T. R.
VAN YUZUNCU YIL UNIVERSITY
INSTITUDE OF NATURAL AND APPLIED SCIENCE
DEPARTMENT OF MECHANICAL ENGINEERING

PRODUCTION OF GRAPHENE NANOCOMPOSITE MATERIALS FOR INFRARED BLOCKING APPLICATION

M. Sc. THESIS

PREPARED BY: Mohammad Salah JALAL
SUPERVISOR: Assist. Prof. Dr. Halil Ibrahim YAVUZ

VAN 2018

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ACCEPTANCE and APPROVAL PAGE

This thesis entitled "**PRODUCTION OF GRAPHENE BASED NANOCOMPOSITE MATERIALS FOR INFRARED BLOCKING APPLICATION**" presented by Mohammad Salah JALAL under supervision of Assist. Prof. Dr. Halil Ibrahim YAVUZ in the department of Mechanical Engineering has been accepted as a M.Sc. thesis according to Legislations of Graduate Higher Education on 31/08/2018 with unanimity / majority of votes members of jury.

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This thesis has been approved by the committee of The Institute of Natural and Applied Science on 02.11.2018 with decision number 2018/55/I

Signature

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Director of Institute

THESIS STATEMENT

All information existing in this thesis obtained according to the proper comportments and academic rule structure. Not all statement and information belongs to me. In this work prepared in agreement with the rules of these cited to the source of information.

Signature

Mohammad Salah JALAL

ABSTRACT

PRODUCTION OF GRAPHENE NANOCOMPOSITE MATERIALS FOR INFRARED BLOCKING APPLICATION

JALAL, Mohammad Salah
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Research & Development strategies has been developed under the project would first be to run Research & Development (R&D), and then to develop highly economically viable National Thermal Camouflage Nano-Composite Plastics and their composites, in order to gain high added value products. “Defense Industry Plastics” emerge as extraordinarily tactically important materials as a result of developing world policies and the geographical environment that we exist in. Lots of monitoring techniques are developed in order to recognize hostile factors in defense technologies. As such, the most important innovation brought about in this area is the acquisition of hostile targets that are not detected by human eye, but by the detectors (thermal cameras) able to produce signals that are based on the principle of absorbing the long wave infrared (IR) energy (heat). These detectors, by their nature of structure, work in two main functioning intervals; 3-5 μm or 8-12 μm. Camouflage is a tactical strategy to mislead and hide from enemy in natural environment. While it is possible to juke the apparent area detectors (bare eye cameras, classical cameras and so on) by various forms and patterns imitated from natural plants and soil texture, visual illusion (or camouflage techniques) requires expensive systems that are not easily applicable. Studies regarding the IR (infrared) wave length are diversified in new topics in scientific world. Most important ones are the reduction in loss of soldiers during night and winter operations, and outer metallic coatings developed for tanks and heavy armored vehicles to infiltrate into operation zones without being detected. As can be inferred from the recent incidents, a large proportion of losses of soldiers and military vehicles in our country results from terrorist weapons modified by thermal cameras or IR controlled heavy vehicles. Steps of theoretical approach can be named as follows: Performing ring opening reaction by using Sulfur and Divinyl-benzene, and using the method of vulcanization. Obtaining innovative polymers through polymerization mechanisms. Obtaining high IR (infrared) absorbing polymers while performing efficient reactions as a result of simultaneously increasing Sulfur dissolvability and crossed bindings in the compound modified by Graphene, Nanotube and Fulleren structures. Establishing a production chain in which the obtained new generation’s materials can be used in waste products and conducting research regarding the dissolvability of the new generation engineering products for easy disposal and easy application. Covering the surfaces (glass, metal, textile) with dissolved polymers obtained in the previous step by a spray covering method.

Key words: Graphene and Divinyl benzene, Infrared, Sulfur, Thermal camera.

ÖZET

KIZIL ÖTESİ ENGELLEME UYGULAMASI İÇİN GRAFEN NANOKOMPOZİT MALZEMELERİNİN ÜRETİMİ

JALAL, Mohammad Salah
Yüksek Lisans Tezi, Makine Mühendisliği Anabilim Dalı
Tez Danışmanı: Dr. Öğr. Üyesi Halil İbrahim YAVUZ
Ekim 2018, 45 Sayfa

Gelişen dünya politikaları ve bulunduğumuz coğrafi çevre etkisi nedeni ile, "Savunma Sanayii Plastikleri" ayrı bir taktiksel öneme sahip malzemeler olarak ön plana çıkmaktadır. Savunma teknolojilerinde düşman unsurların tespiti için birçok görüntüleme teknikleri geliştirilmektedir. Yine bu alanda getirilen yeniliklerin en önemlisi düşman hedeflerinin insan gözünün algılayamadığı uzun dalga boylu enerjiyi (ısıyı) soğurma prensibini esas alan ve sinyal üreten detektörler (Termal Kameralar) ile tespitidir. Bu detektörler yapıları gereği iki ana çalışma dalga aralığında çalışmaktadır; Bunlar sırası ile 3-5 μm ya da 8-12 μm arasıdır. "Kamuflaj" doğal hayatta düşmandan saklanmak, düşmanı şaşırtmak için kullanılan askeri taktiksel bir strateji yöntemidir. Doğal bitki ve toprak dokusunu taklit ederek çeşitli form ve desenler ile görünür alan detektörlerini (çıplak göz, klasik kameralar gibi) yanıltmak mümkün iken, termal kameralarda görüntü yanıltılması (veya kamuflaj teknikleri) kolay uygulanamayan ve pahalı sistemler gerektirmektedir. Kızıl ötesi (KÖ) dalga boyundaki çalışmalar bilim dünyasında yeni konu başlıkları altında açılmaktadır. Bunların en önemlileri gece yada kış operasyonlarında asker kayıplarını azaltma, tank yada ağır zırhlı araçların termal kameralara yakalanmadan operasyon bölgesine ulaştırılması için geliştirilen metalik dış kaplamlardan oluşmaktadır. Son günlerde yaşanan olaylarda da açıkça görüldüğü gibi, Türkiye'mizin asker ve araç zayiatlarının büyük bir bölümünü terörist unsurların ellerindeki termal kamera modifiyeli edilmiş silahlar yada kızıl ötesi güdümlü ağır silahlardan kaynaklanmaktadır. Bu calismada kükürt ve divinil benzen ile vulkanizasyon yöntemi kullanılarak, polimerizasyon mekanizması üzerinden polimerleştirilmiş yenilikçi polimerler elde eldilmistir. Grafen nanotüp, fulleren gibi yapılar ile bu polimerlerin modifikasyonları neticesinde ile verimli polimerleşme

reaksiyonları elde edilirken yüksek kızıl ötesi (KÖ) absorblama yeteneğine sahip yenilikçi polimerler elde edilmiştir.

Anahtar kelimeler: Benzen, Grafen ve Divinil, Kükürt, Kızıl ötesi, Termal Kamuflaj.

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2018

Mohammad Salah JALAL

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LIST OF ABBREVIATIONS

Some symbols and abbreviations used in this study are presented below, along with descriptions.

Symbols	**Description**
µm	Micrometer
n	Refractive index
kg	Kilogram
G	Gram
L	Liter
S	Sulfur
Pb	Lead
S_8	Octa-sulfur

Abbreviation	**Description**
IR	Infrared
DVB	Divinylbenzene
DIB	Diisopropenylbenzene
TIC	Thermal imaging camera
NMR	Nuclear magnetic resonance
TB	Thermal blocker
PVP	Polyvinylpyrrolidone

LIST OF APPENDIX

1. INTRODUCTION

When the light is divided through the spectrum will be some types, most types of invisible one of them is Infrared light (IR). An Infrared light is that it has a wavelength longer than those of visible light, and the wavelength is smaller than microwave light. It is detected for first time by William Herschel (1738-1822) in 1800 (Rogalski, 2012; Rowan-robinson, 2013). The wavelength of infrared light is start from 700nm to 1mm (Marzuki et al., 2015) and its classified to three main types, Near infrared light(0.7µm to 3µm), Mid infrared light(3µm to 6µm) and Far infrared light (6µm to 1000µm) (Astarita et al., 2001; Huang et al., 2017).Infrared light can be applied for many applications like Thermal camera, Night-vision, Communication, Heating, Astronomy, etc.

The ratio of the speed of light in a vacuum to its velocity in a given center is called refractive index (n) (Shobha et al., 2001). Infrared light like other lights will be refracted when passing through different center, some of the materials they are non organic have high refractive index like Silicon, Germanium and glasses that have silicon contain they are used in some infrared tools but these materials are inherently difficult to process, more expensive and toxic compare to organic polymeric materials (Sanghera et al., 2002; Zhang et al., 2008). Some of polymers have high refractive index like sulfur and Phosphorus (Shobha et al., 2001), there are a chance to design polymeric materials for IR optics that possess higher refractive indexes, solution processing and low loss. Polymers that have sulfur (S_8) contain can be process by inverse vulcanization process (Chung et al., 2013), increase its temperature to it will be a melting sulfur (S_8) the molten sulfur, which acting as a solvent in the vulcanization process (Chung et al., 2011), that is copolymerized with .pure Divinylbenzene (DVB) to prepare sulfur plastic that is process able and stable. This process that conducted in molten sulfur is called bulk free radical copolymerization (Griebel et al., 2014). The copolymers and composites based on sulfur make the elemental sulfur a promising alternative to hydrocarbon-based materials (Han et al., 2014). These materials are intriguing for IR optics, because the S-S bonds in the copolymer are impart high refractive index (n) to the macromolecule and largely IR inactive in the mid-infrared and near-infrared regime

(Griebel et al., 2014).

Sulfur and its composites or copolymers especially divinylbenzene one of the Chalcogenide-semiconductors (Mecerreyes et al., 2016; Diez et al., 2017), when Graphene is doped to sulfur copolymers its conductivity will increase. Semiconductor materials can be convert any type of energy to energy, for that can be convert infrared light energy to electrical or to any other energy. Because of that sulfur copolymers can be applied to some of infrared camera tools (thermal camera and night vision camera) like a lens for night-vision and photo-detector and blocker for thermal camera (Griebel et al., 2014).

Sulfur copolymers are a viscous or solid material (Salman et al., 2016), it can be solute in the some of the acids like Chloroform and Dichloromethane, to make a solution for a coating production process (Salman et al., 2016). In the production processes have some techniques like ink-jet, printing, spin-coating and spray-coating that is useful for solution applied, for sulfur and its copolymers solution best technique is Spray coating production process (Girotto et al., 2009).

2. LITERATURE REVIEW

2.1. Thermal Imaging Camera (TIC)

Thermograph is one of the non-destructive testing that operates on the principle of infrared light (IR), thermograph offers wide area detection of subsurface defects with non-contact to the surface, and it can be used as a complement or alternative to traditional inspection technologies (Kaplan, 2007).

Thermograph can be classified into two approaches, the active approach and the passive approach. Passive approach tests materials and structures which are naturally at different temperature than ambient but active approach, an external stimulus is necessary to induce relevant thermal contrasts (Maldague, 2002).

2.2. History of Thermal Imaging Camera (TIC)

The first person that discovered Infrared light spectrum is Herschel at 1800 while searching for the new method which would reduce the brightness of the image of the sun in telescopes (Rogalski, 2012). At 1821 Thomas Johann Seebeck non-directly begins the debate on the nature of heat and light, Based on the experiments induced with an electrical current flow in closed circuits. Nobili constructed the first thermopile by connecting a number of thermocouples in series at 1829 (Barr, 2000; Rogalski, 2002). Modified design of thermocouple by Melloni at 1833 and used antimony and bismuth for it design (Barr, 1962; Rogalski, 2002).

John Herschel was successes to develop the first thermal image, by using the dissimilar evaporation from a thin film of oil when exposed to the heat pattern at 1840.in the history of IR significant breakthrough was achieved by Langley by inventing bolometer at 1880, Langley used two thin ribbons of platinum foil, connected so as to form two arms of a Wheatstone bridge, Langley continued to develop his bolometer. His latest bolometer could detect the heat from a cow at a distance of quarter of mile. Therefore, at the beginning development of IR detectors was connected with thermal detectors (Barr, 1963).

The photon detectors were developed in twentieth century. At 1917 Case developed the first IR photon-detectors (Case, 1917). Tihanyi became the first person to invent the first infrared sensitive camera in 1929, and was engaged in Britain military for anti-aircraft defense. In the University of Berlin, Kutzscher at 1933 discovered that lead sulfide was photoconductive and had response to near 3µm (Cashman, 1959; Rogalski, 2002).

Thermal imaging camera, TIC beginnings date back to 1947, when the first infrared scanner was launched. In the early 1950s the first extrinsic photoconductive detectors were reported, the first high performance extrinsic detectors were based on germanium (Rogalski, 2002). At that time it took one hour to create a single thermo gram. The army became interested in the new technology as they noted a huge range of possible applications in military technology and allocated substantial resources for researches. This led to the rapid development of infrared technology. Any civilian usage was only a derivative of any military applications. Civilian usage was limited due to not sharing semiconductor detector arrays of the highest resolution, or requiring a license from the civil users (Szajewska, 2017). It was by the late 1960's that IR cameras and usage of thermal imaging became accessible to the wide range of audience and not only to the military, British Navy was the first to apply the detection of infrared radiation to fight fires on ships. Rapid advances were being made in narrow band-gap semiconductors that would later prove helpful in extending wavelength capabilities andimproving sensitivity, In sb was the first material. A member of the newly discovered III–V compound semiconductor family (Rogalski, 2002, 2003). Saw the introduction of narrow gap semiconductor alloys at the end of the 1950s and the beginning of the 1960s, in IV–VI (Pb1–xSnxTe), III–V (InAs1–xSbx), andII–VI (Hg1–xCdxTe) material systems, these alloys allowed the band-gap of the semiconductor and hence the spectral response of the detector to be custom tailored for specific applications (Lawson et al., 1959; Rogalski, 2003).

At the late 1960 s, and early 1970s the difficulties in growing HgCdTe material, significantly due to the high vapor pressure of Hg, encouraged the development of alternative detector technologies over the past forty years. Had some materials that were vigorously pursued in parallel with HgCdTe one of these was PbSnTe (Ivars et al., 1970; Rogalski, 2003).

The new technology was very expensive, which limited its application to civil engineering. A special barrier was the cost of the detector which required cooling. Un-cooled IR arrays was developed, capable to imaging scenes at room temperature has been an outstanding technical achievement, public release of this information in 1992 surprised many in the world wide IR community because of much of the technology was developed under classified military contracts in the United States. At the end of the 90s TIC were equipped with detectors based on the Barium Strontium Titanium technology. They did not require cooling, which simplified their design and reduced their costs to the level acceptable for a large part of the civil fire service. Portable cameras were bulky and weight about 3.5 kg. To reduce their weight, their batteries were sometimes placed in a separate bag attached to a rescuer’s harness (Szajewska, 2017). Research institutions and production companies have been working on improving the technology. New types of un-cooled detectors with high temperature and spatial resolution have been developed. And matrix bolometer detectors proved to be particularly useful. More efficient batteries have been used. Cameras have become light, handy and they can operate for several hours without battery replacement. TIC cost has been reduced by about 80% (Szajewska, 2017).

2.3. Principle Working of Thermal Imaging Camera

Every object whose surface temperature is above absolute zero (-273 °C) radiates energy at a wavelength corresponding to its surface temperature, by using highly sensitive infrared cameras, capture this radiated energy in a thermal image of the object being surveyed. These digital thermal images can be captured directly from the camera for processing (Riou et al., 2004).

Heat radiation is available to infrared cameras at the mid-wave (3-5 µm) and long-wave (8-12 µm) ends of the spectrum, but is absorbed by moisture in the air in the center of the infrared spectrum. Generally speaking, the higher an object's temperature, the more infrared radiation is emitted as black-body radiation (Riou et al., 2004). A special camera can detect this radiation in a way similar to the way an ordinary camera detects visible light. It works even in total darkness because ambient light level does not matter. This makes it useful for rescue operations in smoke-filled buildings and underground. A major difference with optical cameras is that the focusing lenses cannot be made of glass, as glass blocks long-wave infrared light. Special materials such as Germanium or Sapphire crystals must be used. Germanium lenses are also quite fragile, so often have a hard coating to protect against accidental contact. The higher cost of these special lenses is one reason why thermo graphic cameras are more costly (Webber and Savage, 1976; Martini et al., 2004). And the photo-detector is a device that can convert the heat energy to the electrical energy to make an image by the processor and the display can show the image, show in Figure (2.1).

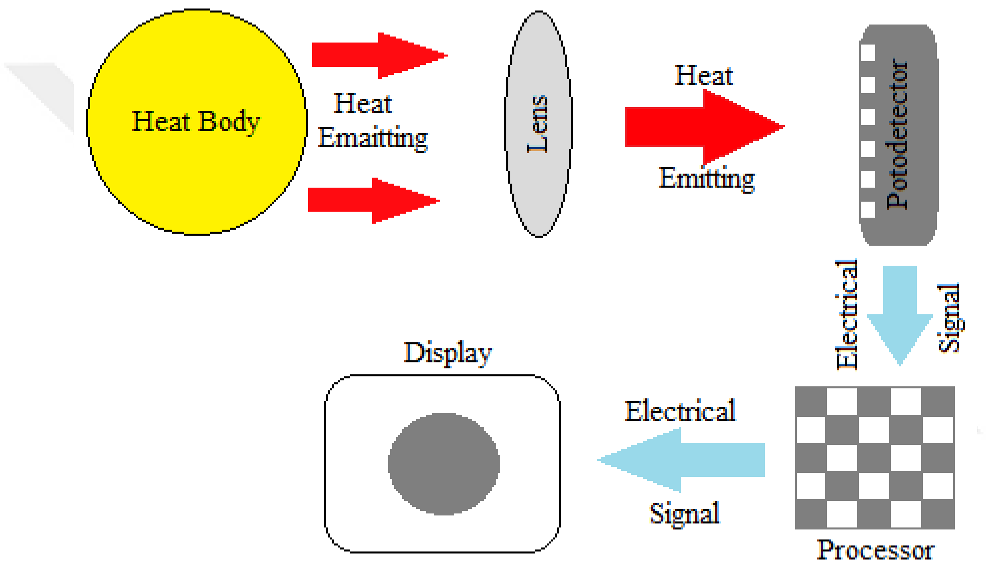


Figure 2.1. Principle working of thermal camera.

2.4. Infrared Detector

The transducer of radiant energy that converts radiant energy in the infrared into a measurable form is called Infrared Detector. An infrared detector is a detector which reacts to infrared energy. The two main types of IR detectors are thermal-detectors and photon-detectors (William, 2009). The response time and sensitivity of a photon-detector can be higher, but they generally have to be cooled in order to cut thermal noise (Rogalski, 2002). The materials in these photon-detectors are semiconductors with narrow band gaps.

2.4.1. Photon-detector

Semiconductors are sensitive infrared detector which can produce an electrical energy from optical energy by the internal photo electronic effect (Emmons et al., 1975). Radiation is absorbed within the semiconductor material by interaction with electrons. The observed electrical output signal results from the changed electronic energy distribution. The photon-detectors exhibit the selective wavelength dependence of the response per unit incident radiation power. They show both a very fast response and perfect signal-to-noise performance, but for obtain this, the photon-detectors require cryogenic cooling (Rogalski, 2003). Cooling requirements are the main obstacle to the more widespread use of IR systems based on semiconductor photo detectors making them heavy, expensive, bulky and inconvenient to use. Can be classify the photon-detector to the another types like extrinsic detectors, intrinsic detectors, quantum well detectors and photo-emissive detectors (Rogalski, 2002).

2.4.2. Thermal-detector

Thermal detector is a device that detects the incidence of electromagnetic radiation by measuring the temperature elevation of a substance caused by absorption of that radiation. Thermal detector can be use for any measurable property which has temperature effect on the object (William, 2009). Thermopiles and thermocouples depend on the See beck coefficient of semiconductors and metals (Emmons et al., 1975).

Thermal detector can absorb the thermal incident radiation and it will change temperature of the material that detected, the result is change of the physical properties like generating electrical output, the detector element is suspended on lags, which are connected to the heat sink (Rogalski, 2002, 2012). Thermal effects are generally wavelength independent the signal not depends upon its spectral content but upon the radiant power. In bolometer a change in the electrical resistance is measured, whereas in the case of pyro electric detectors a change in the internal spontaneous polarization is measured. In compare to photon detectors, the thermal detectors typically working at room temperature. They are generally characterized by slow response and modest sensitivity but they are easy to use and cheap. The greatest usefulness in IR technology has found thermopiles, bolometer and pyro electric detectors (Rogalski, 2002).

2.5. Infrared Camera Blocking

A hot object can be detected by the Infrared heat that it gives off with thermal imaging, while provides a difficult challenge to something or someone wishing to avoid detection. There are two techniques to making infrared camera blocking, first is apply semiconductor material to absorb and converting energy, second is refraction. The refraction is depending on the refractive index that is a ratio between speeds of light on the space to the light speed inside the material. Have some materials owner of high refractive index like Glass (Dony and Rindone, 1962), Aluminum alloy (Toon and Pollack, 1976) and nano-particle of Gold (Kubo et al., 2007).

Principle working of most infrared camera blocking is applying the semiconductor materials because of that convert any type of energy for another type of energy (Figure 2.2). When any object is heated, the infrared light will be radiate and emit the photons, this photon that radiated seated on the semiconductor material surface and it wants to crossing from the valence-band by band-gap to conduction-band, by crossing the type of energy convert from infrared light energy to the another type of energy. This converting cause to don’t detecting by the infrared camera, because the infrared camera can be detects just infrared light.

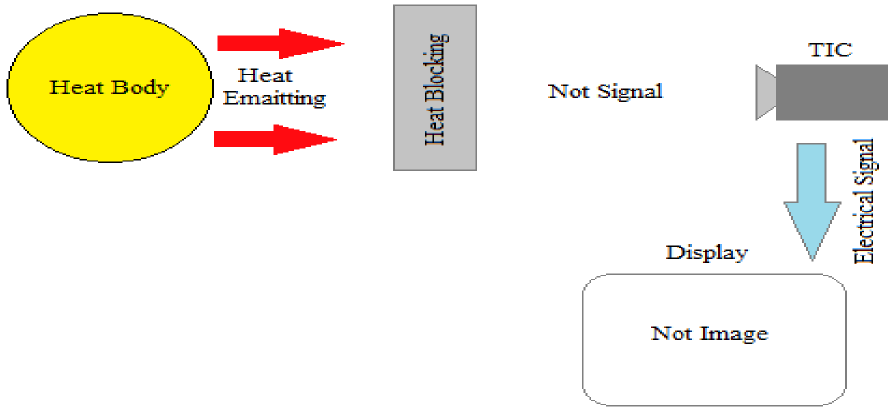


Figure 2.2. Principle working of infrared light blocking.

2.6. Heat Transfer

Heat transfer, is the movement of thermal energy from an object to another object of different temperature. These objects could be a solid, a liquid or gas, or even within a liquid or gas (Lienhard, 2013). Heat can be transfer by three main methods, is conduction through direct contact as a solid, convection through fluid movement (Bejan, 2013), and radiation through electromagnetic waves (Modest, 2013). Heat transfer happen while the temperatures of objects are not same to each another and indicate to how this difference is changed to an equilibrium state (Bruns, 2007), thermodynamics then deals with things that are in the equilibrium state. Thermal camera must be detecting the temperature on the surface of objects by non-conduct tests and IR blocking must be insulate heat transfer, for that heat transfer ways is important for the thermal camera (Figure 2.3).

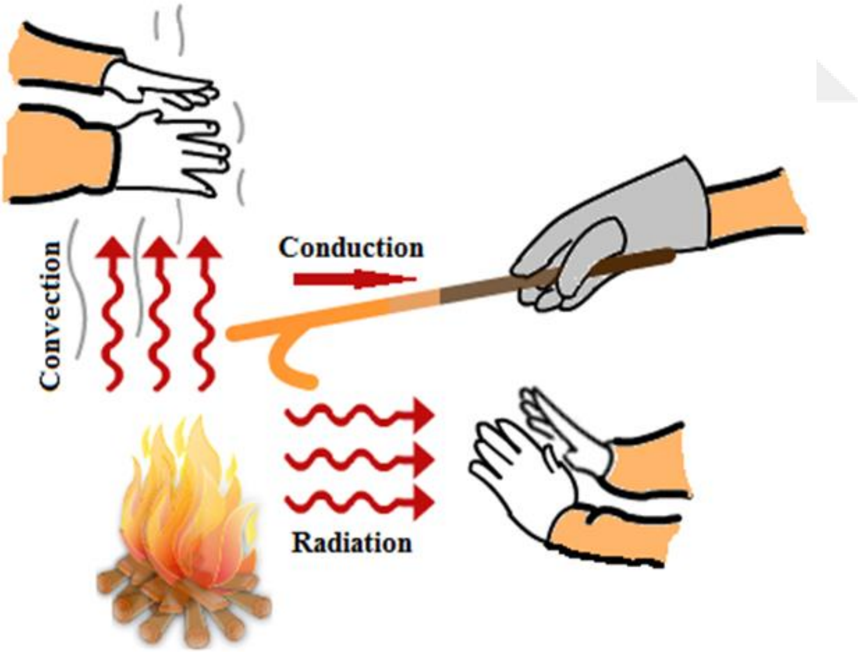


Figure 2.3. Heat transfer types.

2.6.1. Conduction heat transfer

Conduction happen when two object at various temperatures are in contact with each other, the cooler object take the heat from the warmer object until they are both at the same temperature (Bergman et al., 2011).The motion of heat through a substance by the collision of molecules is called conduction heat transfer. When the tow object contacted, the molecules of hot object collide to the molecules of cooler object, the molecules of cooler object take heat from the molecules of hot object, this operation continues till heat energy from warmer object spreads throughout cooler object (Aziz, 2003; Bergman et al., 2011). The perfect materials to the conduction are metals. conduction heat transfer depend on the rate of heat conduction, temperature difference across the material, thickness of the layer, area of the material and thermal conductivity of the material per unit thickness (Bejan and D. Kraus, 2003).

2.6.2. Convection heat transfer

Convection is usually the most efficient way to transfer heat in gases and liquids (fluid), convection happen while warmer zone of a fluid rise to cooler zone in the fluid (Bejan, 2013). When these occur, cooler fluid takes place of warmer areas that have risen higher (Atreya, 2016). This cycle will be continuous of heat circulation until the temperature will be in steady state. Convection heat transfers depend on area of the surface, convective heat transfer coefficient of the process and temperature difference between the surface and the bulk fluid.

2.6.3. Radiation heat transfer

Convection and conduction both of them need a matter to heat transfer but radiation heat transfer does not rely upon any contact between heated object and heat source. Radiation can be transmitting the heat through empty space. Thermal radiation is type of electromagnetic radiation like as infrared light (Modest, 2013). Infrared radiation isn’t need to the medium and its type of light energy that is traveling as a speed of light (Howell et al., 2010; Bergman and Incropera, 2011). When high energy.

electrons in higher atomic level come down to lower energy level the objects emit a radiation. The lost energy is emitted like as light or any type of electromagnetic radiation. When any atom is absorb the energy causes its electrons jump to higher energy levels, temperature of object stay constant if absorption of energy equal to emitted energy, temperatures of object rise when absorption is greater than emitted energy, if absorption is less than emitted energy the temperature will be fall (Kreith et al., 2012). Principle working of both type of infrared camera is heat radiation. The photon detector and thermal detector detect the photons of the radiation.

2.7. Sulfur Polymerization

Sulfur (S) is a chemical element, which is discovered before Christ at the ancient India and ancient Greece. Sulfur has a bright yellow color at the room temperature, in the nature most of sulfur is as octa-sulfur (S_8) that has a shape of eight-member ring, and is tasteless and odorless. It is the most common allotrope of sulfur it is a major industrial chemical that occurs widely in nature (Kutney, 2007). Sulfur melts at a temperature only a little above the boiling temperature of water. Sulfur has a big role in the polymer science and polymer industry. Sulfur used for first time with lead (Pb) for thermal sensor at 1933 (Cashman, 1959), and at last year's could be detected sulfur can be use for thermal camera when it vulcanite with another materials like disopropenyl benzene (DIB) or divinyl benzene (DVB) (Griebel et al., 2014; Wei et al., 2015; Salman et al., 2016).

Polymers that have sulfur containing are great interest and come into much attention because of its wonderful properties which make them useful in a lot of applications. They can be used as engineering plastics (Berg et al., 2013), ion-exchange membranes (Salman et al., 2016), and high refractive index materials (Javadi et al., 2015).

Sulfur can be using for a process called vulcanization, it is a chemical process for converting related polymers into more durable materials or natural rubber by the addition of sulfur or accelerators or other equivalent curatives (Xiao et al., 2012). The polymer will modified by these addition to formation cross links between singular polymer chains (Xiao et al., 2012; Chung et al., 2013). Sulfur vulcanite with some of the monomers, polymers or materials, like as stearic acid (Heideman et al., 2004), zinc oxide (Heideman et al., 2005), antidegradants, diisopropenyl benzene (DIB) (Griebel et al., 2014; Wei et al., 2015) and Divinylbenzene (DVB) (Salman et al., 2016).

When sulfur well vulcanite with divinyl benzene (DVB), and the sulfur that is molted to vulcanite process working as a solvent to the divinyl benzene (DVB) (Chung et al., 2011), should be the divinyl benzene (DVB) and sulfur are pure or near to pure because of that at the end of process make a test of Nuclear magnetic resonance (NMR) to understand its chemical composition is good, at the end of process well produce a material that has a dark brown or black color and it is a viscous material known as poly (sulfur-random-divinyl benzene (S-r-DVB)). The new material working like another semiconductor material like a germanium and silicon for infrared light in a range of (0.9 µm to 14µm) (Salman et al., 2016), when it was compared to this material to the silicon and germanium, that is seen it has same property of them show in (Figure 2.4 and 2.5), because of this property this material can be used in state silicon and germanium or any other semiconductor material in the infrared camera, night vision camera or infrared video camera (Salman et al., 2016).

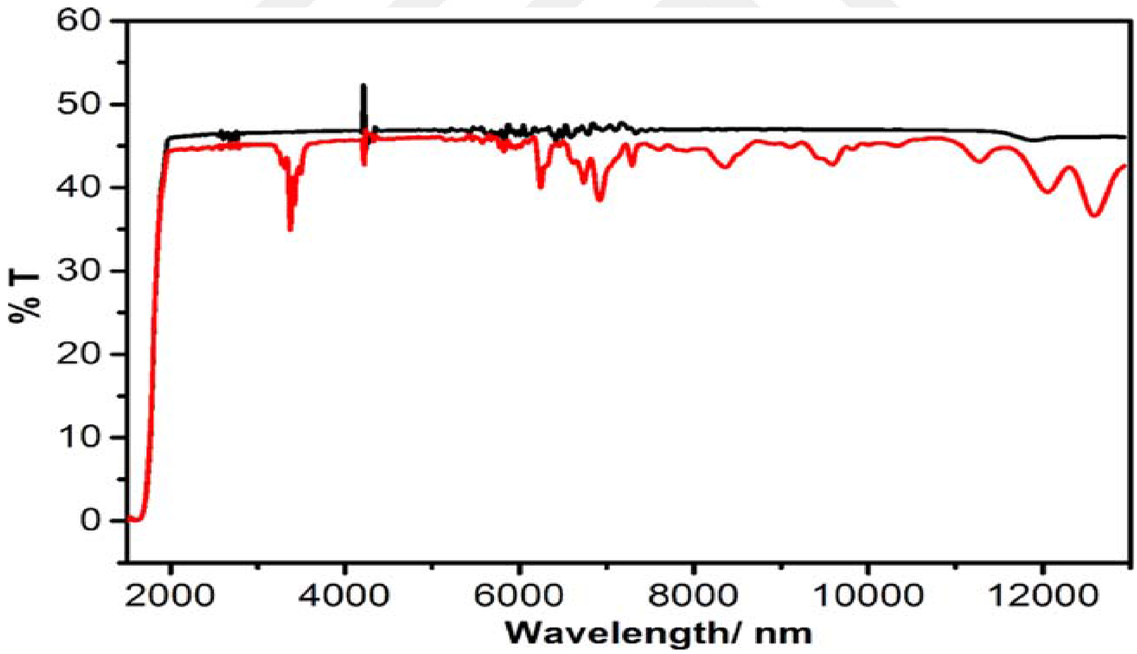


Figure 2.4. The comparison of percentage transmission between Germanium substrate (black line) and coated substrate with poly(S-r-DVB) with 60 wt % DVB (red line) (Salman et al., 2016).

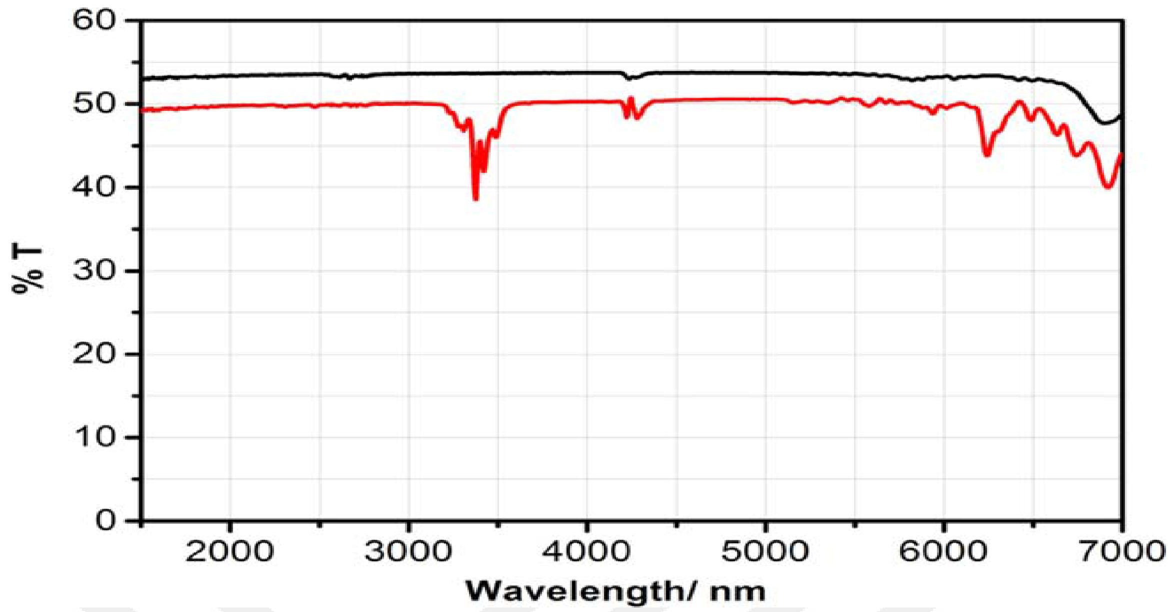


Figure 2.5. The comparison of percentage transmission between silicon substrate (black line) and coated substrate with poly(S-r-DVB) with 60 wt % DVB (red line) (Salman et al., 2016).

To inspect the percentage transmission of infrared light for poly (sulfur-random-divinyl benzene) copolymers, they were coated as thin films on germanium and silicon substrate to compare their percentage transmission, the samples showed the equal percentage transmission of 55% temperature. As well silicon was used instead of germanium also it observed same behavior (Salman et al., 2016). For poly (sulfur-random-divinylbenzene) can be increase its acting by doping with another material that have a better properties like as grapheme (Evers and Nazar, 2012).

2.8. Spray coating

Coating is manufacturing production process, that use for thin film production, coating is apply for the surface of something and it is referred to the substrate. Coating has a many technique for production like as chemical vapor deposition (Manning et al., 2004), physical vapor deposition (Helmersson et al., 2006), spin coating and spray coating etc (Natsume and Sakata, 2000; Bach and Krause, 2013). Spin coating is a good way to using in produce a uniform coating for desired thickness but it has a high material wastage, spray coating method have high potential to mass production, and this technique not have limits to substrate, spray coating without from a waste materials

(Aziz and Ismail, 2015).

The principle working of spray coating technique is a deposition, it has some types like as spray painting, plasma spraying and thermal spraying (Huang et al., 2004). Plasma or thermal spray coating are need to heating but painting spray not need to the heat. Spray coating can be used for manufacturing polymer materials because the polymer materials are viscose and they can be solute in the some solvent liquids (Susanna et al., 2011).

The poly (sulfur-random-divinyl benzene) is a viscose material (Salman et al., 2016), and it’s hard to make a spray coating because it's hard to sucking by air that make a spray, for that must be it make a solute by any anyone of the solvents that can to make the poly(sulfur-random-divinyl benzene) a liquid material. The materials they can make the Poly (sulfur-random-divinylbenzene) well be a liquid are chloroform($CHCl_3$), Tetrahydrofuran (C_4H_8O), toluene(C_7H_8), Dichloromethane (CH_2Cl_2), and 1,2-Dichlorobenzene (1,2-DCB) (Salman et al., 2016). Coating technique where a device sprays a coating polymer material through the air onto a surface is called a spray painting.

The most common kinds employ compressed gas generally air to atomize with direct the polymer particles. It’s containing from two main accessories first compressor second is a gun device. The compressor includes the compressor, thank of air and pressure gauge. And a gun device contains from the tank of polymer, the air tubes and activation button. Both accessories are connected by the tube that transmitted an air pressurized. Spray painting machine can be manually or automatic.

Principle working is the air is compressing bay the compressor, it well storage in the tank of air by the pressure gauge know has the air pressurize. The air will transmit by a tube to the gun machine, the copolymer materials added to the tank when the air pressurized is dashed it well sucking the materials inside a polymer storage tank and it’s spraying to the surface, the polymer material well deposition on the surface that wonted to coat, show in (Figure 2.6).

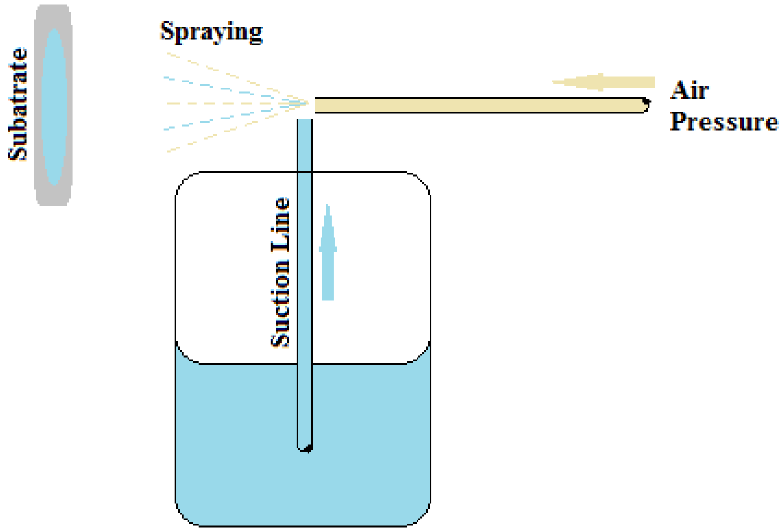


Figure 2.6. Spray principle working.

3. MATERIAL AND METHODS

3.1. Materials

In this project used some materials to preparing poly(sulfur-random-divinylbenzene (S-r-DVB)), like Sulfur as a solute material, Divinylbenzene like a solvent materials, Graphene for increasing a electronic conductivity, Glycerin to have a unique equal heating, Dichloromethane using as a solvent to preparing a final material to spry process.

3.2. Equipments

3.2.1. Tools

- Test-tube: as a reaction media.
- Beaker: as a bath for the media reaction.
- Stand and Clamp: for holding the test tube during a reaction.
- Syringe: for adding the liquid materials for the reaction media.
- Magnetic Stirrer: to stirring the solution.
- Cotton and glass: as sampling tools.
- Thermometer, Spatula, tongue, paper and etc: for helping during the operation.

3.2.2. Machines

- Sensitive balance machine: to weighting the materials.
- Heater and magnetic stirrer machine: for heating and continuous stirring the reaction. Show in (Figure 3.1).
- Spray machine: for spraying a final product on the glass and cotton surface.

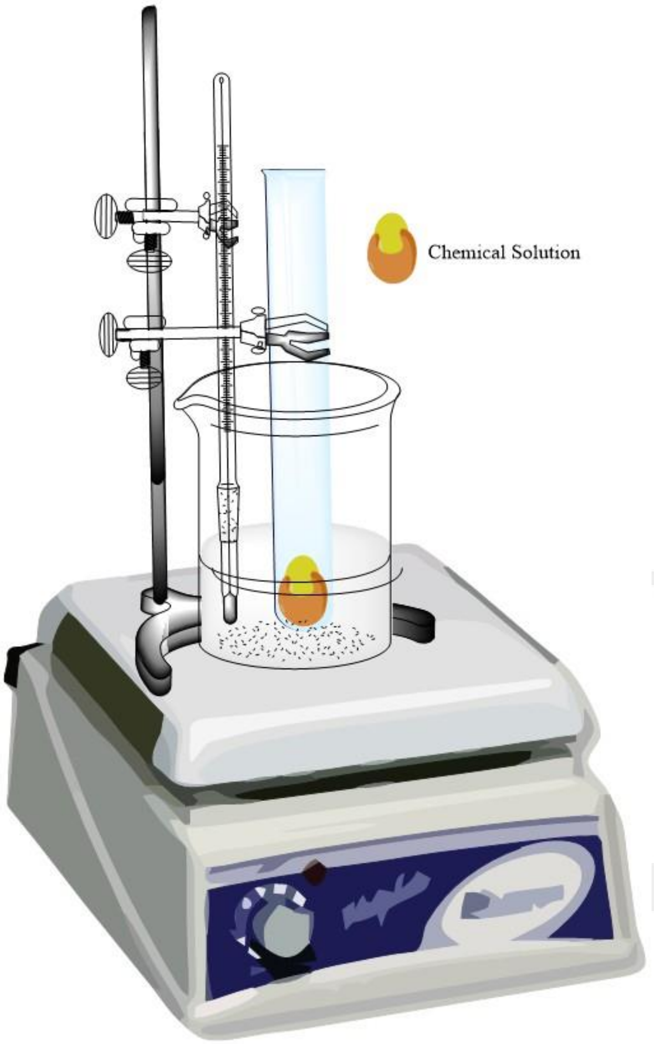


Figure 3.1. Equipments and materials for reaction.

3.3. Methods

3.3.1. Chemical reaction preparation

Elemental Sulfur (S8) that have a yellow color with different percentages of mass (30%, 35% and 40%) that weight on the paper by a sensitive balance machine, it will add to the test-tube with a magnetic stirrer (with graphene if its need to the sampling and its ratio depend of sulfur that %1 of a sulfur ratio in the infrared (IR) blocking application and %0.5 of a sulfur ratio in the photo-detector application). The test-tube take to inside a beaker that filling by glycerin to it have an equal heating, the reaction will start by increase a temperature to the sulfur melting temperature that is

127C° until molten phase was obtained and its color change to clear yellow, at this time by syringe will adding the divinylbenzene with different mass percentages (70%, 65% and 60%) show (Table 3.1), which it will make a tow phase by stirring it will change to one clear yellow phase and increasing its temperature gradually to 180 until it will arrive to its boiling point temperature, when it will be one phase and homogenous solution, remove the stirrer magnetic tool, it will keep on the boiling temperature for 10 minute, during this process its color change from clear yellow to dark brown show in (Figure 3.2) and its change with percentage of the DVB. The final product has a viscous properties to semi-solid depend on the graphene contained or not, and its temperature start to cooling until arrive room temperature this process is called a vulcanization process.

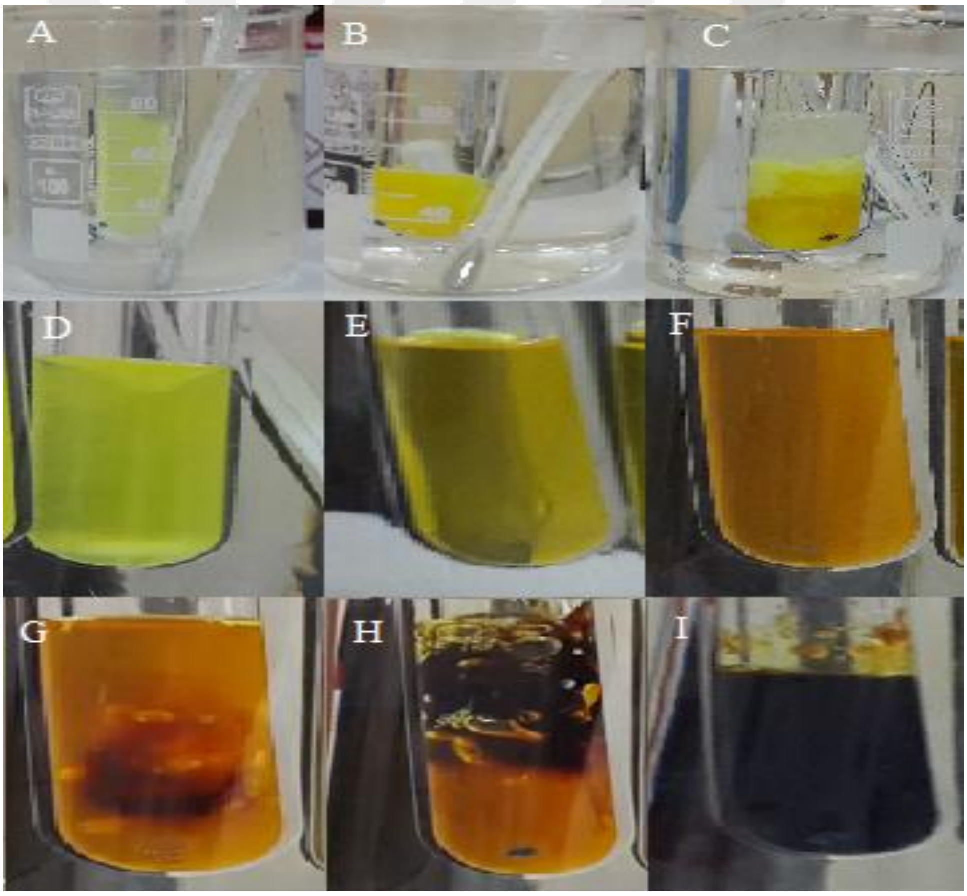


Figure 3.2. Chemical reaction process: (A) sulfur, (B) molten sulfur, (C) adding DVB to molten sulfur, (D) remove magnetic stirrer, (E) increase temperature, (F) start of change color,(G) start polymerization, (H) continue polymerization and (I) final product of vu.

Table 3.1. Samples of the IR blocking application

	Sulfur (%)	DVB (%)	Grapheneg
1-	30(1.5g)	70(3.5g)	---
2-	35(1.75g)	65(3.25g)	---
3-	40(2g)	60(3g)	---
4-	30(1.5g)	70(3.5g)	0.015 (1L)
5-	35(1.75g)	65(3.25g)	0.0175 (1L)
6-	40(2g)	60(3g)	0.02 (1L)
7-	30(1.5g)	70(3.5g)	0.015 (2L)
8-	35(1.75g)	65(3.25g)	0.0175 (2L)
9-	40(2g)	60(3g)	0.02 (2L)

DVB: divinylbenzene, 1L: one layergraphene, 2L: tow layer graphene.

3.3.2. Application of poly (S- DVB)

After the chemical reaction completed the solution will be ready to the applications. Application should be producing by spray production process, for that must be the solution in the liquid phase but the product was a viscous or semi-solid, by the Dichloromethane can be change the solution state from viscous or semi-solid to the liquid phase after that the solution will be ready to spray coating production process and its applications, spray machine contain from compressor, air transition tube and the gun and the gun part has a tank to storage the solution, the solution will add to the tank and air coming from compressor to the gun by the air transition tube by (2 bar) in their by spray principle working the solution will spraying on the cotton to application is the Infrared blocking, IR Photo-Blocker, Samples of IR is normally sprayed on the cotton, show in (Figure 3.3, 3.4 and 3.5).

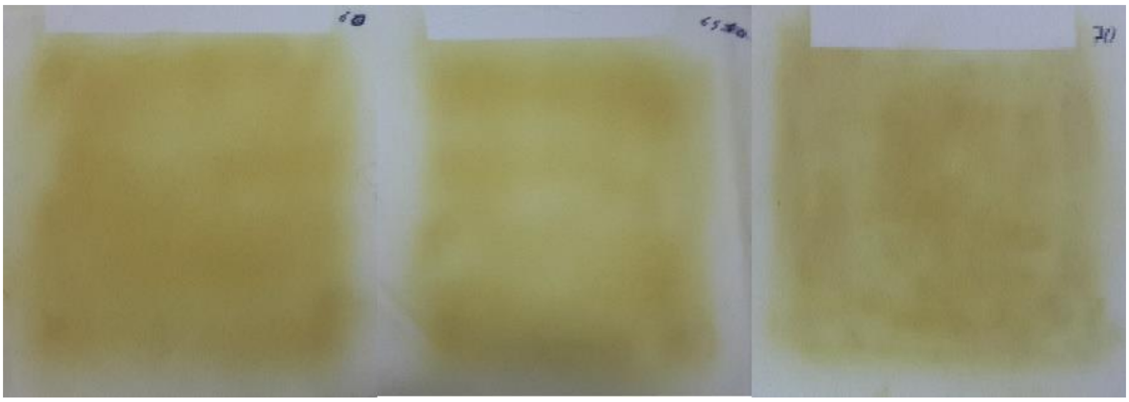


Figure 3.3. IR blocking sample without graphene.

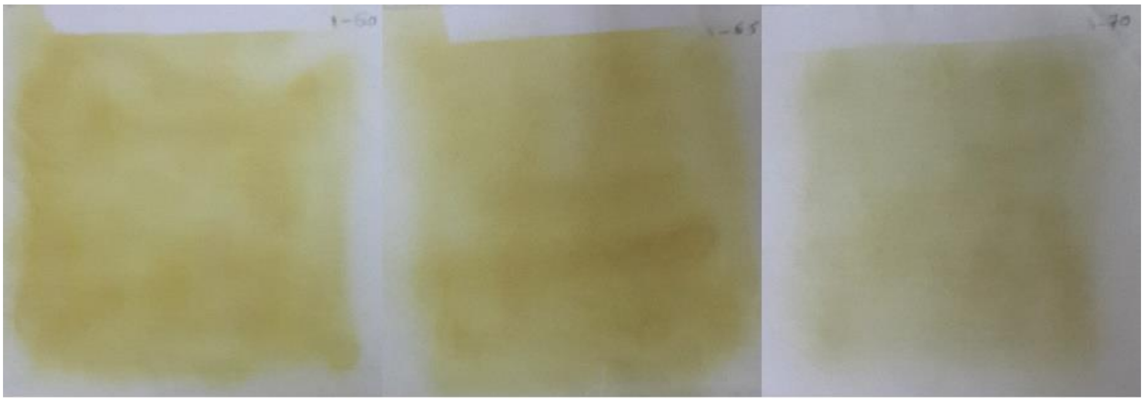


Figure 3.4. IR blocking sample with one layer graphine.

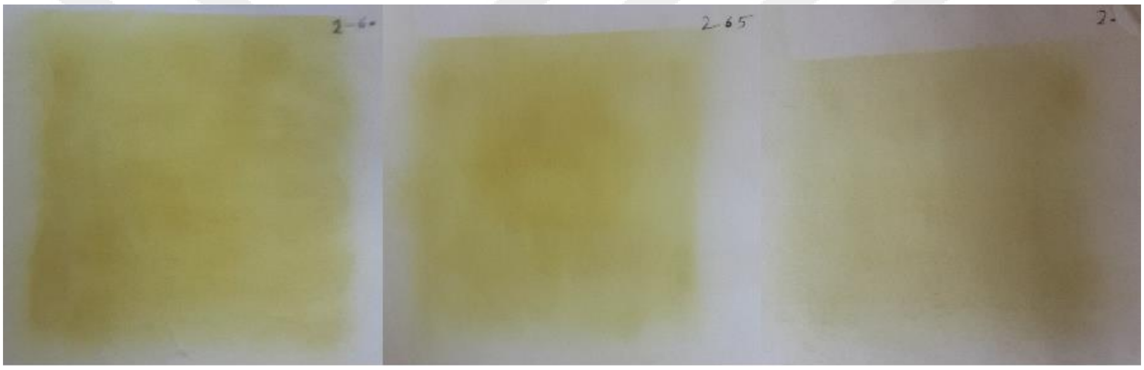


Figure 3.5. IR blocking sample with tow layer graphene.

4. RESULTS

4.1. Result of IR Blocker

After completing the spray process by IR camera can be testing to the samples, human body can be diffuse a heat by all types conduction, convection and radiation and IR detecting is depend on the heat they are diffused, for that can be test the samples on the human body. At the first should be have a picture without any covering (Figure 4.1) to comparing with another's that are covering and spraying, for the covering by cotton only can be detect it reduced some of the heat diffusion (Figure 4.2) but it is not too much.

The cottons that sprayed by poly(S and DVB) can be notice they are blocking best than covering by cotton. The pure poly(S and DVB) s from 60%DVB (Figure 4.3), 65%DVB (Figure 4.4) and 70%DVB (Figure 4.5) contain, 70%DVB contain is best one than another's second is 60% DVB to blocking a heat blocking.

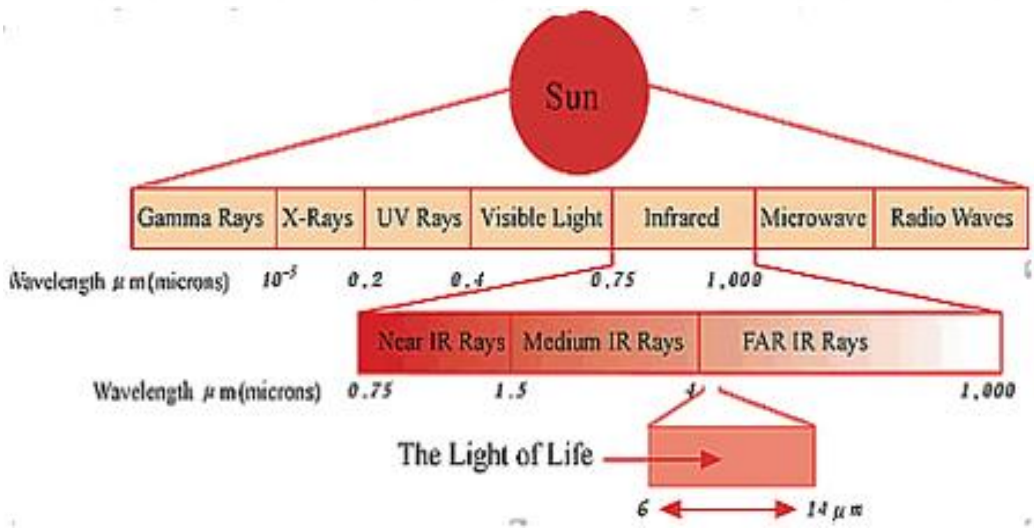


Figure 4.1. Wavelength graphics.

The poly(S and DVB) s that have one layer grapheme contain, to 60%DVB (Figure 4.6), 65%DVB (Figure 4.74) and 70%DVB (Figure 4.8) contain, 60%DVB and 65%DVB is nearly have a same result but 70%DVB is worse than them.

The poly(S and DVB) s that have tow layer grapheme contain, from 60%DVB

(Figure 4.9), 65%DVB (Figure 4.10) and 70%DVB (Figure 4.11) contain, 70%DVB is a best one to blocking IR after is 65%DVB.

Between all tests from without covering, cotton cover and poly(S and DVB) cotton cover the best one is a 70%DVB tow layer graphene, after is a pure 70%DVB, because they can isolate or block both of the convection and radiation heat transferring, but another's can't make this result. For conduction heat transfer both of them reduced it but didn't block.

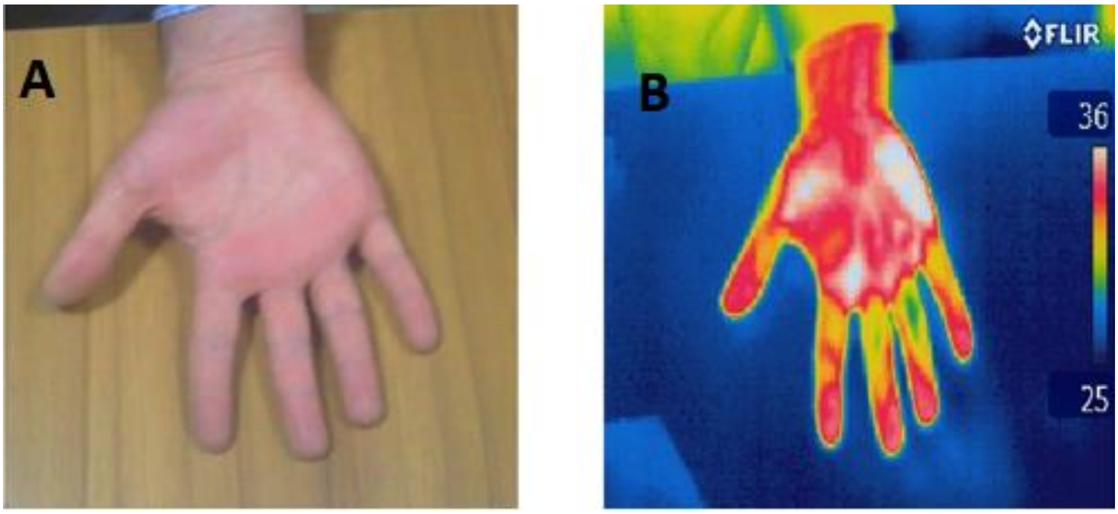


Figure 4.2. a) Hand without cover taken by CCD camera. b) Hand without cover taken by flir e50 thermal camera.

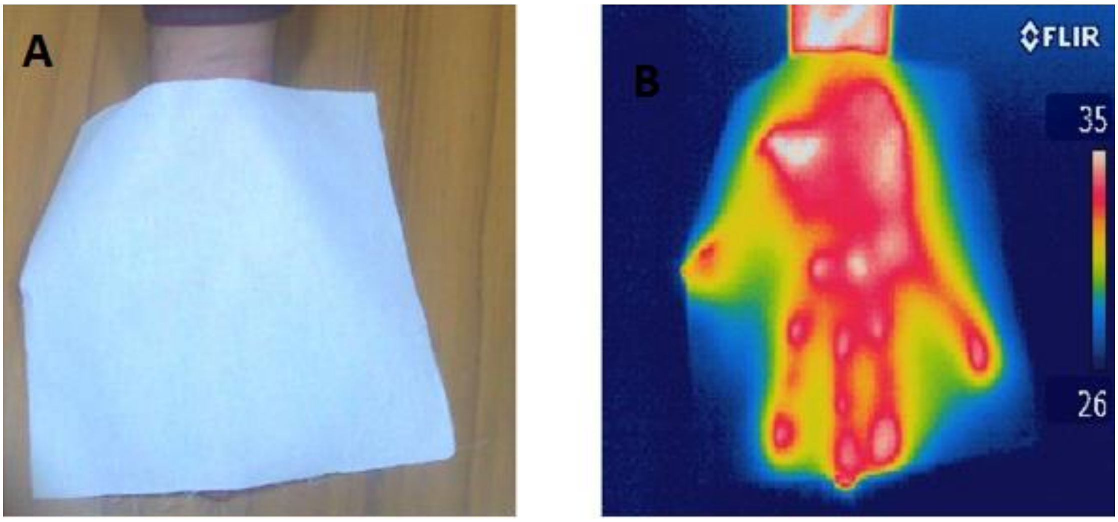


Figure 4.3. a) Hand covering by normal cotton taken by CCD camera, b) Hand covering by normal cotton taken by flir e50 thermal camera.

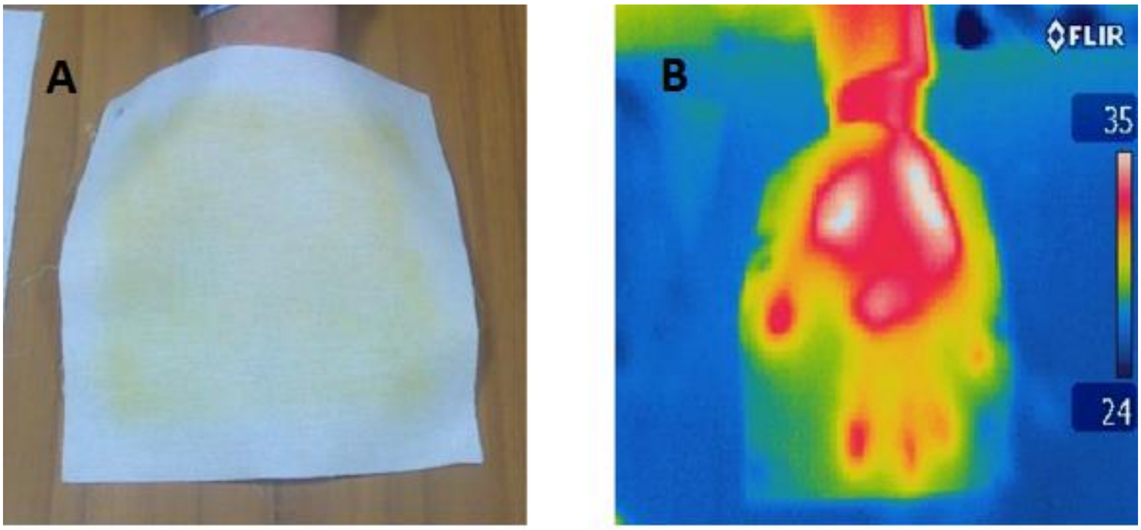


Figure 4.4. a) Hand that covering by cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (60%DVB). Taken by CCD camera , b) Hand that covering by cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (60%DVB). Taken by flir e50 thermal camera.

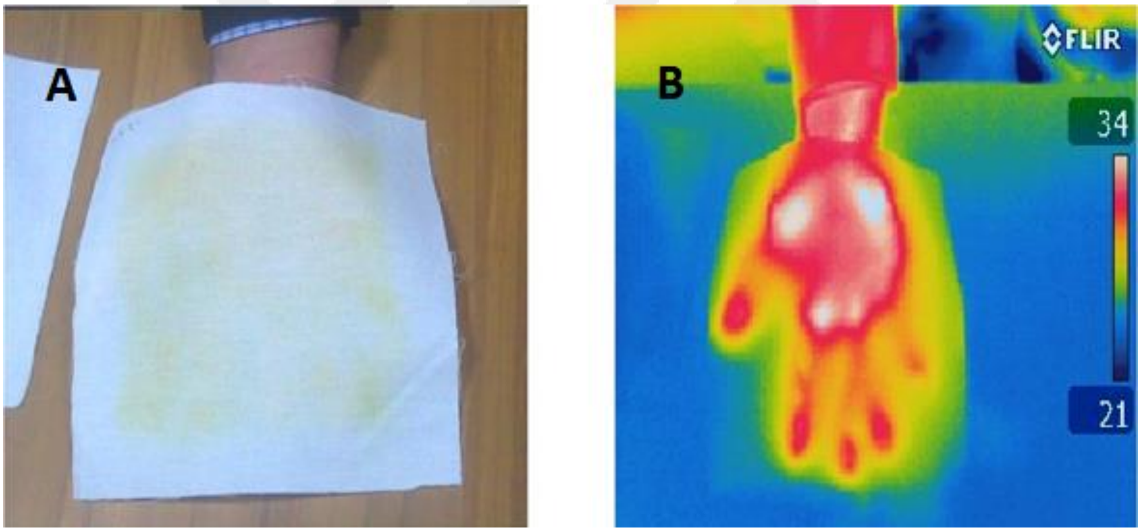


Figure 4.5. a) Hand that covering by cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (65%DVB). Taken by CCD camera, b) Hand that covering by cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (65%DVB). Taken by flir e50 thermal camera.

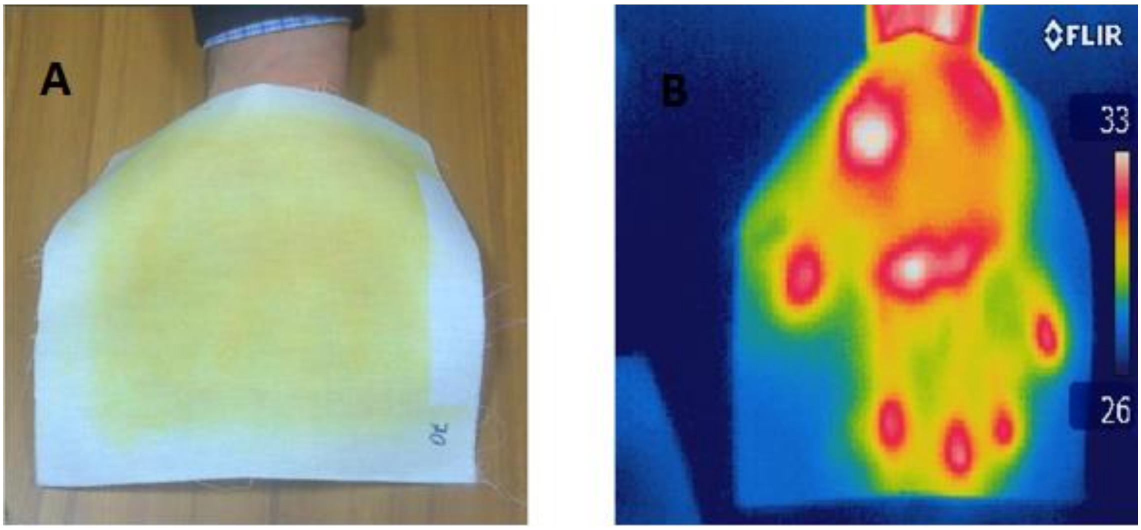


Figure 4.6. a) Hand that covering by cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (70%DVB). Taken by CCD camera, b) Hand that covering by cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (70%DVB). Taken by flir e50 thermal camera.

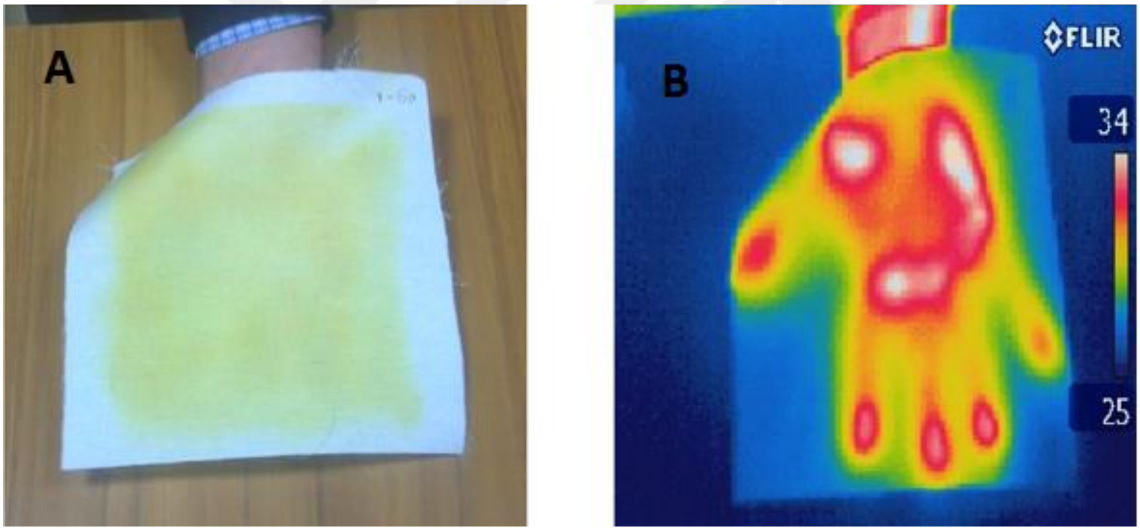


Figure 4.7. a) Hand that covering by a cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (60%DVB) and one layer graphene contain taken by CCD camera, b) Hand that covering by a cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (60%DVB) and one layer graphene contain taken by flir e50 thermal camera.

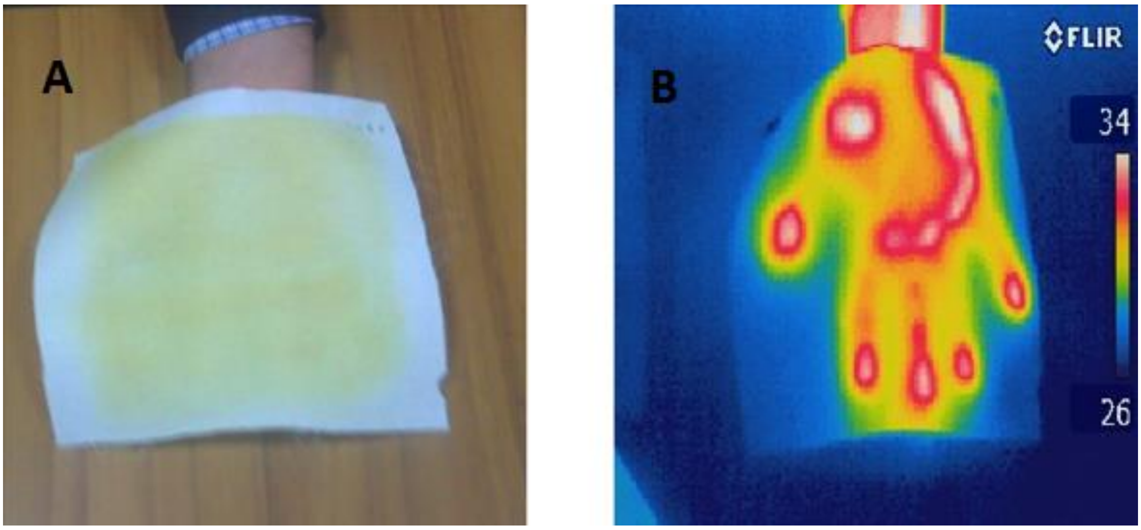


Figure 4.8. a) Hand that covering by a cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (65%DVB) and one layer graphene contain taken by CCD camera, b) Hand that covering by a cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (65%DVB) and one layer graphene contain taken by flir e50 thermal camera.

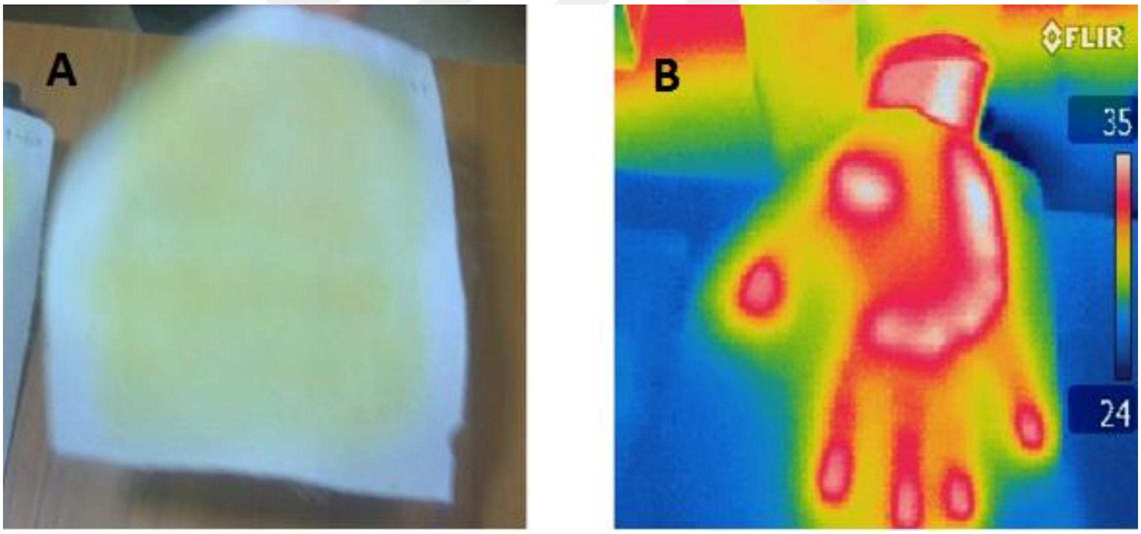


Figure 4.9. a) Hand that covering by a cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (70%DVB) and one layer graphene contain taken by CCD camera, b) Hand that covering by a cotton sprayed with a modified thermal blocker (TB) poly(S and DVB) (70%DVB) and one layer graphene contain taken by flir e50 thermal camera.

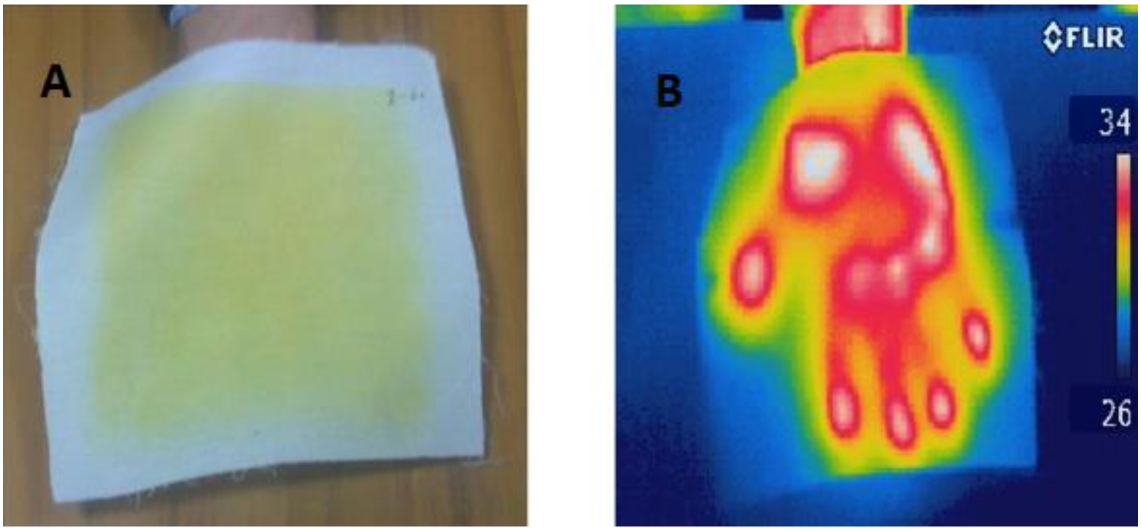


Figure 4.10 a) Hand that covering by a cotton sprayed with a modified thermal blocker (TB)poly(S and DVB) (60%DVB) and two layer graphene contain taken by CCD camera, b) Hand that covering by a cotton sprayed with a modified thermal blocker (TB)poly(S and DVB) (60%DVB) and two layer graphene contain taken by flir e50 thermal camera.

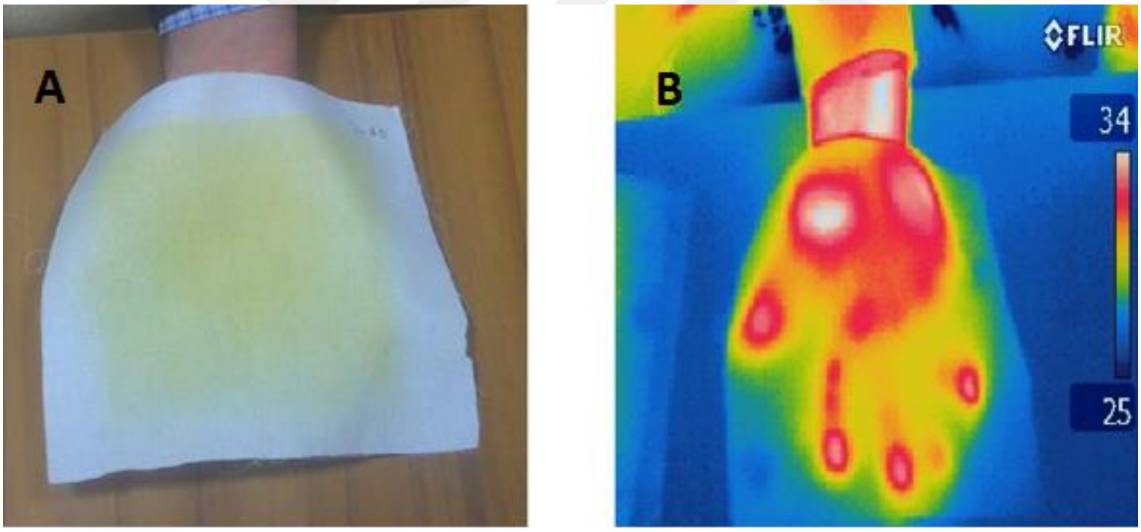


Figure 4.11. a) Hand that covering by a cotton sprayed withmodified thermal blocker (TB) a poly(S and DVB) (65%DVB) and two layergraphene contain taken by CCD camera, b) Hand that covering by a cotton sprayed withmodified thermal blocker (TB) a poly(S and DVB) (65%DVB) and two layergraphene contain taken by flir e50 thermal camera.

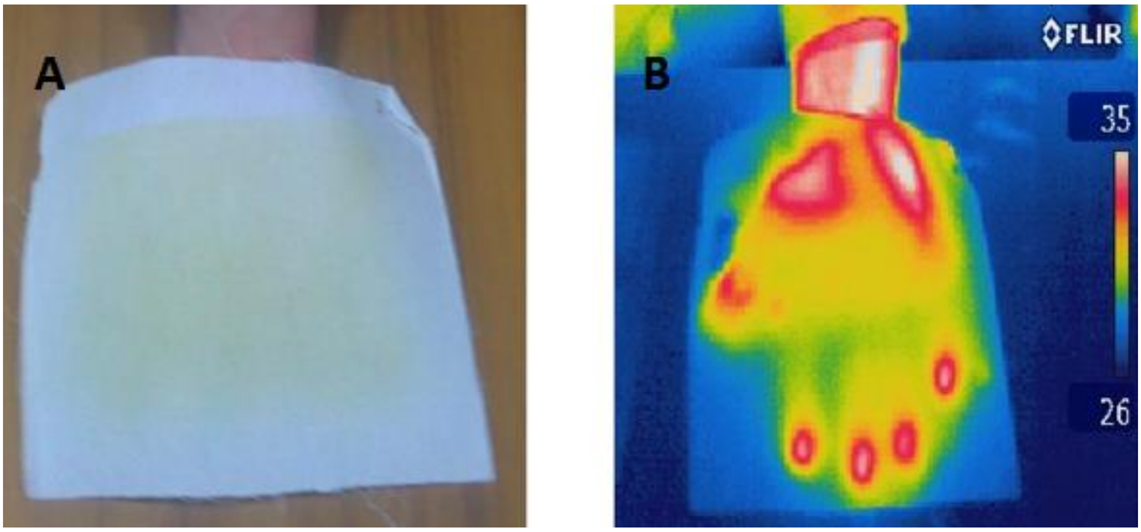


Figure 4.12. a) Hand that covering by a cotton sprayed with modified thermal blocker (TB) (a poly(S and DVB) (70%DVB) and two layer graphene) contain taken by CCD camera, b) Hand that covering by a cotton sprayed with modified thermal blocker (TB) (a poly(S and DVB) (70%DVB) and two layer graphene) contain taken by flir e50 thermal camera.

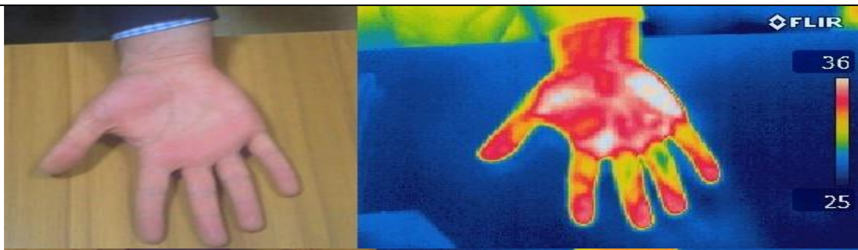
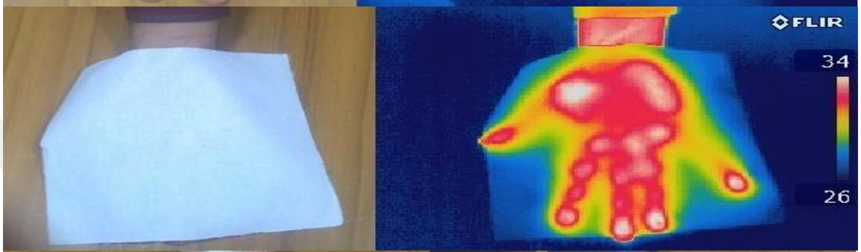
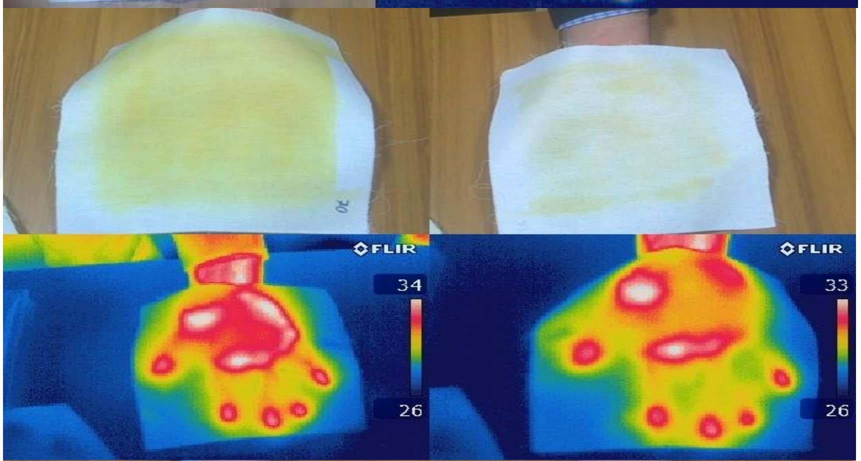
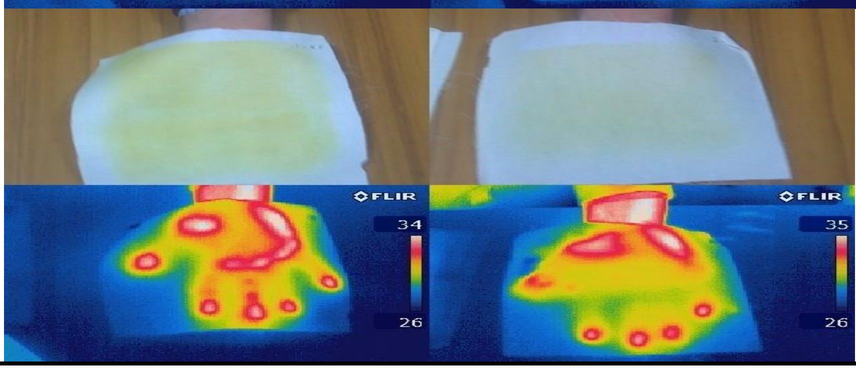
With the results gathered in the light of all the data; the thermal publicity effect of thermal has been reached to 99%. With the application of the obtained nanocomposite materials to the normal cotton fabric, the thermal impermeability was only 79% tolerable compared to the cotton fabric and 99% better than the naked body.

4.2.Result of NMR

According to Figure 4.13 the chemically modified graphene nanocomposite was shown. After starting one layer graphene addition of bare PVP, some chemical structure has been changed on NMR results. According to NMR library some C-S or C-C bonds have been occurring. Actually, it is sign of completely perfect match between PVP and Graphene in other words, one layer graphene not only psychically bonding has for on PVP structure but also some chemical bonds has been occurs. More bonds means that more stable structure can be. On the other hand after modified 2layer Graphene, there is no significantly improvements seen if we compare 1 layer modification. However some chemical bonds also seen.

4.3. Result of IR blocker

Table 4.1. Result of IR blocker

Sample	Type Of Image	Calculation of efficiency (%)
Hand without cover		0
Hand covered Cotton		20
Hand covered poly (S and DVB		65
Hand covered modified TB poly(S and DVB		99

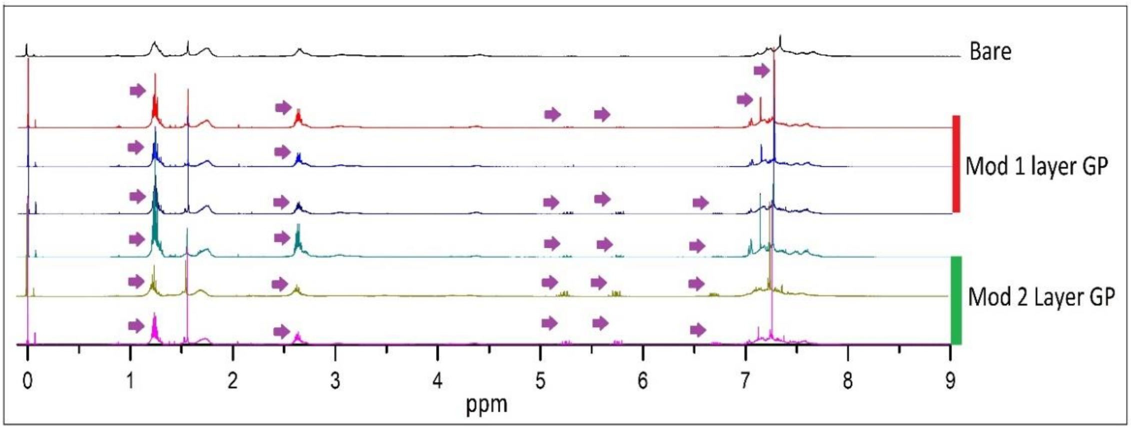


Figure 4.13. Results of NMR selected samples.

5. DISCUSSION AND CONCLUSION

Having with the evolving world politics and the geographical environmental impact, "Defense Industry Plastics" is the foreground as a material with a separate tactical design. Many imaging techniques are being developed to detect enemy elements in defense technologies. Again, the most important of the innovations introduced in this area such as Thermal detectors (Thermal Cameras) based on the long-wave IR energy (heat) absorption principle that the enemy targets cannot perceive by human beings and which produce signal. When the light is divided through the spectrum will be some types, most types of invisible one of them is Infrared light (IR). An Infrared light is that it has a wavelength longer than those of visible light, and the wavelength is smaller than microwave light. "Camouflage" is a military tactical strategy used to hide enemies in natural life, to surprise the enemy. It is possible to mislead the various forms and patterns and visible field detectors (such as naked eyes, classical cameras) by imitating the natural plant and soil texture, however misinterpretation of images in thermal cameras (or camouflage techniques) requires expensive and incapable systems. With the results gathered in the light of all the data; the thermal publicity effect of thermal has been reached to 99%. With the application of the obtained nano composite materials to the normal cotton fabric, the thermal impermeability was only 79% tolerable compared to the cotton fabric and 99% better than the naked body. With which the thermal insulator was discovered without the need for extra energy that was not previously available in liters. The next part of the study will be discussed and continued during PhDs.

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APPENDIX

EXTENDED TURKISH SUMMARY
(GENİŞLETİLMİŞ TÜRKÇE ÖZET)

1. TEZİN AMACI VE ÖNEMİ

Yeni nesil nanokompozit teknolojik malzemelerin; inşaat, ambalaj, tekstil, otomotiv, havacılık, savunma, sağlık, tarım ve elektrik/elektronik gibi gelişmeye açık, Ar-Ge stratejilerinin öncelikle Ür-Ge ye daha sonrasında ise yüksek ekonomik getirili, katma değeri yüksek seri üretime uygun ürünler elde edilmektedir. Gelişen dünya politikaları ve bulunduğumuz coğrafi çevre etkisi nedeni ile, "Savunma Sanayii Plastikleri" ayrı bir taktiksel öneme sahip malzemeler olarak ön plana çıkmaktadır. Savunma teknolojilerinde düşman unsurların tespiti için birçok görüntüleme teknikleri geliştirilmektedir. Yine bu alanda getirilen yeniliklerin en önemlisi düşman hedeflerinin insan gözünün algılayamadığı uzun dalga boylu kızıl ötesi enerjiyi (ısıyı) soğurma prensibini esas alan ve sinyal üreten detektörler (Termal Kameralar) ile tespitidir. Bu detektörler yapıları gereği iki ana çalışma dalga aralığında çalışmaktadır; Bunlar sırası ile 3-5 µm ya da 8-12 µm arasıdır. "Kamuflaj" doğal hayatta düşmandan saklanmak, düşmanı şaşırtmak için kullanılan bir askeri taktiksel bir stratejidir. Doğal bitki ve toprak dokusunu taklit ederek çeşitli form ve desenler ile görünür alan detektörlerini (çıplak göz, klasik kameralar gibi) yanıltmak mümkün iken, termal kameralarda görüntü yanıltılması (veya kamuflaj teknikleri) kolay uygulanamayan ve pahalı sistemler gerektirmektedir. Kızıl ötesi dalga boyundaki çalışmalar bilim dünyasında yeni konu başlıkları altında açılmaktadır. Bunların en önemlileri gece yada kış operasyonlarında asker kayıplarını azaltma, tank yada ağır zırhlı araçların termal kameralara yakalanmadan operasyon bölgesine ulaştırılması için geliştirilen metalik dış kaplamlardan oluşmaktadır. Metalik kaplamalar gerek ağırlıklarının fazla gerek üretimlerinin zor olması nedeni ile alternatif kompozit malzemelere yönelim kaçınılmazdır. Son günlerde yaşanan olaylarda da açıkça görüldüğü gibi, Türkiye'mizin asker ve araç zayiatlarının büyük bir bölümünü terörist unsurların ellerindeki termal kamera modifiyeli edilmiş silahlar yada kızıl ötesi güdümlü ağır silahlardan kaynaklanmaktadır. Literatürde kükürt ve vinil gruplu alkenlerin, vulkanizasyon yöntemi kullanılarak, basit şekilde halka açılması polimerizasyon mekanizması üzerinden polimerleştirilmesi sağlanabilmektedir. Elde edilen polimerin ve 2 µm-18 µm dalga boyu aralığında düşük soğurma sahip olduğu bu hali ile bile her iki dalga aralığında çalışabilen detektörlere karşı kamuflaj malzemesi olarak kullanılabilmektir. Ön denemelerde ortama eklenen kükürtle soğurma miktarının arttığı, ancak beraberinde çapraz bağın da artması sonucu çözünürlüğün azaldığı görülmüştür. Ancak oldukça verimli bir kızıl ötesi soğurma bandı elde edilebilmek için 2D grafen nano yapıları ile nano kompozitlerin uyumunun araştırılması gerekmektedir. Laboratuvar koşullarında yine yapılan ön denemelerde ile yalın polimerlere göre oldukça verimli soğurma eğrileri verildiği ve termal görünmezlik performanslarının arttığı görülmüştür.

2. LİTERATÜR BİLDİRİŞLERİ

2.1. Kızıl Ötesi Radyasyonun Tanımı

Kızıl ötesi radyasyonun mevcudiyeti 1809 yıllarında ingiliz filozofu William HERSCHEL tarafından keşfedilmiştir. Bir cam prizmadan geçirilen güneş tayfının, görünür bölgesine ötesine yerleştirilen termometreler vasıtasıyla infrared ışıklar incelenmiştir. Sürpriz olarak nitelendirilen bu incelemede William HERSCHEL, gözle görünmeyen, henüz inceleme safhasında olan bu ışıkları termometre vasıtasıyla ölçebileceğini ortaya çıkarmıştır. Kızıl ötesi dalga bölgesi elektromanyetik spektrumun görünür ışık ve mikrodalga bölgesi arasında uzanır. İnfrared dalga, yakın, orta ve uzak infrared olmak üzere üç bölgeye ayrılır. Bunlardan yakın infrared , dalga boyu olarak görülebilen ışığa en yakın olanıdır. Uzak kızıl ötesi elektromanyetik spektrumun mikrodalga bölgesine en yakın olanıdır.

2.2. Kamuflaj ve Kızıl Ötesi Yansımalı Boyanın Önemi

Kamuflaj düşman tarafından görülmeyi önlemek için alınan tedbirler olup görülme kelimesi siyah-beyaz veya renkli fotoğraflarla veya optik aletlerle (Gece görüş cihazları, termal kamera vb. cihazlar) tespit anlamında kullanılmaktadır. Parlaklık farkı, renk farkı, uzaklığa bağlı yansıma farkı, doku farklılığı görme ve ayırma işlemlerini etkileyen önemli unsurlardır. Doğada bulunan toprak, çimen, ağaç, kum gibi maddelerin dokusu uzaktan mat görünmesine karşın, yakından incelendiğinde parlak olduğu görünmektedir. Dolayısıyla, kamuflaj boyaların dokusu mat görünüm sağlayacak yapıda olmalıdır. Bu unsurlar göz önüne alınarak gözle tespiti engelleyici veya zorlaştırıcı bir kamuflaj yapmak mümkündür. Kamuflaj işlemi; kamuflaj edilmesi istenilen cismi üzerinde bulunduğu zeminin rengine boyamak, boyanmış cisim üzerine bir ağ gererek kullanılan boyanın dokusunu, rengini ve desenini bulunduğu zemine uydurmak, cismi göze çarpmayan bir yere yerleştirmek şeklinde yapılmaktadır.

2.4. Kızıl Ötesi Yansımalı Boyanın Özellikleri

Kızıl ötesi yansımalı boyalar; renk kontrastı, parlaklık, infrared yansıma yönünden, tabiat ve çevreye uyum sağlayabilen boyalardır. Bu özelliklerinden dolayı üretimleri gizlilik çerçevesinde yapılmaktadır ancak askeri standartlar boya ile ilgili renk, kromatisite koordinatları, görünür parlaklık, kızıl ötesi yansıma gibi özellikleri kapsamaktadır.

3. MATERYAL VE YÖNTEM

3.1. Materyal

Bu projede poly(sulfur-random-divinylbenzene(S-r-DVB) sentezleme için bazı başlangıç kimyasalları kullanılmıştır. Çözücü bir malzeme gibi divinil benzene kulanılmıştır. Elektron iletkenliğini arttırmak için grafen kullanılmıştır. Gliserin eşsiz bir dengeli ısı yayılımına sahiptir. Sprey son işlemi için çözücü olarak diklorometan kullanılmıştır.

3.2. Kimyasal Reaksiyon

Elemental Sulfur farklı bir kütle yüzdesine sahip (30%, 35% and 40%) sarı bir rengi vardır. Elemental sülfür hassas bir terazide tartılıp manyetik bir karışıtıcıda test tüpüne eklenecektir. Test yapılan tüplere eşit bir şekilde ısınma sağlanması için beher içine gliserin eklenir reaksiyon sülfürün erime sıcaklığı olan 127^{o}C de başlar ve erime fazı açık yeşil renge dönünceye kadar devam eder. Bu aşamada şırıngalar ile farklı ağırlıklarda (70%, 65% and 60%) divinilbenzin eklenir (aynı zamanda elektronik iletkenlik özelliği olması için prodot malzemeyi eklemelidir). Karıştırmaya ilk faz başlayacak ve rengin açık sarı renge dönmesiyle ve 180°C olan kaynama sıcaklığına kadar ısıtılacaktır. Tek fazlı homojen bir çözelti haline geldiği zaman manyetik karıştırıcıyı aletten çıkarınız 10 dakika daha kaynama sıcaklığında bekleyiniz bu sırada açık sarı renkten koyu kahve rengine doğru bir değişim yaşanacaktır. Ürün son halindeyken içindeki grafene bağlı olarak yarı katı seviyede viskoz bir hale sahiptir . Bu işlemden sonra vulkanizasyon denilen soğumaya bırakınız.

3.3. Poli Sülfürün Uygulanması

Kimyasal işlem tamamlandıktan sonra çözelti uygulamalarda kullanılmaya hazır hale gelecektir. Uygulamayı sprey olarak yapmalıyız bunun için sıvı bir faz olarak görünsede katıya yakın viskoz bir ürün olduğundan diklorometan ile bu sıvı fazı püskürtmeye hazır bir hale getirdikten sonra püskürterek uygulayabiliriz. Sprey makinesi kompresör hava geçiş borusu, sprey tabancası ve çözelti depolamak için bir hazeneye sahiptir. Kompresörden gelen 2 barlık basınç ile sıvı olan çözelti tabancadan uygulama yapılacak olan pamuğun üzerine gönderilir. Kızıl ötesi engelleme yapılacak olan uygulama için hazır hale gelmiştir.

4. BULGULAR

Püskürtme işlemi tamamlandıktan sonra kızıl ötesi kamera ile testler yapılabilir. İnsan vucudu konveksiyon ve radyasyon olarak ısı yaymaktadır bunlar kızıl ötesi kamera ile tespit edilebilir. Bundan dolayı bu örnekler insan vucudunda test edilebilir. İlk fotoğrafta her hangi bir işlem yapılmadan ki hal mevcut diğerlerinde pamuk üzerine sprey ile kaplama yapılmıştır ve gözle görülür bir azalma mevcuttur. Kaplama yapılan pamuklar normal pamuk ile engelemede daha iyi sonuç verir. Saf poli (S ve DVB) farklı oranlarda uygulandığında %70 orana sahip olan 2. Yapılan %60 olanlara göre daha iyidir.

Poli (S and DVB) bir kat grafen içermektedir 60%DVB (Şekil 4.6), 65%DVB (Şekil 4.74) ve 70%DVB (şekil 4.8) içermekte, 60%DVB ve 65%DVB yakın ve aynı sonuçlar ama 70%DVB onlardan daha kötü duruyor.

Poli(S and DVB) 2 katman grafen içermektedir 60%DVB (şekil 4.9), 65% DVB (şekil 4.10) ve 70%DVB (şekil 4.11) içermektedir, 70%DVB 65%DVB. den sonra en iyi olandır.

Kaplamasız tüm testler arasında pamuklu örtü ve poli(S VE DVB) pamuk kaplılardan en iyisi %70DVB 2 katmanlı grafen olandır. Daha sonra saf %70 DVB dir. Konveksiyon ve radyasyon her ikiside izole edilebilir veya bloke edilebilir. Bu örneklerde ısı transferi ve iletimi azaltıldı ama tam olarak engellenemedi.

4.1. NMR Deney Bulguları

Şekil 4.12'ye göre, kimyasal olarak modifiye edilmiş grafen nanokompoziti gösterilmiştir. PVP'nin bir katman grafen eklenmesinden sonra, NMR sonuçlarında bazı kimyasal yapısal değişmeler olmuştur. NMR kütüphanesine göre bazı C-S veya C-C bağları meydana gelmiştir. Aslında, PVP ve Graphene arasında tamamen mükemmel bir eşleşmenin bir başka ifadesidir . Tek katmanlı grafen sadece fiziksel bağlanmamıştır aynı zamanda bazı kimyasal bağlanmalarda oluşmuştur. Daha fazla bağ daha fazla kararlı yapının meydana gelebileceğini gösterir diğer taraftan modifiyeli 2 katmanlı grafenden sonra 1 katmanlı denemelerde genel olarak belirgin iyileşmeler ile karşılaşılmamıştır. Ancak bazı bağlarda iyileşmeler görülmüştür.

5. SONUÇ

Gelişen dünya siyasetine ve coğrafi çevresel etkisine sahip olan "Savunma Sanayii Plastikleri", ayrı bir taktik tasarıma sahip bir malzeme olarak ön plana çıkıyor. Savunma teknolojilerindeki düşman unsurlarını tespit etmek için birçok görüntüleme tekniği geliştiriliyor. Yine, bu alandaki yeniliklerin en önemlisi, termal hedeflerin (Termal Kameralar), düşman hedeflerinin insan tarafından algılayamayacağı ve sinyalin üretemeyeceği uzun dalga kızıl ötesi enerjisi (ısı) emilim prensibine dayanmaktadır. Işık, spektrumdan bölündüğünde bazı tipler olacak, çoğu görünmez tiplerden biri kızılötesi ışıktır(IR). Bir kızılötesi ışık, görünür ışığın dalga boyundan daha uzun bir dalga boyuna sahip olması ve dalga boyunun mikrodalga ışığından daha küçük olmasıdır. "Kamuflaj", düşmanı şaşırtmak için doğal yaşamdaki düşmanları gizlemek için kullanılan askeri bir taktik stratejidir. Doğal bitki ve toprak dokusunu taklit ederek çeşitli şekil ve desenleri ve gözle görülür alan dedektörlerini (çıplak gözler, klasik kameralar gibi) yanıltmak mümkündür, ancak termal kameralarda (veya kamuflaj tekniklerinde) görüntülerin yanlış yorumlanması pahalı ve yetersiz sistemler gerektirir. Tüm veriler ışığında toplanan sonuçlar ile; Termalin termal tanıtım etkisi %99'a ulaşmıştır. Elde edilen nano kompozit malzemelerin normal pamuklu kumaşa uygulanmasıyla, termal geçirimsizlik, pamuk kumaşa kıyasla sadece %79 oranında tolere edilebilir ve çıplak gövdeden %99 daha iyi olmuştur.

Çalışmanın bir sonraki kısmı doktora sırasında tartışılacak ve devam edecektir.

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