples. The composition of polymeric materials determined by measuring their infrared spectra using FT-IR compared to the results with a commercially available or specifically prepared spectral database. FT-IR spectroscopy was employed to observe any differences between the materials' FT-IR spectra and their manufactured panels. The wavelength of light absorbed is characteristic of the chemical bond. By interpreting the infrared absorption spectrum, the chemical bonds in a molecule are determined. FT-IR was used to examine possible interactions between the NC and ED with urea-formaldehyde adhesive.

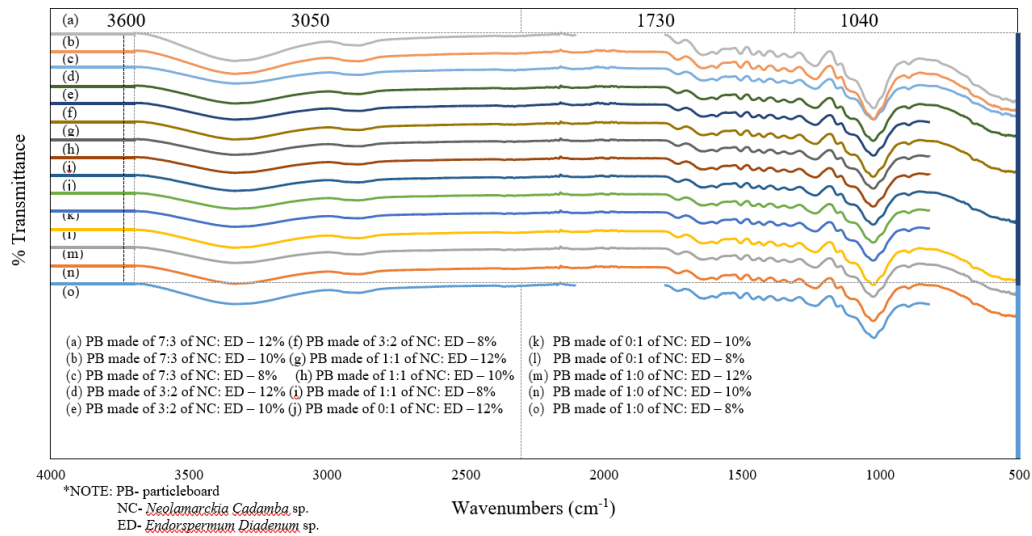


Figure 1. FT-IR spectra of samples from experimental panels.

Figures 1 and 2 show the FT-IR spectra of all samples from experimental panels. The functional groups are similar for all the pieces. There is no substantial difference in the peaks of the particleboard from experimental manufactured panels. However, FT-IR spectra of particleboard made of 1:0, 0:1, and 7:3 of NC: ED show significant differences. Figure 2 shows the apparent sharp peak indicated at wavenumber 1040 cm^{-1} . These peaks were similar to the particleboard peaks made of 1:0, 0:1, and 7:3 of NC: ED.

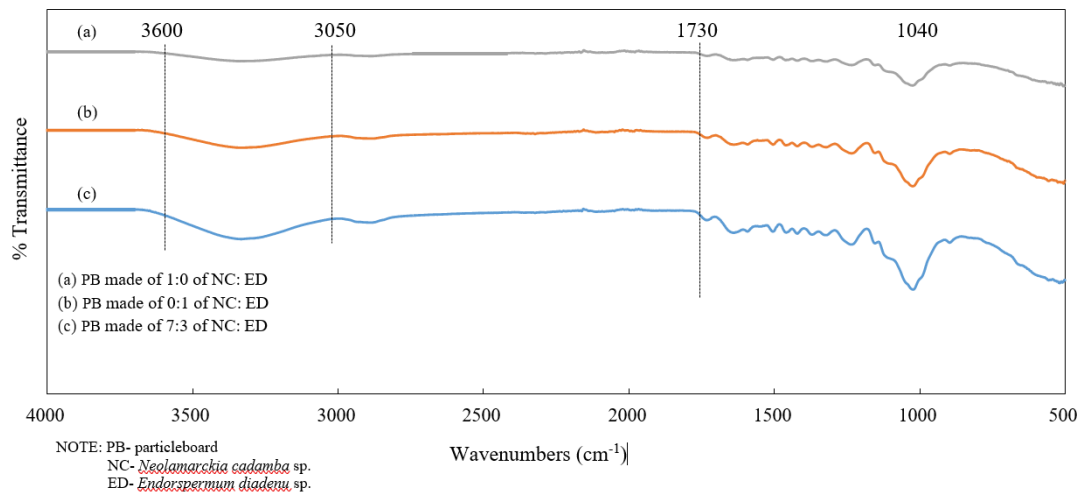


Figure 2. FT-IR spectra of particles and samples from experimental panels from the different ratio of 1:0, 0:1, and 7:3 of NC: ED for 12% of urea-formaldehyde.

The dominant bands appeared at 3600 to 3050 cm^{-1} , which was attributed to amines' stretching (N-H groups). The intense peak at 2850 cm^{-1} is associated with chains of C-H bonding. The peak at 1730 cm^{-1} was detected in the mid-part of particleboard panel manufacture. This peak was assigned to the C-O stretch in unconjugated ketones, carbonyls, and ester groups of carbohydrate origin. The sharp peak at 1050 cm^{-1} of particleboard spectrum indicates the C=O stretching group. Compared to spectrum band 1030 cm^{-1} particleboard made of 1:0 and 0:1 of NC: ED showed lower intensity than particleboard made of 7:3 of NC: ED, indicating that C-O bonding was weaker as shown in Figure 2. The presence of C-O

stretching vibrations due to bands that formed by the cross-linking reaction of panel and urea-formaldehyde or bonding between the wood particles. A lot of N–H vibration peaks were found at every panel made of 1:0, 0:1, and 7:3 of NC: ED, and was believed to come from the urea compound in the UF formulation. Detailed interpretation of each spectral was shown in Tables 1-3.

Table 1. Infrared spectral interpretation for particleboard made of 1:0 of NC: ED 12% of urea-formaldehyde.

Peak	Assigned group	Details
3333.76	Amines Alcohols and phenols	N - H stretching vibrations: Secondary free; one band Polymeric association
2890.79	Hydrocarbon chromophore Alcohols and phenols	C - H stretching Alkane Chelate compounds
1732.04	Carbonyl chromophore	Aldehydes Carbonyl stretching vibrations: Saturated, aliphatic
1370.67	Hydrocarbon chromophore Alcohols and phenols	C-H bending Alkane, gem-dimethyl O - H bending and C-O stretching vibrations: Primary alcohols Secondary alcohols Tertiary alcohols Phenols
518.31	Halogen compounds	C - X stretching vibrations C - Br

Table 2. Infrared spectral interpretation for particleboard made of 0:1 of NC: ED 12% of urea-formaldehyde.

Peak	Assigned group	Details
3333.16	Amines Alcohols and phenols	N - H stretching vibrations: Secondary free; one band Polymeric association
2887.06	Hydrocarbon chromophore Alcohols and phenols	C - H stretching Alkane Chelate compounds
1732.80	Carbonyl chromophore Alcohols and phenols	Aldehyde Carbonyl stretching vibrations: Saturated, aliphatic O - H bending and C-O stretching vibrations: Primary alcohols Secondary alcohols Tertiary alcohols Phenols
1023.79	Halogen compounds	C - X stretching vibrations C-F
898.50	Hydrocarbon chromophore	Alkene, monosubstituted (vinyl) Alkene, disubstituted, gem

Table 3. Infrared spectral interpretation for particleboard made of 7:3 of NC: ED 12% of urea-formaldehyde.

Peak	Assigned group	Details
3340.60	Amines Alcohols and phenols	N - H stretching vibrations: Secondary free; one band Polymeric association
2888.45	Hydrocarbon chromophore Alcohols and phenols	C - H stretching Alkane Chelate compounds
1979.31	Hydrocarbon chromophore	C-C multiple <u>bond</u> stretching <u>Allene</u>
1461.95	Hydrocarbon chromophore Alcohols and phenols	C - H bending Alkane - C H ₂ - Alkane, -CH ₃ O - H bending and C-O stretching vibrations: Tertiary alcohols Phenols
1023.95	Halogen compounds	C - X stretching vibrations C-F
520.63	Halogen compounds	C - X stretching vibrations C - Br

4. Conclusion

The NC and ED functional group evaluation chemistry were analyzed by using the FT-IR. Based on the finding, the influential bands appeared at 3600 to 3050 cm⁻¹, which was assigned to Amines' stretching (N-H groups). The extreme peak at 2850 cm⁻¹ is correlated to chains of C-H bonding.

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