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The Effect of Magnetic Resonance Imaging (MRI) on Some Properties of Acrylic Resin Denture Base Materials

By: Ahmed Isam Jasim Al - Khyeet

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University of Mosul
College of Dentistry

The Effect of Magnetic Resonance Imaging (MRI) on Some Properties of Acrylic Resin Denture Base Materials

A Thesis Submitted by

Ahmed Isam Jasim Al - Khyeet

to the council of College of Dentistry
University of Mosul
In aPartial Fulfillment of the Requirements for the Degree of Master of Science in
Prosthodontics

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ABSTRACT

Magnetic resonance imaging have been used nowadays as one of the accepted tool for diagnosis, estimation, and evaluation of many of human been disease;in dentistry, many of prosthodontic patients and "maxillofacial-prosthesis" patients may fall under the category who might be subjected to routine "MRI" check-up either for follow-up of certain disease or cancer patient for determination the degree of healing or metastasis, thus, there has been growning interest in the research of the possible effect of "MRI" procedure on different component of "dental appliances" wears by those patients and one of these components is "heat cured acrylic resin".

The aims of this study were to evaluate the effects of "magnetic resonance imaging" on some mechanical "tensile strength", physical "volumetric changes", chemical "FTIR, NMR" properties at different periods of time exposure.

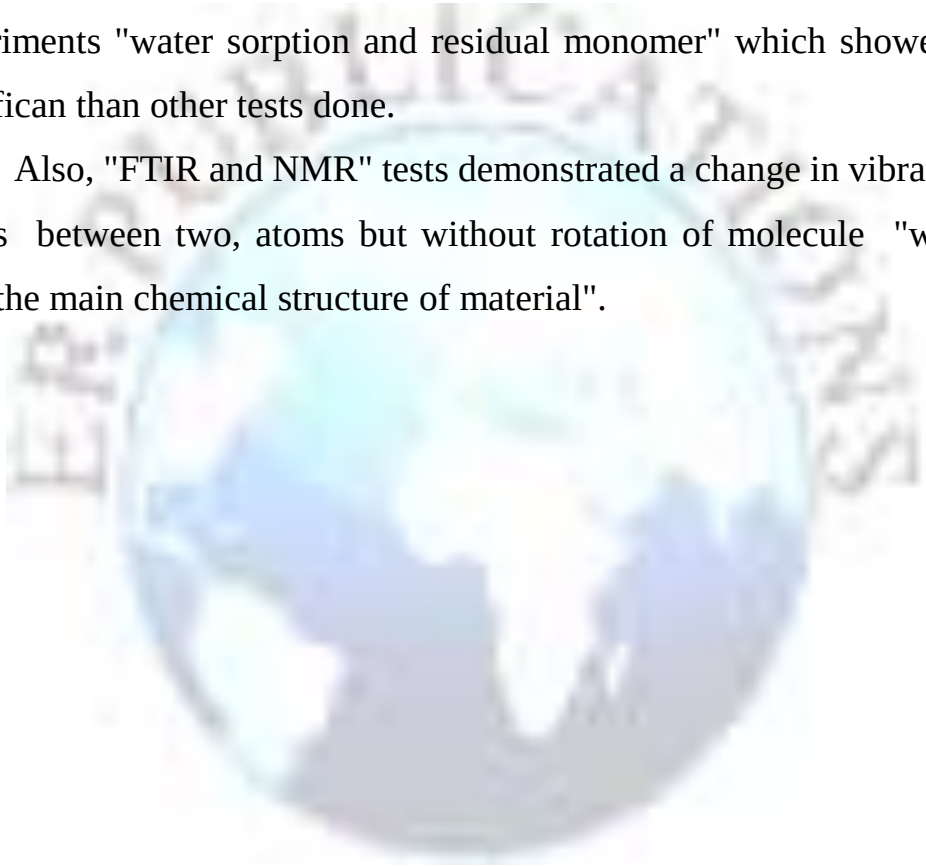
A total samples of (454) were prepared from acrylic based heat cured denture material, which divided into two main groups "Clear, Pink", each main group was subdivide, into four groups according to exposure to "MRI" control;5 minutes, 15 minutes, 30 minutes, each of the four sub-groups undergo different tests" tensile strength, Rockwell hardness test, dimensional accuracy test, color change by spectrophotometer, surface roughness, water sorption, residual monomer release "FTIR" and "NMR".

The results were analyzed by descriptive analysis, analysis of variance, Duncan's multiple range test and student "t" test. The results showed that there were changes in the physical properties of "heat cured" acrylic resin weather it is "Pink or Clear" after exposure to "MRI" and

thes changes happened at different levels and variable degrees, also it was shown that there was a slight tendency to change order of arrangement of atoms within each molecular with no well and clear evidence of chemically altering of the main material itself, at least, at circumstances of experiment.

It was concluded that exposure to "MRI" at different periods of time lead to altering of some visco-elastic properties and physical properties at different level of significan with the exception for one to two experiments "water sorption and residual monomer" which showed less significan than other tests done.

Also, "FTIR and NMR" tests demonstrated a change in vibration of bonds between two, atoms but without rotation of molecule "without alter the main chemical structure of material".



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LIST OF ABBREVIATIONS

Abbreviation	Name
%	Percentage
ADA	American Dental Association
ANOVA	Analysis of variance
DF	Degree of freedom
DMFT	Duncan's multiple range test
^{o}C	Degree centigrade
FTIR	Fourier transform infrared spectroscopy
g	Gram
Kg	Kilogram (1 gram*10^{3})
Min.	Minute
MRI	Magnetic resonance imaging
T	Tesla
MMA	Methyle methacrylate
PMMA	Polymethylenethacrylate
Sec.	Second
Sig.	Significance at $P \leq 0.05$
Hr.	Hour
Ro.	Surface roughness
Tab	Table
Wt	Weight
Dw	Distilled water
Rf	Radio frequency.
PPM	Part per millions
WHO	World Health Organization

INTRODUCTION

Magnetic resonance imaging (MRI) is a non invasive medical test that helps physicians to diagnose and treat medical conditions.(MRI) uses a powerful magnetic field radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues,bone and virtually all other internal body structures,and then the images can then be examined on a computer monitor,transmitted electronically,printed or copied to a CD, (MRI) does not use ionizing radiation (X-Ray) (Nagar, 2011).

In the late 1960s engineer- physician Raymond Damadian, 1st work with nuclear magnetic radiation (NMR) to differentiate between normal from malignant tissues, then Damadian produced a crude (NMR) image of a rat tumor in 1974 and the first body image in 1976, that image took almost 4 hours to produce (Bushong, 2003).

The hydrogen nuclei in the patient, protons , behave like tiny magnets. Hydrogen makes up 80% of all atoms found in the human body,making hydrogen extremely useful for (MRI),because Hydrogen is a single charged spinning nucleon, the hydrogen nucleus exhibits magnetism called a "magnetic moment",under normal circumstances,these magnetic moment each has a north and south pole and they are randomly distributed in space (Bushong, 2003).

Research carried out date suggests that there are no adverse effects caused by short term exposure of head to static magnetic fields up to "2" tesla (T) " each tesla = 10.000 of earth gravity" and the exposure of the whole body should not exceed "4T",with cardiovascular monitoring required in fields greater than "2T",ferromagnetic material and anything which has not been show to compatible with (MRI) equipment and should not be brought in to restricted area. (Allan *et al*., 2002).

Magneto-biology deals with interaction of biological systems with weak static and /or low frequency ultra – low intensity electromagnetic fields. The nature of "physico-biological" effects of weak electromagnetic fields remains unclear . But it may act via this phenomena (Sivasubrmanianv *et al*., 2010):

* Crystallization of iron – bearing magnetic mono-particles in tissue of organism

* Dependence of some biochemical free-radical reactions on the magnetic field magnitude.

* Possible existence of long – lived rotational states of some molecules inside protein parts.

* Magnetical changes in physical / chemical properties of liquid water.

Chemical shift in the most important parameters in (NMR) arising due to the electronic environment around nuclei. The magnetic field at the nucleus is not equal to the applied magnetic field and if electrons around the nucleus are s-orbital electrons, they produce magnetic field that opposes the applied field. This means that if applied magnetic field must be increased for the nucleus to absorb & the transition of electron to be happen. Thus, many metallic implants are generally safe for patients undergoing (MRI) procedure if they are non- ferromagnetic or if the magnetic attraction of the implant is less than the force applied compared with the in vivo application (Edwards *et al*., 2000).

It's, therefore, recommended that patients remove dentures with magnetic and in case of metallic denture base material during "MRI" investigation of the head and neck region to reduce the distortion and to prevent any further injuries of patients (Ceruti *et al*., 2010).

Iron atoms are ferromagnetic material , which are easily to lined up under the action of external magnetic field and this is because of strong

interaction between atoms called "exchange forces" with molecular field, thus the "MRI"

protocol contra-indicate in case of existence of iron – metallic denture base material and the made of "sterostatic-frame " to make use of denture base as a support system in patient with head imaging for surgical problem (Tayama *et al*., 2009).

"MRI" scanners is very useful to define identical changes in the detailed material in three orthogonal planes, with no definitive risk for an adverse reaction in case of a mixed "human – material" experiment as do in "computerized tomography "CT" scan.

Because of the effect of the strong magnetic field and radio frequencies on these devices, any Iron – debris within eyes may cause visual impairment when subjected to magnetic field, unless, open-magnet design with newer scanner geometry coupled with appropriate level of metallic – alloy control to avoid such hazard (Franz and Wippold, 2007).

AIMS OF THE STUDY

They are include the following:

1. Evaluate chemical properties and chemical changes that may be expected to be happened as a result of exposure to (MRI)
2. Evaluate the mechanical properties of acrylic resin denture base material
3. Evaluate physical properties of acrylic resin denture base material

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CHAPTER TWO

REVIEW OF LITERATURE

2.1. Magnetic Resonance Image (MRI) :

2.1.1. Definition:

MRI is a device, which provides a high resolution images, it uses a magnetic field and pulses of radio-wave energy to make picture of organs and structure inside the body, and it may give an information and show certain structures problems more clearly than do other investigation methods (Edwards *et al.*, 2000).

Meriles *et al.* (2006) also defines MRI as the use of homogenous or" gradient" field supplementing in otherwise uniform method and in time variant magnetic field.These additional fields are created by "gradient coils" designed to alter magnetic field amplitude along pre selected direction without change direction of total field.

MRI is usually based on the magnetic properties of the hydrogen nucleus, through; other nuclei can be used and the use of high powerfull magnetic field with which proton in the body become aligned in the form of a radio frequency pulse which transmitted into the patient, this can cause the alignment of the protons to be changed by 90^{o}, once the radio frequency pulse is stopped, the protons in the patient's body returned to their neutral position (Nebauer, 2006).

2.2. History of MRI :

Roy C.W. and Shewington C.S. (1890) were the first to suggest that an-increase of the local blood flow may be a signal for an increase neuronal activity, which is non possibly visualized only through the use of nuclear magnetic resonance (NMR) imaging (Faurion *et al*., 2008)

Early MRIs were constructed based solely on the concentration of protons within a given tissue, these images however did not provide good resolutions, "Nikola Tesla" discovered the rotating magnetic field in 1882 in Budapest, Hungary, "Godfrey Houns field and Allan Cormack" produced the first NMR image in 1973 in stony brook," New York , Felix Bloch and Eduard Purcell" was the Nobel Prize winner for physics in 1952 for the first successful nuclear magnetic resonance experiment to study chemical component

"Raymond Damadian" patented the design and used (NMR) for detecting cancer in 1974 ;" Paul Lauterbur and Peter Mansfield "was also the Nobal Price winner in medicine or physiology in 2003 for the invention of magnetic resonance imaging (Collins, 2008).

Many other European scientists placed their own finger print within the probe of an early (MR) spectrometer and, so, "Block 1946", "lanterber 1973", and "Damadian 1977" who plaed a significant role in first the human images using apro-type super conducting magnets and who first develop point and line scanning signal localization technique and (3D) three-dimension data acquisition (Edelman *et al.*, 1996).

2.3. MRI (Magnetic Resonance Imaging) Theory :

Magnetism, is one of the basic properties of matter, all matter is magnetic media and it is to be divided into three types (Hugon *et al.*, 2010):

1. Paramagnetic substances: They produce the magnetic field and external magnetic field , same as additional magnetic field and most of materials fall in this category (Hugon *et al.*, 2010).
2. Anti-magnetic material: This material produced in the magnetic field and the additional magnetic field opposite the magnetic field like copper and inert gases (Hugon *et al.*, 2010).

3. Ferromagnetic substances: Such substances in the magnetic field produce the same strong magnetic field, for example, Iron, Cobalt and Nickel (Hugon *et al*., 2010).

On the causes of the geomagnetic field, the current scientific theory is not a concerning argument, but the cause for the magnetic is all of the magnetic phenomenon that is caused by the underground current. Since, the core of earth consists almost 80% to 87% of it's composition of iron (Lee and Xue, 2007).

Savoy ,(2002) showed that the Earth's Interior core has a very big iron core, and whether it's state of the" iron alloy or iron oxidation". The atoms of the inner electronic are overlapped by single electron orbits, external to the inherent magnetic which is magnetic as it's magnetic prosperities is also very strong, therefore magnetic field lines can be distributed throughout the earth's center interior and the earth's outer space.

A theory by Yong (1999) conducted on nuclear magnetic resonance (MRI).Is's very simple and can be simply summarized as being a special application of multi dimensional Fourier transformation onnuclear magnetic resonance.(MDFTNMR),the various frequency axes are related to gradient magnetic fields applied to encode space to produce equivalent frequency variation, and in practice, the situation is much more complicated and involves viewing a number of different aspects.

Another recent theory of magnetic resonance image called "field theory of displacement" as in nature the charge can produce forces on the other charge and it is invisible to people because of the high speed Launch of a charged material flow. This high speed collision with the other to be able to force this special kind of substance and it is called "electro- field lines" and because it can produce electrical-field effect, therefore it can produce a power line within electric field. This is a clear

space for the presence of magnetic field lines. This obviously called "gravitation line field" (Cernicanu and Axel, 2011).

2.4 Magnetic Resonance Imaging Physics and Principles :

2.4.1. MRI-Principle :

The wide dissemination of magnetic resonance (MNR) imaging services has directed technology out of few scientists and pleased its daily use under the direction of men who use it as a tool to solve different clinical situations (Mitchell, 2000). The routine (MRI) is based on the magnetic characteristic of the "1H" hydrogen atom inside patients body as patient is to be subjected to high magnetic field (e.g., 1 Tesla = 10,000 Gauss) that is to compare with earth's magnetic field which is "0.3 to 0.7 Gauss" (Engels and Frese, 2003).

The hydrogen nuclei in human-protons behave like tiny magnets, hydrogen makes up 80% of all atoms found in the human body.(Bushong, 2003)

2.4.1.1. Lamor Equation :

The lamor equation is afundamental properties of MRI.It's give by the equation($f=\gamma B_0$),where f=frequency of precession and γ=is gyro magnetic(disintegration constant) measured in megahertiz per tesla.B_0 is intensity of static magnetic field, this equation is a basic principle in differeny MRI application , mainly depending on hydrogen nucleus since it's get a high gyro magnetic ratio compared with other nuclei. (Wang, 2011).

2.4.1.2. Magnetic Resonance Imaging Hardware :

Radiographic imaging system can be identified by it is main components (i.e., X-Ray tube, high voltage generator, operating console).So, "MRI" system can be identified by it's main component (i.e magnetic computer, and operating room) (Bushong, 2003).

The traditional (MRI) unit is a large cylinder-shaped tube surrounded by a circular magnet, some (MRI) unit called "short-bore systems", that are designed so that the magnet does not completely surrounded you ., others are open in the sides (open MRI system) (Safety, 2011).

The number of coils in magnetic resonance imaging (MRI) has been steadily increasing. The (MRI) researches have continuously added to play an important role in the increasing resolution and effective parallel imaging, number of researchers has experienced methods with fibro-optic or wireless links between (MRI) coils and (MRI) system and these alternative-signal links can potentially reduce the complexity, electromagnetic interference (Cabr *et al*., 2009).

Thomas *et al.* (2007) has ultimately increased the feasibility of optimizing a loaded magnetic resonance imaging, by the using of (Radio-frequency probe) (RFp), since, at bagging of magnetic resonance imaging (MRI) the strength of magnetic field is very low frequency less than "0.3 tesla ". This frequency does not help in decrease signal-to-noise ratio.

Amor and Blűmich (2011) referred that magnetic field is steadily increased by several orders of magnitude from a few milli- tesla into up to "9 Tesla" in modern super conducting technique and since the use of magnetic field of value range of "1.5-3" tesla are clinical standard since 1995, The use of ultra high field of up of "7T to 11T" is restricted mainly to researcher application.

2.4.2. Brownian Motion :

Unlike conventional X-R examination and computer tomography (CT) scans, MRI does not depend on the ionizing radiation; instead while in the magnet radio waves redirect the axes of spinning proton which are the nuclei of hydrogen atoms in the field (Hagmann *et al.*, 2010).

Diffusion (MRI) monitors the diffusion process itself, in other words; the actual molecular random walks and it is currently one of most method available to provide a good information (Hagmann *et al*., 2010).

Water molecule exists inside tissues of the body or room temperature, it experiences random motion due to thermal changes and thermal energy, and this random translation motion molecules resulted from thermal energy caused by these molecules and in a free medium during a given time interval, molecular displacement occurs at three distinct dimensions and this phenomena is usually reflected as (Brownian motion).Thus water diffusion measurement is made in an (excised) and/or" changeable" biological tissue by using of (nuclear magnetic resonance) by specific encoding technique which aid in localize the diffusion measurement to obtain a map of all tissue in vivo (Bihan and Berg, 2011).

2.5. Magnetic Resonance Imaging and Computer Tomography CT :

MRI uses Radio frequency (RF), electromagnetic radiation, and magnetic field, which do not cause ionization and therefore, do not have the association potentially harmful effects of ionizing radiation; some known bio-effects of (RF) and magnetic field do exist, but they do not occur at low intensities of (MRI) and are not associated with the induction of malignant disease (Bushong, 2003).

Unlike a (CT) scan, the "MRI" magnetic does not have moving parts, the only think that move is the electron in the conductor, The computer required for (MRI) is more complex since more data are collected and the computation is to be more longer and more difficult. Also, the contrast and resolution of (MRI)is more than that of the (CT) scan.The patient underlying (MRI) is however moved to the center of the magnet to ensure that the body part is to be imaged at that portion. In case of patient motion, the image will be more susceptible to distortion, mainly because (MRI) is not only used to provide information about visualization intensities, but also provides information about functional parameters like blood volume and perfusion and analyzing MRI-Based measurement of different parameters (Caweira *et al*., 2004).

2.6. Factors That Affect The MRI Signal ''MRI parameters'':

Magnetic resonance imaging (MRI)is made possible by the introduction of method that encode the origin of the nuclear magnetic precession signals and the liner magnetic field gradients that applied during or prior to the signal acquisition (Nieminen *et al.*, 2010)

Geometric distraction in (MRI) can arise from a variety of sources. A part from the tissues dependent, chemical shift and susceptibility differences, beside gravity field non-linearity and the static field in-homogeneity. (Wang *et al.*, 2004).

Advances in (MRI) are now enable specialists to acquire a diffusing magnetic resonance image with large no. of magnetic gradient diffusion encoding surrounding area, since the examination is depends on the microscopic diffusion of water molecules in biological tissue (Assemlal *et al.*, 2011).

It is essential to understand that the three principle parameters of magnetic resonance imaging (MRI) is very necessary and each is fundamentally different from and independent on other, including :

- Proton density
- T1 relaxation
- T2 relaxation.

These parameters play an important role in assessing " thermal-changes" and assign any of these thermal changes by using temperature dependence of several (MRI) parameters such as water proton resonance frequency and longitudinal relaxation time (T1) (Aljallad *et al.*, 2011).

2.6.1. Proton Density :

Most structural (SMRI) and functional (FMRI) experience creates an image sensitive to properties of the nuclei of the hydrogen atoms (protons), typically within water molecule. The strong magnetic field of the (MRI) scanners exerts a force upon the protons to create a net magnetization that is conjugated with their angular motion to create a motion called "precession" (Huettel, 2010).

The only imaging technique which allows directly to visualize without any invasive manner is (MRI). However, conventional (MRI) sequences have been shown to be suitable to determine adequate thickness of some structure, but not all of it (Hauber *et al*., 1997).

So, proton density is the measure of the concentration of mobile hydrogen nuclei available to produce an (MRI) signal. The higher the concentration of mobile hydrogen nuclei, the stronger the net magnification and the more intense the (MRI) signal, and a strong (MRI) signal result in a better (MRI) image and this principle of (MRI) are widely used in the clinical practice as powerful. On invasive diagnostic

tools especially in molecular imaging technique represent challenging for imaging technique (Edelman *et al.*, 1996).

2.6.2. Contrast Agents for Magnetic Resonance Imaging :

Chemical compounds have been used to manipulate magnetic resonance image contrast since the development of (MRI). The purpose of this contrast agent is to delineate structural of clinical or scientific importance (Jasanoff , 2008).

In recent decade, several research projects have been focused on this thesis of aggregate nano-particles, they can be useful as "MRI-detectable sensors", since the normal occurring (MRI) appearance of a tissues depends on both physical characteristic of the tissues like (viscosity and temperature) and chemical characteristic that might affect proton density (PD) (Vuong and Gossuin, 2011).

Perfusion measurement by dynamic susceptibility contrast magnetic resonance imaging (MRI) utilizes very rapid imaging (most common echo planar imaging EPI) to computer as the first pass of intravenously injected paramagnetic contrast agent (Ostergaard and Sakoh, 2004)

Usually the use of (MRI) contrast agent causes tissue of interest to appear brighter and positive contrast enhancement occur. The contrast enhancement is negative if the tissue of interest is darker when a contrast agent is used (Schwaz *et al.*, 2003).

2.6.3.'' T1'' and ''T2'' Relaxation time :

Molecular motion image organic material induced by an electrical field is in the center of determination of chemical and biological structure since it is to obtain under two different times and under conditions of both continuous and pulsed electric field (Riley and Augustine, 2000).

In recent years, combination of electro encephalography (EEG) and functional magnetic resonance imaging (FMRI) has been one fully simultaneous measurement established itself on two order of magnitude (Mandekow *et al.*, 2010).

The quality of the information available *in vivo* by MRS is identified by the separation that is to be occured between peaks.It plays an important role to identify and assign the peak value of radiation (Marzola *et al.*, 2003).

Quantitive magnetic resonance imaging (QMRI) studies small samples such as a single "cell or clusters" that require the application of radio- frequency (RF) to provide an homogenous field and high signal to noise (SNR) ratio (Jasinski *et al.*, 2012).

So, the two types of relaxation" longitudinal CT1" or "spin-lattice relaxation" and "transverse CT2" or "spin-spin relaxation T1 and T2 relaxation" may vary among tissues by factor 10, 50 T1 is to refer to the time constant that describe the rate at which net magnetization return to the equilibrium state after it passes through an inflamed or diseased tissue, it is usually take longer time then do in healthy tissues (Bushong, 2003).

Nuclei must give up the energy gained from the transmitted radio frequency pulse to return to equilibrium so. The hydrogen nuclei are bounded with other atoms to form molecule, this arrangement is called a "lattice" (Schild, 1990).

Edelman *et al.*, (1996) conduct that once we have an excited field and tipping of protons into the transverse plane, the coherent processing protons produce the detectable MR signal. This signal may disappear at higher rate than (T1). This process is called "T2 relaxation" and include the exchanges of energy among neighboring spins because of this is also called "spin-spin relaxation". (T1) agents generally increasing the

longitudinal relaxation rates of (T1) of water protons in tissue more than transverse relaxation (T2) and (T2) relaxation never exceeds (T1) relaxation time for any given tissues since they transferee energy from one spin to an other at room temperature (Yan *et al.*, 2007).

For the measurement of both relaxation, an (MRI) scanners (General Electrical Medical System, signal, Wankesha, Wl, USA). Using a sensitivity encoding technique and MRI protocols which consists of spin-echo localize Scan, measured by unite "Coulomb" (unit of electrical charge and each coulomb (C) consisting of 6.24×10^{18} electronic charge (Schulte *et al.*, 2011).

2.7. Medical Application of (MRI) :

High resolution magnetic resonance imaging (HRMRI) has recently seen increased in most of studies. This is because (MRI) provides a detail Information covering the whole body in-comparing with an advanced image processing, which can rapidly localize an area of defect by the use of the structural segmentation technique to enhance analysis (Dorr *et al.*, 2008).

Since (MRI) is a non-invasive medical imaging technique , so it can be used to obtain a detail body information and image of slices / planes from inside the body to give detailed picture without the need for an exposure to X-R radiation. This came with the expertise of the anesthetist to create an image that is to be with superior quality (Byrne, 2008).

Recently, computer models have been generated to calculate the specific absorption rate (SAR) and distribution and temperature rise in and during (MRI) procedures (Brngger and Prayer, 2011).

The only and fundamental limitation has been increasingly overcome in recent years through the use of (MRI) which examine

structure of high interest is to maintain an adequate and accepted level of a resolution with structural analysis (Chan *et al.*, 2007).

2.7.1. Advanced (MRI) Application for Human Brain and Neurological Assessment :

Glutamate, a major neurotransmitter in the brain, shows a PH and concentration-dependent chemical exchange saturation transfer effect (Glulest) . It can be used in recent studies for mapping reactive changes in healthy from diseased human brain by using an advanced (MRI) technique for imaging (Glutcest) to provide higher resolution depending on existence of the hydroxyl protons from different amino acid (Cai *et al.*, 2011).

(MRI) has emerged as a powerful tool in the identification and study of disease of center nervous system (CMS) and it offers quantitative assessment of tissue characterization (Roberts *et al.*, 2000).

Recent studies with (MRI) have found an excess of signal hyper intensities in diseased patients of bipolar patients and patients with brain volume loss (Woods *et al*., 1995) .

Computational models of brain injury can play an important role to supplement human studies in identify mechanism of injury. It can be explored relatively easily by modifying the computational stimulation. (Gefen and Margulies, 2004).

Functional magnetic resonance imaging (FMRI) has rapidly become an elective research tools in assessment of many of visual function and most recently in clinical application of brain problem and brain disease (Liu *et al.*, 1999).

2.7.2. MRI Evaluation and Detection of Brain Anomalies :

The memory system can be characterized as a repository for various types of information and there is a distance cost when shifting attention of a different mental disease (Li *et al*., 2004).

Kempton *et al*. (2011) found arrangement of an automated segmentation algorithms that are available for determining the volume of various local brain regains including widely applied technique area.

Recent advances in MRI imagining have enabled to detection of structural abnormalities in most of patients with temporal lobe disorder with direct observation (Cendes *et al*., 1995).

Magnetic resonance imagining has greatly facility in an assessment for epileptic surgery by reveling underlying cerebral abnormalities associated with seizure onset (Estrin *et al*., 2012).

For this reason, the need for more sensitive assessment method and technique is required for epileptic seizer and for cognitive function measurement of those types of patents are necessary (Duncan S, 2002).

Deep brain stimulation (DBS) of thalamic nuclei is widely used in the treatment of movement disorder and it has been used in conjugated with new technique of the assessment by the use of (MRI) data to identify of the sub-regains within the thalamus (Traynor *et al*., 2011).

Although seizers are of most important feature of epilepsy but, many patients are ranked cognitive impairment highest on their list of complaints, and the use of functional technique of evaluation plays a significant role in diagnosis (Rlooswijk *et al.*, 2010).

2.7.3. MRI Role in Schizophrenic and Psychiatric Patients :

New technique of diffusion (MRI) has been used to assess integrity of the axon fiber because of it is unique ability to map fibers and to measure the extend of orientation and extend of pulls along axon fiber in diseased patients (Kuo *et al.*, 2008).

The blood oxygenation level-dependent (BOLD) has been widely employed in mapping human brain and provide more dynamic information with an improved resolution by use of modern (MRI) scanner to assess brain change (Huang *et al*., 2006).

Price *et al.*(2006) has conducted an reduction in brain volume and enlargement of lateral ventricles in Schizophrenic patients.

The use of new technique is known as (fat sat). This technique allows to suppress the signal of fat in normal bone marrow and allowing abnormal signal to stand out as in Schizophrenic patient (Devries and Manne, 2003). Since working memory capacity and prefrontal cortical function are impaired in those patients (FMRI). Diffusion technique has shown altered regional cerebra blood flow, glucose utilization, and blood oxygenated level. (Thermeros *et al.*, 2005).

The diagnoses of condition may require the use of echo-planer technology using scanners at high field strength and with relatively strong and fast gradient (Terada *et al.*, 2006).

While in case of Alzheimer's disease (one of the most common form of neurodegenerative disorder) may also see some loss of functional cognitive with small percentage of non-age related and secondary to specific gene mutation (Westman *et al.*, 2010).

Although no sex, differences in global cortical thickness, in adult have been reported, but it has been found that gray matter (GM), white matter (WM), and brain size are larger in men than in women (Facorro *et al.*, 2011).

Advanced (MRI) technique allow perfusion for adverse range of multi-parametric information regarding brain physiology and provide useful information on neuro-chemical profile of different neuro-degenerative disease (Moffat *et al*., 2009).

Thus the technique of (MRI) plays a significant role in estimation and assessment chronic pain and pain associated with decrease in gray matter or cortical thickness by showing specific brain reigns that are affected (Seminouiz *et al.*, 2009).

The main disadvantage of (MRI) in these condition is the production of high level of noise produced peaking from (1.22 dB up to 131 dB) which affect cochlear function (Radomski *et al.*, 2002).

2.7.4. MRI and Cancer Diagnosis :

Most frequently, (MRI) is used to examine patients suspected with cancer or in case of reconstruction surgery, since (MRI) has emerged as the most sensitive complementary tool (Szabo *et al.*, 2006).

(MRI) has a higher sensitivity for detection of cancer and it is not affected by the density of organ and the use of non-contrast (MRI) is the appropriate method to check any suspected area (Morrow et al., 2011). Segmentation results should be précised and accurate enough to measure volumetric abnormalities and changes associated with different patho-physiological phenomena, to monitor the effects of therapy and to evaluate its relative performance (Alfano *et al.*, 2011).

The use of this technique is growing exponentially in part because of the excellent anatomic and pathological detail provided by the modality and by recent technologic advances that have to lead to faster acquisition times (Byrne, 2008).

2.7.5. Evaluation of Magnetic Field Effect on Prosthetic Heart-Devices :

Patients with biomedical implants continues to be the major concern for (MR) health care workers, and (MRI) may be contra-indicate for patients with ferromagnetic bio implanted devices, and the induction

of an electrical current may also present possible hazards, but this does not appear problematic for passive implants, those do not operate by mean of electrical power (Edwards *et al*., 2000).

The sensitivity of frequent (MRI) examination to detect different heart-disease has led to the recommendation that (MRI) be used as a primarily out-come measure in preliminary short term (Zhao *et al.*, 2000).

Beside, all current available disease-modifying heart treatment for relapsing remitting heart disease are only partially effective on clinical measurement of disease activity and evolution. Although the (MRI) appearance may vary slightly from patient to patient or even among lesions in the same patient, but (MRI) remains as certain characteristic finding for heart diseases (Stefano *et al.*, 2008).

2.7.6. MRI for Different Medical Application :

MRI and magnetic nanoparticles (MNPS) possess unique magnetic properties and the ability to function the cellular and molecular level of biological interaction made them an attractive platform as contrast-agents for magnetic resonance (Sun *et al.*, 2008).

The use of ultrafast (MRI) seems to be very effective in treatment and detection of many of the congenital anomalies mainly that concern about the internal organs and superficial and deep arteries and veins (Hosny and Elghawabi, 2010).

The use of ultra-fast magnetic resonance image is an excellent method for evaluation of the fetal ganito-urinary and the use of prenatal MRI appears to be as useful complementary diagnosis and the use of the technique allow to obtain detailed visualization of the anatomy (Leonor *et al.*, 2010). This new technique has focused mainly in the modality which is mainly to destroy deep-seated tumors in kidney. This principle based on principle of applying low intensity MRI to provide feedback and

consequently the treatment protocols to eliminated such problem (Damianon, 2004).

The frequent acquisition of the abdominal image and relative difficultly accessing certain area has led to study and investigate and used of "axial imaging" to predict total body lean tissue mass and this technique can use to estimate total body skeletal muscle mass(Baker *et al.*, 2012).

Also, the role of diagnostic imaging in liver surgery has gained increasing importance to provide complementary information and detection of any focal liver lesions via difference in signal intensity between the lesion and the surrounding parenchyma (Braga *et al.*, 2004).

Deep venous thrombosis occurs most frequently in women and mainly in pregnant women about "1 to 200" deliveries. The Venography has not reliable confirmatory test, so the use of (MRI) using gradient recalled echo sequence image as most accurate method to assess (Spritzer *et al.*, 1995).

(MRI) plays a significant role at the cellular level. The effects of (MRI) on cell growth are different among different intensities of these cells Dose of the radiation and calcium ions play (key role) as the messenger in intracellular pathway and it is greatly affected by magnetic field and flowed into cytoplasm to promote bone formation(Hsieh *et al.*, 2008).

Also, in patient with spondylo-arthropaties (ISPA) which are diverse group of disorders characterized by inflammatory low back ache, genetic predisposition and a variety of manifestations and magnetic resonance imaging (MRI) and nuclear scintigraphy (radionuclea bone scan) appear promising in the ability to pick up structural damage and inflammatory before their presence plain radiographs (Schaninugandau, 2006) ; back pain is one of the most common medical problem affecting

8 out of 10 people and it is mainly due to (inter vertebral disc pain) (MRI) mainly acts to determine the disc degeneration the level and also to study the anatomy and abnormalities of the spin (Noury *et al.*, 2008).

This new technique(MRI) opens up the possibility of performing longitudinal investigation on many different parts of body and mainly on neuronal network. This is why main attention that paramagnetic ion manganese (Mn^{2++}) has been attracted as a potential antero- grade neuronal traces for (MRI) experiment (Canals *et al.*, 2008).

2.8. Recent Magnetic Resonance Imaging Application in Dentistry:

In recent years, magnetic nano -particle have been used to their potential application as magnetic carriers in dental care and dental prosthesis. The term "nano-dento-magnetism" can be described as the intersection of nano-magnetisim and dentistry that focused on biological systems (Medeiros *et al*., 2011).

Recent studies have used magnetic resonance imaging (MRI) to objectively assess the configuration of the entire vocal tract during speech production with ability to image soft tissues of the entire vocal tract and without any hazard of being exposure to radiation (Ng *et al.*, 2011). This technique allows for an examination of parts of vocal tract, otherwise to be inaccessible to dynamic imaging moving of tracking and .Technique also allows for viewing the entire vocal tract in its intensity including the velum with sufficient temporal resolution and it effects on syllable structure and propriety of articulation (Byrd *et al*., 2009).

The osteoarthritis of joint" tempro-mandibular joint mainly deals with loss of cartilaginous substances, and the bio-integration and/or bio-functional assessment of this loss requires the use of longitudinal

monitoring of cartilage over-times. This requires the use of high resolution magnetic resonance imaging (Dao *et al*., 2011).

Since the application of "osseointegrated magnetic coated implants" spread widely after it's introduction. However, these magnets received poor clinical assessments, since the evaluation of these magnets requires the use of high resolution magnetic resonance field with minimal disturbance of the image to avoid any artifact " artifact that arises lateral to the orbit of the eye, in the medulla oblongata, and spinal cord" (Gonda and Maeda, 2011).

So far, no extensive study has been published on the elective use and robustness of this technique or about it is unwanted effect, and within different repetition times of acquisition ranging from "hundred of milliseconds to several seconds" (Sladky *et al.*, 2011). Adding temporal derivatives may be advisable to compensate non-linear neural and vascular effects which will lead in-case of non-responding to time shift and time-dispersed response. Loss of many of functional magnetic resonance image data sets acquire during segmental image technique since "FMRI" data analysis necessary and essential with time course (Jensen and Helpern, 2011).

2.8.1. Diagnostic uses of "MRI" for Tempro-Mandibular Joint (TMJ) :

Magnetic resonance imaging (MRI) provides detailed morphologic information on the stress continence mechanism which correlated with finding in anatomic specimens and even for assessing tissues quality. And the delivery related changes of this mechanism can be classified as" reversible" and "irreversible" structural changes. And the occurrence of multiple defect of the stress related muscle and supporting structure conform the multi-factorial origin of stress and on the other

hand, it may be assumed that the isolated anatomic defects do not necessarily lead to aloss of function (Tunn *et al.*, 2006).

(MRI) is widely accepted standard for the assessment of patients complain of (TMj) disorder, the role of (MRI) in patient with these anomalies disorder have been widely investigated. The anterior disc displacement is considered as the first step of cascade of path- physiology events .The extension and compression induced on posterior distal tissues result in synovial proliferation (Farina *et al.*, 2009).

Since the mandible movement has conventionally measured by positioning indices on skull surface, the measurements (TMj) are assessed indirectly. (MRI) provides observation of any section and images of the articular disk soft tissues without radiation exposure. It is very effective for observation tissues but not continuous images (Azuma *et al.*, 2009).

(MRI) now have plaid a significant role in the evaluation and therapeutic measurement of (TMj) disorder and for diagnosis of the disk position, disk configuration,disk perforation ,disk adhesion and joint effusion, osseous change and" bone –marrow" changes also the detection and examination of the relationship of measurement of the mandible and (TMj) (hard tissues) with the articula surface (disk) and masticator muscle "soft tissue was examined" (Limchi *et al.*, 2008).

2.8.2. MRI Application in Oral and Maxillo Facial Compartment :

Mild traumatic injury accounts for(70-90%) of all treated oral and maxillo facial injuries, one of largest challenge in addressing neuropsychological functioning and recovery of this traumatic injuries is the diagnosis itself, (MRI) images of tissues that contain a lot of information may not easily assessed visually to provide mean to obtain this information (Holli *et al.*, 2010).

(MRI) of head a neck region should be tailored for the anatomic region and process under evaluation. The use of "Gadolinium Gd" enhanced images improve delineation of margins in many lesions. The use of the fat suppression technique such as "short tau inversion" recovery which may improve the conspicuity of soft-tissue lesions embedded in fatty tissues. The use of "magnetization transfer MT" protocols for enhancement of poorly enhanced lesions from background tissue (Wippold, 2007).

It is critical to detect changes in intracranial hematomas before clinical deterioration in patients with early evolution of intracranial post-traumatic lesions, the early detection of lesions that will evolve to produce more mass effect can be used in decision-making for surgical intervention. Many of acute head injuries have been investigated by using magnetic resonance imaging of (Takauashi and Shinonaga, 2001).

Although the whole oral cavity are believed to play an significant role in whole swallow and bolus transport, but the posterior oral cavity and adjacent" oro- pharyngeal" and "minor , major" salivary gland are believed to play a significant role.These structures are appear to be mediated not only oral sensation and elemental movements, but also,involved in the initiation and control of variety of complex "oro-pharyngeal" sensormotor behaviors including mastication, swallowing, voluntary tongue movement, and salivation (Soros *et al*., 2008).

2.8.2.1. MRI for Salivary Glands :

Patients with lesions in the major salivary glands may present with symptoms of obstruction or inflammation ,a suspected mass or diffuse glandular enlargement and MRI imaging have plaid an important role in making a diagnosis and in planning further management operatives or otherwise, plan radiography, sialography,magnetic

resonance imaging (MRI) and nuclear scintigraphy/positron emission tomography (PET) all have plaid a role (Buvke *et al*., 2011).

Since, salivary gland tumors accounts for number one of all head and neck tumors, histologicaly, the most common benign tumor is "pleomaphic adenoma", followed by" wathins tumors" and most common typed malignant tumor is "mucoepidermoid" carcinoma, recently (MRI) have been used in diagnosis and definition of the extend of lesions in oral and maxillo facial by modality of the internal structure of the lesions with superior soft tissues contrast (Hisatomi *et al.*, 2007).

(MRI) have been very effective diagnosis of salivary gland disorders, it has been found that the dynamic contrast enhanced MRI (DCE-MRI) is useful for diagnosis of some tumors and also in sinus pericranii "rare vascular anomaly whether congenital or acquired anomalies, connections between the intracranial and emissary veins of the skulls", so MRI have been used to demonstrate diagnosis by revealing the communication between extra cranial vascular systems and intra cranial Dural venous and help to show the characterization of tumor that may helpful to obtain differential diagnosis (Ozyilmaz *et al*., 2008).

2.8.2.2. MRI Features of Pathological Anomalies in Oral Cavity :

Naeoplastic tumors and cyst are common oral pathological lesion that exists in" bony, soft, and hard" tissue structure and most of these naeoplastic changes showed tendency to change into cystic lesion. Although exact pathogenesis is not fully under stood, a thought that these pathological changes may be unilateral, but bilateral pathological cysts are common to be seen in about 10% of cases, the most common relevant differential diagnosis is dento-alveolar abscess (Sumer *et al.*, 2009).

Another important finding is the simple bone cyst (SBC) which is classified as above related lesion according to World Health Organization and odontognic scientist as tumor, and it has been given various names like (solitary bone cyst) (traumatic bone cyst). Recently, (MRI) has been used in the diagnosis of cystic lesion and represent most efficient modality for analyzing the internal structure of a lesion and providing a hemodynamic information that aid in diagnosis and provide histological assessment of vascular density (Yanagi *et al*., 2010).

Besides,(MRI) can well demonstrate the bone marrow changes that is caused by "edema" or "inflammatory tissue" due to increase of water content which aften replace the normal tissue "normal fatty marrow". This change of bone is seen in case of "osteomyelitis inflammatory" of the cortical and cancellers bone caused by bacterial invasion from contagion foci. Thus, "MRI" will help to differentiate between osteomyelitis from other disease with similar clinical symptoms and shows the activity of inflammation (Anji *et al*., 2008).

2.8.3. MRI Uses and Application in Restorative Dentistry :

Various kinds of metal alloy have been applied to dental treatment, wires, clasp inlays, crowns, denture frame, implant, and so on depending of their adequate properties. Magnetic attachment are developed and used since 1996s and it is becoming very popular in Japan, while it is not so well known in Europe and USA.It is found that with magnetic field of magnetic resonance imaging ,loss of signal occurred in the head and neck reign by various kinds of dental alloys .Restorative material, also by fixed crowns of different dental alloys, and this" MRI" artifact generated by dental alloy caused some problems according to magnetic characteristics depending on weather they are diamagnetic, ferromagnetic, or paramagnetic (Hideshima *et al*., 2011).

(Super paramagnetic iron oxide nano-particle,SPION) is one of the most popular candidates for magnetic resonance imaging technique because of it is high relativity for efficient visualization on" MRI", very low toxicity, and high complementary imaging technique. It has widely used in clinical practice and it is high recommended in representing anatomical information, basically" iron oxide nanoparticle with thin silica coating as dual image contrast "agent. This technique is to be used in dental practice with hydrophilic surface and good water stability (Cha *et al.*, 2011).

Thus, the previous technique with other types of the technique rapid NMR image probe can play a significant role in the measurement of micro hardiness, degree of conversion ,and other properties of restorative material mostly is measuring visible light curing of dental resins(Iloyd *et al*., 2011).

Since the transformation from monomer to polymer produces a change in the refractive index of the resin, to reduce the miss-match between it and the filler, and to decrease visible difference by measure depth of cure by dye (Astral Blue), reacts with methacrylate groups resulting in differential staining between monomer and polymer (Llyod *et al.*, 2001).

"MRI" is the most recent addition techniques applied to this condition, the "flash-NMR" sequence applied in a micro-imaging experiment can produce images of di-acrylate resins. The low curing light intensity applied produce slower but effective process of polymerization in the resin by selection of delay time between pulse sequence and the polymerization during visible light curing can be followed to completion and this type of "flash image" affected by intensity of temperature rises, free radical production,and gel formation which indicate degree of or depth of conversion (Llyod *et al.*, 2001).

Finally, one of most recent type of application of "MRI" in dentistry is in" endodontic treatment medical procedure" aimed at restoring damaged teeth. This procedure is extremely important to cheek a correct and precise topographical image of the root canals and carry out precise mapping of the shape of dental cavities and estimating of quality of mapping(MRI) has been used in research of decayed teeth for visualization of dental surface geometry and distinguish between soft tissue "pulp" and mineralized tissues enamel ,dentine ,and root cement enamel and dentine will appear" dark strikes" on all cross-section.The pulp will appear as white gray structure. The image obtains very high resolution (100 $Nm)^3$ and makes it possible to study geometry, location of cavities,compare root structure of young and older patients (Tanasiewicz, 2010).

2.8.4 MRI Role in Prosthodontic Science and Materials

Acrylic based resin consists of polymeric material based on poly methyl methacrylate ,these dental materials are the result of free radical polymerization reaction and in case of heat-cure resins, heat polymerization materials, heat can be generated by hot water path or micro wave energy. This type of acrylic resins are frequently used in the daily dental practice like in denture base, denture liners ,orthodontic appliance and temporally crowns (Bettencourt *etal*.,2010).

Denture base is composed of pre-polymerized polymethymethacylate (PMMA) or polyethylmethacylate (PEMA) powder particles along with a peroxide initiation and a pigment, which are mixed with methacrylate monomers (methylmethacrylate, hexamethyl eneglycolidine methacrylate, n-butyl methacrylatic) and across-linking agents such as ethyleneglycoldimethacrylate, trimethylopropane

trimethacrylate or 1,6-hexanediol dimethyl-acrylate (Bettencourt *et al*., 2010).

(MRI) is one of most common biological and un-biological measure of "Aging", and MRI generally has long interval between evaluation periods. Additionally, the generalizability of findings from prior MRI predictor studies has been limited by biases, anchoret composition and frequency of evaluation (Carmichael *et al*., 2012).

Since, magneto-biology, deals with interaction biological systems with aweak static and/or low-frequency, ultra-low intensity, electro-magnetic fields. Thus, applying pulsed magnetic field to improve property production of the dental material with varying degrees of exposure to pulse magnetic field "Algal-biomass' (Sivasubramanian *et al*., 2010).

Based on the fact that most of prosthodontic material used are on "aqueous solution water plus sodium alginate, agar-agar, dental plaster and stone plus die stone".So,the mechanical properties, cross- linking, and biocompatibility of these materials have recently attracted interest in them as support material of tissue engineering.

The dimension stability of alginate based dental impression material is an area of ongoing research with highly importance in preparation of most types of dental prosthesis (Fellows and Thomas, 2009).

Part of these materials used for fabrication of prosthodontic appliance has disadvantages which can be the dimensional instability and inaccurate result obtained by these materials. So by the use of nuclear magnetic resonance (NMR) is to investigate the environment of water molecules in a matrix of impression material when no dimensional change can be observed directly visualization (Fellows and Thomas, 2004).

Depending on the use of various typed alloy in prothodontic appliance" aluminum -nickel –cobalt" alloys with different magnetic poles force and the repellent face of like magnetic will act to keep the dentures on the residual ridge, but nowadays, a new approach based on use of ferromagnetic metal keeper generally made of stainless-steel for more attractive force and act as magnetic keeper unit (Ceruti *et al.*, 2010).

Although, different types of metals and metallic device have been used in constructional of complete denture, partial denture, implant prosthesis widely in humans for constructional purpose. Evaluation of these materials on human body periodically is a very essential method of investigation is by (MRI).The exists of these metal within human body represent a problem, since they act to create an artifact with the possibility to change in orientation of these implant (implants fixed in the jaw gain an MRI wave lead to change in poles direction)and /or making a minute fracture or crack at surface of these prostheses once they are fixed inside patient mouth (Bagheri *et al.*, 2010).

Also, there is a probability that the relationship between dental prosthesis and any surgically fixed prosthesis(implant, bite plate) depends on time, duration, and weather appliance fixed to maxilla or mandibles prosthesis" maxillary prosthesis is apart of skull with a particular complicated position within bony structure and obstruction of denture space causes instability of the metallic- denture or prosthesis; that contains metal so, check of the entire prosthesis before enter (MRI) unit is necessary (Tayama *et al.*, 2008).

2.9 Some of Mechanical,Physical,andChemical tested Prosperities:

2.9.1. Tensile strength :

The tensile strength usually investigates the ultimate strength which determine the resistance of the material to catastrophic failure,

while ultimate tensile strength is the maximum strength that the material can withstand "elongation" just before fracture of material happen "permanent deformation" (Reis *et al*., 2006).

Acrylic resins, based on polymethyl methacrylate (PMMA), have been widely used for the fabrication of denture bases and it's mechanical prosperities remain far from ideal for longevity and maintaining of denture (Seo *et al*., 2006).

Since "75% -80%" of original material used for fabrication denture base is" heat polymerized", it is thought to be stronger than others, and exhibit superior study prosperities (Rached *et al*., 2004).

With advancing and technology, new technique has been introduced for processing like injection molding technique and microwave activation, but, the mechanical prosperities remain not ideal and denture fracture occurs due to large number of variables, denture function, processing , and other factors. (Faot *et al*., 2006).

Recently, it has been found that increasing the tensile strength and mechanical properties of heat cured denture base material is improved by the use of new "dental polymers" and consists of "methacrylated dendritic monomer. Dendrimes contains symmetrically a ranged branched emanating from a core molecule with a well defined structure (Kawaguchi *et al*., 2011).

The hard direct reline resins have been used with heat cured acrylic resin repeated to contain a higher percentage of cross-linking agents in liquids, which clinically results in dimension stability and reduce heat generated during polymerization lead to high mechanical properties "tensile strength" (Al Rifaiy, 2012).

2.9.2. Indentation Surface Hardness'' Rockwell'' Test :

Rockwell hardness test is a test of the material resistance to indentation and in case of indentation area of small size, this indicated that material hard and not easily deform (Carlos and Harrison, 1997).

Rockwell indentation (scale L) for plastic and semi-plastic material is a valid tool for evaluation of the hardness of rigid material and rigid polymers . This test based upon ability of material to resist indentation under a specific load (Machado *et al*., 2007).

In clinical use, denture base resins material are immersed in saliva, water, aqueous cleansing solution, it has been found that after 4 months period, gradual increase in hardness of denture base polymers (Neppelenbroek *et al*., 2005).

The definitive heat polymerized acrylic resins has the greatest hardness value compared with other materials at'' 24 h''. after immersion in different solution (Mese *et al*., 2008).

Residual monomer exists may adversely effect mechanical property of denture base resins due to plasticizing effect which reduces the inter-chain forces so that deformation occur easily under load during hardness test (Ernst *et al*., 2004).

The effect of disinfected material and solution used has a significant effect on the hardness of the denture base acrylic resins evaluated. This effect is small and this depends on amount of residual monomer remain after a long term water immersion (Neppelenbroek *et al*., 2005).

2.9.3. Dimensional accuracy test :

Dimensional accuracy usually express the evaluation degree of change of original length "linear dimensional accuracy", or change by whole volume "

volumetric dimensional change", and the volumetric dimensional change expresses much more difficulty in estimation and it is to be magnified three times than linear dimensional accuracy (Bettencourt *et al*., 2010).

The dimensional accuracy shown to be affected by degree of water sorption, which reach saturation earlier with high temperature, once the work is saturated with water and becomes softened, the polymer structure stabilizes and no further change in dimension happened (Schmidt and Ilie, 2012).

It has been found that quenched denture has higher shrinkages than bench cooled once Ganzaroli *et al*. (2002), while Kobayashi *et al*.(2004) suggested that a gradual cooling for "12" hr., or more after processing a heat activated acrylic denture base is effective for lessening deformation of prosthesis.

2.9.4. Water Sorption Test :

Sorption means" adsorption plus absorption "whereas, absorption refers to uptake of liquid by the bulk solid, while adsorption indicates concentration of molecules at the surface of a solid or liquid (Power and Wataha, 2008).

Also water sorption of a material represents the amount of water absorbed on the surface and into the body of the material during fabrication or while the restoration is in service; whereas any observed loss of weight of a material is a measure of the material solubility (Philips, 1973 ; Graig and Power, 2002).

The water sorption and solubility is a property of acrylic resin, representing the un-reacted substance releasing (residual monomer, plasticizers and initialize. It is regarded as undesirable property of resins,

since it should be in-soluble in oral fluids, and because of residual substance releasing can cause tissue reaction in area of prosthesis (Machado *et al*., 2004).

American Dental Association recommended that the increase in weight of the polymer should not exceed 0.8 mg/cm^2 of the surface after immersion in water for seven days at "37 ± 1^{o}C" (ADA, specification No.12).

Although resilient liners are suitable material for providing comfort to patients who have supporting tissue alteration. They are vulnerable to water sorption and solubility when immersion in aqueous medium (Dogan *et al*., 1995).

Leon *et al*. (2005) found that water sorption and solubility value ranged from 23% to 3% and from 5.3% to 7.8%, respectively, for heat cured acrylic resins material and these results vary depend on different resilient lining materials used, processing method, period of water emersion.

The percentage of water sorption and solubility are determined by following formula (Kazanji and Watkinson, 1988).

$$* \text{ percent sorption} = \frac{W_2 - W_3}{W_1} X\ 100$$

$$* \text{ percent solubility} = \frac{W_1 - W_3}{W_1}\ X\ 100$$

W_1 = initial weight of specimen after first drying

W_2 = weight of specimen after thermal cycling

W_3 = weight of specimen after second drying.

2.9.5. Surface Roughness Test :

Roughness is a complex property containing both structural related terms and geometrical variables related to the state of stress within the solid, geometrical changes within materials, and others (Jancar *et al*., 2009).

The surface roughness is a measure of the irregularity of the finished surface and is measured with micrometers . A smooth surface has surface roughness of less than" 0.2" micrometer that is desirable to reduce bacterial retention and to have shiny appearance (Craig *et al*., 2004).

The accuracy of denture fit and the used an adequate denture cleansers can be very effective in the treatment of any surface roughness that may appear and also act in the improving of fitting surface and the retention of dental prosthesis (Queiroz *et al*., 2012).

Polymerization process "microwave or water bath" doesn't influence surface roughness values of acrylic resin, while polishing method mechanical or chemical influence surface roughness values of acrylic resin. Mechanical polishing promotes smoother surface than chemical polishing (Rizzatti – Barbosa *et al*., 2006).

In an attempt to reduce the surface roughness of acrylic resin materials, the application of highly cross linked glaze on the surface of the denture is to be recommended. This is done to reduce the plaque accumulation and thus decrease the discoloration of denture base materials and established a smooth surface (Ssesma *et al*., 2005)

Altering the surface of an acrylic resin or other denture base material or metallic surface can have negative or positive effects. Negative one is by the presence the features act as the concentration area in critical reign and area of loss of glazing. Positive effect is by altering

pours layers that can lead to surface damage and residual surface stresses concentration and removing all surface irregularities (Anderse, 2011).

It has been found out that during the study of physical properties of heat cure acrylic resins, the denture cleansing material in the form of solutions produce less surface roughness as compared to the ones in the form of pastes, since the loss of plasticizer can alter the bonding surfaces or the visco-elastic prosperities of resilient material, which become irregular and changing their bond strength (Garcia *et al*., 2003).

2.9.6 Residual Monomer Test

The residual concentration of methyl-methacrylate (MMA) monomer has been examined widely for many reasons including polymerization conversion efficiency. The type of relationship to physical and mechanical properties residual monomer concentration of "MMA" monomer especially dependents on the efficiency of the polymerization heat-cure cycle (Shim and Watts, 1999).

It has been found that physical and mechanical properties of denture base resins is greatly affected by the method temperature and the amount of residual monomer left.It has found that strength and color stability, hardness and other prosperities have been changed and these changes can be attributed to the structural changes in polymer interstitial matrix (Neppelenbroek *et al*., 2005).

The residual monomer is known to be one of the causes of the dermatological disease with other materials like "cobalt, nickel, beryllium", and other substances. The release of residual monomer is the primary cause of mucous membrane irritation(Clark *et al*., 2004).

The reduction of risk of residual monomer is by ing the process of polymerization and manufacture processes, using the thermoplastic and microwave polymerization rather than heat polymerization. Increase

thetemperature and/or denture storing in water after processing play a significant role in reducing amount of residual monomer (Pfeiffer *et al*., 2004).

Gas chromatography is a precise and simple method to determine the residual (MMA) monomer content and method of presenting chromatographic data is via chromatograph which is a plot for signal detector verses time (Santos *et al.*, 2005).

Reducing the amount of residual monomers after the treatment depends on the diffusion of these monomers in the water in accordance with the immersion time. Other studies show that residual monomers of relining and denture base material can be reduced by hot water bath after the polymerization treatment (Tray *et al*., 2011).

2.9.7 Nuclear Magnetic Resonance Test (NMR)

Nuclear magnetic resonance (NMR) spectroscopy is one of the most advanced technique used in biomedical research, and it had been discovered in 1940, (NMR) mainly used in physics to measure nuclear magnetic moments and in chemical analysis with the discovery of the chemical shift and spin-spin coupling (Schuff 2010).

The most common studies" nuclide" certainly in chemical and biological application, in the hydrogen atom, the proton designated (^{1}H. This gives rise in isotropic solution to sharp (NMR) peaks and has the highest sensitivity of any of the naturally occurring nano-radioactive isotropic (Lindon, 2010).

The required amount of material to be analyzed by (NMR) in solution may be minimized through the use of the recently developed cryogenically cooled (NMR) probes "cryoprobes" this takes advantage of the fact that the radio frequency electronic generates less noise at low temperature, and with the development of high resolution 1D and 2D solid state (NMR) techniques and with development of a powerful solid

state bi-dimensional techniques. NMR has a useful tool in the characterization of any element analysis (Capitani *et al*., 2011).

Thus, the bio-mechanical properties of soft biological tissues can be estimated by using "MRI" and "NMR" techniques.Modern (NMR) spectrometers used pulse of radio frequency radiation to cause nuclei in magnetic field to flip into a higher energy alignment and determination of the chemical shift the difference in absorption frequency in parts per million (ppm) (Othman *et al*., 2009).

2.9.8 Fourier – Transform Infra-Red (FTIR)Test:

Vibration spectroscopy has been utilized for the characterization of polymers and other material It has been applied in the characterization of the biological s and their component, Variations in the environment of molecular components of materials and tissues are reflected in shifts in absorbance band intensities and positions in the vibration spectra. The spectrum of a material provides in sight into the chemical composition of absorbance and how it might be altered during processing (Kavukcuoglu and Pleshko, 2011).

Also, "FTIR" is defined as an electromagnetic wave ranged from 400-1000 μm wavelength, and it is called "growth ray" that is efficiently absorbed by living organism so they are used in the treatments of cancer at body temperature (37^{o}C) (Hamada *et al*., 2003).

Recently, anon invasive strategy using near-infrared spectroscopy is introduced for studying hemodynamic of the human skeleton muscles by monitoring of the measuring of blood volume changes (Kuboki *et al*., 2001).

Since infra-red is a highly diagnostic tool, so it has been used recently in the development of new optical diagnostic tools for the detection and imaging of early dental caries since enamel is highly

transparent to infra-red, and the detection of deminerlized dental enamel by the potential use of polarization sensitive optical coherence tomography and infra-red transillumination for imaging of dental cavies (Fried *et al*., 2005).

The main objectives are determined whether modified polyethylene would undergo faster biodegradation than unexposed to "FTIR" under laboratory condition and reduce quantities of plastic waste by design new material that susceptible to chemical or biological process in the environment (Nowak *et al*., 2011).

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CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials :

Materials used in this study are listed in Table (3.1).

Table (3.1) : Materials used in preparing samples of this study.

No.	Product	Type	Manufacture	Batch no.	Expired date
1.	**Vertex regular**	Heat cured acrylic resin denture bas polymer powder and liquid (pink, clear)	Vertix-Dental byjohan van oldenbamevertlaan,62.3705Hszeist the Netherlands	ISO1567 Type 1 Class1	2014
2.	**Imperlon**	Hard plastic foil of thickness 1,5,3 mm	Schen Dental GmbH AmBurgberg 20 58642 IserlohnGermany	4001A 4701A	2009
3.	**Valplast**	Thermoplastic Nylon	China		2015
4.	**Elite Model stone**	Gypsum/ type 3 dental stone	Zhermack SPA. Viva bovazecchino 45221 (Ro)-Italy	201532	2014
5.	**Isodent**	Seperating medium	Spofa dental A.S Markova 238 20646 jlcin CzechRepublic	1753803	2012
6.	**Silky Rock**	Gypsum	Whip-Mix corporation, loniviville, USA	078548004	2012
7.	**Waterproof paper**	Sandpaper No.400	Saudia Arabia Company		2015
8.	**Lora**	Vasuline	Ahlam Company, Syria	70473	2011
9.	**Cellophan paper**	Separating medium	Vertex dental bv Johanvan old enbamerentlaan 63, 3705HS Zeist the Nether land	ISO 1567 type I closs 1	2014
10.	**Distilled water**	Non-ionized distilled water	Ramapharma Aleppo-Syria	A 11	2013
11.	**Easy-Vac Gasket**	Hand elastic foil 3,2.5, and 1 mm thickness	3AMEDES Company – Korea	1824	2014

3.2 Equipment and Instrument Used in the Study :

- Beakers
- Benzene lamp
- Brush, Amigo 16
- Clock timer
- Computer core 2du
- Dental metal flask (ash-England)

- Dental vibrator (Quayle dental, England).
- Digital vernier , (China) accuracy 0,01 mm.
- Digital electrical shaker, (Dragon Labsk-300 Pro, China)
- Different types of disposable containers (Plan tubes, bottles)
- Digital camera (Sony, 72 M pixel. Japan)
- Disposable syringes
- Electronic balance (Sensitive 0,001 g , (Mettler Toledo, Switzerland).
- Electrical Saw (China).
- FTIR spectrophotometer (Fourier transform infra-red spectroscopy) (Bruker 27-tensor, Germany).
- Gloss Jar
- Graduated measuring cylinder
- Heavy duty engine and hand piece W&H – Austria
- Hydraulic press (Quayle dental, England)
- Incubator (Lab tech S. Korea)
- Marker pen
- Mixing spatula
- "NMR_600 MP" device \Colorado University\USA
- Philips magnetic resonance imaging device (Netherland)
- Rock well Hardness tester (Wolpert, Germany)
- Rubber bowel
- Ruler
- Philips magnetic resonance imaging device (Netherland)
- Thermometer
- Tweezers
- Universal tensile tester (gunt Mp 300.20, Germany)
- Ultraviolet – visible spectrophotometer (Schimadzu – 1800 UV)
- Wax knife
- Water bath (DEROTER, UK)
- Scissors

3.3 Pilot Study :

3.3.1 Aims of the Pilot Study :

Before standing main study, pilot study should be done to investigate and explain the effect of magnetic resonance imaging (MRI) on some of the :

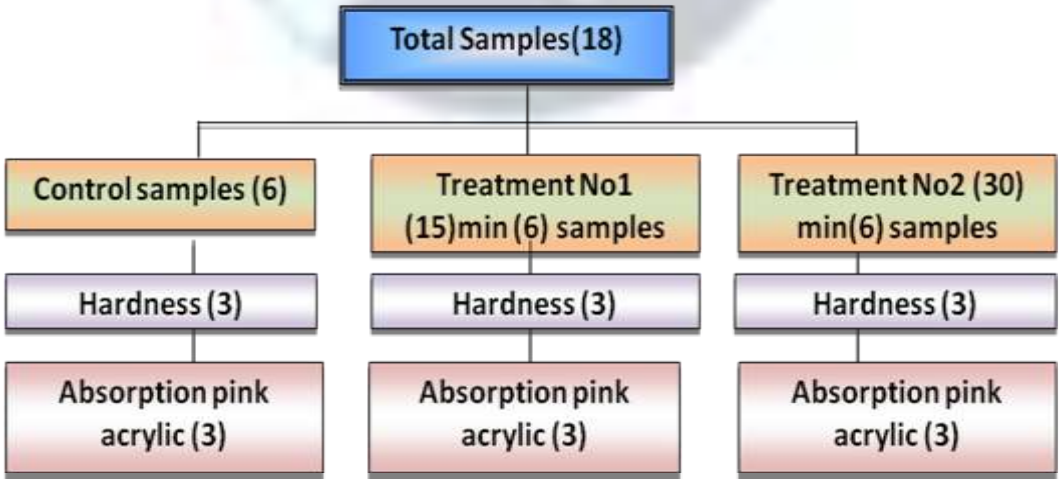
4. The mechanical properties of acrylic resin denture base material
5. Physical properties of acrylic resin denture base material

3.3.2 Experiment Design of Pilot Study:

The total number of the pilot study samples was eighty samples, divided into three groups .They contained six samples, and with exception of six control samples. Each experiment, number, exposed to (MRI) for 15 min. As 1st treatment group . Experiment 2 exposed to (MRI) for 30 min as in 2nd treatment group will done .Both of experiment number. 1 and 2 will be measure respectively:

A. Rockwell Hardness (Indentation) (Scale L for plastic and semi-plastic material).
B. Color change - visible spectrophotometer (Schimadzue 1800).

Figure (3.1) experiment design of pilot study



3.3.3 Sample Preparation and Design :

According to ADA specification for a cyclic resin polymers the dimension of studied sample for the 1st experiment (hardness measurement) will be 30*15*3 ± 0.02 mm (length, width, and thickness) and samples were prepared from (Heat cure acrylic resin).

The second samples prepared for second experiment (ultra-violet visible spectrophotometer, for measurement degree of absorption and prepared in an uniform dimension of 30*20*15 mm (length, width, and thickness respectively) (Hatim *et al*., 2004).

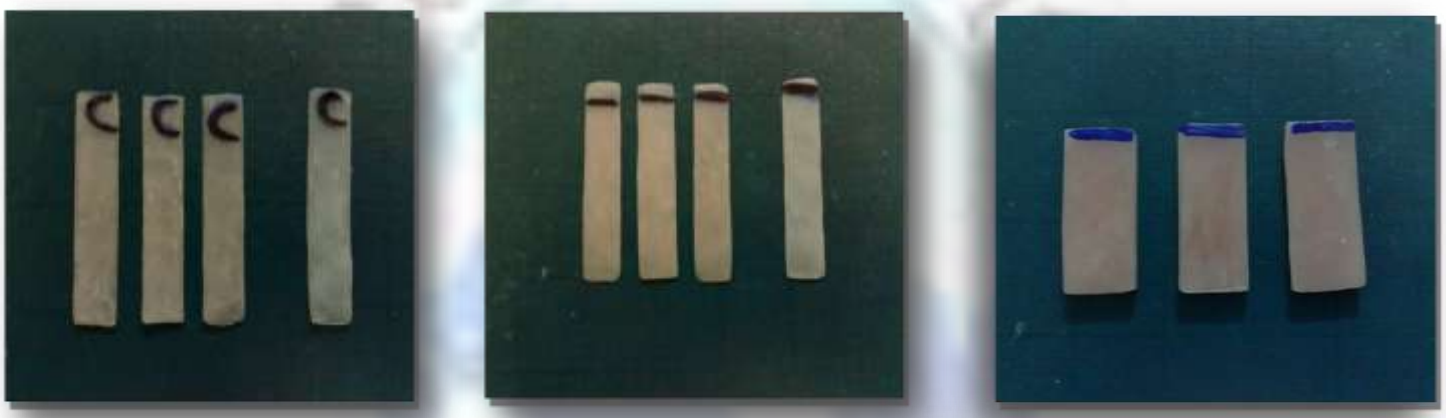


Figure (3.2) different samples preparation of pilot study.

Then wax pattern were prepared at mentioned dimension Flasked, deflasked for wax elimination and then the acrylic will packed after ensuring that no remnant of wax was remaind. It was completely removed by adequate brushing through detergents respectively with preserving stone surfaces intact without any scratches or detachments.

Following that mixing of powder and liquid of hot cure acrylic resin according to manufacture instruction (each 39 ml of powder with 2.5 ml monomer), mixing was done in glass-jar and room temperature 7-9 minutesafter the mixture . Material will reach dough stage and it they be packed under pressure,

cured (one and half hour at "70 ^{o}C" then half an hour in boiling water, leave flask for cooling , open finished, polished and tested.

3.3.4 Conclusions of Pilot Study :

1. There was a significant difference in indentation hardness test value 2nd "experiment 30 min. exposure to (MRI) among other value result.
2. There was a significant difference in the color change absorption via spectrophotometer for "1st "experiment (15) min. exposure to (MRI)" among other value result.

3.4 Main Study :

3.4.1 The Experiment Design for Main Study :

The total no. of samples of this study were four hundred fifty four, the samples were divided into two groups; each group contained two hundred and twenty seven,

1.the samples of 1st group were pink heat cured acrylic resin
2.the samples of 2nd group were clear heat cured acrylic resin.

The total no. of samples of these two main groups were divided into four sub-groups; each sample was cured according to short curing cycle according to ADA specification No.12, 2009, samples were cured for 90 minutes in 70^{o}C followed by 30 minutes in 100^{o}C using thermostatically controlled curing unit. The samples were then incubated into distilled at 37 ± 1^{o}C of two days for conditioning before testing (ADA specification No.12, 1975) followed that samples were exposed to magnetic resonance image (MRI) at (3) three different time periods (5), (15), (30) min. respectively. At end of each period of times, samples were tested for (indentation)hardness, tensile strength, color change, dimension accuracy, residual monomer, surface roughness,water sorption and (FTIR) (Figure 3.3).

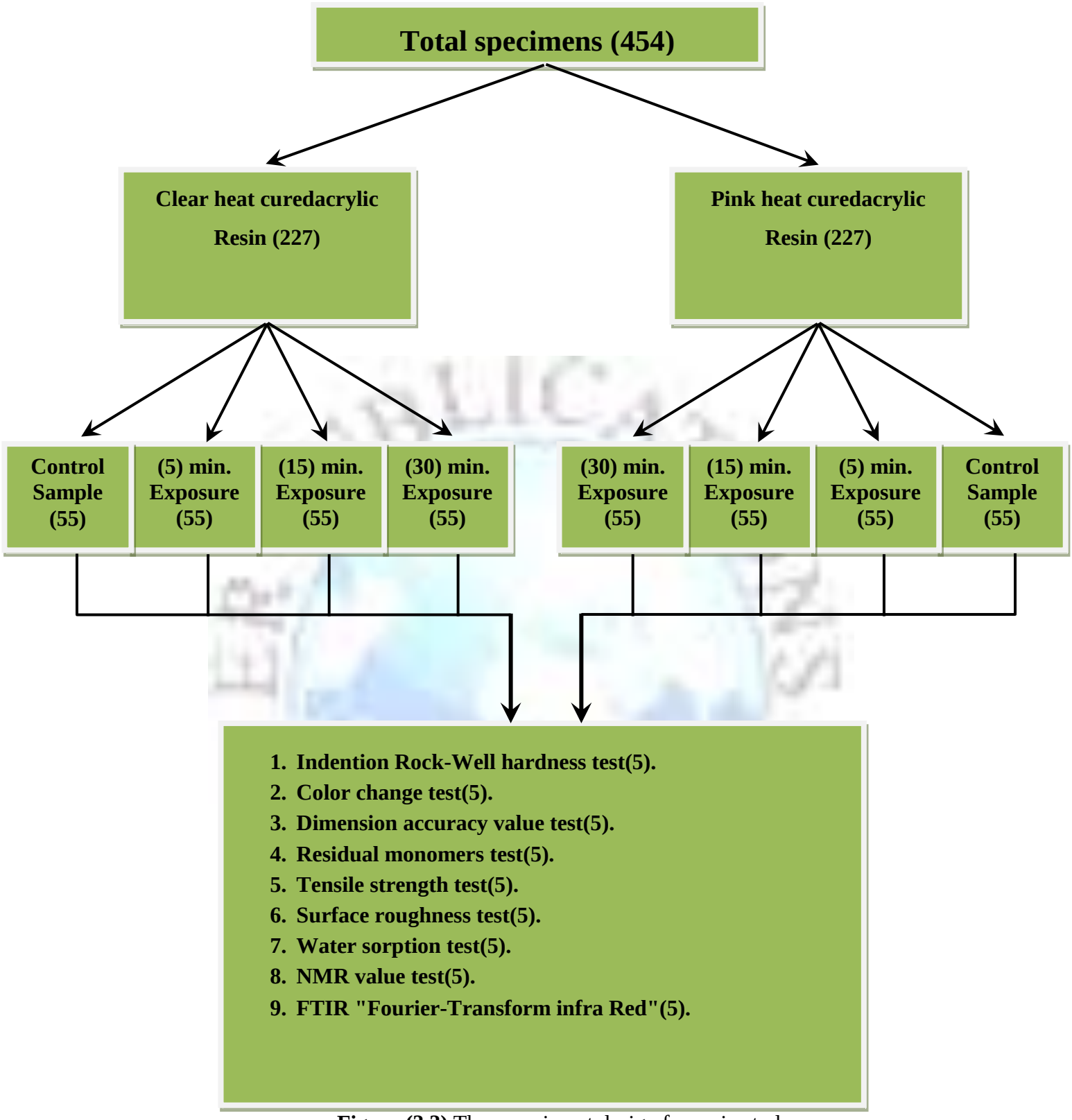
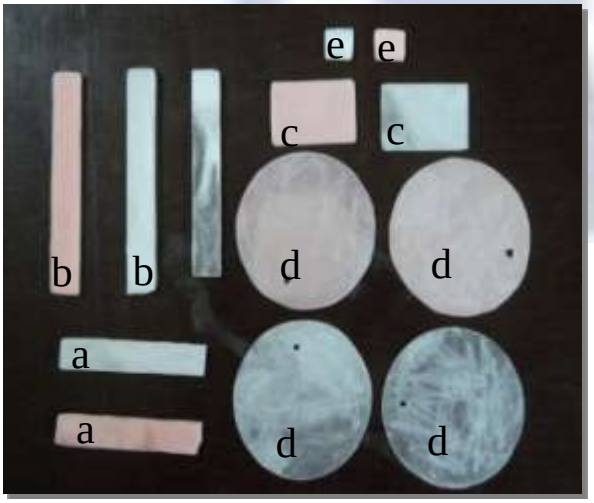


Figure (3.3) The experiment design for main study

3.4.2 Heat Cured Acrylic Resins Samples Preparation and Testing :

Acrylic resin specimens were prepared in mold by investing a hard elastic foil for test, water and stone mixed in ratio of 100;23 powder-water according to manufacturer instruction, with manual spatulation for "10-20" second.The use of electrical vibrator for about" 1-3" minutes to get mixture free from air bubbles as much as possible, then mixture were poured into lower half of flask and after setting of stone, the stone surface was coated with isodent separating medium.The upper half of the flask was filled with stone after ,it was applied over the lower half, the two halves were left for one hour to complete setting, wax elimination was done by immersing the metal flask in boiling water for (4) minutes (Anusavice, 1996).

The sample within flask were left for bench cooling at room temperature, after that samples was removed, carved with engine stone bur, and polished with sand paper No. 400, adjust and incubated in distilled water at" 37 ± 1^{o}"C 48 hours for conditioning before testing (ADA specification No.12, 1975)(Figure 3.4).



a- tensile strength samples

b-dimension accuracysamples

c-rockwell hardness sample

d-water sorption samples

e-surface roughness sample

Figure (3.4) example of some samples used in study

3.4.3 Specimens testing :

Each specimen after complete finishing and polishing is performed;it well be testing by placing samples inside (Magnetic resonance image) at three different times according to the plane or experiment design of main study and for three different times" 5, 15, 30" min. respectively as seen in Figure (3.5).

Figure (3.5) specimens of different tests exposure to"MRI"

3.4.4 Specimens Coding :

After specimens were completed, small identation or mark will done for adequate sample marking to allow adequate recognization of samples and differentia between each period of time like "pink-15M3" .That means pink acrylic and "15" mean "15 minutes exposure" and "3" mean sample No. three. (Figure 3.6).

Figure (3.6) specimens coding

3.5 Tests of Study :

After preparation, the samples for heat cured acrylic resins materials and completed exposure to magnetic resonance image device (MRI) (Figure 3.7) at three different period of time" 5, 15, 30" minutes respectively. The following chemical, mechanical, physical properties of samples will be tested and studied:

1. Color change test(spectrophotometer)
2. Indention hardness test
3. dimension accuracy test
4. surface roughness test
5. water sorption test
6. tensile strength test
7. "FTIR" test.
8. "NMR" nuclear magnetic resonance test.

Figure (3.7) Philips" MRI" Device,AL-khansa Hospital

3.5.1 Methods for Testing Some Mechanical and Physical Properties

3.5.1.1 Tensile Strength Test :

The samples were constructed according to ADA specification No.12 with dimension 90*10*3 ± 0.3 mm (length, width, thickness) respectively as shown in Figures (3.8) and (3.9).

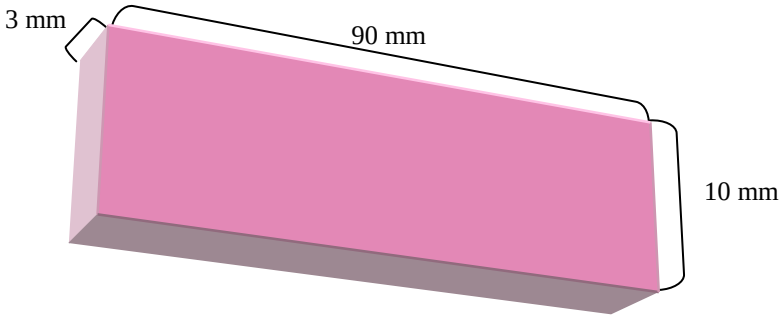


Figure (3.8): Tensile strength testing sample dimensions

Figure (3.9): Tensile testing samples design

The Gunt Universal testing machine was used to measure the tensile strength of specimens. The specimens were grasped by two arms of machine (40 mm/between two armed and pulling forces were started and the samples were tested at room temperature .The results were recorded in a special program on a computer of tensile machine. For each sample, the forces at failure were recorded in Newton (N) and the two tensile strength values were calculated by following formula:

Tensile strength = F (M/A (MM)^2 (Ozkan et al., 2003)

F = tension force at failure (N)

A = cross section area of specimen.

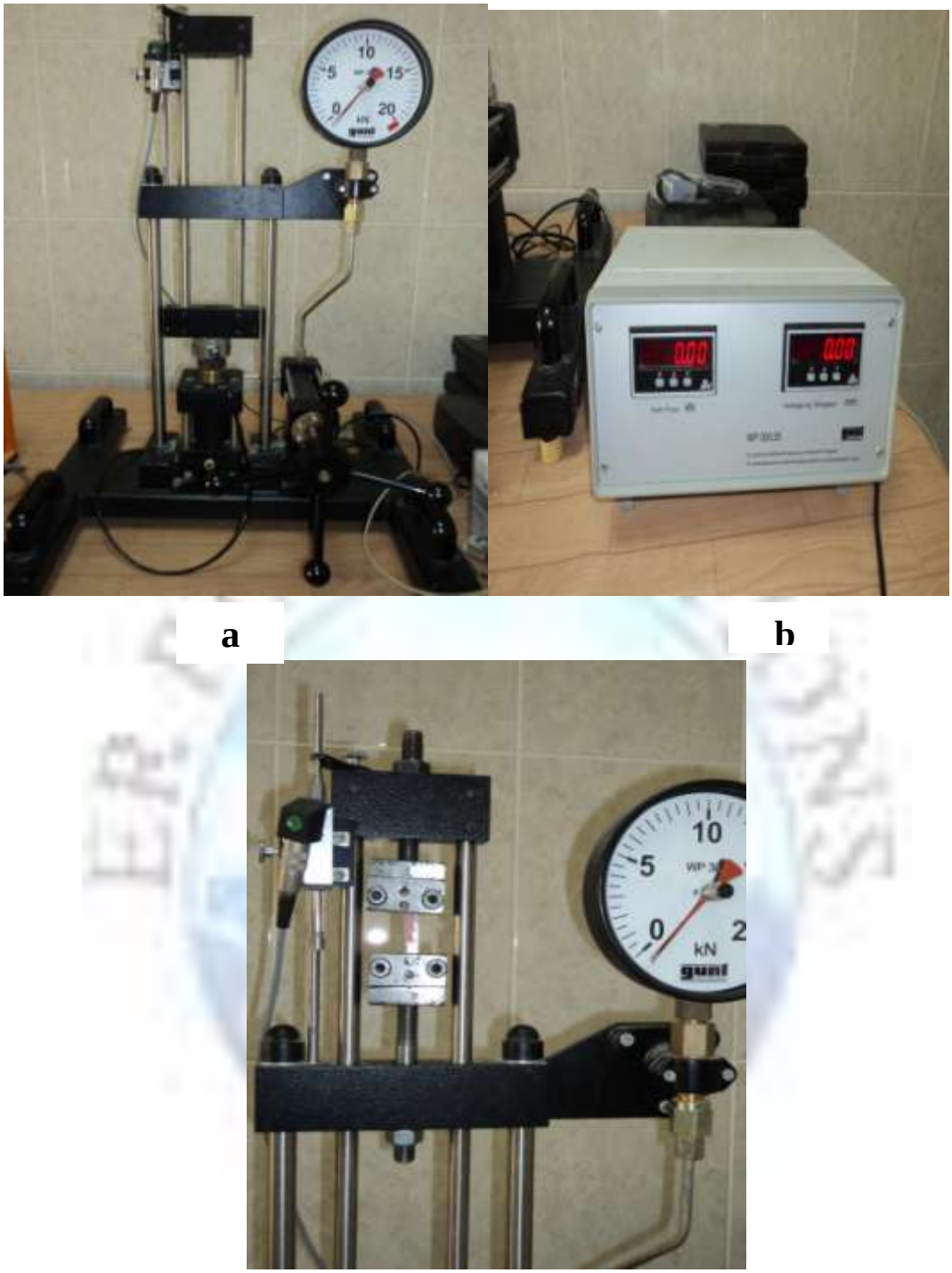


Figure (3.10) shows: a- Gunt universal testing machine. b-Digital recorder. c-sample testing.

3.5.1.2 Water Sorption Test :

A stainless steel die was molded in the lower half of the flask, the stainless steel die dimension was (50 ± 1 min diameter and 1 ±0.05 mm in thickness (Kazanji and Watkinson, 1998).

After the preparation of the specimen, the specimens were numbered and small hole was prepared in the midline of upper part of each specimens to allow dispersion by a nylon dental floss in the solution without contacting each other; so that the specimens is surrounded by solution (distilled water only)

According to (ADA) specification, the specimens were stored in distilled water before each test. They were removed from distilled water with tweezers wiped with clean dry hand towel, waved and dried on air wave for about 15 second to 20 second and weight on digital balance with precision of 0.0001 gm, The specimens were immersed in distilled water and placed in incubator (Figure 3.11).

A B C

Figure (3.11) A-cooled incubator. B-incubator regulator.
C-specimens inside the incubator.

For 24 hours to stimulate condition inside patient mouth and then the specimens were dried in a desiccators containing freshly dried silica gel at 37 ± 2°C for 24 h (Figure 3.12). The specimens were removed to similar desiccators at room temperature for one hour and then weigh on digital balance (AND GX 200).The cycle was repeated until constant weight has attained, thus weight loss of each specimens was not more than 0.5 mg in 24 h period is considered as conditioned weight the value of water sorption calculated for each specimens as follows :

$$\text{water sorption} = \frac{\text{weight after immersion-conditional weight}}{\text{surface one of distil}}$$

water sorption = mg/cm^2 (Crag 1989).

Figure (3.12): specimens drying inside a glass container filled with dried silica gel at room temperature

3.5.1.3 Surface Roughness(Ra) Test :

According to Nevatoglu *et al*., (2007). The specimens were prepared with dimension (10*10*2 mm) as shown in Figures (3.13, 3.14. 3.15).

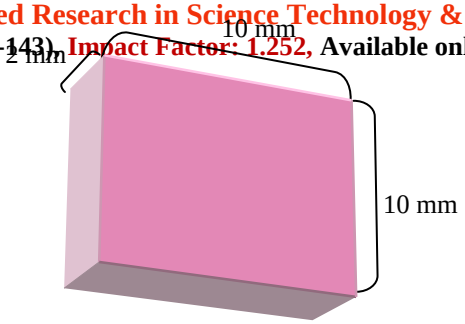


Figure (3.13): Surface roughness testing sample dimensions

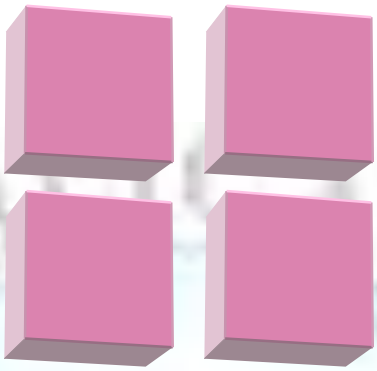


Figure (3.14): Surface roughness testing samples design

Figure (3.15): Surface roughness measurement by stylus profilometer

The surface roughness (Ro) of specimens was measured using a contact profile meter surface roughness (Ro) measured in"µm" which can measure small surface variation by moving a diamond stylus in contact with surface while moving laterally across the specimens, under constant pressure, five measurements of surface roughness were performed for each specimen (Periva et al., 2007)(Figure 3.16).

Surface roughness of heat cured acrylic resins were measured respectively, five specimens were measured from each group and 2-3 reading selected randomly for each specimen and mean value was calculated and used for statistical analysis.

Figure (3.16): contact(stylus) profile meter surface roughness device

3.5.1.4 Dimensional Accuracy Test :

The samples were prepared in the dimension of (65*10*2.5 ± 0.03 mm) (length, width and thickness) respectively according to (ADA specification No. 12, 1275) Figures (3.17, 3.18)

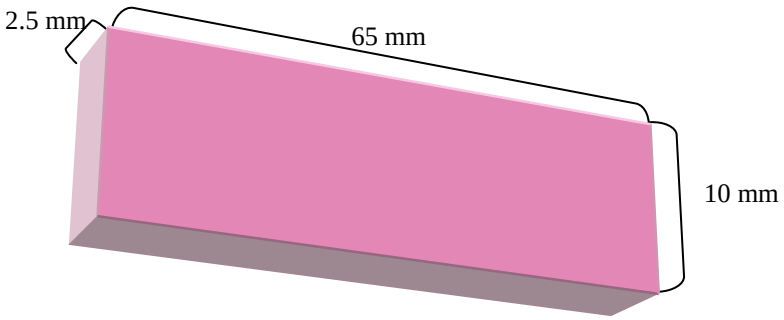


Figure (3.17): Dimensional accuracy testing sample dimensions

Figure (3.18): Dimensional accuracy testing samples design

Measurement were done by using electronic digital caliper accuracy of 0.01 mm as shown in Figure (3.19).

Figure (3.19): ElectronicDigital Caliper

The dimension accuracy samples for each type of acrylic materials in specific 3 periods of time was done for each group of materials.

3.5.1.5 Indentation (Rock well) hardness test:

The samples were prepared with dimension of (30*15*3±0.03 mm) (length, width, and thickness) respectively as shown in Figures (3.20, 3.21).

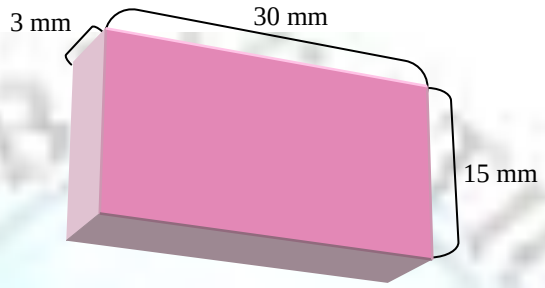


Figure (3.20): Indentation Hardness testing sample dimensions

Figure (3.21): Indentation Hardness Test Samples design

The samples surface were tested for hardness at five different locations, and then the mean was taken for each sample (issac,1992).the test done by using(Rock Well hardness tester). The indenter used in the form of round steel ball of 1\4 inch in diameter the sample subject to fixed minor load of 60kg, then the Rock well hardness inspector was calibrated according to the manufacture instruction after" 15 to 20" second "L" scale for plastic and semi- plastic material (Figure 3.22).

Figure (3.22): DigitalRock-Well hardness tester**.**

The indentation hardness specimens for each types of material and specific (3) period of time of exposure to (MRI) were done for specimens.

3.5.1.6 Color Stability and Changes:

Sample of all three groups were prepared with dimension of "30*20*1.5" mm respectively) length, width, and thickness (Hatim *et al.*, 2004).

The measurement color change and degree of absorption were done by using (ultra-violet-visible spectrophotometer (Schimadzue 1800).That started by putting acrylic specimen in the cell facing or in front of beam direction to pass through it.The distal water was placed on other cells as control for specimen and start the measurement within (visible-range 200-400 nm) of wave length, starting to estimate the spectrophotometer to maximum absorption total.This happened in relation to peak

level of wavelength of each specimens of the two types of heat cure acrylic resin at three different periods of time (Figure 3.23).

Figure (3.23) (Schimadzue-1800) Ultraviolet-0visiable

3.5.1.7 Residual Monometer Release :

Heat cure acrylic resin materials samples for tested groups were assessed for. It contained residual monometer and it's releases. The samples were placed inside glass container that contain "10-15 ml" of non-ionized sterilized distil water and kept "37^{o}C" at room temperature for 5-7 days,and everyday residual monometer releases has measured for each sample over continous"5-7" day.The water was being changed everyday after taking the reading or measurement and then replaced by new" 10 ml "sterilized non-ionized distilled water (Azzari *et al.*, 2003).

The monitoring of the amount of monomer present in the whole medium was done by using (ultraviolet-visible spectrophotometer "Schimadzu-1800') which connect to computer for plotting the results (Figures 2.24 and 3.25).

Figure(3.24) Residual monomer specimens inside glass container with distal water

A **B**

Figure (3.25): A- spectrophotometer device connected to computer. B- specimen tested inside spectrophotometer

The wavelength of measurement done is (λ = 245). Each medium assessed through time scan of"15" second and the value obtained represented a concentration which is equivalent to concentration in ""ppm" "part per milion". a Figure below represents line calibration curve

of heat cure Acrylic monomer (MMA) concentration range of (0.05-0.5) mg/ml (Figure 3.26).

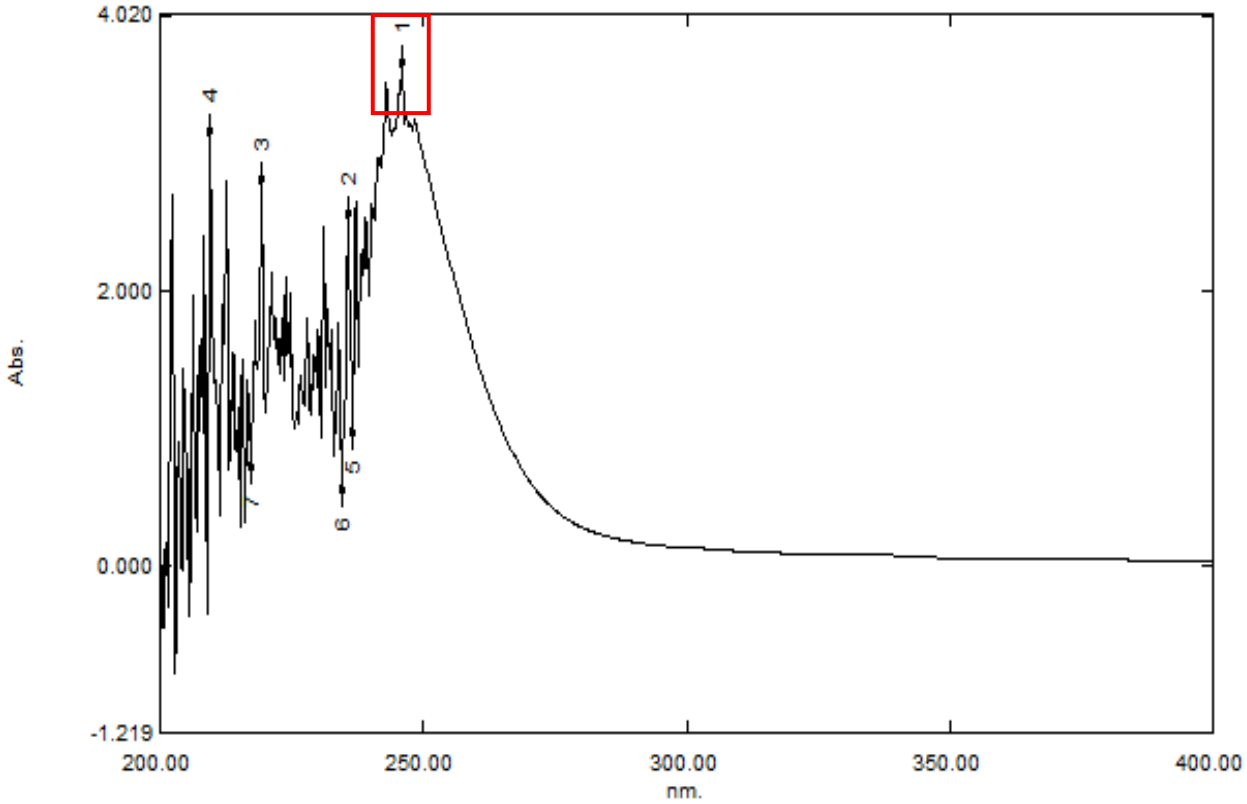


Figure (3.26) Plots shows the £max.absorption for heat cured acrylic monomer.

3.5.2 ''FTIR'' Tests: (Fourier- transform infrared spectroscopy)

Heat cured acrylic resin sample of all specimen have been assessed for any chemical charge or effect that might be happened due to the magnetic resonance image (MRI).

The samples were prepared by using hand piece rotary instrument at very low speed (W&H) and followed by simple grinding of each sample, prepared what equal to almost (0.4-0.6) gm of pure powder of material, then this powder has been placed inside well sealed cap-glass jar container and then it will send for measurement.

The sample whose spectrum is to be obtained may be a solid, liquid gas or a solution; for solid material, should grind about 5mg of solid to a very fine powder with the smallest possible drop of a suitable mulling agent such as "a mixture of paraffinic hydrocarbons",hexachlorobutadiene or one of the per fluorocarbons,such as fluorolube which are transparent at higher frequencies than 1300cm (Parikh,1974).

Then by using" Fourier- transform infrared spectroscopy" device (FITR), The C=C bounds of investigated sample was assessed for any chemical changes(Abdul-Razzak, 2010),after the exposure to the magnetic resonance image (MRI).

The (FTIR) test for each sample of two typical heat cure acrylic resin at three different specific period of time were done.

3.5.3 Nuclear Magnetic Resonance Test : (NMR)

Heat cured acrylic resin, samples were assessed for any chemical changes effect by using of (NMR test) (Nuclear magnetic resonance).

The same method of preparation of samples of (FTIR) (Fourier-transform infrared)was used for preparation of (NMR) samples, to determine the resonance spectrum of the protons of an organic

compound, it must be used in diluted solution (about 2to 10%) in a solvent which contain no hydrogen atoms of its own and mainly "carbon tetrachloride, deuterated chloroform, CDCL3"(Parikh,1974).

Then,by using rotary instrument hand piece at low speed (W&H) and prepare of about (0.4-0.6) of pure powder that is placed in dark well isolated seal cap Of glass jar and then send to the (NMR) measurements (Figure 3.27).

The (NMR) is one of the most commonly and widely used technique in chemical and biological analysis. High resolution (NMR)spectra is usually measured in the solution state inside glass tube of "5" mm diameter, measurement at about 1.4 tesla (unit of magnetic flux density equivalent to 10.000 G) that develop electro- magnetic that took the highest field strengths up to 12.35 T) at which adequate (NMR) spectroscopy provided basis for nuclei studies (Lindon JC., 2010).

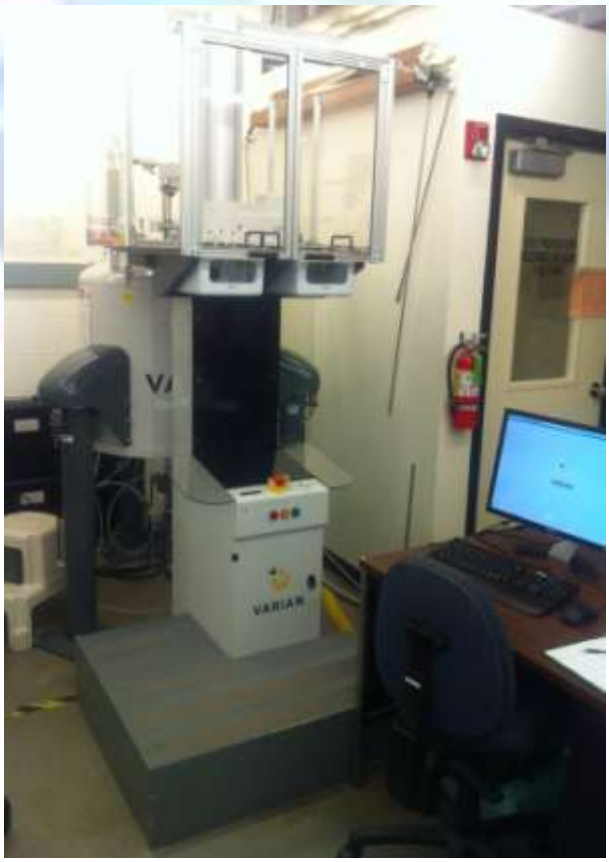


Figure (3.27) "NMR_600 MP" device\Colorado university\USA

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CHAPTER FOUR

RESULTS

4.1. Pilot Study Results :

Results were analyzed statically by One-Way analysis of variance (ANOVA) and Duncan's multiple range test. Tables (4.1 and 4.2) showed a significantly difference at $P \leq 0.05$ of "Rockwell hardness" test of all surface treatment (control, 15 minutes, 30 minutes) with significantly high at "30 min.". Treatment group and Tables (4.3 and 4.4) showed a significantly difference at $P \leq 0.05$ of color estimation by degree of "wavelength" Absorption of all surface treatment (control, 15 minutes, 30 minutes with high significant value at "15 min." treatment group.

Table (4.1) Descriptive for hardness test of pink color

		N	Mean	Std. Deviation	Std. Error
Hardness	Control	3	81.9000	.85440	.49329
	15 Min	3	88.0000	1.00000	.57735
	30 Min	3	94.4333	.51316	.29627
	Total	9	88.1111	5.47345	1.82448

Table (4.2) One way ANOVA test for hardness of pink color

		Sum of Squares	df	Mean Square	F	Sig.
Hardness	Between Groups	235.682	2	117.841	177.353	.000
	Within Groups	3.987	6	.664		
	Total	239.669	8			

Table (4.3) Descriptive for color stability"spectrophotometer" test of pink color

		N	Mean	Std. Deviation	Std. Error
Wavelength "nm"	Control	3	222.6667	0.57735	.33333
	15 Min	3	254.3333	0.57735	.33333
	30 Min	3	229.2667	1.41892	.81921
	Total	9	235.4222	14.49153	4.83051

Table (4.4) One way ANOVA test for color stability "spectrophotometer" of pink color

		Sum of Squares	df	Mean Square	F	Sig.
Wavelength "nm"	Between Groups	1674.676	2	837.338	937.318	.000
	Within Groups	5.360	6	0.893		
	Total	1680.036	8			

Figures (4.1 and 4.2) showed the histograms of "Rockwell hardness test" and "color estimation" test respectively as shown in Figure (4.1):

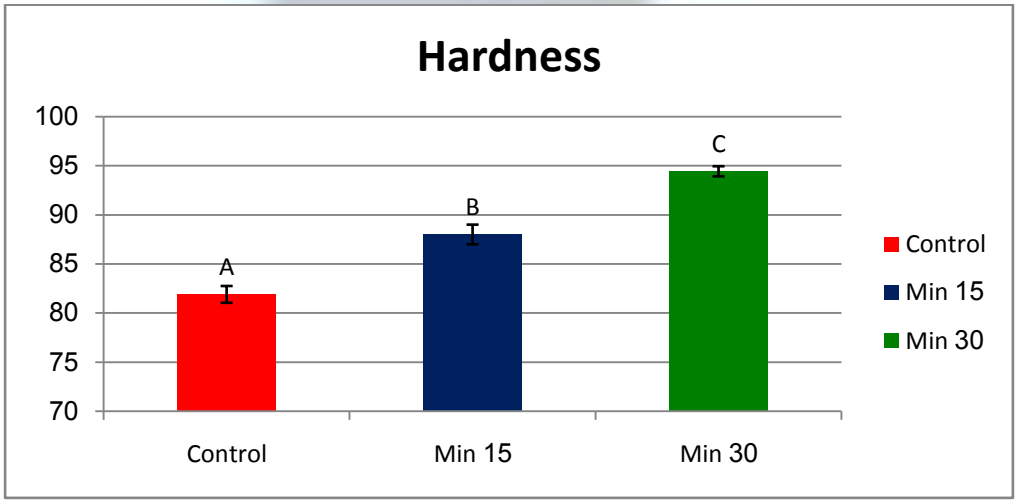


Figure (4.1) Duncan's for hardness test of pink color

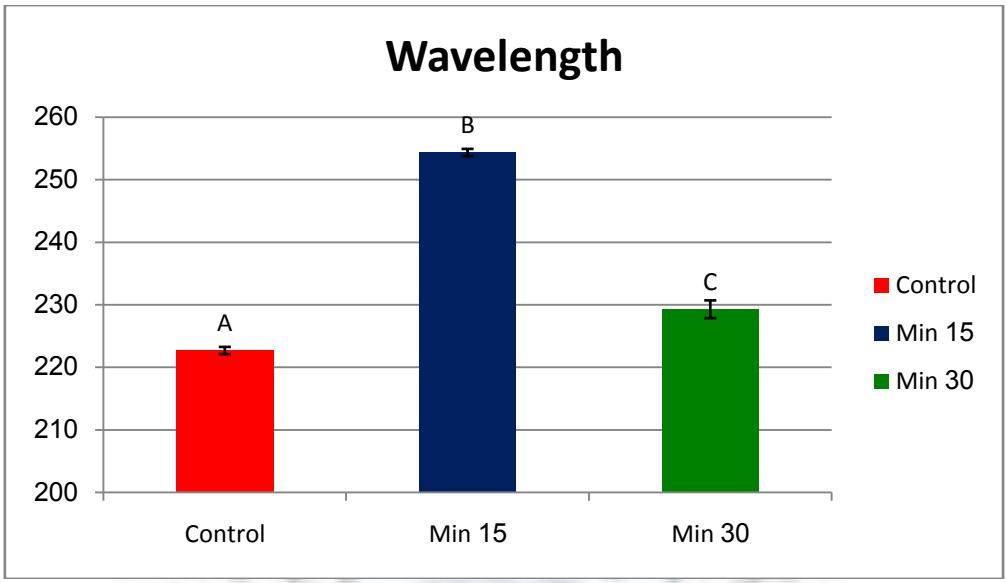


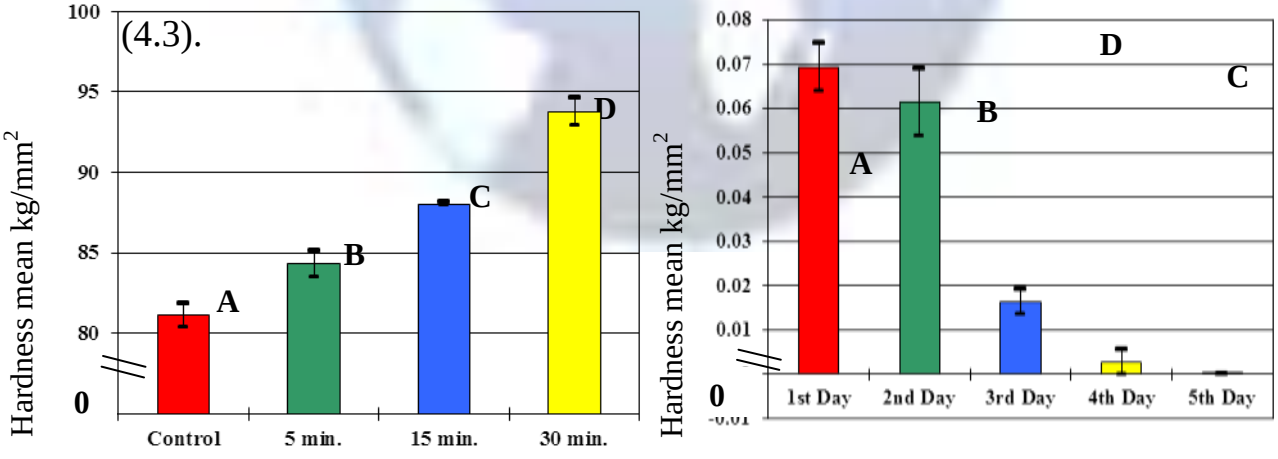
Figure (4.2) Duncan's for wavelength test of pink color

4.2. Results of Main Study :

4.2.1. Physical and Mechanical Result:

4.2.1.1. Rockwell Hardness Test :

Rockwell hardness means and standard deviation for the tested group at different periods of time (5, 15, 30) min. respectively within control for both types of acrylic "Pink and Clear" were showen in Figure (4.3).



A. Pink B. Clear

Figure (4.3): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) test as shown in Table (4.5) and Duncan's multiple range test Figure (4.3) for both types of acrylic (Pink and Clear) demonstrated that there was a significant difference at P <0.05 in the hardness for both types of "acrylic resin heat cured" Pink and Clear at different period of time (5, 15, 30) min. within control.

Rockwell Hardness Value

Table (4.5): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	442.212	3	147.404	230.139	0.000*
	Within Groups	10.248	16	0.641		
	Total	452.460	19			
Clear	Between Groups	186.690	3	62.230	46.182	0.000*
	Within Groups	21.560	16	1.348		
	Total	208.250	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.3)-A for pink acrylic, showed a higher hardness mean for (30 min) sub-group exposure than other tested sub-groups and control.

Figure (4.3)-B for clear acrylic showed a higher hardness mean for (15 min. sub-group exposure higher than other tested sub-groups.

Table (4.6): Student's t–test

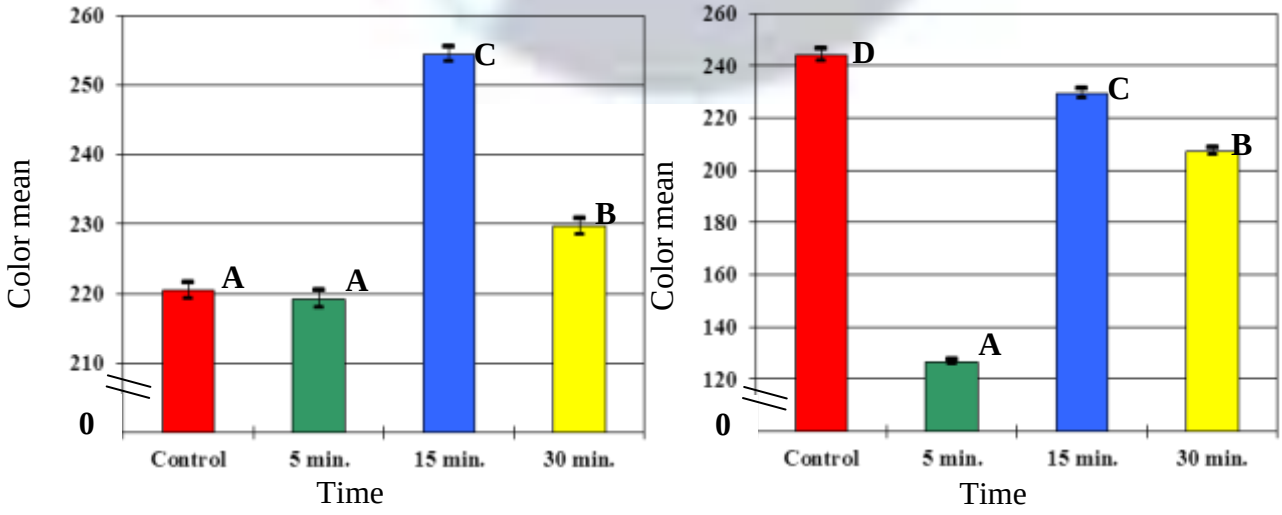
Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	220.400	1.140	20.115	8	0.000*
	Clear	5	244.200	2.387			
5 min.	Pink	5	219.200	1.304	119.546	8	0.000*
	Clear	5	126.600	1.140			
15 min.	Pink	5	254.400	1.140	25.200	8	0.000*
	Clear	5	229.200	1.924			
30 min.	Pink	5	229.600	1.140	26.163	8	0.000*
	Clear	5	207.400	1.517			

* Significant difference existed at 5% level.

Paired samples T-test was performed on "Pink and Clear" acrylic group comparing means of hardness at four period of time (control, 5, 15, 30) min as shown in Table (4.6), there was a significant difference in hardness mean of two types of acrylic at four mentioned period of time.

4.2.1.2 Color stability and changes (Spectrophotometer) Result :

Color change means and standard deviation for the tested groups at different period of time (5, 15, 30) min respectively within control group for both "Pink and Clear" acrylic types were shown in Figure (4.4)



A. Pink B. Clear

Figure(4.4): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) as shown in Table (4.7) and Duncan's multiple range test as in Figure (4.4) for two types of acrylic resin "Pink and Clear" demonstrated that there was a significant difference at $P \leq 0.05$ in color change for both "Pink and Clear" acrylic resin heat cured at different period of time (5, 15, 30) minute within control.

Spectrophotometer ''color change''

Table(4.7): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	4005.400	3	1335.133	953.667	0.000*
	Within Groups	22.400	16	1.400		
	Total	4027.800	19			
Clear	Between Groups	41174.550	3	13724.850	4223.031	0.000*
	Within Groups	52.000	16	3.250		
	Total	41226.550	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.4)-A for Pink acrylic, demonstrated higher color change means for (15 min) sub-group exposure. Than other tested sub-group, follow by high value for (30 min) sub-group, with no significant difference in "control" and "5 min" exposure sub-group.

Figure (4.4)-B for Clear acrylic, demonstrated higher color change means for (control) no-exposure sub-group than other tested sub-groups.

Table(4.8): Student's t–test

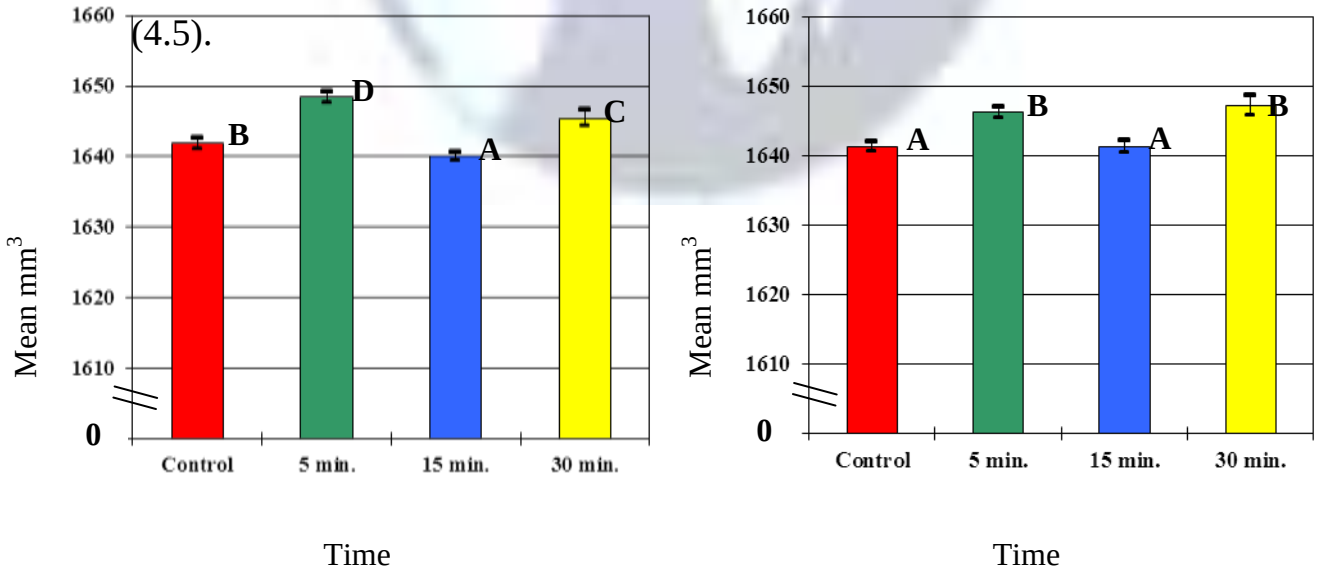
Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	220.400	1.140	20.115	8	0.000*
	Clear	5	244.200	2.387			
5 min.	Pink	5	219.200	1.304	119.546	8	0.000*
	Clear	5	126.600	1.140			
15 min.	Pink	5	254.400	1.140	25.200	8	0.000*
	Clear	5	229.200	1.924			
30 min.	Pink	5	229.600	1.140	26.163	8	0.000*
	Clear	5	207.400	1.517			

* Significant difference existed at 5% level.

Paired sample T-test performed on (Pink and Clear) acrylic group comparing means of color change at four periods of time (control), 5, 15, 30) min as shown in Table (4.8).There was a significant difference in color change means of two types of acrylic resins "Pink and Clear" at Four mentioned period of time.

4.2.1.3 Dimensional Accuracy Results :

Dimensional accuracy means and standard deviation for the tested groups at different periods of time (5, 15, 30) min, respectively within control group for both (Pink and Clear) acrylic were shown in Figure (4.5).



A. Pink B. Clear

Figure (4.5): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.9) and Duncan's multiple range test as in Figure (4.5) for two types of acrylic (Pink and Clear) acrylic, demonstrated a significant difference at $P \leq 0.05$ in dimension accuracy for both types of acrylic (Pink and Clear) at different period of time (5, 15, 30) within control group.

Dimensional Accuracy Value

Table (4.9): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	209.076	3	69.692	86.333	0.000*
	Within Groups	12.916	16	0.807		
	Total	221.992	19			
Clear	Between Groups	150.468	3	50.156	44.327	0.000*
	Within Groups	18.104	16	1.132		
	Total	168.572	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.5)-A for (Pink) acrylic, demonstrated higher dimensional accuracy means for (5 min) sub-groups exposure than other tested sub-groups.

Figure (4.5)-B for (Clear) acrylic, demonstrated higher dimensional accuracy means for both (5) and (30) min sub-groups respectively in compare with other (2) sub-groups tested (control), and (15) min.

Table(4.10): Student's t–test

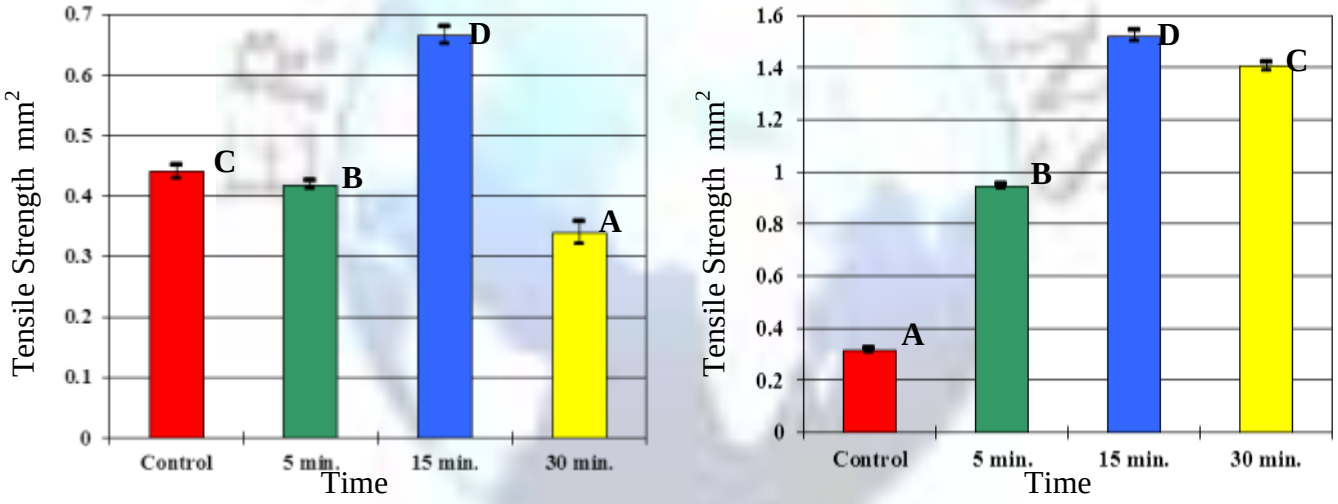
Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	1641.830	0.870	1.079	8	0.312
	Clear	5	1641.260	0.799			
5 min.	Pink	5	1648.380	0.820	4.162	8	0.003*
	Clear	5	1646.200	0.837			
15 min.	Pink	5	1640.000	0.707	2.310	8	0.050*
	Clear	5	1641.260	0.994			
30 min.	Pink	5	1645.400	1.140	2.151	8	0.064
	Clear	5	1647.200	1.483			

* Significant difference existed at 5% level.

Paired sample T-test performed on (Pink and Clear) acrylic group comparing means of dimensional accuracy at four periods of time (control, 5, 15, 30) min as shown in Table (4.10) demonstrated a significant difference in dimensional accuracy means of two types of acrylic resins (Pink, Clear) at two periods of time (5, 15) min, with no significant difference at other two periods of time (control, 30 min).

4.2.1.4. Tensile Strength Results :

Tensile strength means and standard deviation for the tested groups at different periods of time (5, 15, 30) min. respectively within control group for both (Pink and Clear) acrylic were shown in Figure (4.6).



A. Pink B. Clear

Figure(4.6): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.11) and Duncan's multiple range test as in Figure (4.6) for two types of acrylic (Pink and Clear) demonstrated a significant difference at $P \leq 0.05$ in tensile strength for both types of acrylic (Pink and Clear) at different period of time (5, 15, 30) min, within control group.

Tensile Strength

Table (4.11): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.297	3	0.099	482.626	0.000*
	Within Groups	0.003	16	0.001		
	Total	0.300	19			
Clear	Between Groups	4.505	3	1.502	5177.977	0.000*
	Within Groups	0.005	16	0.001		
	Total	4.510	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.6)-A for (Pink) acrylic, demonstrated higher mean of tensile strength for (15) min sub-groups exposure than other tested sub-groups.

Figure (4.6)-B for (Clear) acrylic demonstrated higher means of tensile strength for (15) min sub-group exposure than other tested sub-groups.

Table (4.12): Student's t–test

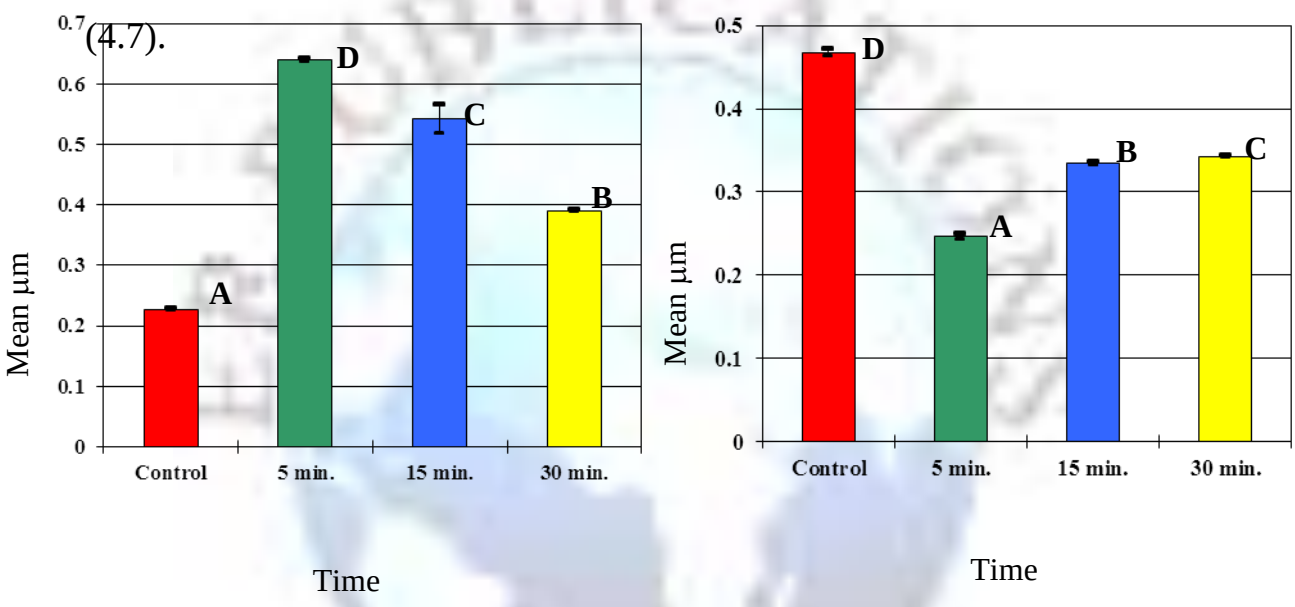
Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	0.440	0.012	16.837	8	0.000*
	Clear	5	0.314	0.011			
5 min.	Pink	5	0.418	0.008	83.168	8	0.000*
	Clear	5	0.944	0.011			
15 min.	Pink	5	0.666	0.015	69.892	8	0.000*
	Clear	5	1.522	0.023			
30 min.	Pink	5	0.338	0.019	87.039	8	0.000*
	Clear	5	1.404	0.019			

* Significant difference existed at 5% level

Paired sample T-test performed on (Pink and Clear) acrylic group comparing means of tensile strength at four period of time (control, 5, 15, 30) min as shown in Table (4.12), demonstrated a significant difference in tensile strength means of two types of acrylic (Pink and Clear) at four period of time.

4.2.1.5. Surface Roughness Results :

Surface roughness means and standard deviation for the tested groups at different periods of time, (5, 15, 30) min respectively within control group for both (Pink and Clear) acrylic were shown in Figure (4.7).



A. Pink B. Clear

Figure (4.7): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.13) and Duncan's multiple vanes test as in Figure (4.7) for two types of acrylic (Pink and Clear), demonstrated a significant difference at $P \leq 0.05$ in surface roughness for both types of acrylic (Pink and Clear at different period of time (5, 15, 30) min within control group.

Surface Roughness

Table(4.13): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.490	3	0.163	1126.273	0.000*
	Within Groups	0.002	16	0.001		
	Total	0.492	19			
Clear	Between Groups	0.124	3	0.041	4231.842	0.000*
	Within Groups	0.000	16	0.001		
	Total	0.125	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.7) A- for (Pink) acrylic, demonstrated higher means of surface roughness for sub-group (5) min exposure than other tested sub-groups.

Figure (4.7) B- for (Clear) acrylic, demonstrated higher means for (control) sub-group than other tested sub-groups.

Table (4.14): Student's t–test

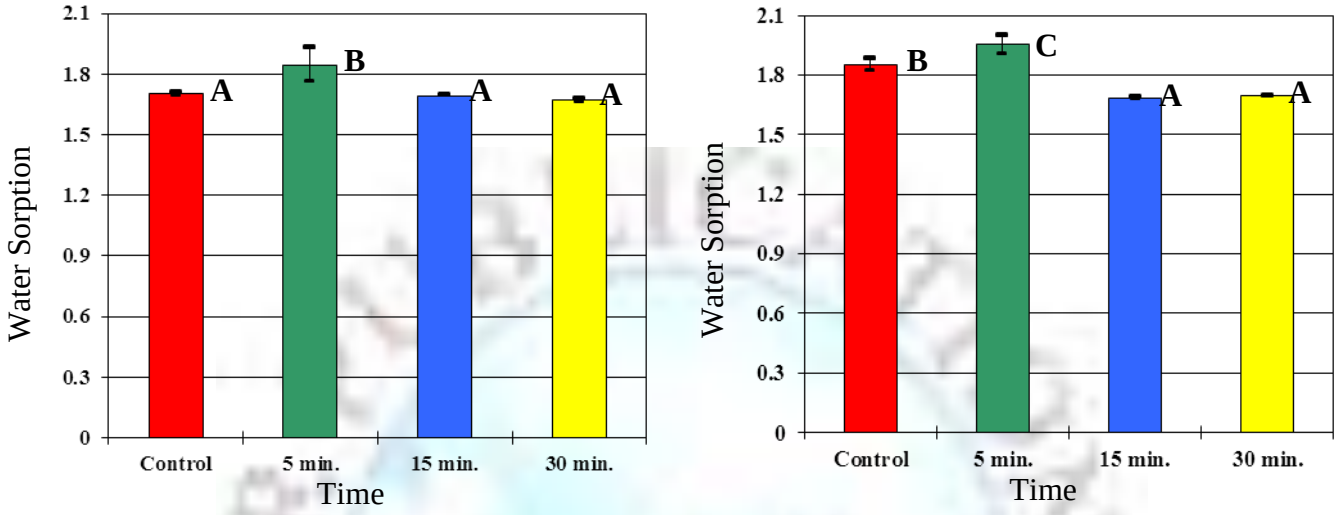
Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	0.226	0.002	117.596	8	0.000*
	Clear	5	0.467	0.004			
5 min.	Pink	5	0.639	0.004	161.143	8	0.000*
	Clear	5	0.246	0.004			
15 min.	Pink	5	0.542	0.024	19.740	8	0.000*
	Clear	5	0.334	0.002			
30 min.	Pink	5	0.390	0.003	31.373	8	0.000*
	Clear	5	0.342	0.002			

* Significant difference existed at 5% level

Paired sample (T-test) performed on both types of acrylic (Pink and Clear) comparing means of surface roughness at four periods of time (control) (5, 15, 30) min as in Table (4.14), demonstrated a significant difference in surface roughness, means of two types of acrylic (Pink and Clear) at four period of time.

4.2.2 Water Sorption Results :

4.2.2.1 Water Sorption Results Before exposure to "MRI" water sorption means and standard deviation for the tested groups at different periods of time (5, 15, 30) min within control group for both (Pink and Clear) acrylic were shown in Figure (4.8).



A. Pink B. Clear

Figure (4.8): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.15) and Duncan's multiple range test as in Figure (4.8) for two types of acrylic (Pink and Clear) demonstrated significant differences at $P \leq 0.05$ in water sorption (before exposure) for both types of acrylic (Pink and Clear) at (one-two) period of total period of time (5, 15, 30) min within control group.

Water Sorption Before

Table(4.15): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.095	3	0.032	16.944	0.000*
	Within Groups	0.030	16	0.002		
	Total	0.125	19			
Clear	Between Groups	0.255	3	0.085	100.391	0.000*
	Within Groups	0.014	16	0.001		
	Total	0.269	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.8)-A for (Pink) acrylic, demonstrated a higher means of water sorption (before exposure) at (15) min exposure sub-group than other tested sub groups.

Figure (4.8)-B for (Clear) acrylic, demonstrated higher means of water sorption before exposure for sub-group (5) min exposure than other tested sub-groups.

Table (4.16): Student's t–test

Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	1.702	0.008	10.656	8	0.000*
	Clear	5	1.853	0.031			
5 min.	Pink	5	1.844	0.086	2.482	8	0.038*
	Clear	5	1.954	0.049			
15 min.	Pink	5	1.692	0.004	3.482	8	0.008*
	Clear	5	1.684	0.004			
30 min.	Pink	5	1.669	0.007	7.990	8	0.000*
	Clear	5	1.696	0.003			

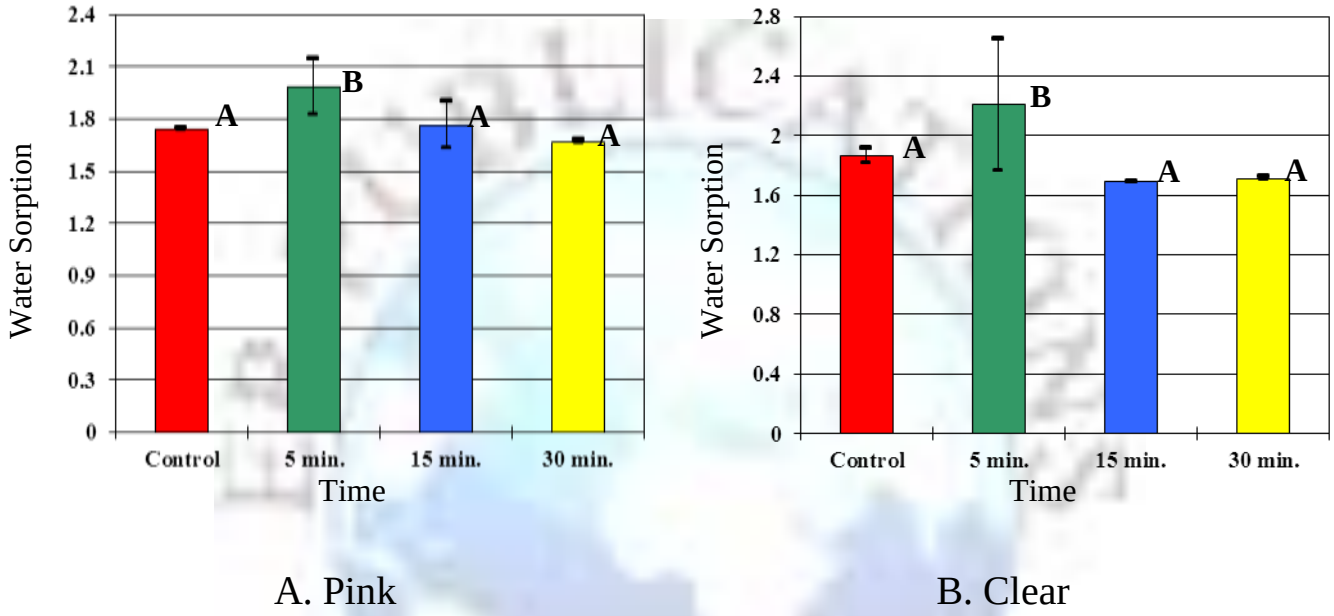
* Significant difference existed at 5% level

Paired sample (T-test) perform on both types of acrylic (Pink, Clear) comparing means of a water (control, 5, 15, 30) as in Tale (4.16)

demonstrated a significant difference at two period of time (control, 30 min) than other two periods, which show high significant.

4.2.2.2 Water Sorption (After Exposure to "MRI") Results :

Water sorption means and standard deviation for the tested groups at different period of time (5, 15, 30) min within control group of both (Pink, Clear) were shown in Figure (4.9).



A. Pink B. Clear

Figure (4.9): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.17) and Duncan's multiple range test as shown in Figure (4.9) for two types of acrylic (Pink, Clear) demonstrated significant difference at $P \leq 0.05$ in water sorption after exposure for both types of acrylic (Pink, Clear) at three periods of time (5, 15, 30) , within control group.

Water Sorption After

Table (4.17): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.280	3	0.093	8.421	0.001*
	Within Groups	0.178	16	0.011		
	Total	0.458	19			
Clear	Between Groups	0.861	3	0.287	5.690	0.008*
	Within Groups	0.807	16	0.050		
	Total	1.669	19			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.17) –A for (Pink) acrylic, demonstrated higher means of water sorption after exposures tested sub-group, which show no significant difference.

Figure (4.17)-B for (Clear) acrylic, demonstrated higher means of water sorption after exposure at (5) min exposure sub-group, than other tested sub-groups, which show no significant difference.

Table (4.18): Student's t–test

Group	Acrylic	No.	Mean	± SD	t–value	df	*p*–value
Control	Pink	5	1.741	0.010	5.394	8	0.001*
	Clear	5	1.863	0.050			
5 min.	Pink	5	1.987	0.163	1.036	8	0.330
	Clear	5	2.208	0.446			
15 min.	Pink	5	1.767	0.133	1.323	8	0.222
	Clear	5	1.688	0.005			
30 min.	Pink	5	1.671	0.008	5.627	8	0.000*
	Clear	5	1.711	0.014			

* Significant difference existed at 5% level.

Paired sample T-test performed on both types of acrylic (Pink, Clear) comparing means of water sorption after exposure at four period of

time (control, 5, 15, 30) min as in Table (4.18), demonstrated a significant difference at two period of time than other two periods.

4.3 Residual Monomer Results:

4.3.1Residual Monomer (Control) Results:

Residual monomer (control) means and standard deviation for the tested group at different periods of time (1st day, … 5th day), for both (Pink, Clear) acrylic were shown in Figure (4.10)

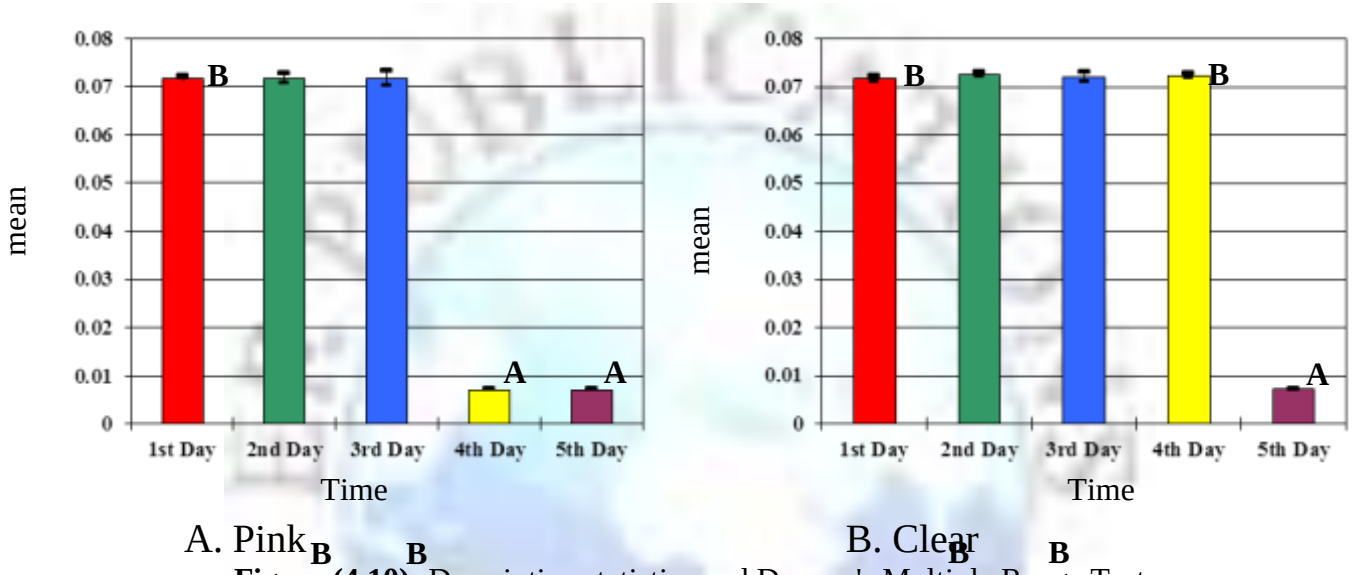


Figure (4.10): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in table (4.19) and Duncan's multiple range test as shown in Figure (1.10) for two types of acrylic (Pink, Clear) demonstrated a significant difference at $P \leq 0.05$ in residual monomer control for both types of acrylic (Pink, Clear) at (one-two) periods of the total periods of time (1st day … 5th day).

Residual Monomer (Control)

Table (4.19): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.015	4	0.004	4630.641	0.000*
	Within Groups	8.1076	10	8.1077		
	Total	0.015	14			
Clear	Between Groups	0.010	4	0.003	6334.486	0.000*
	Within Groups	4.0066	10	4.0067		
	Total	0.010	14			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.10) A- for (Pink) acrylic, demonstrated a higher means of residual monomer release for sub-groups (1^{st}., 2^{nd}., 3^{rd}.,) day, than other tested sub-groups (4^{th}. And 5^{th} day), although the first three days showed no significant changes in release within 1^{st}, 2^{nd}., 3^{rd}., day. Sub-groups itself.

Figure (4.10) B- for (Clear) acrylic, demonstrated a higher means of residual monomer release for sub-groups (1^{st}., 2^{nd}., 3^{rd}., 4^{th}) days, than other tested sub-group 5^{th} day. Although, no significant difference means were shown within these (1^{st}, 2^{nd}., 3^{rd}., 4^{th}.). Sub-groups itself.

4.3.2 Residual Monomer (5 Minutes Exposure) Results :

Residual monomer (5 min exp.) means and standard deviation for the tested groups at different periods of time (1^{st} day, …, 5^{th} day) for both (Pink, Clear) acrylic, were shown in Figure (4.11).

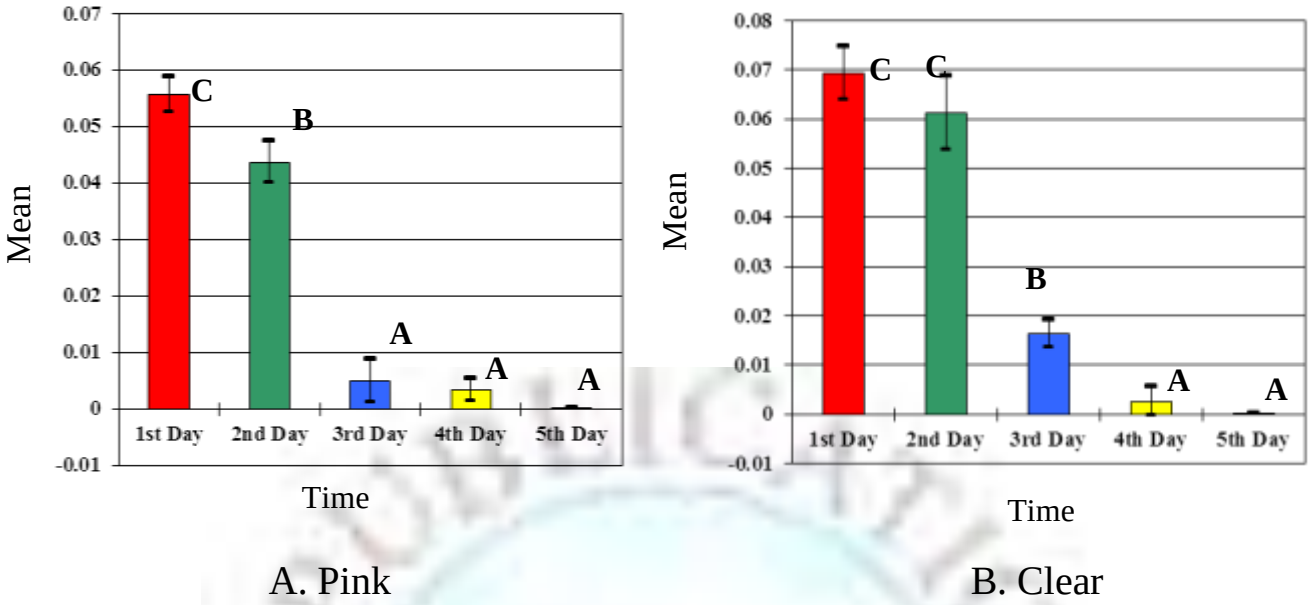


Figure (4.11): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.20) and Duncan's multiple range test as shown in Figure (4.11) for two types of acrylic (Pink, Clear) demonstrated a significant difference at (two three periods of total periods of time (1^{st}., 5^{th} day) and at $P \leq 0.05$.

Residual Monomer (5 Minutes)

Table (4.20): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.008	4	0.002	232.945	0.000*
	Within Groups	8.7855	10	8.7856		
	Total	0.008	14			
Clear	Between Groups	0.013	4	0.003	162.889	0.000*
	Within Groups	2.0074	10	2.0075		
	Total	0.013	14			

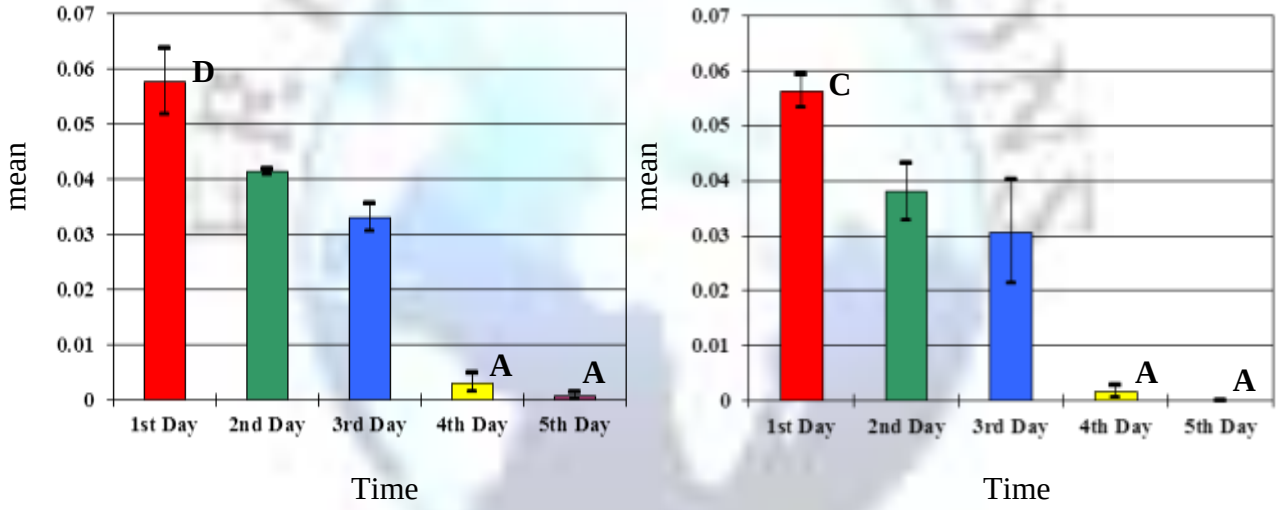
* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.11) A- for pink acrylic, demonstrated higher means of residual monomer release for (1st day) sub-group than other tested sub-groups.

Figure (4.11) B- for (Clear) acrylic, demonstrated higher means of residual monomer release for 1st. and 2nd days sub-groups than other tested sub-groups.

4.3.3 Residual Monomer (15 Minutes) Exposure Results :

Residual monomer (15 min Exp.) means and standard deviation for the tested groups at different periods of time (1st day., 5th day), for both (Pink, Clear) were shown in Figure (4.12).



A. Pink B. Clear

Figure(4.12): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) shown in Table (4.21) and Duncan's multiple range test as shown in Figure (4.12) for the two types of acrylic (Pink, Clear) at $P \leq 0.05$ demonstrated a significant difference at different periods of time

Residual Monomer (15 Minutes)

Table(4.21): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.007	4	0.002	191.503	0.000*
	Within Groups	9.65	10	9.66		
	Total	0.007	14			
Clear	Between Groups	0.007	4	0.002	68.900	0.000*
	Within Groups	2.564	10	2.565		
	Total	0.007	14			

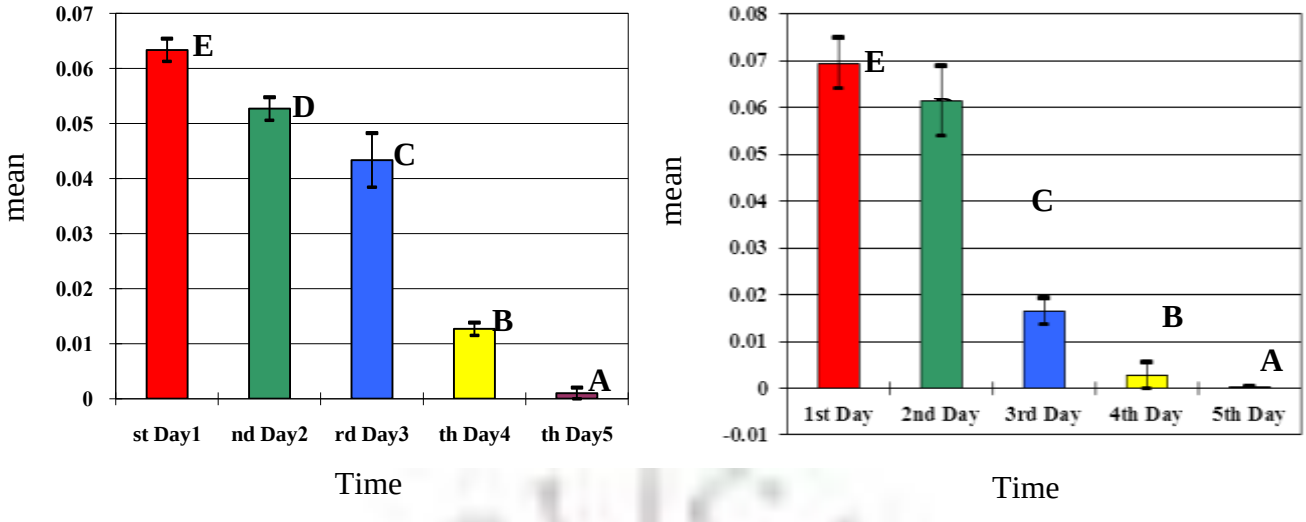
* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.12) A- for pink acrylic, demonstrated higher means of residual monomer release at 1st. day sub-group treatment, than other tested sub-groups.

Figure (4.12) B- for (Clear) acrylic, demonstrated higher means of residual monomer release at 1st. day sub-group tested, than other tested sub-groups.

4.3.4 Residual Monomer (30) Minutes) Exposure Results :

Residual monomer (30 min. exp.) means and standard deviation for tested groups at different periods of time (1st., 5th., days and for both type (Pink, Clear) acrylic, were shown in Figure (4.13).



A. Pink B. Clear

Figure (4.13): Descriptive statistics and Duncan's Multiple Range Test

One way analysis of variance (ANOVA) show in Table (4.22) and Duncan's multiple range test as shown in Figure (4.13) for the two type of acrylic (Pink, Clear) at $P \leq 0.05$ demonstrated a significant difference of release at different periods of time.

esidual Monomer (30 Minutes)

Table (4.22): Analysis of variance (ANOVA)

Acrylic Type	SOV	SS	df	MS	F–value	*p*–value
Pink	Between Groups	0.009	4	0.002	301.236	0.000*
	Within Groups	7.0675	10	7.0676		
	Total	0.009	14			
Clear	Between Groups	0.008	4	0.002	247.894	0.000*
	Within Groups	8.0055	10	8.0056		
	Total	0.008	14			

* Significant difference existed at 5% level.
SOV: Source of Variance; SS: Sum of Squares; df: Degree of Freedom; MS: Mean Square.

Figure (4.13) A- for (Pink) acrylic, demonstrated significant higher means of residual monomer release at (1st. day), sub-group treatment, than other tested sub-groups.

Figure (4.13) B- for (Clear) acrylic, demonstrated significant higher means of residual monomer release at (1st. day) sub-group treatment, than other tested sub-groups.

4.4 FTIR and NMR Result :

4.4.1 FTIR Chart Results :

The chemical changes that may be expected to happen by exposure to "MRI" of both types of acrylic resin "Pink and Clear" were studied via Fourier Transform Infrared Spectroscopy "FTIR" plots which are shown in Figures (4.14-4.21) for the eight tested "Pink and Clear" specimens within control samples.

These plots demonstrated bonds in between two carbon atoms C=C for methylmethacrylate, all tested specimens examined for different wavelengths of peaks (1731, 1260-1000, 3100-2900).

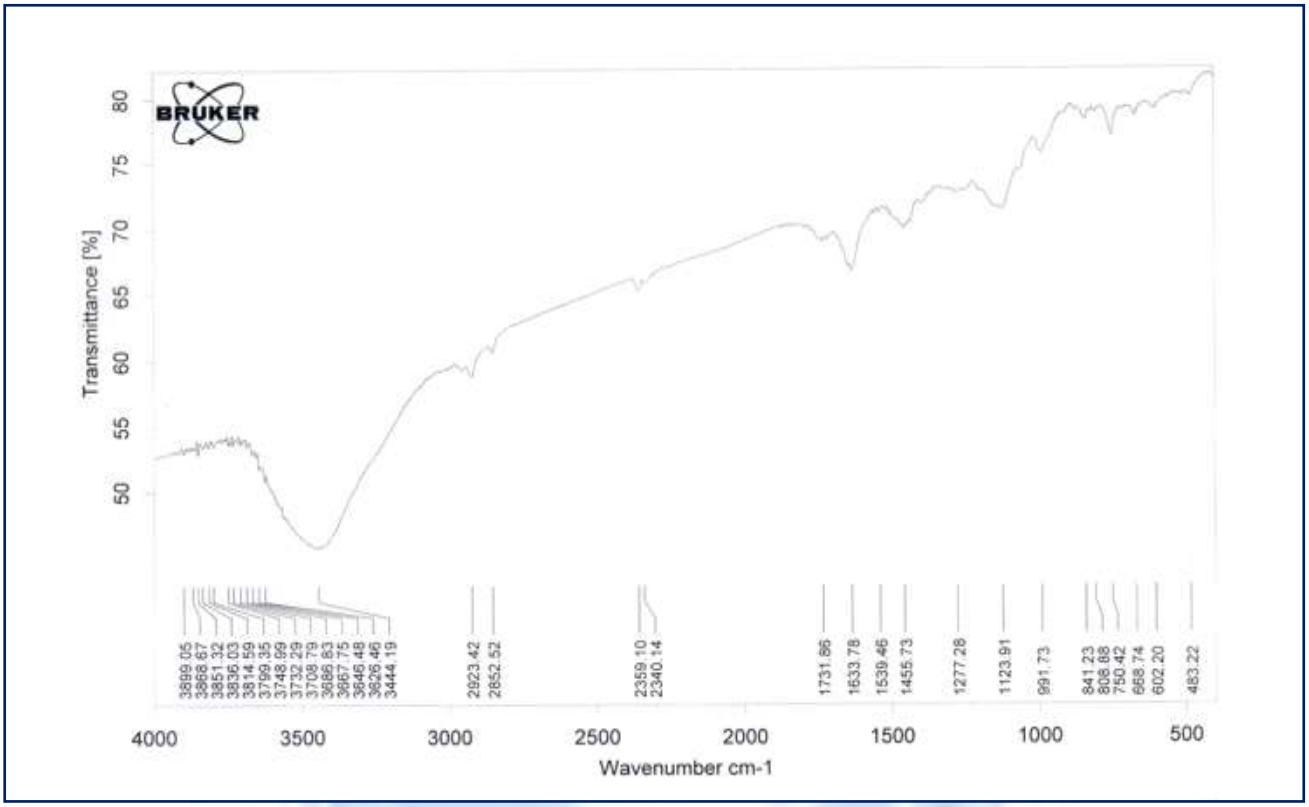


Figure (4.14) : FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.) exposure showing C=C bond at different peak level.

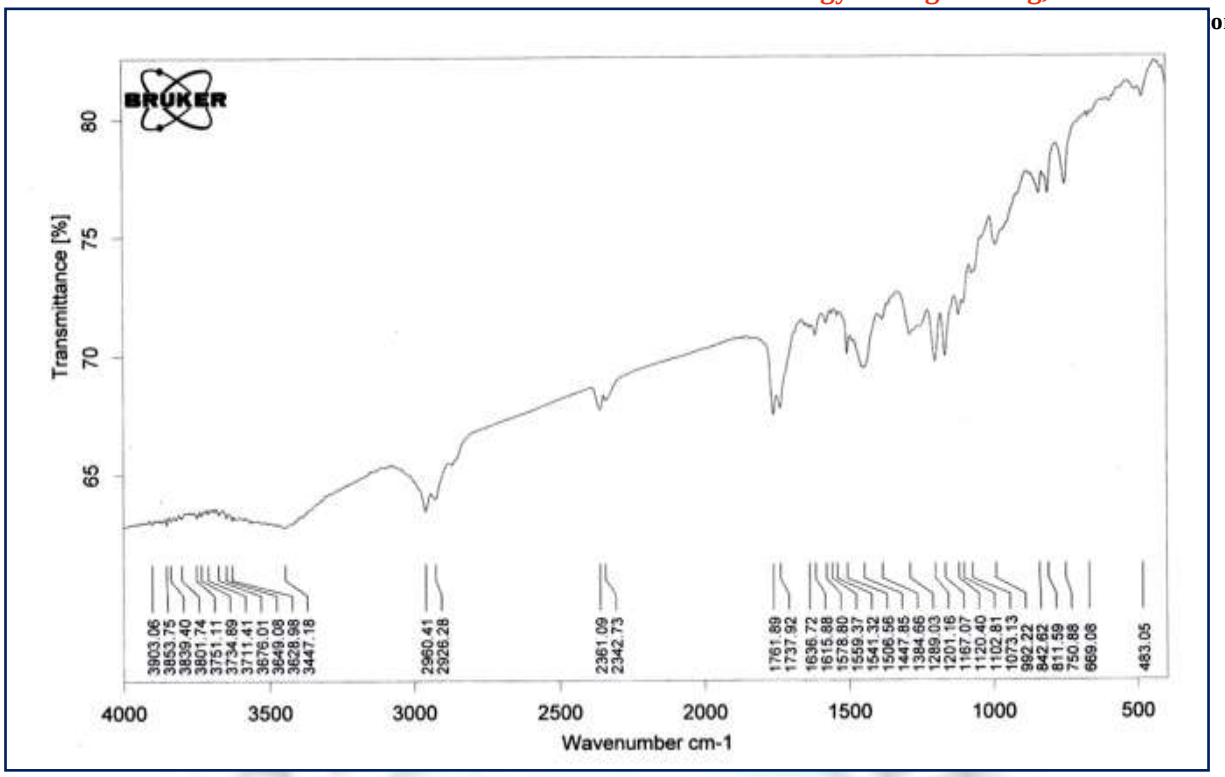


Figure (4.15): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.) exposure showing C=C bond at different peak level.

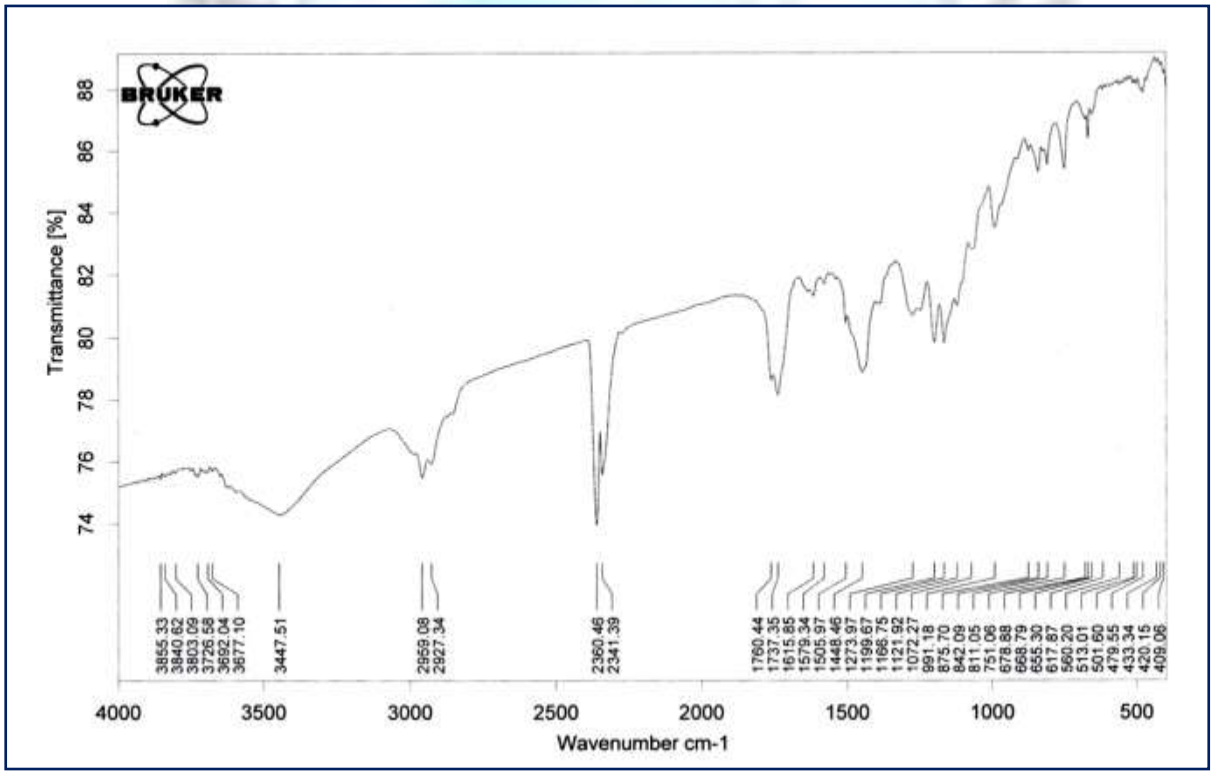


Figure (4.16): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.)

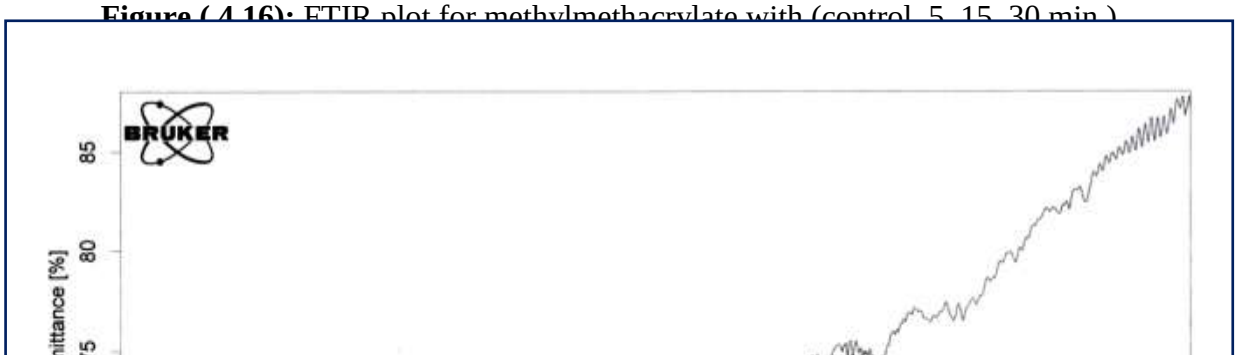


Figure (4.17): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.) exposure showing C=C bond at different peak level.

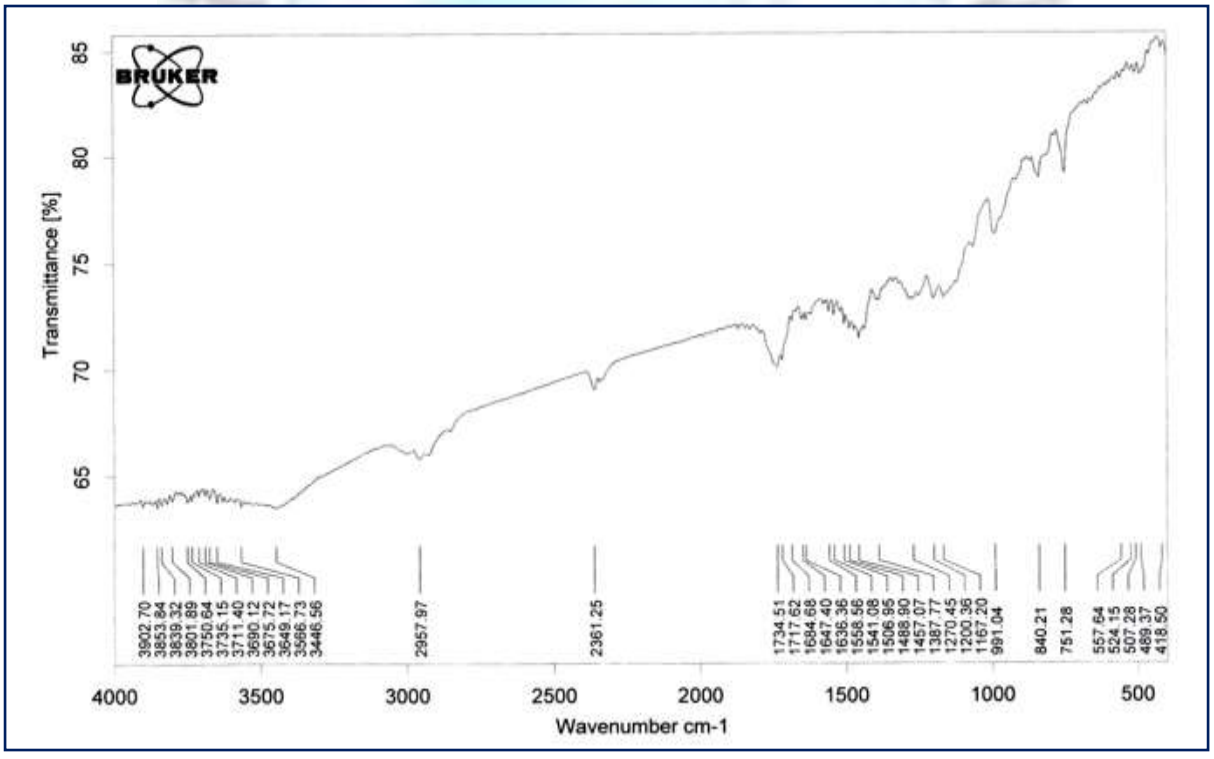


Figure (4.18): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.)

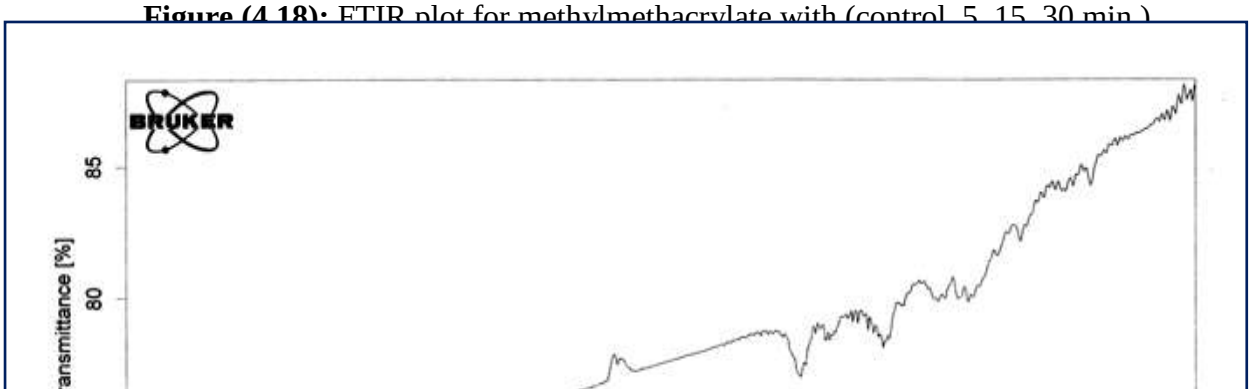


Figure (4.19): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.) exposure showing C=C bond at different peak level.

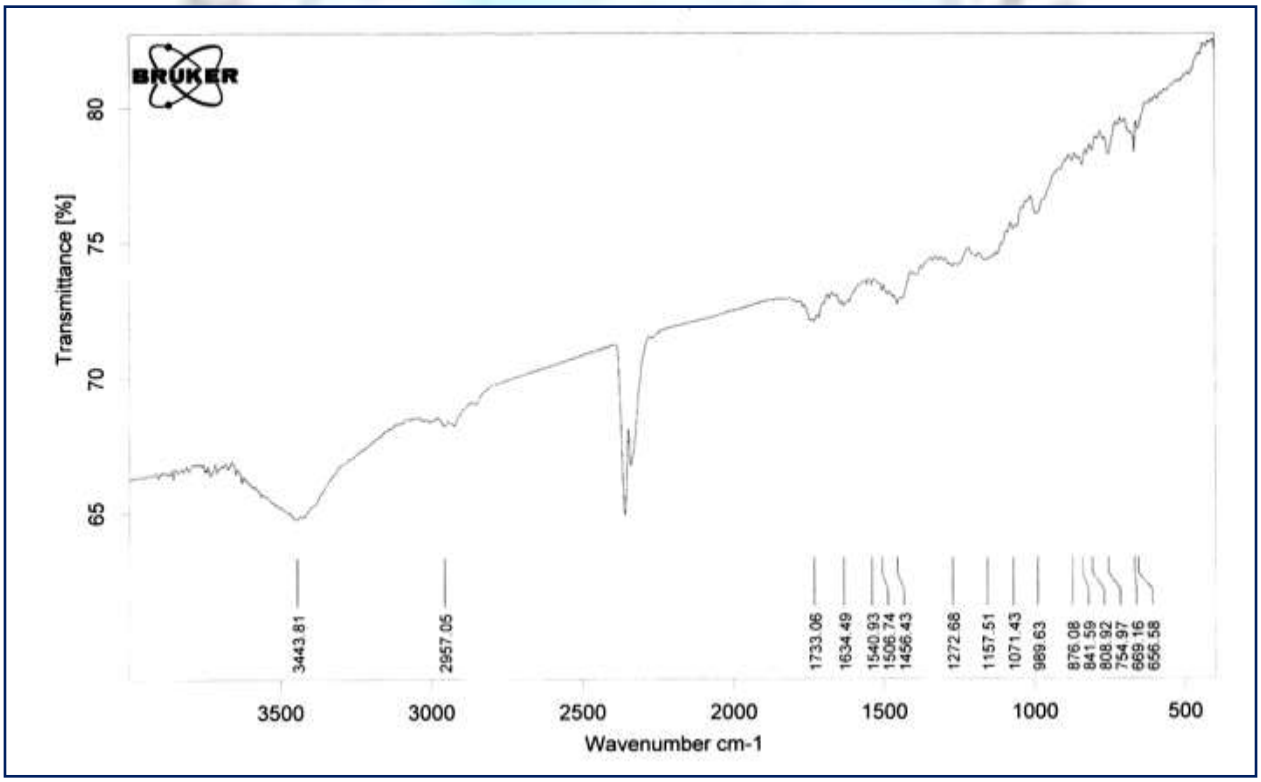


Figure (4.20): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.)

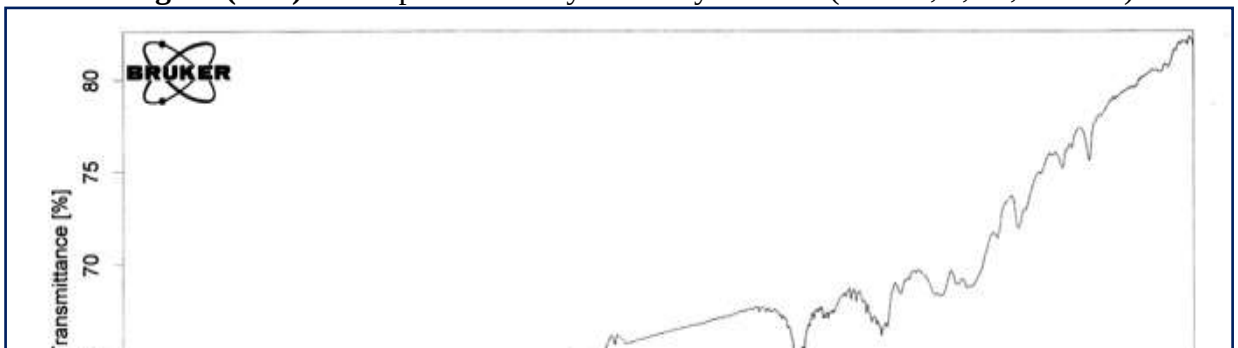


Figure (4.21): FTIR plot for methylmethacrylate with (control, 5, 15, 30 min.) exposure showing C=C bond at different peak level.

4.4.2 NMR Chart Results :

Results obtain in Figures (4.22 to 4.24) shown synthesized PMMA and results of peak at different plots shown that a sharp peak at "1731" cm^{-1} appeared due to presence of ester carbonyl group stretching vibration, the broad peak ranging from "1260-1000"cm-1 be explained owing to the C–O (ester bond stretching vibration, the broad band from 950-650 cm^{-1} is due to bending of C–H and the large broad peak ranging from 3100-2900 cm^{-1} is due to the presence of stretching vibration. "Vibration of bonds in between two atoms" without alter the main atoms (Balamurugan et al., 2004). "NMR" results shows in Figures (4.22, 4.23. 4.24) demonstrated that methylmethaacrylate did not chemically altered, only rotation movement of molecule has happen and the main feature is to be obtained due to the presence of the "methoxy carbon" ($-OCH_3$) at σ = 3.57-3.64

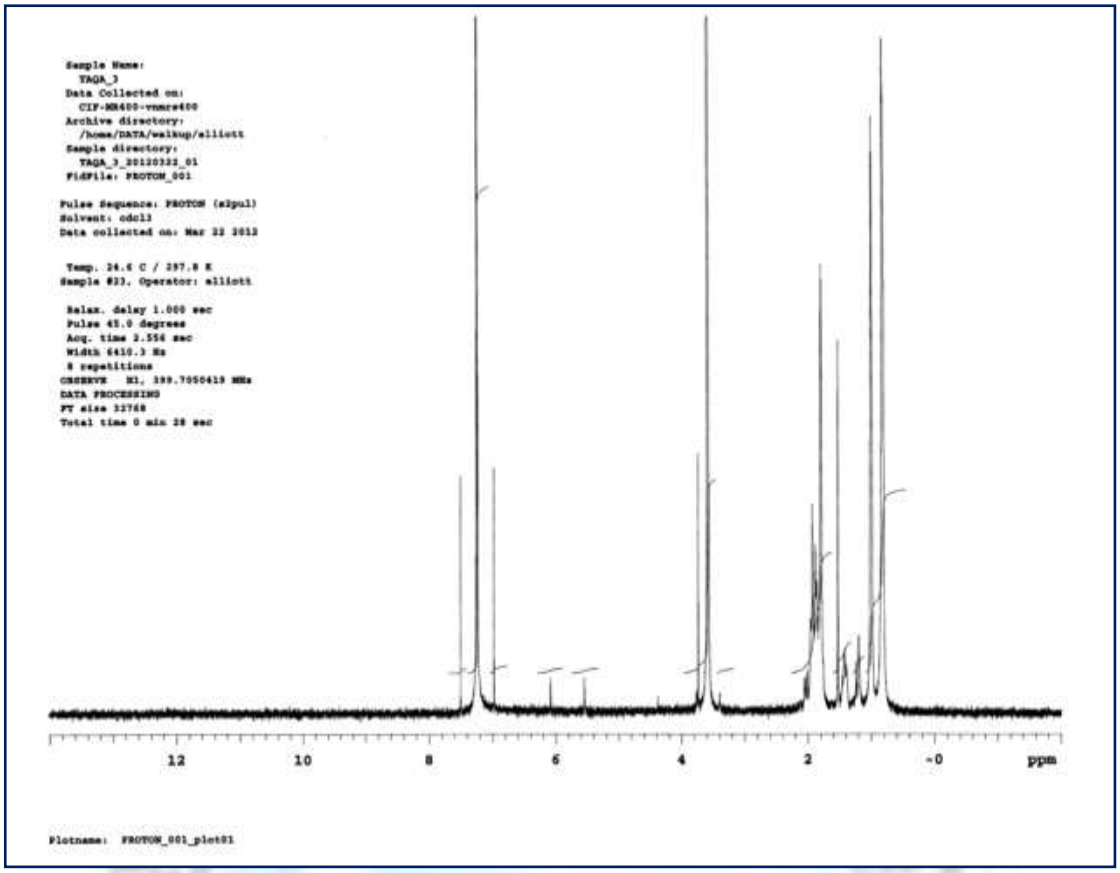


Figure (4.22): Plot of NMR Chart for control sample methyl methacylate

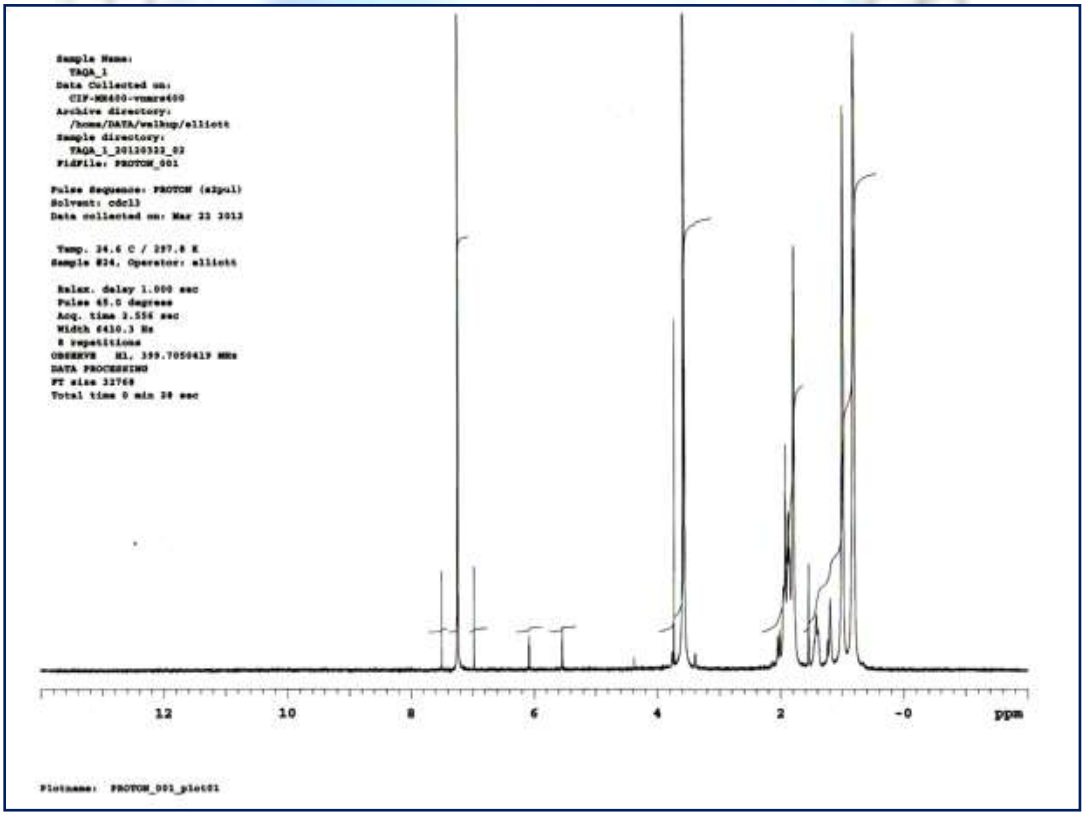


Figure (4.23): Plot of NMR Chart for five minute exposure clear methyl methacylate

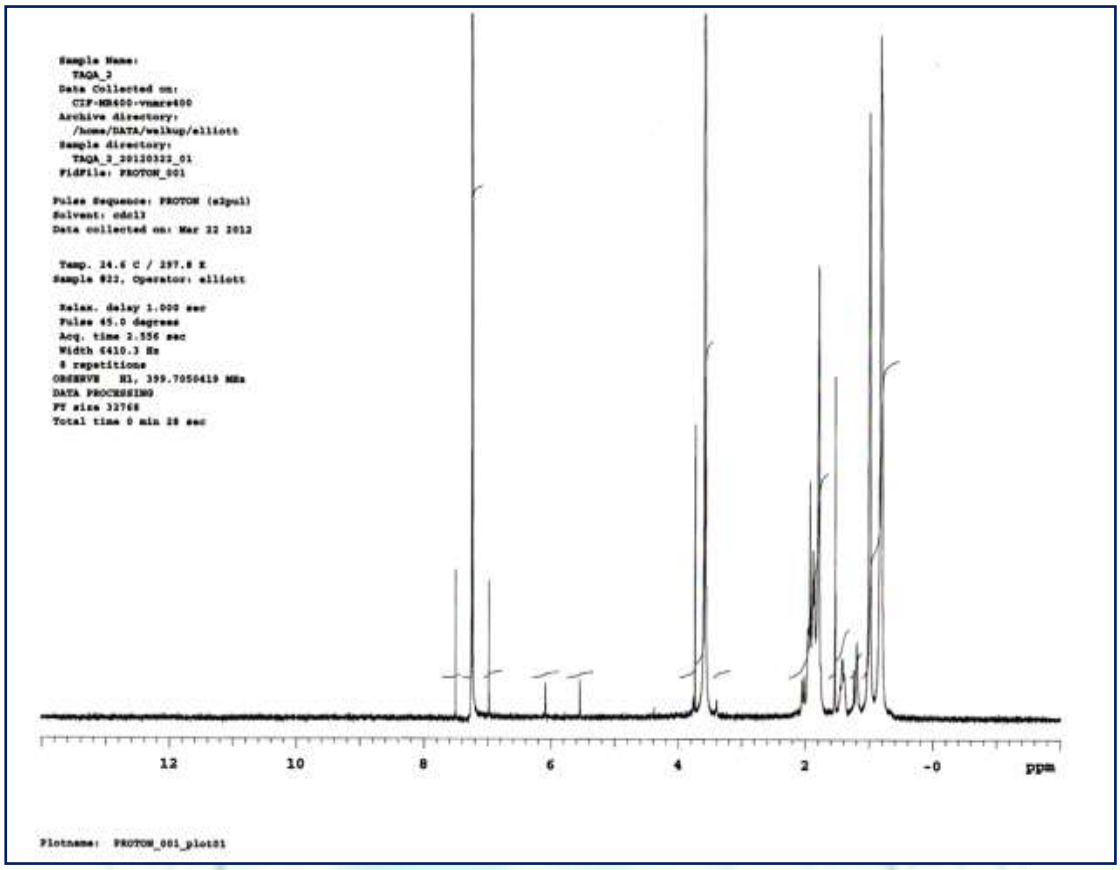


Figure (4.24): Plot of NMR Chart five minute exposure pink methyl methacylate

CHAPTER FIVE

DESCUSSION

5.1. Rockwell ''Indentation'' Hardness :

Indentation hardness Rock well hardness results for two types of acrylic "Pink and Clear" at different periods of time as shown in Figure (4.3-A).A noticeable increase explained in hardness means for all tested sub-groups (5 min., 15 min., 30 min) with a noticeable higher means for (30) min sub-group in comparison with other tested sub-groups, and with a significant value as seen in Table (4.5).

There was a significant value of indentation hardness for Clear acrylic as shown in Figure (4.3-B) with high noticeable value for (15) min tested sub-group in comparison with other tested (sub-groups) and with significant at $P \leq 0.05$.

Results found in Figure (4.3-A) and Table (4.5),demonstrated a significance at $P \leq 0.05$. in indentation hardness among time intervals. This result is in agreement with Huettel s.(2010) who concluded that with the increase in the magnetic resonance, the "precession or Lamar frequency" is proportional to the strength.

The results obtained in Figure (4.3-B) and Table (4.5) showed a significant result at $P \leq 0.05$. It can be explained by fact that composition of Pink acrylic is different from that of Clear acrylic by (dyes, stains, shades) used in Pink acrylic and not used in Clear acrylic which lead to altering in response to (MRI) wave This explanation is in agreements with (Wange et al., 2004), who found that a geometric distortion can arise from a variety of sources, a part from chemical and susceptibility differences.

Results obtained by Table (4.6) showed significant differences at four periods of time of two types of acrylic Pink and Clear, and at P≤ 0.05.This may be explained by the fact that Pink and Clear acrylic are chemically match, but they showed a compositional differences, which can be responsible for significant difference existence.

5.2. Spectrophotometer (Color stability) :

Spectrophotometric result (color change) measurement of both types of acrylic Pink and Clear at different periods of time (5, 15, 30min.) within control were shown in Table (4.4- A_B) and it is showed a noticeable increase in means for (15) min sub-group than other tested sub-groups for Pink acrylic in Figure (4.4-A), while for Clear acrylic as in Figure (4.4-B) a noticeable increase in means of multiple sub-groups with highly significance at (control) sub-group, with highly significance demonstrated at P≤ 0.05 as shown in Table (4.7).

It was shown that results obtained by Figure (4.4)-A_B were in agreement with the finding of (Craig *et al*., 2004), who clearly demonstrated that the composition of Pink acrylic contain mercuric sulfide or ferric oxide brown pigments which are ferromagnetic material.They can be synchronized and among in trapezoidal form, mainly after exposure to (MRI) for period.Once it arranges, no morel effect happen, while results founded in Figure (4.4-B) for Clear acrylic are in agreement with the finding of (Edelman *et al*., 1996) and (Craigl *et al*.,2004) since clear acrylic with no pigments and replaced by "titanium dioxide" to increase opacity.Thus the enhanced absorption of the energy occured when exposed to external magnetic field,it is much more high. Based on" Lamar Equation" and results in avariable degree of absorption at different periods of time .

The results obtained and shown in Table (4.8) may be explained by same principle mentioned before, since the significant difference at P ≤ 0.05 at four periods of time was due to compositional differences in chemical structure.

5.3. Dimensional Accuracy :

Dimensional accuracy results from both types of acrylic Pink and Clear at different periods of time (5, 15, 30) min within control group and at P ≤ 0.05 were shown to be in Figure (4.5).

Figure (4.5-A) for Pink acrylic demonstrated a noticeable differences at means value for different tested sub-groups and with significant higher means for (5) min sub-group than other tested.The results obtainedis in agreement with Craig .,(2004) who foundthat both types of acrylic powder are present in small spheres called (beads) or (pearls) .The increase of Pink acrylic are surrounded by inorganic pigment like (cadmium sulfide) once expose to (MRI) lead to alter in original arrangement of these inorganic particles and result in the increase of molecular weight and dimensional changes.

Figure (4.5-B) for (Clear acrylic) showed a results that are almost to be equivalent four tested sub-groups. Control and 15 min sub-groups and (5,30) min. sub-groups.This result agreed with Craig *et al*,(2004), that acrylics powder sphere (beads) are filling the matrix with no inorganic compound so exposure to (MRI) creates a repeated circle of energy between" sphere to sphere" and "sphere to matrix" with periodic expansion as polymerization began.

Table (4.10) refer to both types Pink and Clear acrylic resin, comparison between results at four periods of time showed a significant difference at two periods of time (5, 15) min. than other periods .This result is in agreement with (Edelman *et al*.,1996) as the other in chemical

environment can modify a resonance frequency and electron cloud surrounding the nucleus of an atom shields, which led to change the effective local magnetic field experienced.

5.4. Tensile Strength :

Tensile strength results shown in Figures (4.6-A and B) for both types Pink and Clear acrylic exposed to (MRI) at different periods of time (5, 15, 30)min. and at $P \leq 0.05$ showed a significant difference as shown in Table (4.11) to refer to higher means at (15) min. sub-groups for both Pink and Clear acrylic than other tested sub-groups and the results shown in Figure (4.6-A) for Pink acrylicmay be explained due to the fact that Pink acrylic contains Ferromagnetic material.This leads to the increasing susceptibility to" magnetism changes" with several magnetic lines and at different degrees depending on time,dose of exposure.

The results shown in Figure (4.6-B)for clear acrylicis in agreement with Leon *et al*., (2005). Founded that clear acrylic contain more spaces between polymer chains and contain cross-linking agent to compensate for translucent color.These diamagnetic composition weakly repeating lines of magnetic and reduce magnetic field about million fold than applied field at low time exposure and high time exposure. Lead to opposite polarity (repelling), the significant differences in results showe in Table (4.12) of both Pink and Clear acrylic can be explained basically on different compositions of acrylic types lead to different magnetic susceptibility.

5.5. Surface Roughness :

Surface roughness results shown in Figure (4.7-A_B) for both types of acrylic "Pink and Clear" and at different periods of time (5, 15,

30) min and at $P \leq 0.05$, it is showed a significant difference as shown in Table (4.13).

The results in Figure (4.7-A) for Pink acrylic, demonstrated a noticeable high means of (5) min sub-group than other tested sub-groups, and this result is in agreement with, Andersen P.(2011)andCraig *et al*.,(2004) found that altering of surface condition by mechanical finishing and polishing can have different effect that incase of Pink acrylic lead to critical region of stress concentration which together within ferromagnetic particles exist in Pink acrylic lead to high response at exposure to (MRI).

Figure (4.7-B) for clear acrylic demonstrated a significant difference and noticeable higher means for (control) sub-group than other tested sub-groups . This result may be due to Weakley repelling property of Clear acrylic ,thus high dose of(MRI) only can alter acrylic specimens in compare to control.

Table (4.14) results of both Pink and Clear acrylic and at four periods of times shown significant differences.This result is in agreement with the finding of Bushong s.(2003) who found that different exposure to (MRI) create a different area of magnetic domains with different orientation and strength.

5.6. Water Sorption :

Water sorption results obtain for both experiments (water sorption before exposure to MRI) and(water sorption after exposure to MRI) that were shown in Figures (4.8) and (4.9) respectively and showed a significant differences at one or two sub-group than other tested sub-groups and at $P \leq 0.05$.

The results shown in Figure (4.8-A) for Pink and Clear acrylic demonstrated a noticeable higher means at (5) min sub-group than in other tested sub-groups for Pink acrylic (4.8-A).

Figure (4.8-B) for clear acrylic demonstrated higher means for (control, 5 min.) sub-group.,Results in figures(4.8AandB) is in garment with (Pfeifeer and Rosenbauer, 2004) who concluded that water sorption is one of the properties of acrylates which responsible for many of dimensional instability and responsible for decrease in mechanical properties and changes result .

Figure (4.9) for Pink and Clear acrylic after exposure to "MRI" shown a noticeable higher mean at (5) min sub-group than other tested sub-groups for Pink acrylic (A), while for Clear acrylic, Figure (4.9-B) a higher means found to be much higher at sub-group (5)min. than other tested sub-group at $P \leq 0.05$.

The results in Figure (4.9) A_B is in agreement with (Bushon, 2003) that exposure to (MRI) alter surface characteristic and subjecting material to internal stress, result in Cracks formation who crack is easily change (net magnetization) lead to equilibrium and no more protons spin are happen with external field once it exposure to (MRI).

Results obtain in Tables (4.16) and (4.18) of both (Pink and Clear, acrylic at four periods of time and at two experiments (before and after exposure) to (MRI).

The results shown in Table (4.16) can be explained by fact that significance exists four periods due to chemical shift in each type of acrylic resin (Pink and Clear), while results shown in Table (4.18) may be explained by property of water (brounian motion) or (diffusion) as water particle diffuse through homogenous (MRI) lead to loss of signal (effects) and dephasing as in (control, 30 min.) sub-group than other tested groups (5, 15) min.

5.7. Residual Monomer:

5.7.1. Residual Monomer for Control Samples: They are shown in Table (4.19), which showed a significant value at P≤ 0.05 and in Figure (4.10-A_B) for (Pink and Clear acrylic, which showed a noticeable difference at no. of tested sub-group than other sub-groups.

The results in Figure (4.10-A_B) are mainly in agreement with finding of (Pfeifeer and Rosenbauer, 2004) , (Craige *et al*., 2004) and other scientists who founded that residual monomer release is one of the undesirable properties of acrylic and can affect mechanical properties.The difference released may be explained by previous explanation, since Pink acrylic contains ferromagnetic substance(materials with large and positive magnetic activity) and clear acrylic contains diamagnetic substance(materials that slight decrease magnetic field when placed with it) which explained to some degree variation in release.

5.7.2. Residual Monomer for (5 minute exposure to MRI): They are shown in table (4.20) which showed a significant difference exists at P≤ 0.05 and results shown in Figure (4.11-A_B) for Pink and Clear showed a noticeable higher means of release at(1^{st} day) sub-group than other test sub-groups for (Pink acrylic), while for (Clear acrylic in Figure (4.11-B) higher means are noticed at (1^{st}, 2^{nd}., day) sub-group than other tested sub-groups.

This results arein agreement with the findings of (Erickson and Coworkers, 1991) who found that orientation in the static field is responsible for the frequent occurrence of increased intensities several folds from normal tendon of (MRI) . This results in an increased residual monomer release,once it is exposed to (MRI)

5.7.3. Residual Monomer for (15 minute exposure to (MRI)):

Residual monomer results of (15) min. exposure is shown to be significant difference as in Table (4.21) and at $P \leq 0.05$, and results shown in Figure (4.12-A_B) for Pink and Clear acrylic resin are shown to be a noticeable higher means at (1^{st}) daysub-group of Pink acrylic (4.12-A) than other tested sub-groups, and for Clear acrylic (4.12-B), also a higher means are found at (1^{st})day sub-group than other tested sub-group.

This result found is in agreement with (Edelman, *et al*., 1996) who founded that the residual, undesirable magnetic gradient persist for a variable time, once exposure time exceeds (6-9) min,and it will resulted in a much more noticeable effect and more rapid deposing of transverse magnification.This together are with basic principle of high residual monomer relay with variable degree of differences at different sub-groups of two types of acrylic due to different chemical composition exsist a phenomena called (EDDY CURRENTS)

5.7.4. Residual Monomer for(30 minute Exposure to MRI) :

Residual monomer results of (30) min. are shown in Figure (4.13-A_B) for both types of acrylic Pink and Clear demonstrated a noticeable higher means at (1^{st} day) sub-group of both types of acrylic than other tested sub-groups and with significant difference as shown in Table (4.22) and at $P \leq 0.05$.

The results showed in Figure (4.13-A _B) are in agreement with findings of (Craig*et al*., 2004) who founded that residual monomer release is mainly high at (1^{st}) day and decrease until (4^{th},$5^{th)}$.,day where no release found and also can agree with (EDDY CURRENTS) phenomena since exposure tine is about (30 min) to MRI, result in typical residual monomer release over periodic time up to $5^{th)}$.,day.

5.8.Fourier – Transform Infra-red (FTIR) and Nuclear Magnetic Resonance (NMR) :

"FTIR" results obtained in Figures (4.14_4.21) showed synthesized "PMMA", and results of peak at different plots showed that a sharp peak at "1731" cm^{-1} appeared due to presence of ester carbonyl group stretching vibration.The broad peak ranged from 1260-1000^{-1} cm explained owing to the C–O (ester bond stretching vibration, the broad band from 950-650 cm^{-1} is due to bending of C–H and the large broad peak ranging from 3100-2900 cm^{-1} is due to the presence of stretching vibration. "Vibration of bonds in between two atoms" without alter the main atoms (Balamurugan *et al*., 2004). **"NMR" results** showed in Figure (4.22_4.24) demonstrated that methylmethaacrylate did not chemically altered or change, only rotation movement of molecule has happened and the main feature is to be obtained due to the presence of the "methoxycarbon"

(-OCH_3) at σ = 3.57-3.64

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CHAPTER SIX

CONCLUSIONS AND SUGGESTIONS

6.1. Conclusions:

With the limits of this study; it is concluded the following :

1. Exposure to magnetic resonance imaging "MRI" at different periods of time lead to change in physical properties of denture base material "heat cured acrylic resin", and this change happen at different levels and degree.
2. Denture base material "heat cured" exposed to "MRI" a different level of time exposure showed a change in the order of arrangement of atoms within same molecular.
3. "FTIR" test demonstrated a significant change in vibration of molecular "increased vibration of bonds in between two atoms" without alter the main atoms at different time exposure sub-groups.
4. "NMR" test results demonstrated that methylmethacrylate "heat cured" acrylic resin did not chemically altered or change since on rotational movement of the molecular has happened after exposure to "MRI" field.
5. In comparison between materials "Pink and Clear" acrylic resin at different time exposure within control group, there were significant difference for Rockwell hardness test, color change by spectrophotometer ,dimensional accuracy test, tensile strength test, surface roughness test.
6. In comparison between materials at different periods of time exposure, water sorption showed a significant difference at one or

two of tested sub-groups, while others showed lowest effect, at some tested sub-groups, the others showed lowest effect.

6.2 Suggestions :

1. Further investigations are needed to evaluate effect of "MRI" on other properties of heat cured acrylic resin weather, it is modified or it is flexible such as impact strength, shelf life, and others.
2. Further investigations are needed to evaluate effect of "MRI" on two separated materials like "Pink acrylic" or "Clear acrylic" alone and at longer periods of time, such as one hour continuous and intermittence.
3. A study is needed to evaluate the biocompatibility of material after exposure to "MRI" and to study the possibility of any "side effect" due to exposure and compare it with un-exposed specimens, and with "ADA" specification.
4. A study is needed on biological-properties of exposed "heat cured" denture base material in comparison with un-exposed "heat cured" denture-base material.

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