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Measuring the Effect of Mobile Phone Communication on the PC - Track Detector by using UV-visible and FTIR Spectroscopy

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Abstract **– The effect of microwave-MW radiation emitted from mobile phone communication on polycarbonate-PC detector was measured by using UV-visible and FTIR spectroscopy. The microwave-MW exposure times were 12, 23, 27 and 32 hours. It was found after increasing the exposure time -T_e of MW- radiation to PC-detector leads to increase the absorbance-A UV-visible spectrum in the wavelength range 300-700 NM. The MW- radiation response of PC detector was calculated at the wavelengths 362 NM and 700 NM after 12 h exposure time -T_e. The increase of exposure time -T_e change in peak area-P_a transmission percent -T% of FTIR spectrum at of following wave numbers 828 Cm^{-1}, 1080 Cm^{-1},1504 Cm^{-1},1770 Cm^{-1} and 2970 Cm^{-1}. The peak area–P_a of wave numbers 1504 cm^{-1} and 1080 cm^{-1} have MW-response for exposure time range-T_e (0-12 h) and (0-22.5 h) respectively. While the peak area -P_a of wave numbers 1770 cm^{-1} and 828 cm^{-1} not have response before 25 h exposure time -T_e.There was an increase in peak area-Pa at wave number 2970 cm^{-1} with increase of exposure time -$T_e$at the low range (0-13h) by the exponential function relation. This represents the wave number 2970 $cm^{-1}$was a good MW- response at the low exposure time.While there was a decrease in peak area-$P_a$in wave number 1014 Cm^{-1} with increase exposure time -T_e at the range (12-21 h) by exponential relation function. The wave number 1014 Cm^{-1} obtained was a good MW-response at the high exposure time -T_e.**

Keywords**— effect of mobile phone , PC - track detector UV-visible , FTIR spectroscopy.**

I. INTRODUCTION

The effect of electromagnetic –EM radiation on many materials, including the living tissues of the body has been addressed in many scientific studies and researches [1-3]. The radiowave - RW band is the one of electromagnetic - EM radiation which has a frequency range 300 GHz – 3 Hz and include microwave-MW band at the rang 300 GHz – 1 GHz . The mobile phone communication uses frequency ranges of microwave-MW band. There are two systems of mobile phone communications, one of these systems is Global System for Mobile Communications – GSM and another is Code Division Multiple Access - CDMA and these two system represent the most prevalent second generation-2G mobile communication technologies [4] .

This is advocated in the World Health Organization's recent research agenda (2006) for studies on radio frequency - RF suggests that in vitro studies play a supporting role in health risk assessments and are critical to the optimal design of animal and epidemiological studies [5]. The effects of radiofrequency electromagnetic waves (RF-EMW) was studied from cellular phones on human ejaculated semen, and obtained that cell phone radiation (talk mode) disturbs free radical metabolism in human semen by increasing free radical formation, by decreasing antioxidants, or by both mechanisms [6]. There was a relation between mobile MW effect and bacterial antibiotic sensitivity [7].

Where obtained the controlled / uncontrolled MW- exposed tissues are based on the intensity of exposure that produces heating of these tissues due to energy absorption leading to temperature rise and manifested as thermal effects [1]. One of the most important human organ of response for microwave-MW of mobile phone was brain, were investigated whether a pathologic leakage across the blood–brain barrier might be combined with damage to the neurons [8]. The effects of EM-waves emitted from cellular phones operating at a frequency band 900 to 1800 MHz were determined on the bone mineral density of the human iliac bone wings [9], which are the most

common carriage sites for mobile phones. The effect of MW- radiation on mice memory with lower from the permitted limit density can be cause signs such as headache, heat feeling in ear, memory loss and fatigue [10] and found that the GSM system with above frequency bands has the largest effect on brain compared to mobile phone serving .

There was many detector used to determine the effect of radiation , one of these detectors, named solid state track detectors -SSTDs which used for detection the effect of particle radiation as alpha particle [11] , neutrons [12] and fission fragments [13]. As well as , these detectors used for detection the effect of non particle radiation, including EM-radiation, such as gamma ray, x-ray, UV-radiation, infrared–IR, radiowave-RW and microwave-MW, which mobile phone radiation is located under the range of microwave band .

One type of solid state track detectors - SSTDs represent as an organic chemical structure which have the composition similar to that of human tissue [14].

There was many techniques used for determining the effect of EM-radiation on SSTDs, from testing through characterization of the PC-detector at various stages of their fabrication using Atomic Force Microscopy-AFM, Transmission Electron Microscopy -TEM, Optical Microscopy –OM, and Four Point Probe conductivity measurements - FPP, transmission Fourier Transform Infrared Spectroscopy – FTIR and UV-visible Spectroscopy [15] . Where the effect of IR exposure on nuclear track detector -NTDs type CR-39 was determined by using UV-visible Spectroscopy [16] .

Polycarbonat – PC detector represents one type of solid state track detector - SSTDs which used to determine the effect of electromagnetic – EM radiation [17] [18] . For the last studies obtained that the optical / chemical properties of polycarbonate – PC after gamma irradiation produce the yellowing of PC- samples with the increase of gamma absorbed dose , and the changes in the optical properties were studied by recording UV-visible absorbance spectra of the pristine and irradiated polycarbonate- PC films [19] .

II. EXPERIMENTAL PROCEDURE

The type of solid state track detector - SSTDs which used in this study was PC-detector, which manufactured by Suzhou Demine Plastic Co., Ltd. District , suzhoh 215155, China. The PC - detector was in the form of sheets with thickness 175 μm . These sheets were cut into five pieces with dimensions 1cm × 1cm.

One piece use as un-exposure sample to compare with other four samples which exposure to MW-radiation. PC-detector samples were exposed to MW-radiation produce from phone communication with mobile type Spider Phone , Huazhi Technology Industries (H.K.) Ltd. The exposure time-T_e (h) for four PC-detector samples were 12 , 23 , 27 and 32 h. During the exposure to mobile phone communication put PC- detector sample contact for the position of the GPS receiver and transmitter of mobile.

The effect of MW- radiation on PC-detector was measured by using two techniques, first was UV-visible spectroscopy system model UV-1601PC from SHIMADZU company. The second technique was Fourier transform infrared spectroscopy-FTIR system model FTIR - 8300 from SHIMADZU company. The V-visible spectroscopy measurements were in the wavelength range 200 – 800 NM to measuring the absorbance-A at this wavelength range. And the FTIR - spectroscopy measurements were in the wave number range 4000 - 400 Cm^{-1} to measuring transmission percent-T% and the peak areas-P_a at limits wave numbers.

III. RESULTS AND DISCUSSION

Fig. 1 shows UV-visible spectrum in the wavelength range 200-400 nm for (a) un-exposure and (b) MW-radiation exposure of PC-detector to 32 h. From this figure obtain there are increases in absorbance - A of PC - detector with increase of exposure time-T_e.

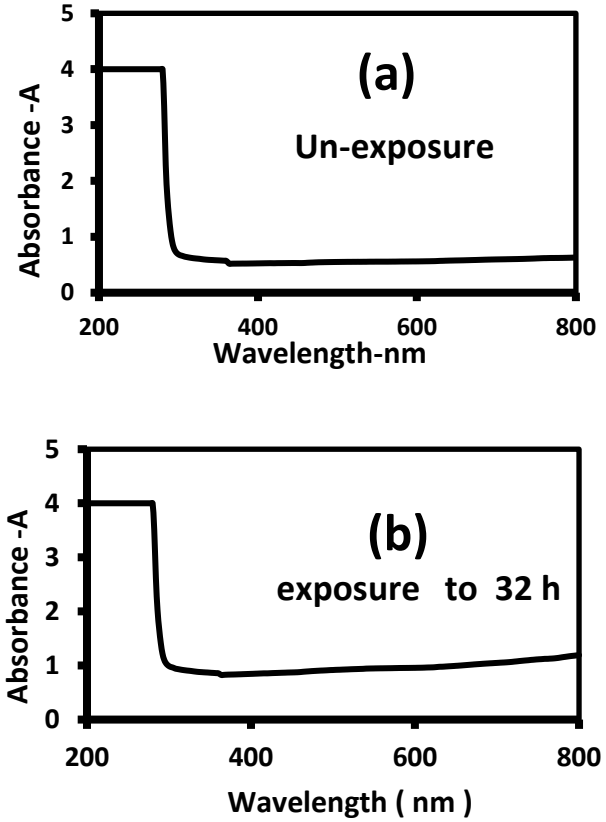

Fig. 1 UV-visible absorbance –A spectrum for PC- detector with the wavelengths in the range 200 – 800 nm for (a) un-exposure (b) MW – radiation exposure time –T_e (h) to 32 h

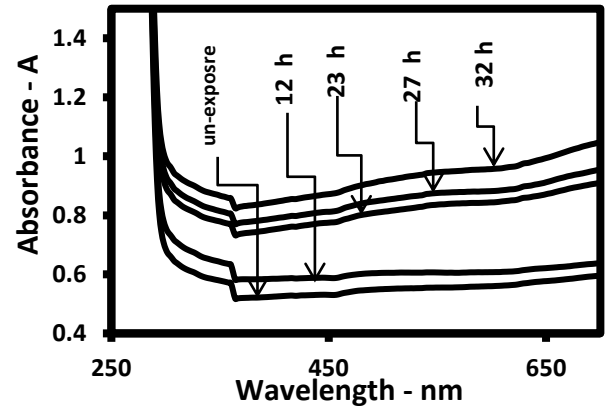

Fig. 2 UV-visible absorbance –A spectrum for PC- detector exposure to MW-radiation with exposure times -T_e , 12 h, 23 h, 27 h and 32 h compared with un-exposure sample

Fig. 2 shows the increase in absorbance - A of PC-detector with increase of exposure time - T_e (h) at 12, 23, 27, and 32 h compares with un- exposure sample. The relation of the absorbance -A values in the wavelength 362 nm and 700 nm which measuring by UV-visible spectroscopy with exposure time T_e(h) was shown in fig. 3 .

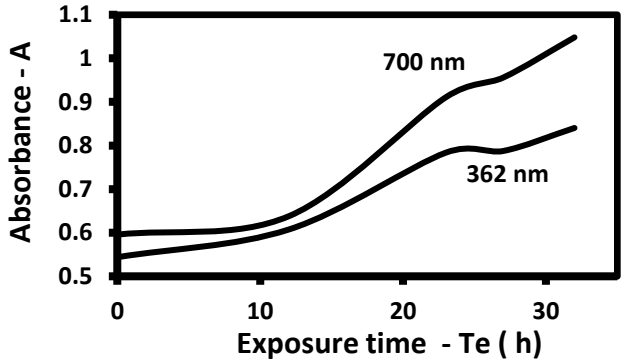

Fig. 3 UV-visible absorbance –A spectrum for PC- detector at the wavelengths 362 nm and 700 m with MW-radiation exposure time –T_e (h)

The response of wave number 700 nm was better than wave number 363 nm . Where the response for the wavelength 362 nm and 700 nm appear after 10 h exposure time -T_e and follow increase this response until to 32 h . The relation of exposure time-T_e (h) at the range(10-32 h) with absorbance – A at the wavelength 700nm, 362 nm was behavior by polynomial relation function eq. (1) and eq. (2) respectively .

$$T_e(h) = 247.11 \quad A_{700}^2 - 271.45 \; A_{700} + \; 5.7 \quad (1)$$

$$T_e(h) = 48.48 \; A_{362}^2 - 32.43 \, A_{362} \; + \; 12.9 \quad (2)$$

Where A_{700} and A_{362} are absorbance –A UV-visible spectrum for wavelength 700 nm and 362 nm respectively.

Fig. 4 show FTIR- spectroscopy in the wave number range 4000-400 cm^{-1} for (a) un-exposure and (b) MW- radiation exposure of PC-detector to 32 h .

The values of peak area-P_a of the FTIR transmission percent - T% to PC- detector was changed with exposure time -T_e at 12 , 23 , 27 and 32 h compares with un-exposure samples . That change in peak area-P_a was appearing in following wave numbers 633 Cm^{-1}, 828 Cm^{-1}, 1014 Cm^{-1}, 1080 Cm^{-1}, 1504 Cm^{-1},1600 Cm^{-1}, 1770 Cm^{-1} and 2970 Cm^{-1} fig.5 , fig. 6 and fig.7

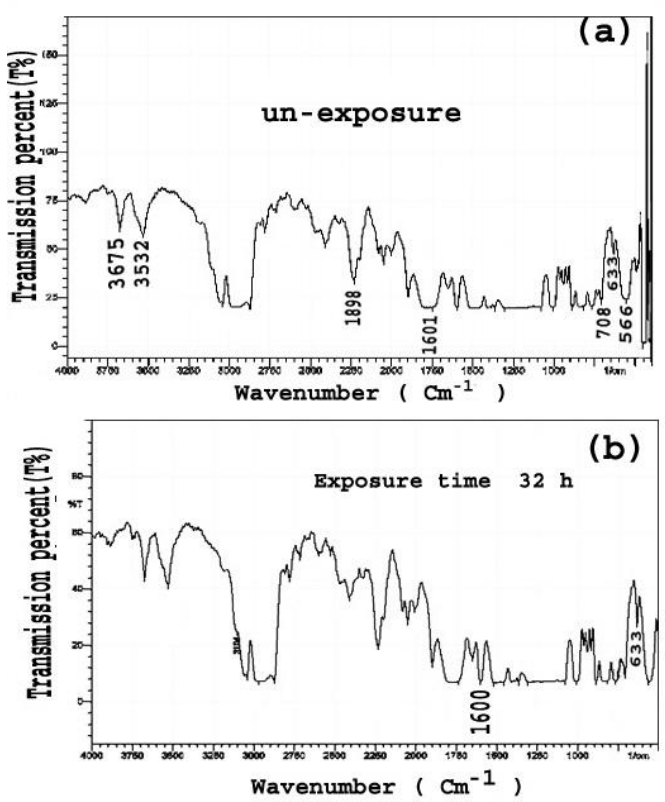

Fig. 4 FTIR transmission percent – T% spectrum in the wavenumber range 4000 – 500 Cm^{-1} for PC-nuclear track detector (a) un-exposure (b) MW - radiation exposure to 32 h

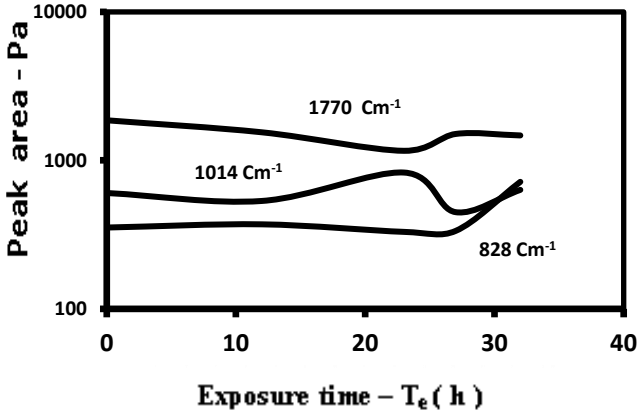

Fig. 5 FTIR spectrum peak area-Pa for PC-detector with MW - radiation exposure time – Te (h) at the wave numbers 828 Cm^{-1}, 1014 Cm^{-1} and 1770 Cm^{-1}

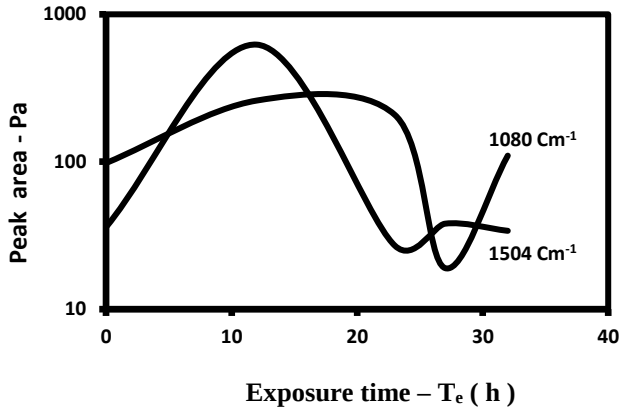

Fig. 6 FTIR spectrum peak area-Pa for PC-detector with MW - radiation exposure time – T_e (h) at wave number 1504 Cm^{-1} and 1080 Cm^{-1}

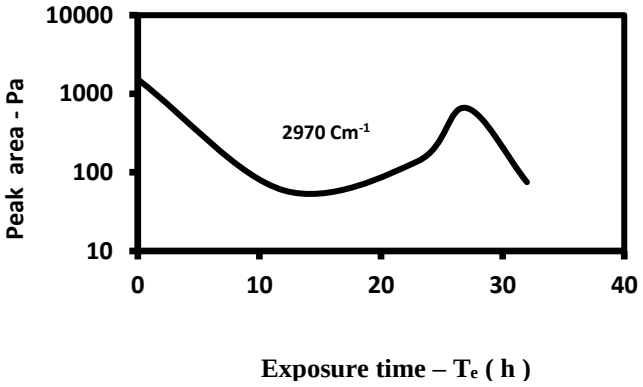

Fig. 7 FTIR spectrum peak area-Pa for PC-detector with MW - radiation exposure time – Te (h) at the wave number 2970 cm^{-1}

The microwave -MW effect for PC-detector have not responded before exposure time -T_e (h) to ~ 25 h as obtained in low change in the values of peak area -P_a of wave numbers 828 Cm^{-1} and 1770 Cm^{-1} while appearing the response for wave number 1014 Cm^{-1} after 12 h until to 21 h. The relation between peak area -P_a and exposure time - T_e for the wave number 1014 cm^{-1} at the high range (12- 21 h) was behavior as linear relation function eq. (3)

$$Te(h) = 0.264\ P_a - 0.62 \qquad (3)$$

That means the out of plane deformation of C-H [20] of PC-detector was not changed before 24 h exposure time -T_e (h). This is advocated some researchers to confirm that the C-O bond (C in the C=O bond) is

more susceptible compared to that of other C-O bond (C on the ring) [21].

Jacky Tang [22] show that the PC region already exists in a lower energy state (1770 cm^{-1}). As well as, another others [23] add the transmission percent –T% at the wave number 1775 Cm^{-1} have low value compared with other wave numbers through study the crystallization, mechanical, rheological and degradation behavior of polycarbonate – PC blend. Also, the intensity of the peak band corresponding to the C=O stretch at 1700 cm^{-1} decreases slightly on irradiation of Polycarbonate -PC by 8 MeV electron beam [24] . While the stretching O-C-O [20] was changed after 12 h exposure time-T_e. The behavior of wave number 1504 cm^{-1} and 1080 cm^{-1} . Fig. 6 appears as the same through the increase in peak area –P_a response with increase of exposure time -T_e . And that maximum regains obtained at the exposure time – the 10 h and 22.5 h for wave number 1504 cm^{-1} and 1080 cm^{-1} respectively. Fig. 6 shows there was drop for peak area -P_a after the maximum response for wave numbers 1504 cm^{-1} and 1080 cm^{-1} to 22.5 h and 27.5h respectively. This change in peak area -P_a at wave number 1504 Cm^{-1} and 1080 Cm^{-1} leads to the bending of C-C-C and ring stretching (C-C) [20]. The same behavior of peak area - P_a with exposure time – T_e appear in the wave numbers 1504 cm^{-1} and 1080 cm^{-1} (fig. 6) .

This behavior may be as a result of the bending change of C-C-C was equivalent to the change of stretching C-C . While the starch of O-C-O at 1014 cm^{-1} and the ring stretching C-C at 1504 cm^{-1} which obtained in fig. 5 and fig. 6 respectively.

The change in stretching was interpreted from the cleavage of the aromatic C-C and carboxylic CO-O bonds together with some nitrogen incorporated into the surface layer after photo degradation of polycarbonate- PC [25] . The variance change in peak area - P_a with the time exposure -T_e for wave number 2970 cm^{-1} was shown in fig. 7 .

The peak area - P_a of wave number 2970 cm^{-1} was decreased with increase of time exposure -the until to 13 h and then increase in peak area -P_a with increase of time exposure -T_e until to 27 h and then drop after this value. From the fig. 7 show that wave number 2970 cm^{-1} having a high response for MW-radiation to PC-detector through low exposure time -T_e at the range 0-13h. Represent the wave number 2970 cm^{-1} associated with stretching (asymm.) methyl group (C-H) [20] .

Which means this C - H stretching was a good response to MW- radiation in the low exposure time - T_e . The variance of response of PC-detector at wave number 2970 cm^{-1} was observed also, where one type of PC-detector irradiated with 100 MeV Si^{8+} ion beam [26]. On the grounds the H atom at 2970 cm^{-1} required for its formation coming perhaps from the isopropyl group as the absorption around this wave number which arise due to CH_3 symmetric stretch [20] which decrease in intensity with an increase in ion beam fluence [26].

The relation between peak area - P_a and exposure time - T_e for the wave number 2970 cm^{-1} at the low range (0-13 h) was behavior as exponential relation function eq. (4) .

$$T_e(h) = 12.56\, e^{-0.001 P_a} \qquad (4)$$

While at high range (13-27 h) with peak area -P_a in wave number 2970 cm^{-1} was the behavior of as a logarithmic relation function eq. (5)

$$T_e(h) = 3.186\, \ln P_a + 6.62 \qquad (5)$$

The low range of exposure time -T_e which appear in wave number 2970 cm^{-1} (0-13 h) was repeated in wave number 1504 cm^{-1} by the range (1-10 h) and the relation between peak area –P_a and exposure time -T_e was behavior as a power relation function eq (6)

$$T_e(h) = 0.0006\, P_a^{1.54} \qquad (6)$$

The high range of exposure time -T_e in wave number 1504 cm^{-1} by the range (12 - 21 h) and the relation between peak area –P_a and exposure time -T_e was behavior also exponential relation function eq (7).

$$T_e(h) = 3.17\, e^{0.0027 P_a} \qquad (7)$$

The wave number which having a good behavior response for MW-radiation at low and high response was obtained clear in wave numbers 1014 , 1504 cm^{-1} and 2970 cm^{-1} , which represent better than other wave numbers . The equations which reflect the

relation of exposure time -T_e of MW- radiation with peak area - P_a at the wave number 2970 cm^{-1}, 1504 cm^{-1} and 1014 cm^{-1} were shown in Table I.

TABLE I

Equations relation functions between the peak area - P_a with the wave numbers 2970 cm^{-1}, 1504 cm^{-1} and 1014 cm^{-1} at different ranges of MW-radiation exposure time -T_e (h)

Wave number (Cm^{-1})	**MW-radiation Exposure time –T_e (h)**	**Range**	**Equation**
1504	12-21	High	$T_e(h) = 3.17\ e^{0.0027P_a}$
1504	1-10	low	$T_e(h) = 0.0006\ P_a^{1.54}$
2970	0-13	Low	$T_e(h) = 12.56\ e^{-0.001P_a}$
2970	13-27	High	$T_e(h) = 3.186\ \ln Pa + 6.62$
1014	12-21	High	$Te(h) = 0.264\ P_a - 0.62$

The effect of MW-radiation effect on PC-detector which measuring by peak area -P_a FTIR spectrum have two range levels, first level for low range of (0-13 h) from wave number 2970 cm^{-1} and (1-10 h) from wave number 1504 cm^{-1}. And the second level for high range at (12-21 h) from wave number 1504 cm^{-1} and (13-27 h) from wave number 2970 cm^{-1}, and (12-21 h) from wave number 1014 cm^{-1}.

IV. CONCLUSION

The response of PC-detector from MW-radiation , which produces from mobile phone communications may determination by following measuring a) The UV-visible absorbance- A spectrum at wavelength 362 nm and 700 nm b) FTIR peak area – P_a at wave numbers 633 Cm^{-1}, 828 Cm^{-1}, 1014 Cm^{-1}, 1080 Cm^{-1}, 1504 Cm^{-1}, 1600 Cm^{-1}, 1770 Cm^{-1} and 2970 Cm^{-1}. The response of PC- detector for MW-radiation obtained after exposure time -T_e (10h) for UV-visible technique and direct response for FTIR - spectroscopy technique . And the range of exposure time -T_e response using FTIR spectroscopy was dependent on the wave numbers. The wave numbers 1504 Cm^{-1} and 2970 cm^{-1} have a good response comparerd with other wave numbers. The wave numbers 1504 Cm^{-1} and 2970 cm^{-1} have a good response compared with other wave numbers. To reflect the effect of mobile phone communication on PC-detector to MW- radiation dose, need to make calibration method between exposure time -T_e and MW- radiation produce from MW-generator produce frequency in the range of GSM band.

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