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Characterization of Blend of Plantain Peel, Pawpaw Peel and Watermelon Rind using FTIR

Olusegun P. AKINYEMI[1*], Juliius G. AKINBOMI[2], Moyosore D. ABBEY[3]

Chemical Engineering Department, Lagos State University
[1]poakinyemi@yahoo.com; [2]jayju2004@yahoo.com; [3]moyosoredorcas4@gmail.com
*Corresponding author: poakinyemi@yahoo.com

Abstract The performance of a material as a good adsorbent is largely determined its structures. This study was aimed at determining and comparing the functional groups and bonds present in the structures of blend of pawpaw peel, plantain peel and watermelon rind in different proportion using Fourier Transform Infra Red (FTIR) spectroscopy. The adsorbents were prepared from agricultural waste collected from Female hostel Lagos State University, Epe campus, Lagos State, Nigeria by crushing them into powdery form after drying in the oven at temperature of 110 ^{o}C until constant weight was attained. The products from the agricultural waste blended in binary ratios of 1:1 and 3:2 were characterized using Agilent FTIR spectroscope (range: 4000-650). All the pure and blended samples were found to contain O-H stretching, C-H stretching, C=C stretching, O-H bending and C-O stretching functional groups which implied all the agricultural wastes contained hemicellulose, cellulose and pectin which are important components of biological adsorbents. Comparatively, blend of plantain peel and pawpaw peel in ratio 3:2 displayed other specific functional groups like C-H stretching of aldehyde bond type, O-H stretching of carboxylic bond and C-H bending of di-substituted aromatic among others that could enhance the performance of the material as a good adsorbent for removal of crude oil from oil contaminated water better than other blends. The agricultural wastes and their blends in appropriate proportion were found to possess the capacities to be used as adsorbent and thus provide a favorable platform to researchers to work on and to come out with a sound technology applicable for removal of crude oil from crude oil contaminated water.

Keywords FTIR, Pawpaw peel, plantain peel, watermelon rind, blend, adsorbent

1. Introduction

Several plant-based adsorbent agents have been tested under different conditions, such as banana peel [1-3], papaya wood [4], grape stalk wastes [5], neem bark [6], neem biomass [7]), potato peel waste [8] among others. This is because they have been found to be environmental friendly and economically viable alternative to activated carbon as adsorbent for treating crude oil contaminated water. However, only few agricultural wastes like banana peel have been investigated as adsorbents for the treatment of crude oil-contaminated water [9-10]. The performance of these agricultural wastes as adsorbent is largely dependent on their structures. There are other agricultural waste that could also be considered for this purpose some of which are pawpaw peel, plantain peel and watermelon rind. As at 2017, the world production of plantain (*Musa paradisiacal*) stood at 39,241,376 tons while its production in Nigeria was 3,164,878 tons [11]. The peels of plantain generally known as cooking banana in Nigeria are substantially treated as waste products of little or no benefits in the country. Although pawpaw (*Carica papaya*) originates from the tropics of the Americans, southern Mexico, and neighboring Central America, Nigeria is the main producer of papaw in the African continent with 751,000 MT [11]. Pawpaw which belongs to the Caricaceae family contains over 22 species in the genus Carica. The various types of pawpaw are typical Maradol, wax pawpaw, Sunrise solo, mountain pawpaw, red royale f1 Kamiya (Hawaii), Mexican Red (Mexico), JS.22, pink solo, kapoho solo. All the types of pawpaw can be cultivated successfully in Nigeria. However the popular types in Nigeria are pink solo, large maradol, JS.22, and red royale. It was observed that none of most important pawpaw producers in Africa namely Nigeria, South Africa, Mozambique and Congo reports any export activity. As at 2017, the global production of watermelons was 118 million tonnes, with China alone accounting for 67% of the total [11]. Though watermelon (*Citrullus lanatus*), a vine-like flowering plant, is a highly cultivated fruit worldwide, it originated in West Africa and has more than 1000 varieties. The flowering plant is in the family called Cucurbitaceae. Watermelon rinds constitute a lot of agricultural waste in Nigerian society. Fruit peels, generally, contain organic compounds such as hemicellulose, cellulose, pectin substances (complex heteropolysaccharides containing galacturonic acid, arabinose, galactose, and rhamnose), chlorophyll pigments, and some other low molecular weight compounds [12-13]. The galacturonic acid which has carboxyl functional group could make pectin substances a strong metal adsorbent in aqueous solutions [14]. Hence, the effectiveness of the adsorbent as an adsorber can be influenced by the functional groups present in the structure of the adsorbent. Previous researchers reported that banana peel is a good source of pectin (10-21%), lignin (6-12%), cellulose (7.6-9.6%), hemicelluloses (6.4-9.4%), and galactouroninc acid [15]. The pectin extracted from banana peel was also found to contain glucose, galactose, arabinose, rhamnose, and xylose [16] and these contributed to the interest of various researchers in investigation of banana peel as adsorbent of oil from crude oil contaminated water [9, 17-18]. FTIR analysis of banana peel was carried out to drive home the effectiveness of the banana peel as the adsorbent by previous researchers in their study of the use of banana peels for oil spill removal [18]. FTIR spectroscopy is non destructive technique for materials analysis and used in the laboratory for over seventy years. It is the study of interaction of infrared radiation with matter as a function of photon frequency which provides specific information about the vibration and rotation of the chemical bonding and molecular structures, making it useful for analyzing organic materials and certain inorganic materials. Furthermore, an infrared spectrum represents a fingerprint of a sample with absorption peaks which correspond to the frequencies of vibrations between the bonds of the atoms making up the material. Since, each different material is a unique combination of atoms no two compounds produces the exact same infrared spectrum. Thus, infrared spectroscopy can result in a positive identification (qualitative analysis) of every different kind of material. Also, the size of the peaks in the spectrum is a direct indication of the amount of material present and running FTIR is essential in that it exposes the functional groups that could be responsible for the excellent sorption properties of the material [19]. Therefore, the focus of this study is to investigate the three agricultural wastes (plantain peel, pawpaw peel and watermelon rind) and their blends in different proportion for possible usage as adsorbent for treating crude oil contaminated water by carrying out FTIR analysis on the samples of the peels and rind. The results of these analyses can be good foundation for further determining the effectiveness of these agricultural wastes as adsorbent for treating crude oil contaminated water.

2. Materials and Methods

The plantain peels, pawpaw peels and watermelon rinds used in this research were obtained from Female hostel, Lagos State University, Epe campus, Lagos State, Nigeria. Distilled water was obtained from various AC outdoor units in Chemical Engineering Department, Lagos state university, Epe campus.

2.1. Preparation of Samples

The plantain peels, pawpaw peels and watermelon rinds were washed with ordinary water to remove suspended particles and then sun dried for seven days. The dried material was then washed thoroughly with distilled water to remove water soluble materials and later dried in the oven at 110 ^{o}C until constant weight was attained. The peel was removed from the oven and allowed to cool at ambient temperature. The adsorbent material was later crushed into powder form as shown in Figure 1 using mortar and pestle and stored in plastic container.

2.2. Fourier Transform Infrared (FTIR) Analysis

One gram of each pure sample of the agricultural waste adsorbent in powder form was measured using the OHAUS digital weighing balance (Ohaus Pioneer plus PA1602) and analyze with the Agilent FTIR spectroscope (range: 4000-650) using ASTM E1252-98 standard method. Furthermore, the blend of the pure sample of each agricultural waste with another were prepared and thoroughly mixed in the following ratio by mass and analyzed with the FTIR spectroscope using the standard method:

Plantain peel to Pawpaw peel = 1:1
Plantain peel to Pawpaw peel = 3:2
Plantain peel to watermelon rind = 1:1
Plantain peel to watermelon rind = 3:2
Pawpaw peel to watermelon rind = 1:1
Pawpaw peel to watermelon rind = 3: 2

The FTIR analysis was carried out at the central laboratory of Yaba College of Technology, Lagos, Nigeria. In the FTIR analysis, an Infra Red (IR) light source passed through the sample onto a detector, which precisely measures the amount of light absorbed by the sample. The absorbance created a unique spectral fingerprint that was used to identify the molecular structure of the sample and determined the exact quantity of a particular compound in the sample.

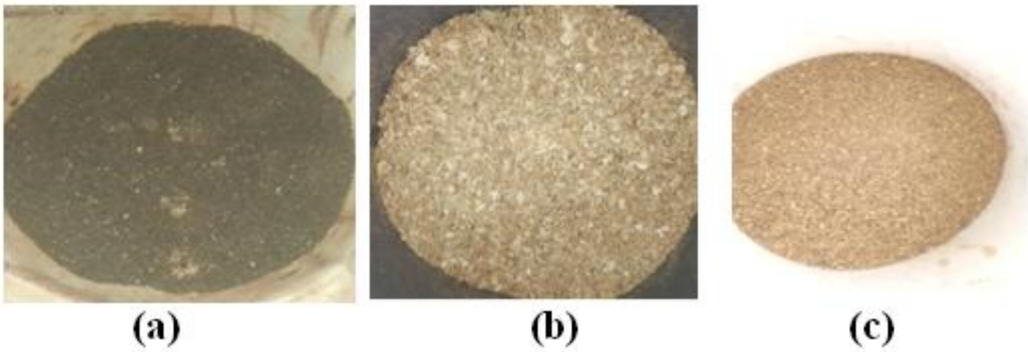

Figure 1: Samples of crushed agricultural wastes (a – Plantain peel, b – watermelon rind, c- pawpaw peel)

3. Results

From Table 1, blend of plantain and pawpaw peels either in ratio 1:1 or ratio 3:2 contains O-H stretching functional group corresponding to band range from 3200 to 3500 cm^{-1} with broad and strong peak as it was in the pure substances of the two agricultural wastes. In addition, the 3:2 ratio composition of plantain and pawpaw displayed presence of two additional peaks (3261.4 and 3082.5 cm^{-1} with strong and broad appearance) corresponding to O-H stretching functional group for alcohol and carboxylic acid respectively. This implied the existence of high concentration of hydroxyl group of polymeric compounds such as lignin or pectin that contains the functional groups of alcohols, phenols and carboxylic acids, which is in agreement with findings of other researchers [10, 20-21]. Also, blending of the plantain peel and pawpaw peel in ratio 3:2 could improve the interaction of the structures of the two agricultural waste and consequently put in better position effectively act as adsorbent. Furthermore, Table 1 showed that blend of plantain and pawpaw peels either in ratio 1:1 or ratio 3:2 contains C-H stretching functional group corresponding to band range from 2840 to 3000 cm^{-1} with medium peak appearance as it was in the pure substances of the two agricultural wastes. This implied the presence of alkane type of C-H bond in the two agricultural wastes and the interactions of the two when blended also displayed this. It was observed that blending of the plantain peel and pawpaw peel in ratio 3:2 further displayed bands 2724.7 and 1773.2 corresponding to C-H stretching and C=O stretching of Aldehyde type respectively, which were not displayed in the pure samples of plantain peel and pawpaw peel. This is an indication that on blending the two agricultural wastes in the ratio 3:2, interactions of their molecules enhance the better manifestation of the galactosidic structure in the adsorbent material. This is in agreement with findings of previous researchers that the pectins in the adsorbent contains galactose and galacturonic acid [12-13]. The pure peels of the plantain and pawpaw and their blend in the two ratios contain O-H bending bond corresponding to Alcohol type while on pure pawpaw peel and its blend with plantain peel in the two ratios displayed the presence of O-H bending bond of phenol type. Thus blending the pawpaw peel and plantain peel will bring on board phenol structure which could improve the effectiveness of the blend as adsorbent. C-O stretching bands for primary (1073.5 cm^{-1}) and secondary (1099.6 cm^{-1}) alcohols type of bond were found in pure plantain peel alone while C-O stretching band for tertiary found in pure plantain peel was retained in the 3:2 ratio blending of the plantain peel and pawpaw peel. This further indicates that there are molecular interactions between the two substances after blending [22]. This was further established by the presence of band (887.1 cm^{-1}) corresponding to C=C bending for alkene which was neither found in the plantain peel nor the pawpaw peel in the two blend ratios.

Table 1: Summary of FTIR Bands on blend of Plantain peel and Pawpaw peel

Absorption range (cm^{-1}) [Appearance]	Functional group	Plantain peel 1:0	Pawpaw peel 0:1	Plantain: Pawpaw 1:1	Plantain: Pawpaw 3:2	Type of bond
		Absorption (cm^{-1}) [Appearance]				
3200 – 3500 [strong, broad]	O-H Stretching	3265.1	3265.1	3265.1	3388.2 3261.4	Alcohol
2500-3300 [strong, broad]	O-H Stretching				3082.5	Carboxylic acid
2840-3000 [medium]	C-H Stretching	2922.2,	2914.8 2847.7	2922.7, 2851.4	2922.2 2855.1	Alkane
2695-2830 [medium]	C-H Stretching				2724.7	Aldehyde
1720-1740 [strong]	C=O Stretching				1733.2	Aldehyde
1566 – 1650	C=C Stretching	1595.3,	1617.7	1599.0,	1595.3 1453.7	Cyclic alkene
1330-1420 [medium]	O-H Bending	1375.4	1408.9 1371.7	1371.1	1375.4	Alcohol
1310-1390 [medium]	O-H Bending		1315.8	1315.8	1319.5	Phenol
1124 -1205 [strong]	C-O Stretching	1148.0			1148.0,	Tertiary alcohol
1020-1250 [medium]	C-N Stretching	1241.2	1233.7	1237.5, 1103.3	1244.9	Amine
1050 -1085 [strong]	C-O Stretching	1073.5				Primary alcohol
1087-1124 [Strong]	C-O [stretching]	1099.6				Secondary Alcohol
1000-1300 [strong]	C-O Stretching		1021.3	1013.8	1010.1	Esters
885-895 [strong]	C=C Bending			887.1	887.1	Alkene
800 – 860 [strong]	C-H Bending	857.3				(aromatic) Para di-substituted
750 – 800 [strong]	C-H Bending	760.4			661.0	(aromatic) Meta di-substituted
650-1000	=C-H [Bending]	998.9	667.2			Alkene
1087-1124 [Strong]	C-O [stretching]	1099.6				Secondary Alcohol

It was observed from the Table 1 that both the pure samples and the blended samples plantain peel and pawpaw peel displayed the presence of C-N stretching (1020 -1250 cm^{-1} band range) functional group of amine type. Findings of previous researchers showed that amine structure can enhance the effectiveness of a material as adsorbent of crude oil from contaminated water. Bands corresponding to C-O stretching for esters type of bond were only found in pawpaw peel and blend of plantain peel and pawpaw peel in ratio 1:1 (1021.3 cm^{-1} and 1013.8 cm^{-1} strong respectively). Bands corresponding to C-H bending for di-substituted aromatics were only found in pure plantain peel and blend of 3:2 ratio of plantain and pawpaw peel [18].

The hydroxyl group and the C-O stretches could have come from the cellulose, hemicelluloses, pectin and lignin compounds in the plantain peel. This is in agreement with findings of other researchers [10, 20-21]. Furthermore, The C-H could be attributed to C-H bending of crystalline cellulose and C-H bending of cellulose, hemicelluloses or lignin polymer.

It was observed from Table 2 that blend of plantain peel and watermelon rind either in ratio 1:1 or ratio 3:2 contains O-H stretching functional group corresponding to band range from 3200 to 3500 cm^{-1} with broad and strong peak as it was in the pure substances of the two agricultural wastes. This implied the existence of high concentration of hydroxyl group of polymeric compounds such as lignin or pectin that contains the functional groups of alcohols, phenols and carboxylic acids, which is in agreement with findings of other researchers [10, 20-21]. Furthermore, Table 2 showed that blend of plantain peel and watermelon rind either in ratio 1:1 or ratio 3:2 contains C-H stretching functional group corresponding to band range from 2840 to 3000 cm^{-1} with medium peak appearance as it was in the pure substances of the plantain peel and watermelon rind.

Table 2: Summary of FTIR Bands on blend of Plantain peel and Watermelon rind

Absorption range (cm^{-1}) [Appearance]	**Functional group**	**Plantain peel 1:0**	**Watermelon rind 0:1**	**Plantain: watermelon 1:1**	**Plantain: watermelon 3:2**	**Type of bond**
		Absorption (cm^{-1}) [Appearance]				
3200 – 3500 [strong, broad]	O-H Stretching	3265.1	3317.3	3328.5	3313.6 3280.1	Alcohol
2840-3000 [medium]	C-H Stretching	2922.2,	2914.8 2847.7	2914.8 2847.7	2914.8 2847.7	Alkane
1720-1740 [strong]	C=O Stretching		1736.9		1729.5	Aldehyde
1566 – 1650	C=C Stretching	1595.3	1591.6	1587.8	1587.8	Cyclic alkene
1395-1440 [medium]	O-H Bending		1401.5	1401.5		Carboxylic acid
1330-1420 [medium]	O-H Bending	1375.4		1367.9	1371.7	Alcohol
1310-1390 [medium]	O-H Bending		1319.5	1315.8	1315.8	Phenol
1124 -1205 [strong]	C-O Stretching	1148.0			1148.0	Tertiary alcohol
1020-1250 [medium]	C-N Stretching	1241.2	1099.6	1103.3 1244.9	1241.2	Amine
1050 -1085 [strong]	C-O Stretching	1073.5				Primary alcohol
1087-1124 [Strong]	C-O [stretching]	1099.6				Secondary Alcohol
1000-1300 [strong]	C-O Stretch		1013.8	1013.8	1010.1	Esters
885-895 [strong]	C=C Bending		894.6		887.1	Alkene
800 – 860 [strong]	C-H Bending	857.3				(aromatic) Para di-substituted
750 – 800 [strong]	C-H Bending	760.4				(aromatic) Meta di-substituted
650-1000	=C-H [Bending]	998.9				Alkene

This implied the presence of alkane type of C-H bond in the two agricultural wastes and the interactions of the two when blended also displayed this. It was observed that only pure watermelon rind and blend of the plantain peel and watermelon rind in ratio 3:2 displayed bands (1720-1740 cm^{-1}) corresponding to C=O stretching of Aldehyde type. This is an indication that on blending the two agricultural wastes in the ratio 3:2, interactions of their molecules resulted in manifestation of the galactosidic structure in the plantain peel blend with watermelon rind which was not originally displayed in the plantain peel to enhance its adsorbent property. This is in agreement with findings of previous researchers that the pectins in the adsorbent contains galactose and galacturonic acid [12-13]. Bands corresponding to C=C stretching (1566 – 1650 cm^{-1}) of cyclic alkene type of bond of was present in the pure plantain peel, watermelon rind and their blend as shown in Table 2. Band corresponding to O-H bending of carboxylic type was found only in pure watermelon rind and 1:1 ratio of plantain peel and watermelon rind while band corresponding to O-H bending of phenol type was found only in pure watermelon rind and the two ratios of blend of plantain peel and watermelon rind (Table 2). Also, O-H bending of alcohol type was found only in pure plantain and the two ratios of the blend of plantain peel and watermelon rind (Table 2). The presence of these O-H bending further confirm the high concentration of hydroxyl group of polymeric compounds such as lignin or pectin that contains the functional groups of alcohols, phenols and carboxylic acids in the plantain peels, watermelon rinds and their blends which could enhance their effectiveness as good adsorbent of crude oil from oil contaminated water [19]. It was observed that the bands corresponding to C-O stretching of the primary, secondary and tertiary alcohols type of bonds found in pure plantain peel were never seen in the pure watermelon rind and its blend with plantain peel except for the tertiary alcohol type that manifested in 3:2 ratio of plantain peel and watermelon blend (Table 2). Thus the blending of the plantain peel and watermelon 3:2 may give better improvement in the effectiveness of the agricultural wastes as adsorbent. This appearance of new peaks and disappearance of some peaks indicate that there are molecular interactions between the two substances after blending [22]. Table 2 further showed that both the pure samples and the blended samples of plantain peel and watermelon rind displayed the presence of C-N stretching (1020 -1250 cm^{-1} band range) functional group of amine type. Findings of previous researchers showed that amine structure can enhance the effectiveness of a material as adsorbent of crude oil from contaminated water. Bands corresponding to C-O stretching for esters type of bond were only found in watermelon rind and blend of plantain peel and watermelon rind in the two ratios 1:1and 3:2. Bands corresponding to C-H bending for di-substituted aromatics were only found in pure plantain peel and blend with watermelon rind did caused the disappearance of the peaks corresponding to this bond type (Table 2). Band corresponding to C=C bending of alkene type (885 – 895 cm^{-1},strong) was only found in the pure watermelon rind and the blend of plantain peel and watermelon rind in ratio 3:2. Also, addition of watermelon rind caused disappearance of the band corresponding to the =C-H bending of alkene type (998.9 cm^{-1}) originally in the plantain peel.

From Table 3, it was found out that blend of pawpaw peel and watermelon rind either in ratio 1:1 or ratio 3:2 contains O-H stretching functional group corresponding to band range from 3200 to 3500 cm^{-1} with broad and strong peak as it was in the pure substances of the pawpaw peel and watermelon rind. This implied the existence of high concentration of hydroxyl group of polymeric compounds such as lignin or pectin that contains the functional groups of alcohols, phenols and carboxylic acids, which is in agreement with findings of other researchers [10, 20-21]. Table 3 showed that blend of pawpaw peel and watermelon rind either in ratio 1:1 or ratio 3:2 contains C-H stretching functional group corresponding to band range from 2840 to 3000 cm^{-1} with medium peak appearance as it was in the pure substances of the pawpaw peel and watermelon rind. This implied the presence of alkane type of C-H bond in the two agricultural wastes and the interactions of the two when blended also displayed this. It was observed that only pure watermelon rind and blend of the pawpaw peel and watermelon rind in the two ratios 1:1 and 3:2 displayed bands (1720-1740 cm^{-1}) corresponding to C=O stretching of Aldehyde type. This is an indication that on blending the two agricultural wastes, interactions of their molecules resulted in manifestation of the galactosidic structure in the pawpaw peel blend with watermelon rind which was not originally displayed in the pawpaw peel to enhance its adsorbent property. This is in agreement with findings of previous researchers that the pectins in the adsorbent contains galactose and galacturonic acid [12-13].

Bands corresponding to C=C stretching (1566 – 1650 cm^{-1}) of cyclic alkene type of bond of was present in the pure pawpaw peel, watermelon rind and their blend as shown in Table 3. Band corresponding to O-H bending of carboxylic type was found only in pure watermelon rind and ratio 3:2 of pawpaw peel and watermelon rind while band corresponding to O-H bending of alcohol type was found only in pure pawpaw peel and the two ratios of blend of pawpaw peel and watermelon rind (Table 3).

Table 3: Summary of FTIR Bands on blend of Pawpaw peel and Watermelon rind

Absorption range (cm^{-1}) [Appearance]	Functional group	Pawpaw peel 1:0	Watermelon rind 0:1	Pawpaw: Watermelon 1:1	Pawpaw: Watermelon 3:2	Type of bond
		Absorption (cm^{-1}) [Appearance]				
3200 – 3500 [strong, broad]	O-H Stretching	3265.1	3317.3	3272.6	3287.5	Alcohol
2840-3000 [medium]	C-H Stretching	2914.8 2847.7	2914.8 2847.7	2918.5 2851.4	2914.8 2847.7	Alkane
1720-1740 [strong]	C=O Stretching		1736.9	1729.5	1729.5	Aldehyde
1566 – 1650 [medium]	C=C Stretching	1617.7	1591.6	1587.5	1602.8	Cyclic alkene
1395-1440 [medium]	O-H Bending		1401.5		1416.4	Carboxylic acid
1330-1420 [medium]	O-H Bending	1408.9 1371.7		1375.4	1371.7	Alcohol
1310-1390 [medium]	O-H Bending	1315.8	1319.5		1312.0	Phenol
1124 -1205 [strong]	C-O Stretching			1148.0	1162.9	Tertiary alcohol
1020-1250 [medium]	C-N Stretching	1233.7	1099.6	1241.2	1103.3 1244.9	Amine
1087-1124 [Strong]	C-O [stretching]	1099.6				Secondary Alcohol
1000-1300 [strong]	C-O Stretch	1021.3	1013.8	1010.1	1017.6	Esters
885-895 [strong]	C=C Bending		894.6	887.1		Alkene
650-1000	C=C Bending	667.2			719.4	Substituted Alkene
1400-1500	C-C [Stretch (in ring)]				1461.1	Aromatics

Also, O-H bending of phenol type was found only in pure pawpaw peel, watermelon rind and ratio 3:2 of pawpaw peel and watermelon rind blend (Table 3). The presence of these O-H bending further confirm the high concentration of hydroxyl group of polymeric compounds such as lignin or pectin that contains the functional groups of alcohols, phenols and carboxylic acids in the pawpaw peels, watermelon rinds and their blends which could enhance their effectiveness as good adsorbent of crude oil from oil contaminated water [10]. It was observed that the band corresponding to C-O stretching of the secondary alcohol type of bond found in pure pawpaw peel was never seen in the pure watermelon rind and its blend with pawpaw peel while band corresponding to C-O stretching of tertiary alcohol type which was neither found in the pure pawpaw peel nor in the watermelon rind was manifested in 1:1 and 3:2 ratios of pawpaw peel and watermelon blends (Table 3). This appearance of new peaks and disappearance of some peaks indicate that there are molecular interactions between the two substances after blending [22]. Furthermore, Table 3 showed that both the pure samples and the blended samples of pawpaw peel and watermelon rind displayed the presence of C-N stretching (1020 -1250 cm^{-1} band range) functional group of amine type. Findings of previous researchers showed that amine structure can enhance the effectiveness of a material as adsorbent of crude oil from contaminated water [ ]. Similarly, bands corresponding to C-O stretching for esters type of bond were found in pure pawpaw peel, watermelon rind and blend of pawpaw peel and watermelon rind in the two ratios 1:1and 3:2. Band corresponding to C=C bending of alkene type (885 – 895 cm^{-1}, strong) was only found in the pure watermelon rind and the blend of pawpaw peel and watermelon rind in ratio 1:1. Band corresponding to C=C bending of substituted alkene type (650 – 1000 cm^{-1}) was only found in the pure pawpaw peel and the blend of pawpaw peel and watermelon rind in ratio 3:2. Furthermore, band corresponding to C-C stretching (in ring) aromatic type (1461.1 cm^{-1}) was found only 3:2 blend of pawpaw peel with watermelon rind.

From the foregoing, blend of plantain peel with either pawpaw peel or watermelon rind in ratio 3:2 could perform better than pure plantain peel, pawpaw peel, watermelon rind or their blend in ratio 1:1. Comparing the FTIR spectrum of blend of plantain peel and pawpaw peel in ratio 3:2 (Figure 2) with the FTIR spectrum of blend plantain peel and watermelon in 3:2 (Figure 3) revealed that the plantain blend with pawpaw displayed the presence of 16 peaks while the plantain blend with watermelon in the same ratio displayed 12 peaks.

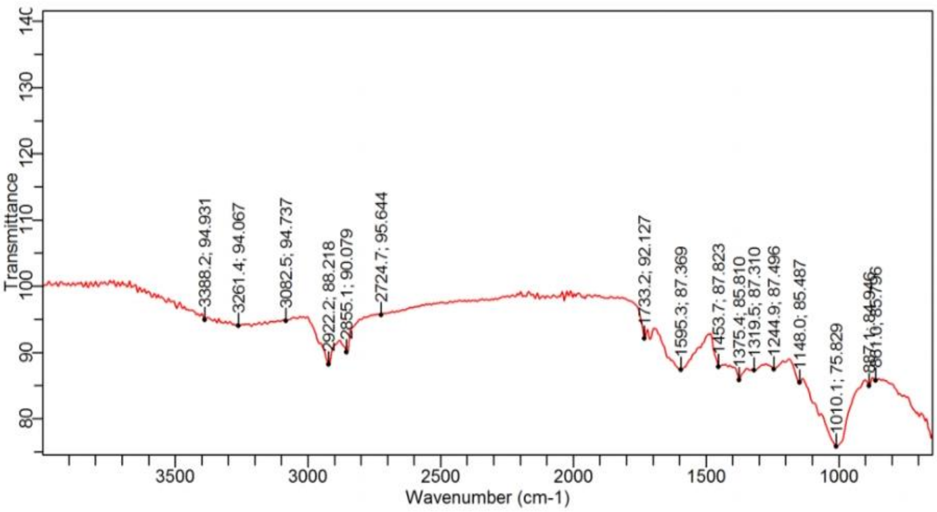

Figure 2: FTIR spectrum of sample of plantain and pawpaw blend in ratio 3:2

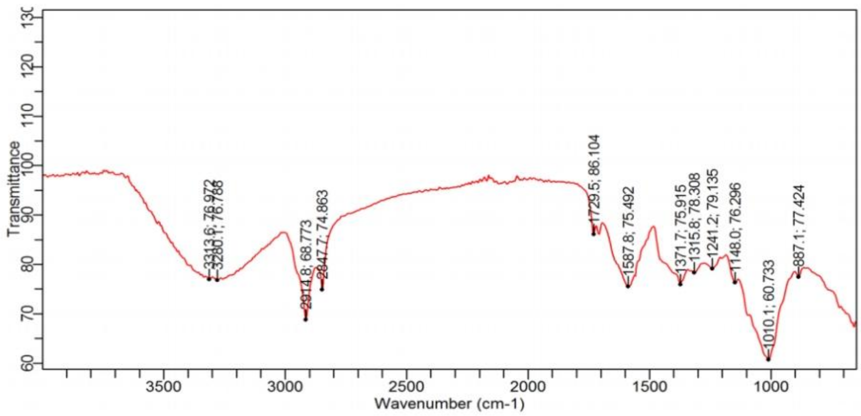

Figure 3 FTIR spectrum of sample blend of plantain peel and watermelon rind in ratio 3:2

Apart from containing other similar functional groups like that of plantain peel and watermelon rind blend, the plantain peel and pawpaw blend contained 3082.5, 2724.7 and 661.0 bands corresponding to the O-H stretching functional group of carboxylic bond type, C-H stretching functional group of aldehyde bond type and C-H bending functional group of di-substituted aromatic bond type respectively. These are indications that the blend of plantain peel and pawpaw peel in ratio 3:2 contains additional structures of hydroxyl group of polymeric compounds such as lignin or pectin (with some other galactoseidic structure) that contain the functional groups of alcohols, phenols and carboxylic acids, which may not be in the blend of the plantain peel and the watermelon rind.

4. Conclusion

Plantain peel, pawpaw peel and watermelon rind are generated in large quantities worldwide hence they could be recognized as promising crop-based material available for exploring alternative uses. In this study, plantain peel, pawpaw peel and watermelon rind were dried, grounded into powdered form and blended in binary ratios of 1:1 and 3:2. The functional groups presence in the pure samples and blended samples were determined using FTIR analysis. All the pure samples and blended samples were found to contain O-H stretching, C-H stretching, C=C stretching, O-H bending and C-O stretching functional groups which implied all the agricultural wastes contain hemicellulose, cellulose and pectin which are important components of biological adsorbents. Also, all the samples contained C-N stretching functional group which indicates presence of amine group in the materials. Comparatively, blend of plantain peel and pawpaw peel in ratio 3:2 displayed other specific functional groups like C-H stretching of aldehyde bond type, O-H stretching of carboxylic bond and C-H bending of di-substituted aromatic among others that could enhance the performance of the material as a good adsorbent for removal of crude oil from oil contaminated water better than other blends. Plantain peel, pawpaw peel, watermelon and their blends in appropriate proportion were found to possess the capacities to be used as adsorbent and thus provide a favorable platform to researchers to work on and to come out with a sound technology applicable for removal of crude oil from crude oil contaminated water. The use of these native agricultural materials as adsorbents will lead to cost efficiency and reduce operational cost in crude oil contaminated water treatment and definitely give an additional value to these agricultural wastes enhance fruit industry through such technology.

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