RESEARCHERID
THOMSON REUTERS
[Abass, 4(7): July 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.825479 Impact Factor- 4.022
GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

RAMAN AND FTIR SPECTRUM AND CHARACTERIZATION OF PMMA/KAOLINITEMIXTURE

Mohammed Margani Rashed Abass[*1], Nafie A. Al Muslet[2], Asim Ahmed Mohamed Fadol[3] & Mubarak Dirar A. Allah[4]

[*1]Department of Physics, faculty of science and technology, Shendi University, Shendi - Sudan
[2&4]Department of Physics, Sudan University of Science & Technology, Khartoum –Sudan
[3]Department of Physics, College of Applied and Industrial Science, Bahri University, Khartoum-Sudan

ABSTRACT

Nanocomposite material which contains inorganic nanolayer clay and organic polymer has attracted considerable attention in recent years. Particularly, intercalation of organic polymer into inorganic layered host lattice has approved to be an effective way to construct inorganic–organic nanosystem. The Raman and FTIR spectrum of kaolinite, a layer silicate of composition A12Si2O5(OH)4, from Aldrich Company (Germany) with a diameter of 5–10 , is reported. Kaolinite treated by dimethylsulfoxide (DMSO) as an aqueous system to expand the interlayer basal spacing.In the OH stretching region, a Raman band of kaolinite is observed at 3624 , and at 3481 after modified. IR kaolinite have four bands for OH stretching, and five bands after modified. Then the organic molecules-modified kaolinite (Kaolinite/DMSO) uses clay precursor to synthesize the PMMA/kaolinite intercalation nanocomposites via solution intercalation. The spectrum of Raman and FTIR shows results which agrees of high degree of precision with experiments and previous studies.

Keywords*: PMMA, kaolinite, Nanocomposite material,FTIR spectrum.*

I. INTRODUCTION

Fourier transform spectroscopy is a measurement technique whereby spectra are collected based on measurements of the coherence of a radiative source, using time-domain or space-domain measurements of the electromagnetic radiation or other type of radiation.[1] It can be applied to a variety of types of spectroscopy including optical spectroscopy, infrared spectroscopy (FTIR, FT-NIRS), Fourier transform (FT) nuclear magnetic resonance, mass spectrometry and electron spin resonance spectroscopy.[2] There are several methods for measuring the temporal coherence of the light, including the continuous wave Michelson or Fourier transform spectrometer and the pulsed Fourier transform spectrograph (which is more sensitive and has a much shorter sampling time than conventional spectroscopic techniques, but is only applicable in a laboratory environment).[3]

In many cases, however, direct analysis of "as received" samples by transmission or reflection methods is not practical because the sample either transmits inadequate light to measure or it lacks suitable surface or particle size conditions for reflectance spectroscopies. In other cases, reflectance spectroscopies may not probe deeply enough into the sample to yield the desired information.[4]

Raman spectroscopy is a spectroscopic technique based on inelastic scattering of monochromatic light, usually from a laser source. Inelastic scattering means that the frequency of photons in monochromatic light changes upon interaction with a sample. Photons of the laser light are absorbed by the sample and then reemitted. Frequency of the reemittedphotons is shifted up or down in comparison with original monochromatic frequency, which is called the Raman effect.[5]This shift provides information about vibrational, rotational and other low frequency transitions in molecules. Raman spectroscopy can be used to study solid, liquid and gaseous samples. [6]

This work is concerned with using FTIR, Raman spectrum to characterize PMMA/kaolinite noncomposite.[7] Kaolinite is the main constituent of kaolin.[8] Its chemical structure is $Al_2Si_2O_5(OH)_4$ (39,8 % alumina, 46,3 % silica, 13,9 % water) which represents two-layer crystal (siliconoxygen tetrahedral layer joined to alumina

octahedral layer exist alternately), which has a molecular weight of 258,071 g/mol. Kaolinite is build up from pseudohexagonal triclinic crystals with diameter 0,2–10 μm, with thickness 0,7 nm and its density is 2,6 g/cm3Kaolinite has a 1:1 sheet structure composed of SiO4 tetrahedral sheets and Al(O, $OH)_6$ octahedral sheets (or, expressed in other way, $[Si_2O_5]^{2-}$ sheet and $[Al_2(OH)_4]^2$ sheet) with pseudo-hexagonal symmetry [9].

II. INSTRUMENTATIONS

Different instrumentations were used in this study to evaluate the intercalation of PMMA into kaolinite nanocomposite.

In this study, the intercalation of Poly(methyl methacrylate) into kaolinite is the main target. Poly(methyl methacrylate) was mixed with kaolinite directly, and also mixed after modification of kaolinite by DMSO, using the ultrasonic oscillations.

The ultrasonic oscillations can also affect the microstructure of clay, causing more regions of exfoliated clay. Due to better dispersion of clay and smaller crystal size, the elongation at break of polymer/layered nanocomposites ultrasonically treated got greatly increased; meanwhile ultrasonic oscillations also improved their other mechanical properties, such as tensile and impact strength.

III. PREPARATION OF KAOLINITE/ DMSO

Kaolinite–DMSO intercalate was typically prepared by mixing 9gram of kaolinite with 60 mL of DMSO in a sealed container for a sufficient time (72 hour) with occasional stirring to achieve maximum intercalation. A representation of this process is shown in figure (3.5). The product was vacuum-filtered and washed with ethanol for three times to remove excess DMSO and then air-dried to yield an off-white powder.

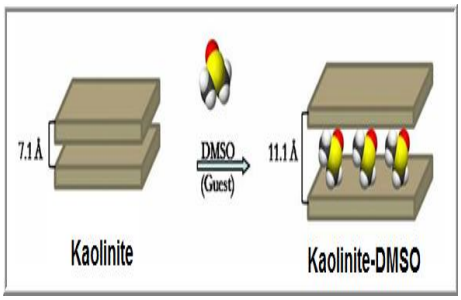

Fig.3.1 Intercalation of organic molecules (DMSO) in kaolinite

1. **Preparation of PMMA/kaolinite**intercalation nanocomposites

Different ratios of PMMA and pure kaolinite were mixed with different ratios as listed in table (3.1).

Table (3.1) The ratio of PMMA and kaolinite mixed

Mixture No	Kaolinite %	PMMA %
1	95	5
2	80	20
3	70	30
4	60	40

0.2 g of PMMA was taken from the first mixture (with ratio 5:95) and solved in 50 mL of chloroform using magnetic stirring for about 30 min or until the polymer become soluble. In the other side, 3.8 g of kaolinite with 50mL of chloroform was put in the ultrasonic for one hour. After that, clay was put in magnetic stirring and drops

of PMMA were added to achieve a good intercalation. The produced powder was dried in oven with 60^0C for about 24 hours. The other ratios were treated by the same manner.

2. PMMA/(kaolinite+DMSO)

Intercalation nanocomposites the modified kaolinite was mixed with PMMA in the same ratios that were mixed without modification. In this series of experiments, Kaolinite was prepared by the displacement of DMSO with polymer. (3.8 g) of Kaolintie/DMSO mixture and an aqueous solution of PMMA (0.2g) was stirred for one hour, then the product was dried in dry oven for 24hour, washed with ethanol, and air-dried to yield nanocomposite.

IV. SAMPLE CHARACTERIZATION

Other instrumentation techniques have a different sample analysis. In this study PMMA/kaolinite was characterized by different techniques, FTIR, XRD, TEM, and laser Raman spectroscopy. These instruments were used to confirm that good intercalation was achieved, through the change in the spectrum which is the real indication for this intercalation.

To characterize the samples by FTIR, a very small amount of the powder sample, approximately (2 mg), was finely grounded and intimately mixed with approximately 198 mg of dry potassium bromide (KBr) powder. Grinding and mixing can be done with an agate mortar and pestle. Then the samples were placed between two disks and put under mechanical pressure. The pressure was 40kPa, fixed for several minutes before removing the KBr disk formed. Re-crystallization of the KBr results in a clear glassy disk of about 1 mm thick. This disk is now ready to be analyzed by transmission. Then the disk was placed in the sample holder ready for scanning.

Mount the grinding container into the mixer, fasten snugly, close the lid and turn on the mixer for at least 5 minutes. After grinding is completed, the powder was transferred to a piece of weighing paper and sieves it through the 270 mesh sieve.

If insufficient sample was reduced to <270 mesh, it then return to the grinder for another run.

The spectra were recorded by JASCO 6300 Laser Raman spectrometer, no special sample preparation was needed in the experiment. Each sample was defrosted at room temperature, and the measurements were carried out by putting the powder in a sample holder. A total of 11 scans were recorded at a resolution of $4cm^{-1}$ in the region 4000 to 50 cm^{-1}. The laser power used was 0.5 W.

V. RESULTS AND DISCUSSION

Results obtained by FTIR, and laser Raman spectroscopy for kaolinite, kaolinite+DMSO, PMMA/kaolinite nanocomposite are presented and discussed. The experimental results are illustrated in tables and figures.

1. FTIR Spectra for samples

FTIR Spectra for all samples are shown in figures from (5.1) to (5.10). Intensity and wavenumbers of the peaks also are listed in tables (5.1) to (5.10) for each sample. The spectra recorded for PMMA/(Kaolinite+DMSO) nanocomposite are shown in figures from (5.4) to (5.7), while that for PMMA/Kaolinite nanocomposite are shown in figures from (5.8) to (5.11) all the spectra are recorded in the range from 400 to 4000 cm^{-1}.

ISSN 2348 – 8034
Impact Factor- 4.022

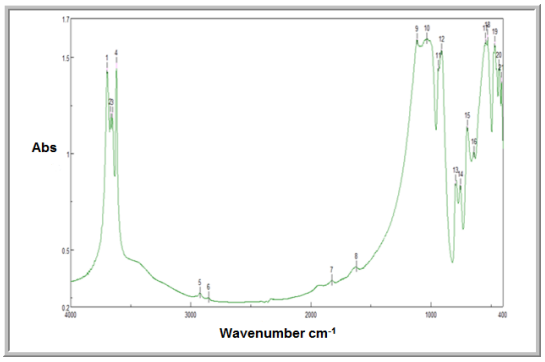

Figure (5.1) FTIR spectrum of kaolinite

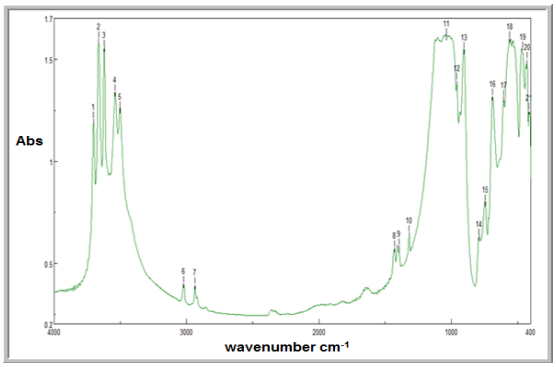

Figure (5.2) FTIR spectrum of kaolinite after treatment with DMSO

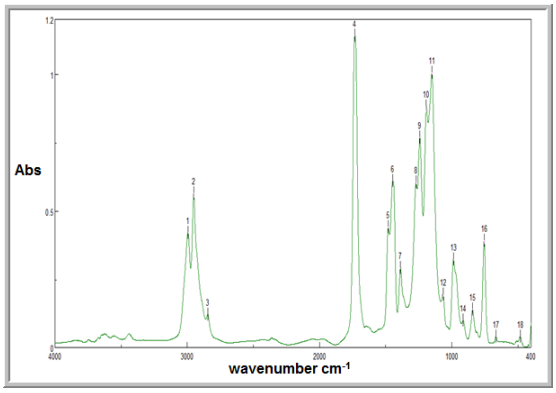

Figure (5.3) FTIR spectrum of PMMA

ISSN 2348 – 8034
Impact Factor- 4.022

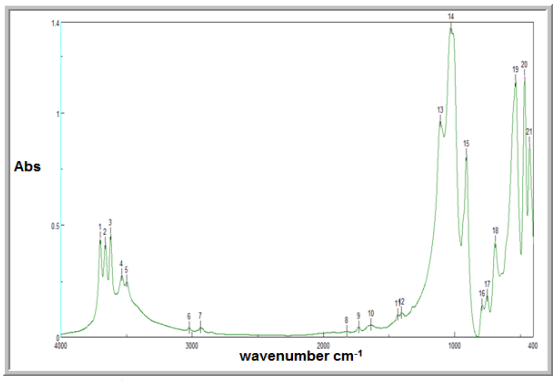

Figure (5.4) FTIR spectrum of 95% (kaolinite+ DMSO) 5% PMMA nanocomposite spectrum

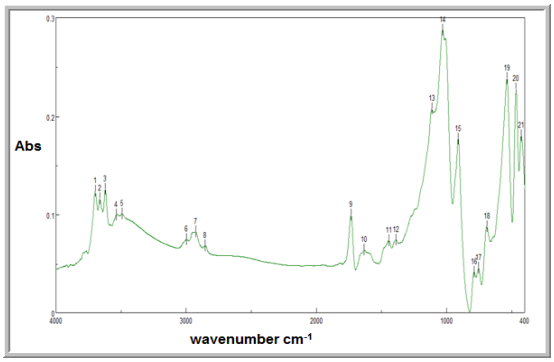

Figure (5.5) FTIR spectrum of 80% (kaolinite / DMSO) 20%PMMA nanocomposite spectrum

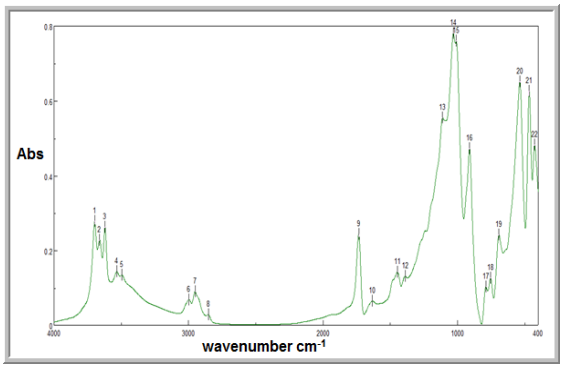

Figure (5.6) FTIR spectrum of 70% (kaolinite / DMSO) 30%PMMA nanocomposite spectrum

ISSN 2348 – 8034
Impact Factor- 4.022

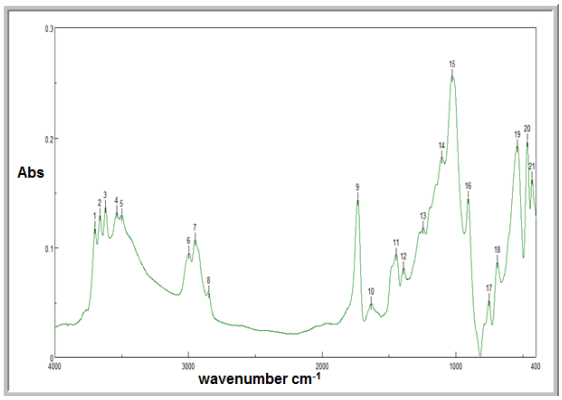

Figure (5.7) FTIR spectrum of 60% (kaolinite / DMSO) 40%PMMA nanocomposite spectrum

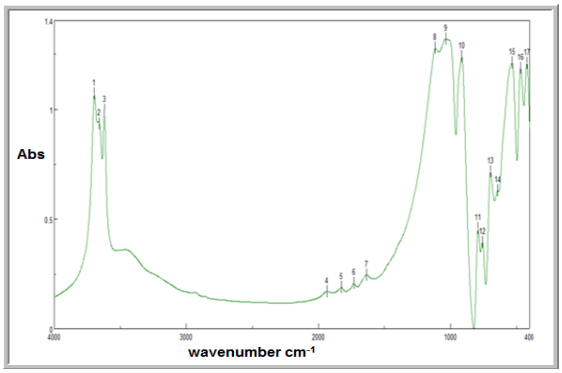

Figure (5.8) FTIR spectrum of 95%kaolinite / 5%PMMA nanocomposite spectrum

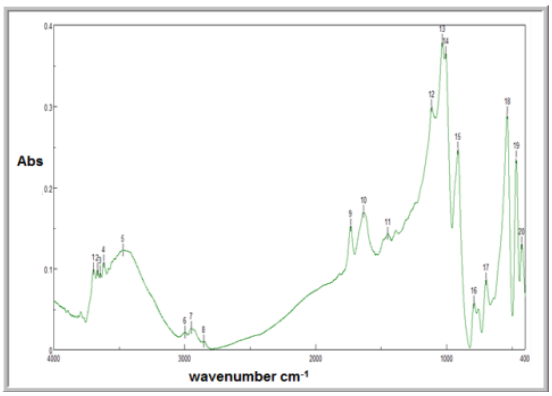

Figure (5,9) FTIR spectrum of 80%kaolinite / 20%PMMA nanocomposite spectrum

ISSN 2348 – 8034
Impact Factor- 4.022

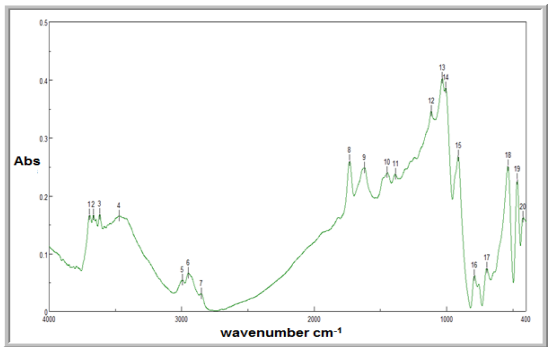

Figure (5.10) FTIR spectrum of 70%kaolinite / 30%PMMA nanocomposite spectrum

Table (5.1) The wavenumbers and intensities of Kaolinite spectrum

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3696	1.44077	2	3667	1.21433
3	3652	1.21139	4	3619	1.46785
5	2923	0.273493	6	2852	0.251825
7	1824	0.339708	8	1621	0.409491
9	1114	1.59315	10	1033	1.59754
11	937	1.45262	12	912	1.53957
13	794	0.859442	14	755	0.836759
15	698	1.14316	16	642	1.00682
17	545	1.59739	18	528	1.61396
19	468	1.57803	20	433	1.45821
21	412	1.39224			

Table (5.2) The wavenumbers and intensities of Kaolinite spectrum after treatment with DMSO

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3702	1.21193	2	3664	1.60408
3	3621	1.56467	4	3540	1.34379
5	3502	1.26271	6	3021	0.404158
7	2935	0.39798	8	1428	0.57961
9	1394	0.587479	10	1319	0.654742
11	1037	1.61949	12	958	1.39919
13	904	1.55274	14	790	0.636691
15	744	0.804327	16	690	1.32291

ISSN 2348 – 8034
Impact Factor- 4.022

17	605	1.31867	18	561	1.60526
19	462	1.55613	20	428	1.50377
21	414	1.25634			

Table (5.3) The wavenumbers and intensities of PMMA spectrum

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	2994	0.420771	2	2951	0.563391
3	2844	0.121964	4	1732	1.1412
5	1481	0.440301	6	1447	0.610161
7	1387	0.291551	8	1270	0.603592
9	1240	0.768469	10	1192	0.881882
11	1150	1.00514	12	1066	0.194932
13	987	0.322327	14	913	0.100071
15	842	0.13968	16	754	0.391723
17	666	0.0399935	18	483	0.0400481

Table (5.4) The wavenumbers and intensities of 95% (Kaolinite+ DMSO) 5%PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3700	0.439141	2	3661	0.418294
3	3620	0.459994	4	3535	0.276192
5	3497	0.247761	6	3022	0.042691
7	2935	0.0436125	8	1820	0.0261101
9	1730	0.0444089	10	1637	0.0544859
11	1431	0.100105	12	1404	0.107683
13	1108	0.96024	14	1028	1.37547
15	910	0.812026	16	790	0.144524
17	752	0.185217	18	691	0.422251
19	535	1.14069	20	466	1.16079
21	429	0.861879			

ISSN 2348 – 8034
Impact Factor- 4.022

Table (5.5) The wavenumbers and intensities of 80% (Kaolinite/ DMSO) 20%PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3697	0.124088	2	3663	0.115952
3	3620	0.125451	4	3535	0.0997575
5	3493	0.100711	6	2998	0.0745035
7	2927	0.0823008	8	2853	0.0683479
9	1734	0.0995156	10	1632	0.0639172
11	1444	0.0735241	12	1389	0.0741222
13	1113	0.207329	14	1030	0.287734
15	910	0.176931	16	789	0.0417425
17	754	0.0455008	18	691	0.0878512
19	536	0.23859	20	466	0.227551
21	426	0.180264			

Table (5.6) The wavenumbers and intensities of 70% (Kaolinite/ DMSO) 30%PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3697	0.277543	2	3661	0.228343
3	3620	0.261705	4	3532	0.143596
5	3494	0.134583	6	2996	0.0687497
7	2951	0.0894737	8	2852	0.0289248
9	1734	0.24295	10	1632	0.0648534
11	1447	0.141886	12	1389	0.131584
13	1110	0.554574	14	1030	0.781604
15	1008	0.760096	16	910	0.473134
17	789	0.102638	18	754	0.126222
19	692	0.241811	20	537	0.651665
21	466	0.625666	22	427	0.482018

Table (5.7) The wavenumbers and intensities of 60% (Kaolinite/ DMSO) 40%PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3700	0.118035	2	3662	0.129803
3	3620	0.136974	4	3536	0.132248
5	3497	0.129418	6	2996	0.0951882
7	2951	0.107411	8	2849	0.0595036
9	1733	0.143989	10	1632	0.0491334
11	1445	0.0939676	12	1390	0.0813329
13	1244	0.118187	14	1105	0.182084
15	1027	0.25612	16	907	0.145165

ISSN 2348 – 8034
Impact Factor- 4.022

17	752	0.0519769	18	689	0.0869308
19	539	0.192244	20	465	0.197224
21	430	0.163031			

Table (5.8) The wavenumbers and intensities of 95%Kaolinite /5%PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3695	1.0674	2	3658	0.9334
3	3619	0.994197	4	1934	0.16919
5	1824	0.187407	6	1730	0.20634
7	1633	0.244416	8	1114	1.27654
9	1033	1.31779	10	913	1.2378
11	790	0.455202	12	756	0.393019
13	696	0.713405	14	643	0.628715
15	533	1.20803	16	468	1.18549
17	420	1.20634			

Table (5.9) The wavenumbers and intensities of 80%Kaolinite /20%PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3696	0.0999962	2	3666	0.0987665
3	3644	0.095916	4	3616	0.108824
5	3471	0.122766	6	2998	0.021565
7	2950	0.027153	8	2856	0.0103757
9	1732	0.15312	10	1633	0.169595
11	1451	0.143364	12	1114	0.300503
13	1032	0.380965	14	1007	0.366171
15	913	0.248145	16	790	0.058849
17	699	0.0868198	18	538	0.291953
19	468	0.236861	20	426	0.130928

Table (5.10) The wavenumbers and intensities of 70% Kaolinite /30% PMMA nanocomposite

No of peak	Wavenumber (cm^{-1})	Intensity (a.u)	No of peak	Wavenumber (cm^{-1})	Intensity (a.u)
1	3695	0.166675	2	3666	0.167
3	3617	0.168059	4	3472	0.164698
5	2994	0.0540881	6	2949	0.0663119
7	2852	0.0311005	8	1731	0.260388
9	1620	0.248505	10	1449	0.239715
11	1386	0.237421	12	1116	0.346088
13	1032	0.403494	14	1006	0.386329
15	912	0.268396	16	790	0.0625192
17	697	0.0746817	18	538	0.251735
19	467	0.228309	20	423	0.163052

ISSN 2348 – 8034
Impact Factor- 4.022

In figure (5.1) the FTIR bands observed at 3696,and 3619 cm^{-1} are attributed to the in plane vibration of the inner surface hydroxyl, and inner hydroxyl, respectively.[35] The inner hydroxyl stretching is not usually influenced by the interlayer of kaolinite. The bands at 3667 and 3652 cm^{-1} are the characteristic vibration bands of outer surface hydroxyl and absorbed water.

In the spectrum of kaolinite treated with DMSO, shown in figure (5.2), additional bands at 3540, 3502, 3664 and 904 cm^{-1} are observed, while the bands of 3667 and 3652, 2852 cm^{-1}, observed in fig(5.1), are disappeared. The intensity of the band at 3696 cm^{-1} decreased while the intensity of the band at 3619 cm^{-1} remains the same. The band at 3664 cm^{-1} is attributed to the hydroxyl stretching vibration of the inner surface hydroxyl which is hydrogen bonded to the DMSO. The band at 904 cm^{-1} is the hydroxyl deformation of inner surface hydroxyl groups that are hydrogen bonded to the –S=O group of the DMSO.The bands at 3021 and 2935 cm^{-1} are attributed to in-plane bending vibration and out of plane vibration of C–H bond, respectively.

Figure (5.3) shows the FTIR spectrum of PMMA, the wavenumbers and intensities were listed in table (5.3). The significant vibration bands of PMMA are observed at 2994 cm^{-1} (–CH3), 2951 cm^{-1} (–CH2-), and 1732 cm^{-1} (C=O). The band of in-plane vibration of outer-surface –OH is shifted to 3702 cm^{-1} from 3696 cm^{-1}, this proves that there are reciprocities between the C=O group of PMMA and the –OH group of kaolinite. As the loading of precursor kaolinite increases, the intensity of precursor kaolinite significant bands at 3702, 3619 cm^{-1} become stronger in the FT-IR spectra of (Kaolinite+DMSO) /PMMA nanocomposites. In other words, the rate of intercalation was affected by the content of clay.

The band at 3540 cm^{-1} in figure (5.2) was shifted to 3535 cm^{-1} in figure (5.4), and its intensity was decreased also. The appearance of bands 1730 cm^{-1} in figure (5.4), 2998, 1734, and 1444 cm^{-1} in figure (5.5), 2996, 2951, 1734, 1447, and 1389 cm^{-1} in figure (5.6), 2996, 2951, 1733, 1445, 1390, and 1244 cm^{-1} in figure(4.7), 1730 cm^{-1} in figure (5.8), 2998, 2950, 1732, and 1451 cm^{-1} in figure (5.9), 2994, 2949, 1731, and 1449 cm^{-1} in figure (5.10), 2994, 2950, 1733, 1447, and 1243 cm^{-1}, indicated the presence of PMMA in the samples.

2. Laser Raman spectroscopy

Laser Raman Spectra for all samples are shown in figures from (5.11) to (5.20). Intensity and wavenumbers of the peaks also are listed in tables (5.11) to (5.13) for all samples. The spectra recorded for PMMA/(Kaolinite+DMSO) nanocomposite are shown in figures from (5.11) to (5.20),in the range from 49 to 4000 cm^{-1} .

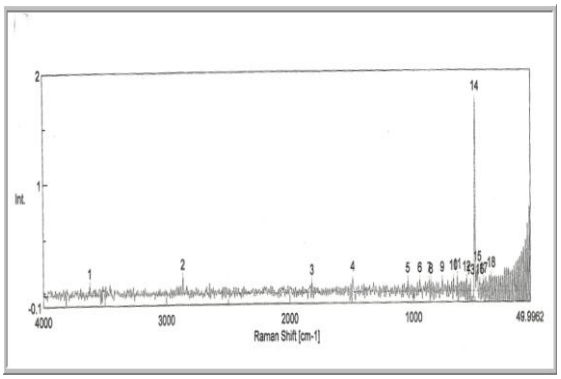

Figure (5.11) Laser Raman spectrum of kaolinite

ISSN 2348 – 8034
Impact Factor- 4.022

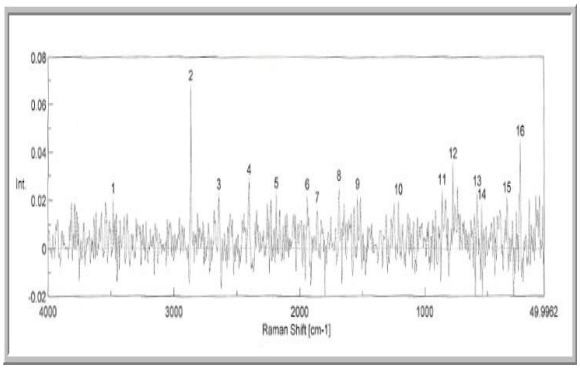

Figure (5.12) Laser Raman spectrum of kaolinite+DMSO

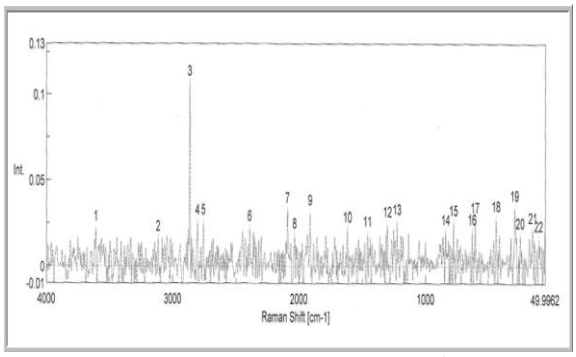

Figure (5.13) Laser Raman spectrum of PMMA

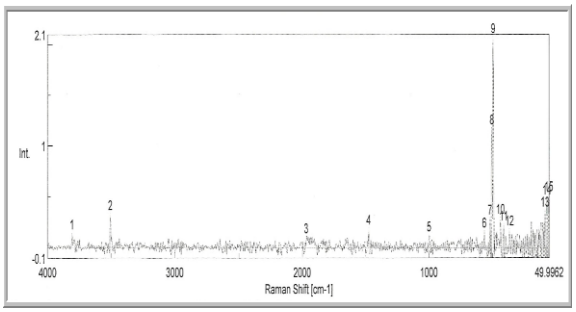

Figure (5.14) Laser Raman spectrum of 95 %(kaolinite +DMSO) 5%PMMA nanocomposite

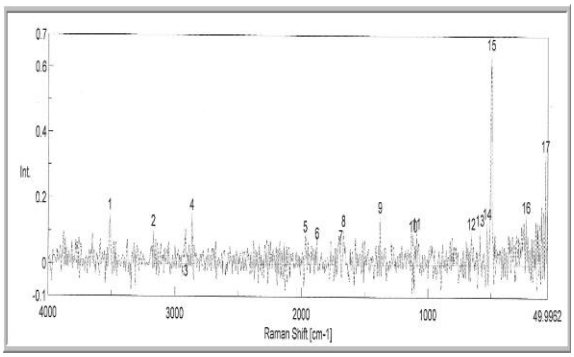

Figure (5.15) Laser Raman spectrum of 80 %(kaolinite +DMSO) 20%PMMA anocomposite

ISSN 2348 – 8034
Impact Factor- 4.022

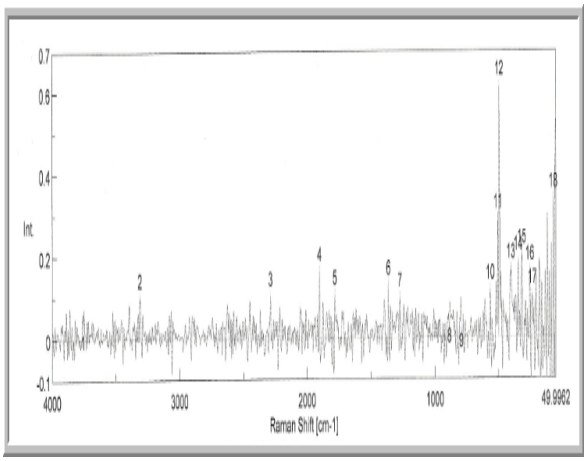

Figure (5.16) Laser Raman spectrum of 70 %(kaolinite +DMSO) 30%PMMA anocomposite

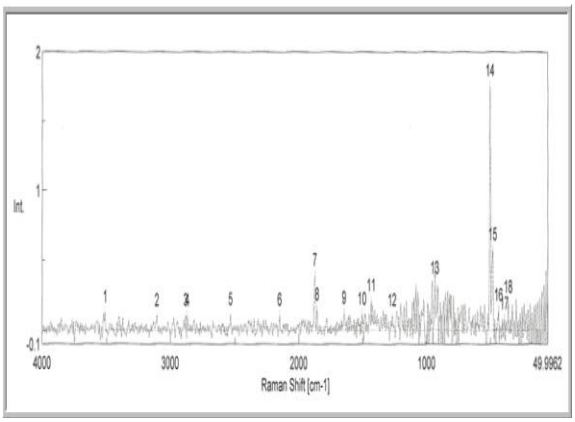

Figure (5.17) Laser Raman spectrum of 60% (kaolinite+ DMSO) 40%PMMA nanocomposite

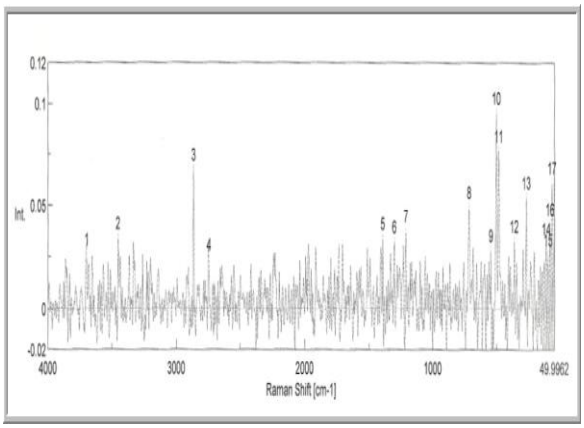

Figure (5.18) Laser Raman spectrum of 95%kaolinite/ 5%PMMA nanocomposite

ISSN 2348 – 8034
Impact Factor- 4.022

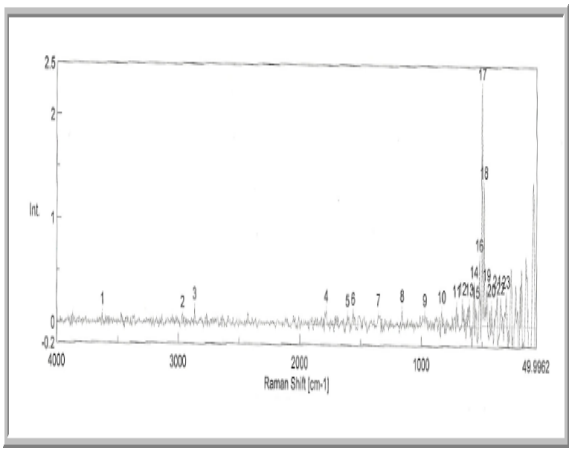

Figure (5.19) Laser Raman spectrum of 80%kaolinite/ 20%PMMA nanocomposite

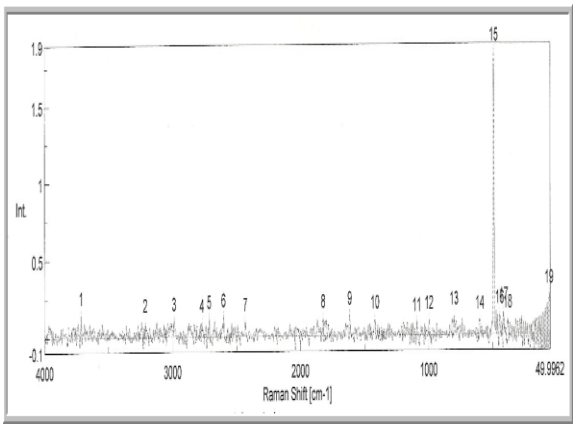

Figure (5.20) Laser Raman spectrum of 70%kaolinite/30% PMMA nanocomposite

Table(5.11) The peaks and intensity of kaolinite and (kaolinite+DMSO) Raman spectra

Kaolinite		Kaolinite +DMSO	
Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)
3624	0.08025	3589	0.02055
2865	0.1497	2865	0.1398
1820	0.09062	1773	0.0258
1492	0.1178	1561	0.0216
1047	0.0986	1062	0.03188
859	0.08935	824	0.02022
766	0.1037	759	0.0293
676	0.1191	720	0.0202
644	0.1301	589	0.0220
501	1.7400	554	0.0221
479	0.1971	438	0.0204

Laser Raman spectra show that the band at 3624 cm^{-1}, assigned to the inner sheet hydroxyl, was shifted to 3589 cm^{-1} with decrease in intensity. The bands at (1047, 501, 479, and 429 cm^{-1}) are attributed to the Si-O bending

ISSN 2348 – 8034
Impact Factor- 4.022

vibration. These bands are observed when the kaolinite had been intercalated with DMSO at 1062, 554, 438, and all intensities were decreased. The band at 766 cm^{-1} attributed to the Al-OH vibrations of surface hydroxyls, was shifted to 720 cm^{-1} after treated with DMSO and also decreased in intensity as listed in table (5-11).

Table (5.12) The peaks and their intensities of (kaolinite+ DMSO)PMMA nanocomposite Raman spectra

Kaolinite + DMSO		**Kaolinite+DMSO/PMMA**							
		95%KD,5%P		**80%KD,20%P**		**70%KD,30%P**		**60%KD,40%P**	
Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)
3481	0.01946	3507	0.2981	3511	0.1349	3510	0.0452	3510	0.1032
2954	0.0658	-	-	2913	0.0201	-	-	2879	0.1049
2865	0.1398	-	-	2865	0.1356	2869	0.0463	2879	0.1049
1936	0.01950	1969	0.0726	1969	0.0716	1903	0.1597	1873	0.3905
1561	0.0216	1475	0.1553	-	-	-	-	1503	0.1136
1062	0.03188	1000	0.0887	1089	0.0826	1091	0.0862	936	0.3331
492	0.2860	517	0.2530	491	0.6328	491	0.6113	500	1.7548
435	0.0720	434	0.2593	491	0.6328	460	0.2169	434	0.1402

kD=kaolinite+DMSO, P=PMMA

The band 3481 cm^{-1} attributed to the OH stretching upon that kaolinite was treated with DMSO, fig (5-12), this band was shifted to bands at 3507, 3511, 3510, and 3510 cm^{-1}, table (5-12) which the ratios between kaolinite and polymer are 95:5, 80:20, 70:30, and 60:40, respectively, all intensities at shifted bands were increased than the intensity of the kaolinite/DMSO figures (5-11 to 5-20).

Table (5.13) The peaks and their intensities of kaolinite/PMMA nanocomposite Raman spectra

Kaolinite		Kaolinite / PMMA							
		95%K,5%P		**80%K,20%P**		**70%K,30%P**		**60%K,40%P**	
Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)	Peaks (cm^{-1})	Intensity (a.u.)
3624	0.08025	3618	0.0323	3627	0.0751	3715	0.1470	-	-
2865	0.1497	-	-	2864	0.1336	2772	0.0936	-	-
1820	0.09062	1796	0.0391	1782	0.1256	1825	0.1146	-	-
1047	0.0986	-	-	-	-	1093	0.0854	1016	0.0748
766	0.1037	808	0.0281	832	0.1322	801	0.1268	770	0.1389
644	0.1301	670	0.0614	661	0.2119	599	0.0982	-	-
501	1.7400	501	0.174	521	0.6297	491	1.8480	500	1.4057

k=kaolinite, P=PMMA

From table (5-13) the band at 3624 cm^{-1} assigned to the inner sheet hydroxyl of kaolinite, was shifted to 3618, 3627, and 3715 cm^{-1}, with ratios 95:5, 80:20, and 70:30, while no band observed at ratio 60:40. The band at 766

cm^{-1} was appear at 808, 832, 801, and 770 cm^{-1}, with ratios 95:5, 80:20, and 70:30, 60:40. In general one observes in most different ratios the intensities will decreased than the intensity of kaolinite

VI. CONCLUSIONS

FT Raman spectroscopy using near infrared excitation has been shown to be very useful for the study of the vibrational spectrum of polymer clay nanocomposite. The technique has several advantages (a) no sample treatment as the spectra can be obtained from the solid or powdered samples (b) low wavenumber vibrational bands are inaccessible to mid IR spectrometers are easily measured (c) vibrational bands which are not infrared active are observable.

One can also conclude the intercalation of PMMA in the kaolinite clay mineral is so impossible, until the kaolinite have been treated with a polar solvent (e.g.: DMSO). The FT Raman spectra of kaolinite hydroxyl region are reported and are shown to be complex with FT Raman spectroscopy being sensitive to the variations in clay mineral structure

REFERENCES

1. *J. Michael Hollas, MODERN SPECTROSCOPY (Fourth Edition), John Wiley & Sons Ltd, 2004.*
2. *Siegfried Wartewig, IR and Raman Spectroscopy, WILEY-VCH Verlag GmbH, Germany, 2003.*
3. *WILLIAM S. C. CHANG, PRINCIPLES OF LASERS AND OPTICS, Cambridge University Press, 2005.*
4. *John R. Ferraro, Introductory Raman Spectroscopy (Second edition), Elsevier, Spain, 2003.*
5. *Siegfried Wartewig, "IR and Raman Spectroscopy Fundamental Processing". Copyright by Wiley-VchVerlag, Germany (2003).*
6. *Michael Mueller, Fundamentals of Quantum Chemistry, Kluwer Academic Publishers, 2002.*
7. *properties of polymer–kaolinite nanocomposite resins, Journal of Composites Science and Technology, Taiwan, 2007.*
8. *F. Bergaya, B.K.G. Theng and G. Lagaly, Handbook of Clay Science, Published by Elsevier Ltd, Spain, 2006.*
9. *Q. H. Zeng, Clay-Based Polymer Nanocomposites, American Scientific Publishers, 2005.*