

THERMAL & HYDROPHOBIC PROPERTIES OF SILICONE RUBBER COMPOSITE

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Science in Chemistry

By

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DEPARTMENT OF CHEMISTRY
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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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MAY – 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **TARANYA S (40030041) KOWSHICK RAJA S (40030019)** who carried out the project entitled " **MECHANICAL AND THERMAL PROPERTIES OF SILICONE RUBBER COMPOSITE** " under our supervision from December 2022 to April 2023.

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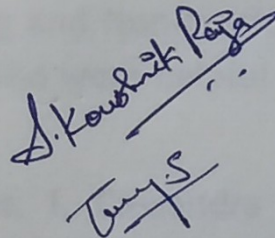
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DECLARATION

We **S.TARANYA (40030041), S.KOWSHICK RAJA (40030019)** hereby declare that the Project Report entitled **MECHANICAL AND THERMAL PROPERTIES OF SILICONE RUBBER COMPOSITE** done by us under the guidance of **Dr. K. CHENNAKESAVULU, M.Sc., Ph.D.**, Associate Professor, Department of Chemistry at **Sathyabama Institute of Science and Technology**, Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600119 is submitted in partial fulfilment of the requirements for the award of Bachelor of Science degree in Chemistry.

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ABSTRACT

This study aimed to develop a graphite/silicone rubber composite and evaluate its mechanical properties. The graphite/silicone rubber composites were prepared using a two-roll mill, and the effect of varying graphite content on the mechanical properties of the composites was investigated. The mechanical properties evaluated include tensile strength, elongation at break, hardness, and compression set. The results showed that the addition of graphite to silicone rubber significantly improved the tensile strength and hardness of the composites. The increase in contact angle can be attributed to the surface properties of the graphite sheets. This reduction in contact area leads to an increase in the contact angle, indicating a more hydrophobic surface.

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CHAPTER 1

INTRODUCTION

1.1 SILICONE RUBBER

Silicone or polysilicone is a polymer made up of siloxane. silicone rubber is a strong and high strength elastomer composed of silicone containing of silicon as well as other molecules such as carbon , hydrogen and oxygen. Its structure always consists of a siloxane (siliconoxygen chain)framework and an organic part bonded to silicon.

Silicon rubber one or many types of industrial rubbers. Taking traits such as flexibility and temperature resistance from both plastic and rubber , material comes in sheets, tubes , liquid , and other forms that allow it to be used in application ranging from aerospace to medical to construction purposes. Silicone is sometimes mistakenly referred to as silicon, which is chemical element and a crystalline metalloid widely used in computers and other electronic equipment. And they have totally different physical and chemical properties.

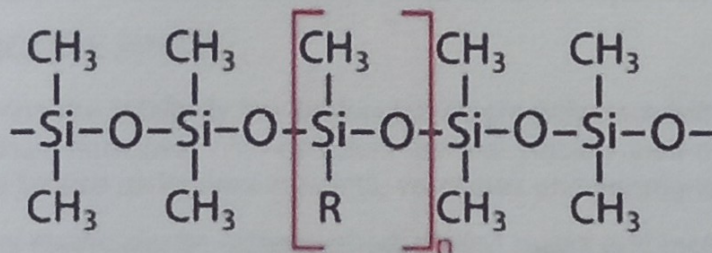


Fig.1.1 Structure Of Silicone Rubber

The methyl group is called MQ. These are basic silicone rubbers developed for the first time. The methylvinyl group, which exhibits good compressive properties, is called VMQ.

These are the most commonly used silicone rubbers because vinyl helps to cure. The methyl phenyl group (MPQ) and methyl phenyl vinyl (PVMQ) are used to increase the low temperature ability of the rubber.

The fluorine, vinyl and methyl groups(FVMQ) are chemically more resistant to oils, fuels and solvent Liquid silicone rubber has the smallest molecular chain of the three, giving its polymers a low molecular weight.

It can be extruded or injection molded using specialized machinery. This silicone rubber is more weather resistant and transparent. RTV Silicone Rubber(Room

Temperature Vulcanization) may be one or a mixture of two components and cures at room temperature to soft or medium hardness.

It is commonly used for making potting, mastic and packing. Silicone rubber molds are also made from RTV silicone rubber. Solid silicone rubber or HTV(High Temperature Vulcanization) contains the heaviest molecular weight long chain polymers. This is usually in its unprocessed form and must be vulcanized at the same temperature as more traditional rubbers.

1.2 COMMON FORMS OF BASIC SILICONES

- Silicone Fluid
- Silicone Resin
- Silicone Rubber

1.2.1 SILICONE FLUID

Silicone fluids are silicone oils (polydimethylsiloxane) which exhibit different degrees of polymerization, and thus viscosity. Within the silicone oils, the polymeric chains, which have a very high methyl density and thus low intermolecular association, glide and slip over one another: the oils are fluids.

Replacing a minority of the methyl groups with organic functionalities like phenyl (inert) or vinyl or amino groups (reactive) modifies the oils to give them special characteristics. The silicone oils can be used as is, in dispersion or in emulsions.

1.2.2 SILICONE RESIN

Silicone resins are relatively low molecular weight polymers with a three-dimensional branched-chain structure. With excellent thermal stability their many properties make them suited for use as binders in paints, varnishes and impregnating products.

Two types of resins can be distinguished: methyl resins and methyl phenyl resins.

Three types of reactive groups allow the resin to crosslink.

- **Hydroxy groups** are the most common type. They enable crosslinking to occur by a condensation reaction at room temperature either in the presence of a catalyst or in alkaline systems. The use of a catalyst and higher temperatures, especially in the case of methyl phenyl resins, generally accelerates the cure rate.
- **Alcoxy groups** hydrolyse to give hydroxy groups at room temperature and in the presence of humidity. Curing then occurs as above. These resins are more stable when stored.
- **Vinyl groups** react at moderate temperature by an addition reaction in the presence of platinum, as in RTV's (Room Temperature Vulcanisation), or sometimes at high temperature in the presence of peroxides as in HCR's (Heat-Cure Rubber).

1.2.3 SILICONE RUBBER

- Silicon Rubber is a human-made elastomer (a polymer with elastic properties) that has the properties of both plastic and rubber.
- Silicone can be used to form liquids, hard solids, and rubbery products, but since elastomers are generally referred to as rubbers, it's also usually referred to as a rubber.
- Silicone rubber is a high-performance elastomer characterized by an unusual combination of properties. These properties range from high temperature performance to durability, excellent electrical insulation properties as well as its transparency.
- Silicone rubber is a durable & highly-resistant elastomer (rubber-like material) composed of silicone (polymer) containing silicon together with other molecule like carbon, hydrogen and oxygen.



Fig.1.2 Silicone Rubber Image

1.3 TYPES OF SILICONE RUBBER

1.3.1 Solid Silicone Rubber Or High Temperature Vulcanized (HTV)

Solid silicone rubber contains polymers with a high molecule weight and relatively long polymer chains. They are available in an uncured form and require traditional rubber processing techniques. (heat curable)

1.3.2 Liquid Silicone Rubber

Liquid silicon rubber contains polymers of lower molecule weight and hence shorter chains. It has better flow properties. It is processed on specially designed injection molding and extrusion equipment. Liquid silicone rubber is a low viscosity and purity thermoset elastomer maintains properties over a wide range of temperature.

1.3.3 Room Temperature Vulcanized

RTV silicon is a type of silicon rubber made from one part or two components systems where their hardness range of very soft to medium.

1.3.4 Fluorosilicone Rubber

Fluorosilicone rubber is a long lasting elastomer that is stable, typical applications include aerospace fuel system components, seals and o rings.

1.4 PROPERTIES OF SILICONE RUBBER

Silicone rubber has high heat resistance and chemical stability that helps it to supply higher electrical insulation. It's high physical property and squeezability yet as wonderful resistance to cold temperatures. Synthetic rubber is immune to a large temperature vary. It provides wonderful resistance to extreme temperatures, which may vary from minus a 100 F to and 500° F. This rubber is used indefinitely at 150 C that doesn't result in any modification within the properties of synthetic rubber. It will stand up to temperatures of 200° C for 10,000 hours or a lot of.

Some polymer rubbers will stand up to temperatures of up to 350 C for brief periods of your time. Synthetic rubber has wonderful oil resistance to high temperatures. Of the opposite common varieties of caoutchouc, nitril rubber and butadiene rubber have somewhat higher oil resistance at temperatures below a 100 ° C however at higher temperatures, synthetic rubber is superior to any or all alternative varieties of rubber.

Silicone rubber has exceptional weather resistance. Ozone generated by halo discharge does not deteriorate silicone rubber. Therefore, silicone rubber can be exposed to wind, rain and UV rays for a longer time without any change in its physical properties. The tensile strength, tear strength, elongation and compressibility of silicone rubber are far superior to those of ordinary rubbers. Silicone rubber has a higher thermal conductivity than most other rubbers. High thermal conductivity silicone rubber is used to manufacture products such as thermal interface plates and thermal rollers.

Silicone rubber has excellent resistance to moisture and steam. It can be soaked in cold, hot or boiling water for a long time with a water absorption of about 1%. This does not affect its mechanical strength or electrical properties. When exposed to steam under normal pressure, silicone rubber does not degrade.

However, high pressure steam at temperatures 6 above 15°C can degrade the siloxane polymer and reduce rubber properties. This metal is traceable. It glows in the dark. Silicone rubber is also a conductor of electricity. In addition to being oil

resistant, silicone rubber is also resistant to chemicals, acids and gases. Silicone rubber is flame retardant and has low smoke emission properties.

1.5 PHYSICAL PROPERTIES

1.5.1 HARDNESS

Silicone materials use comparative scales known as Shore hardness to characterize their hardness. Two commonly used Shore scales for silicon are Shore for silicon porous products and Shore A for dense products.

1.5.2 ELECTRICAL CONDUCTIVITY

Silicones in their original state are very insulating. Therefore, they are often used in applications requiring high dielectric strength. What's unique about silicone is that it accepts high loads and retains its handling.

1.5.3 THERMAL CONDUCTIVITY

Silicones in their initial state are very thermoelectric. As a result, they are often used in applications requiring low heat transfer, such as in piping for fluid transfer in food handling or oven applications. What's unique about silicone is that it accepts high loads and retains its handling.

1.6 APPLICATIONS

- This rubber can be extruded into tubes, strips, solid wire or any custom configuration. Silicone rubber can also be molded into custom designs and shapes.
- Silicone rubber can also be molded into custom designs and shapes. This form of neoprene is available for molding to be poured, brushed or sprayed onto the model.
- Suitable for casting low-melting metal alloys such as lead, tin, powder. Also used in molding plastic production. alloy like lead, pewter, pewter. Also used in molding plastic production.

1.7 ADVANTAGES

- Excellent resistance to high and low temperature.
- Resistant to ozone and sunlight.
- Permeable to gas.
- Fine electrical properties

1.8 GRAPHITE

Graphite, also referred to as plumbago or black lead, mineral inclusive of carbon. Graphite has a layered shape that includes earrings of six carbon atoms organized in widely spaced horizontal sheets. Graphite hence crystallizes inside the hexagonal gadget, in contrast to the identical element crystallizing within the octahedral or tetrahedral system as diamond. Such dimorphous pairs usually are rather comparable of their physical residences, but not so in this case. Graphite is darkish

grey to black, opaque, and very smooth (with a hardness of 1 half on the Mohs scale), at the same time as diamond can be colorless and transparent and is the hardest evidently occurring substance. Graphite is formed by means of the metamorphosis of sediments containing carbonaceous fabric, by using the reaction of carbon compounds with hydrothermal answers or magmatic fluids, or likely via the crystallization of magmatic carbon. It occurs as isolated scales, massive loads, or veins in older crystalline rocks, gneiss, schist, quartzite, and marble and also in granites, pegmatites, and carbonaceous clay slates. Small isometric crystals of graphitic carbon (possibly pseudomorphs after diamond) observed in meteoritic iron are known as cliftonite.

1.9 STRUCTURE OF GRAPHITE

Graphite is composed of layers of carbon atoms which are arranged in six membered, hexagonal rings. Carbon atoms in those ring arrays are inside the sp^2 -hybridized kingdom. In the sp^2 molecular orbital model each carbon atom is connected to a few different species, 3 other carbon atoms within the case of graphite. These "ring arrays" are organized in huge sheets of carbon atoms, and man or woman sheets are referred to as graphene layers. The carbon carbon bond length in a layer aircraft is 1.418. Graphene layers are stacked one on pinnacle of every parallel with the "c" crystallographic axis of the hexagonal 4 – axis system wherein graphite crystallizes.

This crystal carbon has a structure that is planar and layered. Graphene is the term used to denote each layer of the same. Every layer has atoms of carbon arranged in a honeycomb-like network with the division of 0.142 nm with 0.335 nm distance between planes. There is a covalent bonding for atoms in the plane with the criteria being met by only three out of four probable bonding sites.

The graphite would be conductive electrically owing to the fourth electron having a chance to migrate into the plane. The layers of the carbon crystal could swiftly move past each other as the layers could be separated easily as van der Waals bonds that are weak-hold them together

1.10 PHYSICAL PROPERTIES OF GRAPHITE

The residence of the right graphite fabric that most carefully corresponds to an infinitely large graphite crystal, are reviewed on this section. Such a fabric does not exist inside the actual global and the homes given beneath or both calculated or based on the actual residences of graphite crystals closely drawing this close this ideal shape as already noted and as maybe seen in later chapters , a extensive variety of substances comes under the heading of carbon or graphite and those substances regularly have properties which can be good deal one of a kind from those of the perfect graphite crystal. Obviously its miles necessary to outline the material as it should be whilst talking of the houses of carbon.

1.11 SUMMARY OF PHYSICAL PROPERTIES

The bodily properties of graphite are summarized in below should be stressed that to gain correct measurements of the residences of materials a lot above 3000 K is a attempting undertaking. In the case of graphite , lots of these measurements are based totally on carbon-arc experiments difficult to carry out and interpret. The consequences must be viewed hence and some of those outcomes and conclusions are nevertheless controversial.

- Physical properties of Graphite
- Crystalline form : Hexagonal
- Color : Black
- Density at 300 K, 1 atm :2.26 g/cm³
- Atomic Volume :5.315 cm³/mol
- Sublimation point at 1 atm (estimated): 4000 K
- Triple point (estimated): 4200 K
- Heat of fusion: 46.84 kJ/mol
- Boiling point (estimated): 4560 K
- Heat of vaporization to monoatomic gas (estimated): 716.9 kJ/mol
- Pauling electronegativity: 2.5

1.12 THERMAL PROPERTIES OF GRAPHITE

1.12.1 SUMMARY OF THERMAL PROPERTIES

The physical residences reviewed in the preceding phase are essentially unaffected through the dimensions and orientation of the crystallites within the aggregate (excluding density). As a result, they may be considered legitimate for all styles of graphite. This is not genuine for a few of the residences listed in this and the subsequent sections, and these houses may additionally range extensively depending on crystallite size and orientation and different elements associated with the processing conditions.

Heat of combustion Del H _{co} at 25 deg C	393.13
Standard entropy S at 25 deg C, J/mol-K	5,697 – 5.743
Entropy Del S 298, J/mol – K	152.3

Specific Heat at 25 Deg C kJ/kg-K	0.690 – 0.719
-----------------------------------	---------------

Table 1.1 Theoretical and Thermal Properties of Graphite

1.12.2 HEAT CAPACITY

The molar heat capacity (specific heat) of graphite is reported as 8.033 - 8.635 J/molK at 25°C. [8] As with all elements, it increases with temperature, with the following relationship (T in deg K)

$$C_p = 4.03 + (1.14 \times 10^{-3}) T - (2.04 \times 10^{-5}) T^2$$

The specific heat will increase rapidly with temperature, up to 1500 K in which it degrees off at about 2.2 kJ/kg-K as proven in Fig.1.2. It is believed to be extraordinarily insensitive to the differences among the numerous grades of artificial graphite, and the spread of values determined within the literature may be attributed to experimental versions.

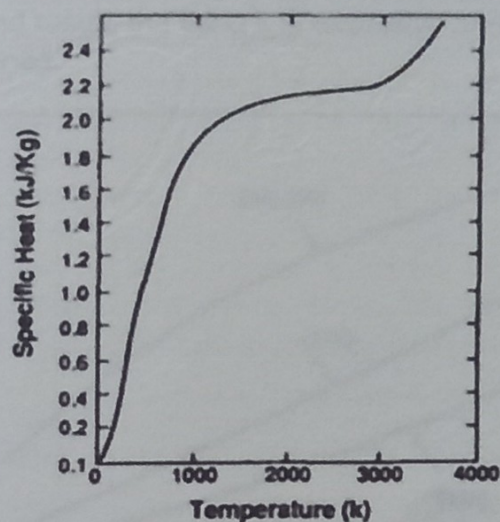


Fig.1.3 Specific heat of graphite vs. temperature at one atmosphere

Graphite	0.690 – 0.719
Diamond	0.502 – 0.519
Boron	1.025
Aluminum	0.900

Table 1.2 Specific heat of Selected Elements

1.12.3 THERMAL CONDUCTIVITY

The thermal resistances of conductivity and enlargement are strongly motivated via the anisotropy of the graphite crystal. The thermal conductivity (K) is the time charge of transfer of warmth by conduction. In graphite, it occurs essentially by lattice vibration and is represented via the subsequent courting (Debye equation):

$$K = bCpvL$$

Where : b = a constant

C = specific heat per unit volume of the crystal

v = speed of heat-transporting acoustic wave (phonon)

L = mean free path for wave scattering

In a polycrystalline substances, the waves (phonon, i.e., quantum of thermal strength) are scattered through crystallite limitations, lattice defects, and different phonons. Little of this takes place in a perfect or close to-perfect graphite crystal in the basal aircraft and, as a end result, the thing L is excessive and thermal conductivity is high within the ab guidelines.

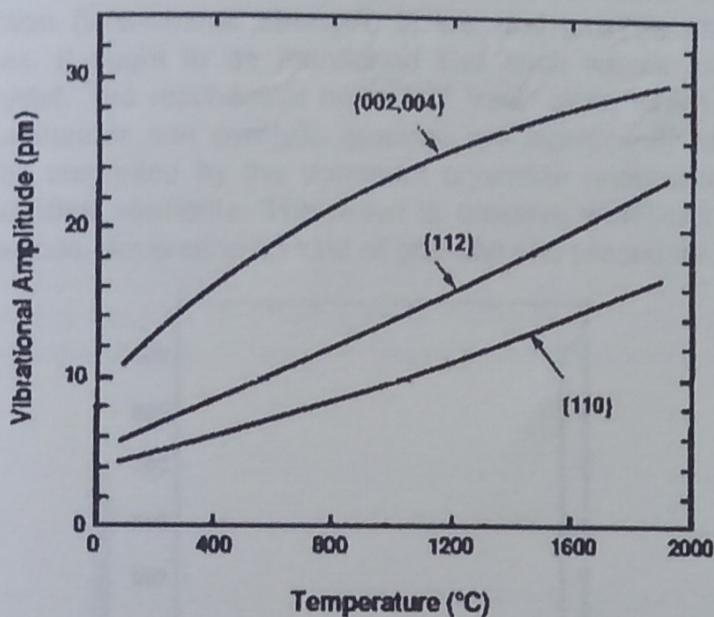


Fig 1.4 Thermal vibrational amplitude of graphite crystal

1.13 ELECTRICAL PROPERTIES OF GRAPHITE

In electrical conductors such as metals, the attraction between the outer electrons and the nucleus of the atom is weak; the outer electrons can move readily and, since an electric current is essentially a flow of electrons, metals are good conductors of electricity. In electrical insulators (or dielectrics), electrons are strongly bonded to the nucleus and are not free to move.118K 19I Electrically, graphite can be considered as

a semi-metal, that is a conductor in the basal plane and an insulator normal to the basal plane. Its atomic structure is such that the highest-filled valence band overlaps the lowest-empty conduction band by approximately 36 meV and the delocalized fourth-valence electrons form a partially-filled conduction band between the basal planes where they can move readily in a wave pattern as they respond to electric fields.^[2°] Consequently, the electrical resistivity of graphite parallel to the basal planes (ab directions) is low and the material is a relatively good conductor of electricity. In the c direction, the spacing between planes is comparatively large, and there is no comparable mechanism for the electrons to move from one plane to another, in other words, normal to the basal plane. As a result the electrical resistivity in that direction is high and the material is considered an electrical insulator. In some cases, it may be 10,000 times higher than in the ab directions.^{^20'} Often quoted resistivity values are $3000 \times 10^{-6} \text{ ohm.m}$ in the c direction and $2.5 - 5.0 \times 10^{-8} \text{ ohm.m}$ in the ab directions.

1.14 MECHANICAL PROPERTIES OF GRAPHITE

The bond between atoms within the basal plane of a graphite crystal is considerably stronger than the bond between the planes with an anisotropy ratio of approximately 75. This means that, while the strength in the ab directions is considerable, that in the c direction (interlaminar strength) is low and graphite shears easily between basal planes. It ought to be mentioned that such values are those of the ideal graphite crystal. The mechanical homes of "real" cloth, which includes the molded graphite substances and pyrolytic graphite are significantly extraordinary because they may be controlled by the dominant crystallite orientation, porosity, structural defects and other elements. The result is massive variations within the variety of these residences, depending on kind of graphite and procedure.

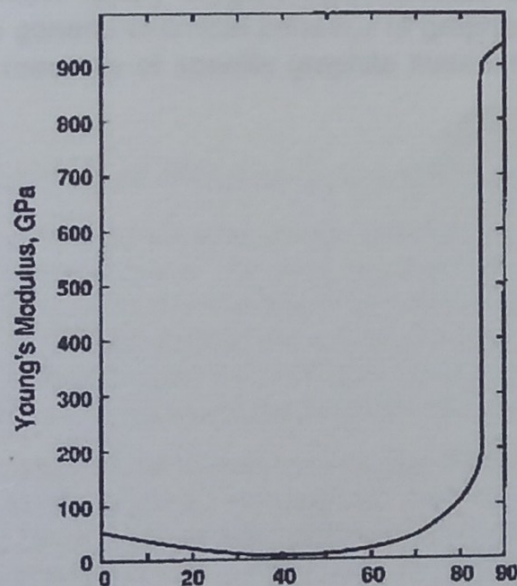


Fig.1.5 Young's modulus of graphite crystal

1.15 CHEMICAL PROPERTIES OF GRAPHITE

Pure graphite is one of the most chemically inert materials. It is resistant to maximum acids, alkalis and corrosive gases. However impurities are nearly always present to some diploma in each natural and artificial graphites and often have an vital catalytic impact with resulting boom within the chemical reactivity.

The anisotropy of the graphite crystal is pondered in its chemical behavior. Reaction with gases or vapors occurs preferentially at "energetic web sites", i.e., the end of the basal planes of the crystal which can be the zigzag face 101 and the armchair face 112 and at illness\ websites, inclusive of dislocations, vacancies, and steps. Reaction with the basal plane surfaces is far slower.

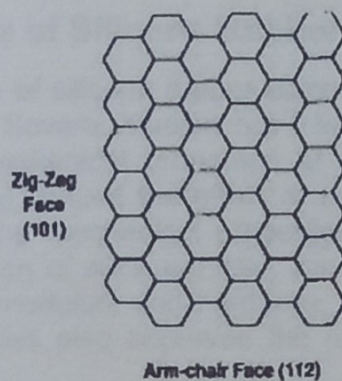


Fig.1.6 The faces of a graphite crystal

Reactivity also generally increases with increasing temperature and, at high temperatures, graphite becomes far more reactive. For instance, above 450°C, it oxidizes readily with water, oxygen, some oxides, and other substances. In this section, only the general chemical behavior of graphite will be considered. Reviews of the chemical reactivity of specific graphite materials will be given in subsequent chapter.

CHAPTER 2

LITERATURE SURVEY

Silicone rubber composites are widely used in engineering applications because of their excellent mechanical and thermal properties. These composites can be tailored to meet specific requirements of different applications by incorporating different types of fillers, such as ceramics, carbon fibers, and nano-particles. The properties of the composites depend on the type and concentration of filler used. In this literature review, we will discuss the mechanical and thermal properties of silicone rubber composites with different types of fillers.

Mechanical Properties of Silicone Rubber Composites:

The mechanical properties of silicone rubber composites are important for their use in structural applications. Several studies have investigated the effect of different types of fillers on the mechanical properties of silicone rubber composites. For instance, Das et al. (2015) studied the effect of adding different amounts of nano-sized silica particles on the mechanical properties of silicone rubber composites. They found that the addition of silica particles improved the mechanical properties, such as tensile strength, modulus, and hardness, of the composites. Similarly, the addition of ceramic particles also improved the mechanical properties of silicone rubber composites.

On the other hand, carbon fibers have also been used as fillers in silicone rubber composites to improve their mechanical properties. For example, Liu et al. (2012) investigated the effect of adding different amounts of carbon fibers on the mechanical properties of silicone rubber composites. They found that the addition of carbon fibers improved the mechanical properties, such as tensile strength and modulus, of the composites. In addition, carbon fibers also improved the fatigue resistance of the composites.

Thermal Properties of Silicone Rubber Composites:

The thermal properties of silicone rubber composites are important for their use in high-temperature applications. Several studies have investigated the effect of different types of fillers on the thermal properties of silicone rubber composites. For example, Liu et al. (2015) studied the effect of adding different amounts of alumina particles on the thermal properties of silicone rubber composites. They found that the addition of alumina particles improved the thermal conductivity of the composites.

In addition, the addition of carbon nanotubes (CNTs) also improved the thermal properties of silicone rubber composites. For instance, Cheng et al. (2015) investigated the effect of adding different amounts of CNTs on the thermal conductivity of silicone rubber composites. They found that the addition of CNTs improved the thermal conductivity of the composites.

CHAPTER 3

AIM AND SCOPE

Aim:

The aim of this project is to investigate the thermal and hydrophobic properties of silicone rubber composite. The project aims to develop a composite material that has improved thermal insulation and water resistance properties for potential applications in various industries.

Scope:

The scope of this project includes the development and characterization of silicone rubber composite. The project will involve the preparation of silicone rubber composite using various fillers, such as ceramic, carbon, or metal particles. The thermal conductivity and insulation properties of the composite will be evaluated using thermal analysis techniques, such as differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). The hydrophobic properties of the composite will be evaluated using contact angle measurements. The project will also involve the optimization of the composition and processing parameters to obtain the desired thermal and hydrophobic properties of the composite. The potential applications of the developed composite material will also be explored, including but not limited to, insulation materials, electrical and electronic devices, and outdoor equipment. The project aims to contribute to the development of new and improved materials for various industrial applications, with particular focus on thermal insulation and water resistance.

CHAPTER 4

MATERIALS AND METHODS

Materials:

The materials used in this study include silicone rubber, graphite powder, curing agent, and other necessary chemicals. The silicone rubber used in this study will have a shore hardness of 50 A and a viscosity of 50,000 cps. The graphite powder will have an average particle size of 20 μm .

Methods :

Preparation of Silicone Rubber/Graphite Composites:

The silicone rubber/graphite composites will be prepared by mixing the silicone rubber, graphite powder, and curing agent in a high-speed mixer. The mixing will be carried out at room temperature for 10 minutes at a speed of 2000 rpm. The graphite filler content will be varied from 5% to 25% by weight.

Characterization of Mechanical Properties:

The mechanical properties of the composites will be characterized using tensile testing and hardness testing. Tensile testing will be performed on a universal testing machine at a crosshead speed of 5 mm/min. The specimens will have a dumbbell shape with a gauge length of 25 mm. The hardness of the composites will be measured using a Shore A durometer.

Characterization of Thermal Properties:

The thermal properties of the composites will be characterized using thermal conductivity testing and coefficient of thermal expansion testing. The thermal conductivity of the composites will be measured using a thermal conductivity meter. The coefficient of thermal expansion will be measured using a dilatometer.

Mixing of Graphite and Silicone Rubber in Two Roll Mill:

Two-roll mills are commonly used for mixing and compounding rubber compounds. The following method describes the process of mixing graphite and silicone rubber in a two-roll mill.

Materials:

- Silicone rubber
- Graphite powder
- Curing agent

Equipment:

- Two-roll mill
- Mixing blades
- Weighing scale

Procedure:

- 1) Preheat the two-roll mill to a temperature of 70°C to 100°C.
- 2) Weigh the required amount of silicone rubber and place it on the front roll of the two-roll mill.
- 3) Start the two-roll mill and adjust the front and back roll gap to the desired thickness, usually 0.2 mm to 1 mm.
- 4) Slowly add the graphite powder to the silicone rubber on the front roll of the two-roll mill.
- 5) Use mixing blades to mix the graphite powder and silicone rubber until they are uniformly dispersed.
- 6) Add the curing agent to the mixture and continue mixing until it is uniformly dispersed.
- 7) Remove the mixture from the two-roll mill and place it into a mold for further processing or testing.

CHAPTER 5

RESULTS AND DISCUSSION

Contact Angle Measurements:

Contact angle is a measure of the degree of hydrophobicity or hydrophilicity of a material's surface. A higher contact angle indicates a more hydrophobic surface, while a lower contact angle indicates a more hydrophilic surface.

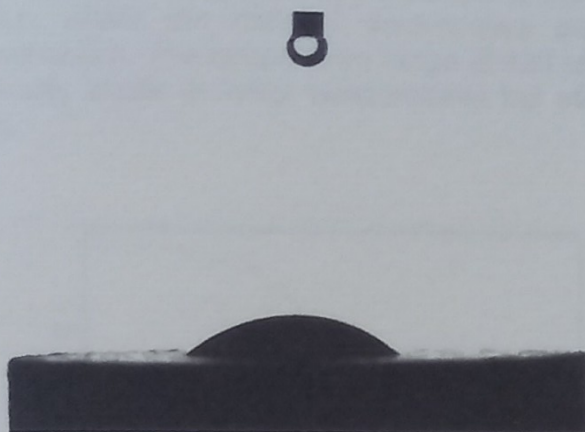


Fig.5.1 The contact angle image for silicone rubber

In this case, the contact angle of pure silicone rubber is 105, indicating that the surface of the silicone rubber is moderately hydrophobic. When graphite sheets are added to the silicone rubber, the contact angle increases to 135, indicating a significant increase in the hydrophobicity of the composite surface.

The increase in contact angle can be attributed to the surface properties of the graphite sheets. Graphite is a hydrophobic material, meaning that it repels water due to its non-polar surface. When graphite sheets are added to the silicone rubber composite, they create a rough surface that reduces the contact area between water droplets and the composite surface. This reduction in contact area leads to an increase in the contact angle, indicating a more hydrophobic surface. The increase in contact angle from 105 to 135 for the silicone rubber + graphite sheet composite indicates a significant increase in hydrophobicity.

This is due to the hydrophobic nature of the graphite sheets and the rough surface they create on the composite, reducing the contact area between water droplets and the surface. This increased hydrophobicity has potential benefits in applications where water resistance is desired, such as in outdoor equipment or electrical and electronic devices.

TGA ANALYSIS:

Thermogravimetric analysis (TGA) is a thermal analysis technique used to study the thermal stability and decomposition behavior of materials. In this case, the TGA interpretation indicates that the sample undergoes a single-step decomposition in the temperature range of 420 to 630 °C, with a residual mass of around 34%.

The single-step decomposition suggests that the sample undergoes a simple thermal degradation process, where the material decomposes into smaller molecules through a single mechanism. The temperature range of 420 to 630 °C indicates that the sample is thermally stable at lower temperatures but starts to decompose at higher temperatures.

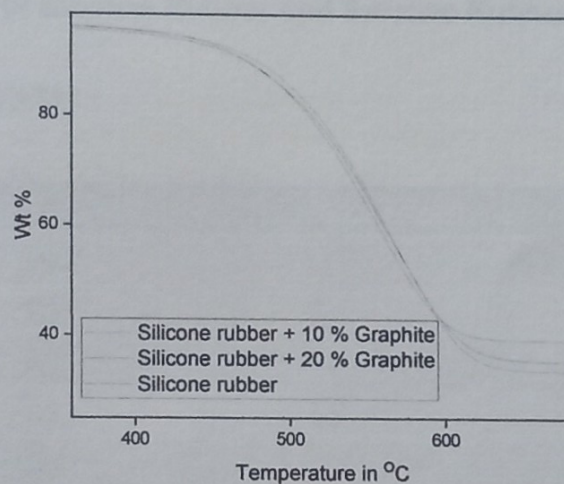


Fig.5.2 TGA of Silicone rubber and silicone rubber + Graphite sheet

The residual mass of 34% indicates that a significant portion of the sample remains after the decomposition process, which may indicate the presence of fillers or other additives in the composite. The residual mass can provide information about the composition and quality of the sample, as well as its potential for further processing or use.

HARDNESS:

S.No	% of silicone	% of graphite	Hardness
1.	100	0	51
2.	95	5	61
3.	90	10	64
4.	85	15	67
5.	80	20	71
6.	70	30	74

Table5.1 Hardness of Silicone Rubber and Silicone Rubber + Graphite Sheet

TENSILE STRENGTH :

S.No	% of silicone	% of graphite	Tensile Strength
1.	100	0	4.74
2.	95	5	5.64
3.	90	10	5.81
4.	85	15	6.27
5.	80	20	6.36
6.	70	30	6.01

Table5.2Tensile Strength of Silicone Rubber and Silicone Rubber + Graphite

CHAPTER 6

CONCLUSIONS

Contact Angle Measurements:

- The contact angle of pure silicone rubber is 105, indicating a moderately hydrophobic surface.
- The addition of graphite sheets increases the contact angle to 135, indicating a significant increase in hydrophobicity.
- The hydrophobic nature of the graphite sheets and the rough surface they create on the composite contribute to the increased contact angle.
- The increased hydrophobicity has potential benefits in applications where water resistance is desired.

TGA Analysis:

- The TGA interpretation indicates that the sample undergoes a single-step decomposition in the temperature range of 420 to 630 °C.
- The single-step decomposition suggests a simple thermal degradation process through a single mechanism.
- The residual mass of 34% suggests the presence of fillers or additives in the composite.
- The TGA analysis provides information about the thermal behavior of the material and its potential for further processing or use.

CHAPTER 7

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