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Editor
Prof. Bayram KIRAN Ph.D.

DUVAR

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Chapter-1

THERMAL INSULATION WİTH THERMAL INSULATION IN BUILDINGS, SELECTION OF APPROPRIATE MATERIALS AND INVESTIGATION OF SHEATHING TECHNOLOGY

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Abstract:

Insulating materials, which have been professionally used in the world since the 1800s and whose conscious use has increased over the last five years with an unprofessional use in Turkey from the 1960s to nowadays, have diversified and increased under time and changing conditions (e.g. weather conditions, research and development, economy, environmental pollution). As a result, distinctions have come out in preferred properties and strengths. To get the highest efficiency in construction, a quality philosophy should be established from the very first stage to the last stage. First of all, where and for what purposes the material will be used as well as the selection of most suitable materials are important issues. Besides, though it is believed that operation of these by qualified operators is as strong as the longevity of the building, maintenance should be carried out in time.

Keywords:heat insulation, structure, insulation, energy-saving, environment

1.INTRODUCTION

Today when constructing a building, the first issue is the type of the architecture and how static projects will be carried out depending on this architectural project. However, insulation is not valued sufficiently. Only when insulation is carried out is it understood to be important.

Considering problems to arise when failing to place sufficient importance to insulation, it can be observed that insulation is as important as an architectural and static project.

1.1. General Information

As is in all sectors, there is a natural competitive environment within the insulating material market and insulation applications construction sector.

It is highly natural to experience problems in case of competition. Competition will lead to an increase in quality, thus the quality that is reached will provide an advantage rather than a problem.

The main problem is to bring notably obligatory standards related to insulation to the level of developed countries and to make their application obligatory [1].

For, economic losses of our country and energy wastage in this respect are unfortunately at high levels [2]. It is not possible to dissociate economic problems of a country from companies resident in that country.

In the increase of global warming and which played an important role in the depletion of energy resources The construction sector can reduce these negative effects caused by eco-friendly, sustainable, environmentally friendly, natural resources for

It should act in accordance with the understanding of production that can use efficiently [22].

Factors affecting the heating energy need of the building The factors affecting the heating energy need of the building have been explained below:

- Building characteristics: Heat losses realized via the transmission, convection and ventilation (if any heat recovery) and thermal capacity,
- Characteristics of the heating system: Duration of responding to the changes in the heating energy need by especially the control systems and heating system,
- Internal climate conditions: Temperature value that the ones using the building want, changes in these temperature changes at the different sections of the building and the different times of the day,
- External climate conditions: External air temperature, direction and magnitude of the prevailing wind,
- Internal heat gain resources: Various devices and people expanding heat to

the environment and used with the aims of internal heat resources having contribution to the heating, food cooking, obtaining hot water, illumination other than the heating system.

It is believed that the accession to customs union will not be negatively affected in terms of insulating materials. It is possible to state that they have European Union Standards in terms of quality. As regards price formation, It is also believed that there will not be a negative competitive environment in terms of both customs zeroing advantages in raw material intake and advantages of imported products.

Contactors regard insulation not as a necessity but as a luxury and approach the issue arbitrarily. The main reason of this is the most primitive way of application of guarantee system applied in western countries in construction sector. Full liability of a contractor of a building that has final acceptance in Turkey terminates at this point. However, this acceptance is generally carried out when each year passes over the date of manufacture. Considering the total service life of the building, this one-year guarantee makes sense. Regarding abroad, guarantee periods are measured in decades thanks to guarantee certificates obtained by owners from the contractor.

When building the project of a construction in Europe and USA, insulation detailing is made. Yet in Turkey except for few major projects, insulation is taken into consideration during the last stage in nearly all constructions.

Insufficient application of insulation imposes more burdens on the national economy. For example, only due to insufficient insulation the loss of Turkey is about 9 billion dollars in one year according to İZODER reports [3].

The magnitude of energy savings as a result of using thermal insulation varies according to the type of building, the climatic conditions of the building and the type of insulation material used.

The importance of heat insulation is based on two main concepts, mainly energy and environment. We can add healthy and comfortable living spaces to this. Energy is an important and strategic macro concept not only for us but also for other countries. It is a fact that our country is not very rich in terms of energy resources. 60-65% of the energy demand is imported from the outside [20.21]. Heat insulation in housing contributes hugely to the energy saving. According to the reports of Ministry of Energy and Natural Resources in 1989, 3.2 billion dollars was spent on heating, of which 2.5 billion dollars was spent to pollute the environment and heat air due to lack of heat insulation in buildings and poor housing. In the wake of world oil crisis in 1970, energy was used efficiently. [24]Turkey did not have such an effort. Saving provided from the heating system balances insulation expenses and besides, fuel saving throughout the longevity of the building turns out to be a profit for the investor. In general, we can talk about three basic stages.

1. First evaluation level - building materials
2. Second evaluation level—thermal insulation solutions
3. Third evaluation level—building [25]

In addition to these, the thermal and energy performance of the buildings depends on the thermal properties of the building envelope and especially the thermal resistance of the insulation material used. The performance of the thermal insulation material is mainly determined by its thermal conductivity, which defines the ability of heat to flow through the material at a different temperature. The thermal conductivity value of a particular material can vary due to changes in both moisture content and temperature. In reality, thermal insulation in buildings is subject to significant and continuous temperature changes due to changing outdoor temperature and solar radiation [37].

The most crucial property that describes the heating insulation materials is the value of HEAT CONDUCTIVITY. This value, known as Lambda (ʎ), is accepted as maximum 0.060 W/mK in heat insulation materials according to international standards. Heat insulation materials with lambda values over this value are not accepted as heat insulation materials in any international literature [1]. Sert iklimlerde, binada ısı yalıtımının kullanılması , binanın termal yükünü ve dolayısıyla enerji tüketimi. Isı yalıtım malzemesinin performansı esas olarak malzemenin termal iletkenliğine bağlı olarak belirlenir. (yoğunluk, gözeneklilik, nem içeriği ve ortalama sıcaklık farkı.) [23,38]

As a result of literature review, following heat insulation materials are being used at various standards [4]:

CEN (European Union)

* Mineral Wools (glass wool, rock wool)
* Expanded Polystyrene Foam (EPS)
* Extruded Polystyrene Foam (XPS)
* Polyurethane Hard Foam (PU)
* Phenol Foam
* Glass Foam
* Wood wool
* Expanded Perlite Plates
* Cork plates

*   Wood dust plates

DIN (Germany)

*   Wood dust plates
*   Polyurethane Foam Filling
*   Cork plates
*   Expanded polystyrene foam
*   Polyurethane hard foam
*   Phenol Foam
*   Mineral Wools
*   Glass Wools

1.2. Optimum thermal insulation thickness

The total building heat load consists of external heat load and internal heat load. External heat load includes: heat conduction and direct solar radiation The building envelope from outdoor to indoor conditions. Total building heat load with constant internal heat load is calculated in various thermal insulation It is calculated as 0 ~ 12 cm thickness [29].

Increase in fuel cost optimum insulation thickness as well as annual savings causes to increase. In this case, the maximum annual savings in case of using fuel oil while obtaining the most suitable in terms of insulation thickness the result is if natural gas fuel is used . It was found to be obtained [30].

We will analyze the relationship between the thermal conductivity of the building wall and the thickness of the selected insulation materials:

Let us assume that a relationship between thermal conductivity (k) and optimum thickness (xopt) of the insulation material is not linear and xopt = a + bk + ck2 conforms to a polynomial function where a = 0.0818, b = 2.973 and c = 64.6. The relationship will be very useful for practical use to estimate the optimum thickness of the insulation material in reducing the heat flow rate through the building wall by knowing only its thermal conductivity [35].

1.3. External heat insulation on the facade of building

In buildings that do not have the necessary heat insulation, the use of heat insulation is becoming more and more important in the renewal of the building facade with new materials and components in order to reduce the energy consumed for heating and cooling, to prevent heat bridges and to provide internal comfort conditions. Therefore, heat insulation is used to prevent thermal influences from inside to outside or from inside to outside, depending on the severity of external climatic conditions, to prevent the negative effect of the temperature difference between the internal environment and the external environment, and thus to reduce heating and cooling energy costs [16]. The processes carried out to reduce the heat transfer between two environments with different temperatures are called "Heat Insulation". For people to live a comfortable life, 20-22 °C temperature environments are needed. For this purpose, the external wall insulation is the insulation made to the elements such as walls, columns, beams and cantilever slabs in the outer shell of the building. Exterior insulation of the building can be made from outside (sheathing), between walls and from inside [1]. Whichever insulating material is used and even without any use of insulating material, fire barriers composed of fireproof materials should be used in curtain wall systems. These elements are located in a way to completely prevent the air circulation at floor line. The air circulation in the gap is solved within the story height. Otherwise, a permanent gap will create a chimney effect, leading the fire to spread all over the facade and building in a short while making people unable to escape. Cement or ceramic-based plates are among the materials to be used for the glass, marble protective layer. The insulation process should be carried out all over the windows and doors as well, given in Fıgure 1. Details around the roofs and gutters should be solved to prevent heat bridges [5]. Although external heat insulation, which constitutes the most important part of heat insulation, was started to be applied in developed countries in 1970s, it was in 1991 when it was introduced to our country with exterior heat insulation materials comprised of imported products. Also in the early 1990s, the use of double glazing units began in the window joinery, where significant heat losses were experienced [1].

Studies have shown that energy savings of up to 76.8% can be achieved when using polystyrene for both wall and roof insulation [34].

Figure 1. External Heat Insulation (Sheathing)

External heat insulation with extruded polystyrene or rock wool (Sheathing)

Works within this specification contain the external heat insulation application on the façade of the building to be made in places specified within the architectural project, all materials, insulation plates, workers of placement, adhesives, etc. [6].

Heat-insulation-related worksite projects, material samples, certificates, brochures and catalogues will be submitted for the approval of the Engineer.[26]

The extruded polystyrene or rock wool to be used in heat insulation will be subject to the test certificate obtained from an experienced and renowned international manufacturer. Sheathing will be considered as a system, and to avoid any problem in the interaction of materials with each other, all components will be supplied from the same source [32]. The supplier is obliged to certify the durability of the sheathing system through aging test.

In our country, the use of easily flammable materials on building facades is prohibited in accordance with the fire protection regulation. Among the heat insulation plates given in the above application (Figure 1), rock wool was preferred because it is a non-flammable A1 class thermal insulation material. This situation makes stone wool one step ahead compared to other thermal insulation boards.

1.4. Materials

Heat insulation materials are used to reduce the heat transfer between two environments with different temperatures. In other words, special materials used in reducing heat losses and gains with high thermal resistance and low heat conduction coefficient are called heat insulation materials [17]. The most important condition of making a good choice in heat insulation materials is to know the material to be used in every aspect and to know the application properties of this material well. Therefore, the performance of heat insulation materials is evaluated according to the basic properties such as thermal conductivity and thermal resistance coefficient, compressive strength, tensile strength, vapour diffusion resistance, water and moisture resistance, fireproof and flame resistance, density, dimensional stability, chemical stability [18]. Extruded polystyrene foam plates to be used in the heat insulation of the facade will have the thickness specified in projects, a heat conductivity value of 0.030 W/mK, a compressive strength of 200 kPa, water vapour diffusion resistance at values between 100 and 200 and will be fire-resistant of B1 class in fireproofing self-extinguishing type, rough on both surfaces and grooved on one surface. All plates will be connected to avoid heat build-up [1, 6, 7].

Extruded polystyrene foam (XPS) and expanded polystyrene foam (EPS) are the materials commonly used in the heat insulation applications of existing buildings in our country. These materials are frequently used for exterior sheathing, protective layer on surfaces that come into contact with the soil, basement floors of buildings and heat insulation on traditional terraces and exterior applications for decorative purposes [19].

Plastic wall plugs should be made of first class plastic and in the same colour as heat insulation plates. The net should have an intraocular distance of 4x4 mm, resistant to alkaline medium with minimum 160 gr/m2 and certified to have a tensile strength of 1500 N/5 cm under standard conditions [6].

Adhesive and covering mortars should be those special that are hydraulically bound whose quality has been improved with synthetic admixtures and used in covering of heat insulation plates, whose pour and mortar density are 1,5 kg/dm3 and 1,6 kg/dm3 respectively along with a very good adherence and processing of long duration, and resistance to rain and freeze-thaw cycles [6].

Final surfacing is the ready-to-use siding that is acrylic based with silicon admixture. It should be supplied and applied in the colour specified within the projects, given in Figure 2.

Figure 2. Final surfacing of the facade, made of acrylic based with silicon admixture

Dimensions based on computations will be computed as net surfaces from the projects, placed as described and to the satisfaction of the engineer and contain all materials and labour required for pinning [6].

1.5. Heat Insulating On Roofs, Grounds, Basement Ceilings And Soil-Contact Walls

The basic principle in heat insulation is the continuous insulation application. Besides, it is not fundamental to apply the insulation on the element that separates the external environment. The heat insulation in practice should always be applied between the heated volume and the low-temperature volume that is adjacent to it.

Though the heat loss varies depending on the architectural project and status of the building, in general for multi-storey houses 40% of the total heat loss is composed of external walls, 30% of windows, 7% of roofs, 6% of cellar floor and 17% of air leaks. Heat losses in a single-storey house stem from external walls by 25%, from roofs by 22%, from windows by 20%, from the basement by 20% and from air leaks by 13%. As it is clear from these figures, the heat loss in buildings stems most from walls, windows, ceilings and roofs and floorings respectively [8,33].

* Heat insulating on roofs
* Heat insulating on the ground
* Heat insulating on the basement ceiling
* Heat insulating on soil-contact walls

Works within this specification will contain heat insulations of roof, ground, basement ceiling and soil-contact walls in places specified within the architectural project, application conditions and related materials.

Material samples, certificates, catalogues and brochures will be submitted to the approval of the engineer.

1.5.1 Heat insulating on the roof:

While particularly residents at the top floors of apartments located in cold climates complain that they do not get heated enough, among the solutions for this are an increase in radiator fins and boiler water temperature. Yet, this leads to a complaint by those living at ground floors due to high temperature and thus, they open their windows. On the other hand, those resident at the top floors of apartments in warm climates complain about very high temperatures in summers and find the solution with air conditioning regardless of whether it is enough or not and heavy utility bills [9].

A roof design has a multi-layered complex construction composed of a great many special components. The roof substructure can be formed through ferro-concrete, steel and wooden materials and various building systems. As these materials serve as bearing elements, the selection of the system, the calculation of element sizes and roof bedding should be done suitably. Failure to do these may lead to dimensional deviations in components that form the roof construction, mistakes in the joints of the components, water vapour condensation and air leaks [10].

Continuous ventilation should be provided along the eaves (or roof ridge). As the slope decreases, ventilation distance area is expected to grow. There is ease of application [11].

* Heat insulating on the terrace roof with extruded polystyrene

In the application of heat insulation, extruded polystyrene insulation plates with armoured surfaces will be used with the thickness specified in projects, a density of minimum 32 kg/m3, a heat conductivity value of 0.027 W/mK, a compressive strength of 300 kPa and will be fire-resistant of B1 class in fireproofing self-extinguishing type.

Extruded polystyrene plates will be laid freely in accordance with the approval of the engineer on waterproofing and separator plates within the terrace roof detail. To avoid spacing on plate junctures, connected types will be used. Layers specified in projects will be used on waterproofing to complete the detail.

* Waterproofing on the ground under the hipped-roof with extruded polystyrene

In the application of heat insulation, extruded polystyrene insulation plates with armoured surfaces will be used with the thickness specified in projects, a density of minimum 30 kg/m3, a heat conductivity value of 0.028 W/mK, a compressive strength of 200 kPa and will be fire-resistant of B1 class in fireproofing self-extinguishing type.

Extruded polystyrene plates will be places in tapes on the ground under the roof to allow the application of adhesives in accordance with the approval of the engineer. Connected types will be used to avoid spacing between plate junctures.

1.5.2 Heat insulating on the ground:

If the heat insulating materials are sensitive to moisture or water or affected by the acid or chemicals in the components on the ground, the thermal capacity will decrease. Besides, heat bridges and surface condensation occur where the continuity of the heat insulating layer is interrupted [5].

* Heat insulating under-screed on the ground with extruded polystyrene

In the application of heat insulation, extruded polystyrene insulation plates with armoured surfaces will be used with the thickness specified in projects, a density of minimum 30 kg/m3, a heat conductivity value of 0.028 W/mK, a compressive strength of 200 kPa and will be fire-resistant of B1 class in fireproofing self-extinguishing type.

Extruded polystyrene plates will be laid on the landing freely and the section will be completed through the application of separator mat and screed. The approval of the engineer will be obtained at all stages of the work. Connected types will be used to avoid spacing between plate junctures [27]

1.5.3 Heat insulating on the basement ceiling:

* Heat insulating on the basement ceilings with extruded polystyrene foam

In the application of heat insulation on the basement ceiling, extruded polystyrene insulation plates with rough surfaces on each side will be used with the thickness specified in projects, a heat conductivity value of 0.030 W/mK, a compressive strength of 200 kPa and will be fire-resistant of B1 class in fireproofing self-extinguishing type. Heat insulating plates will be fixated on the ceiling with plastic wall plugs.

At least 6 plastic wall plugs which are more than m2 will be used during the fixation of the heat insulating plates. Plastic wall plugs should be in type that will allow insulating plates stand on the ceiling strong and straight. Necessary preparations should be completed prior to the fixation of insulating plates on the ceiling for lighting components on the ceiling. Holes to be made in insulating plates in pipe passages will be maximum 1 cm bigger than the pipe diameter. The approval of the engineer will be obtained at all stages of the work. Connected types will be used to avoid spacing between plate junctures.

1.5.4 Heat insulating on the soil-contact walls:

There is a heat loss due to heat movements from the inside out (from hot to cold) in cold weather conditions. The basic factor in decreasing this heat loss is the high temperature resistance of the building envelope. That the temperature resistance of the elements that constitute the building envelope is high ensures that both building internal temperature and internal surface temperature is maintained at favourable comfort conditions level. The internal surface temperature of the building envelope is one of the most important elements that affect the indoor temperature comfort. There is a continuous heat exchange between the user and the internal surface of the building envelope through radiation [5].

Keeping indoor temperature at a certain level is desirable during cold winter days. Adjusted or favoured comfort conditions were provided by means of thick walls of the masonry buildings constructed before the World War II. These walls prevented temperature fluctuations within the building by providing sufficient heat retention and accumulating a good amount of heat. In volumes surrounded by thin walls, there were quicker cooling and monetary problems such as an increase in fuel expenses as well as dampness on the wall surface and glass surfaces of the windows. These problems led to the emergence of the building physics notion [12].

□ Heat insulating on the soil-contact walls with extruded polystyrene

In the application of heat insulating, extruded polystyrene insulation plates with armoured surfaces on each side will be used with the thickness specified in projects, a density of 30 kg/m3, a heat conductivity value of 0.027 W/mK, a compressive strength of 300 kPa and will be fire-resistant of B1 class in fireproofing self-extinguishing type.

Heat insulation will be applied on the waterproofing layers to meet [13] specifications as material and labour. The approval of the engineer will be obtained at all stages of the work. Connected types will be used to avoid spacing between plate junctures.

1.6. Scope of Works

Heat insulation works will contain supply and mobilisation of all required labour force and equipment, mobilisation of all required facilities, tools and equipment of the materials, storage, the secured and clean protection of works, cleaning after the completion of work and the completion of tall the other works. Though heat insulating plates to be used on the basement ceilings are suitable for plastering, plastering will not be applied on plates under this insulation work.

Any material, labour, transportation, cleaning after the completion of work, tests and works should be completed to the satisfaction of the engineer under the scope of works.

2. COMPUTATION

Under this specification:Heat insulation with extruded polystyrene plates on the roof, basement ceiling and soil-contact walls will be computed as m2. Spaces which are bigger than 0.10 m2 will not be included in the computation of the heat insulation.

2.1. Problems in Application

Along with an increase in consciousness related to the importance of the heat insulation and the enforcement of heat regulations in Turkey, heat insulating applications have been carried out in every part of the country. As insulation still remains to be a new notion in Turkey, there are problems arising from lack of knowledge in both design and application processes. During this development process, mistakes made due to the lack of knowledge and experience leads to a failure to show expected performance in buildings with heat insulation systems in some of the designs and applications. During the project designing of the building, Turkey has four separate climatic zones as 1st, 2nd, 3rd and 4th degree according to [6]. Where the building is within the 1st climatic zone, it generally provides ventilation for hot, lumped and yard-type masses and can work with wide fringed systems which have middle halls in planning and with cold roof systems on the roofs. Besides, it is important to decrease window surfaces and pay attention to installation solutions. Where the building belongs to the 4th climatic zone, it is better to solve the building project as massive masses and locate the aisles and narrow sides of the front towards the cold side. Where the heat transmission resistances of the elements that form the building are insufficient according to the architectural and static construction of the building, it is essential to apply heat insulation [14]. A failure to comply with laws of physics on walls and terraces in buildings leads to problems related to bleeding and condensation. Bleeding is the process where the steam occurring with a decrease in temperature on the building element surface turns into water. Condensation, on the other hand, is the process where the steam occurring between materials of the building element due to various steam temperatures. Bleeding and condensation give rise to deterioration in building materials as well as swelling and outpouring in coating materials. Utmost attention should be paid to condensation computations in detailing and in laying together the materials according to the results from these computations [15].

Heat insulation is directly related to pollution. Fuel consumption of a building without heat insulation is not the same as a building with heat insulation. Where heat insulation is not applied, unnecessary energy consumption causes air pollution. The accumulation of harmful gases in the atmosphere leads to global warming and major changes in climates.

Computation-based dimensions will be obtained from the projects and contain all materials and labour required for placement and pinning as described and to the satisfaction of the engineer.

3. CONCLUSION AND RECOMMENDATIONS

Heat insulation is directly related to pollution. Fuel consumption of a building without heat insulation is not the same as a building with heat insulation. Where heat insulation is not applied, unnecessary energy consumption causes air pollution. The accumulation of harmful gases in the atmosphere leads to global warming and major changes in climates. Insufficiency in heat insulation causes losses related to health and finance, air pollution and degradation in flora. Findings stressed related to the advantages of the heat insulation in this study are as follows:

Considering that sheathing heat insulation system leads heated mass of the building to cool late and saving in heating, heat insulation with sheathing system has been presented along with application details. Considering that today the percentage of contractors who are well-informed about heat insulation is 7%, which is highly low, it is obvious that this study will be useful visually and logically.

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Chapter-2

SILVER NANOPARTICLES AND THEIR ANTIMICROBIAL EFFECT

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Introduction

Nanotechnology has gained tremendous impetus in the recent century due to its capability of modulating metals into their nanosize (Govindaraju et. al., 2010**).** Nanotechnology is an important field of modern research dealing with synthesis, strategy and manipulation of particle's structure ranging from approximately 1 to 100 nm in size. Nanoparticles are small particles or particulate matters less than 100 nm in diameter that can be classified as liposomes, metallic nanoparticles, polymeric nanoparticles and albumin bound nanoparticles (Pangi et al., 2003). Many reports have been published about the syntheses of silver nanoparticles using plant extracts.

Metal nanoparticles have received considerable attention in recent years because of their unique properties and potential applications in catalysis (Kamat, 2002), plasmonics (Maier et al., 2001), optoelectronics (Gracias et al., 2002), biological sensor (Mirkin et al., 1996; Han et al., 2001) and pharmaceutical applications (Chan and Nie, 1998). In the food sector, the uses of nanotechnology-derived food ingredients, additives, supplements and contact materials are expected to grow rapidly. Chaudhry et al. (2007) claimed that, worldwide, over 200 companies conduct research and development projects regarding the use of nanotechnology in agriculture, engineering, processing, packaging or delivery of food and nutritional supplements. Food safety is also potential benefit with the introduction of nano-based detectors, sensors and labelling (Weiss et al., 2006). In some countries, nanomaterials are already used in food supplements and food packaging, with nanoclays as diffusion barriers and nano-silver as antimicrobial agents (Sanguansri and Augustin 2006; Chaudhry et al., 2008).

Controlling the size/shape of nanoparticles to achieve monodispersity are the frequently encountered common challenges by researcher. To overcome over the difficulties, eco-friendly approaches have been developed by using biological principles such as microorganisms or plant extracts in the process of synthesis (Saifuddin et al., 2009). Hard template, using bacteria, fungi and plants are other methods used for the synthesis of nanomaterials such as gold (Au), silver (Ag), platinum (Pt) and palladium (Pd) (Ravichandran et al., 2019). Nanoparticles, including metal-containing nanoparticles, silver nanoparticles (AgNPs) are noble metal nanoparticles with particular importance due to their wide range of application (Hamedi and Shojaosadati, 2019). The syntheses of AgNPs are very common due to their numerous applications in various fields. AgNPs have unique properties such as: optical and catalytic properties, which, depend on the size and shape of the produced nanoparticles (Khodashenas and Hamid Reza Ghorbani, 2019). AgNPs are mainly used in electric batteries, glass and ceramic pigments and devices for the treatment of diseases such as cancer, HIV, diabetes, malaria and tuberculosis (Popescu et al., 2010; Akhbari et al., 2011; Song et al., 2019) and also known to have inhibitory and bactericidal effects.

Green Nanotechnology and Silver Nanoparticles

Presently, metallic AgNPs are used as antimicrobial agent and is synthesized by following various protocols (Guzman et. al., 2012). Synthesis of metallic and semiconductor nanoparticles through physical and chemical routes has been extensively reported. However, these methods are not cost-effective and moreover, the chemicals used in chemical methods are highly reactive and have potential environmental hazards (Zare et al., 2017). These methods also have potential risks to environment and human health and thus, limited the application of nanoparticles especially, in clinical fields (Dhand et al., 2016).

Green chemistry is one of the most accepted natural remedy for the protection of our biodiversity (Thomas et al., 2019). Green synthesis is a biological method in which nanoparticles are easily obtained; as well as being environmentally friendly and inexpensive in terms of cost, and being more preferred than chemical and physical methods by minimizing the usage or production of chemicals. Reduction of any toxic chemical substances to zero level can be regarded as green synthesis (Elemike et al., 2017; Thomas et al., 2019).

However, green synthesized metal nanoparticles are currently in the limelight due to the simplicity, cost-effectiveness and eco-friendliness of their synthesis (Elemike et al., 2017). Hence, many reseachers have been adopting green methods for nano ion synthesis (Sahayaraj et al., 2020).

The reduction and stabilization of silver ions by combination of biomolecules such as proteins, amino acids, enzymes, polysaccharides, alkaloids, tannins, phenolics, saponins, terpinoids and vitamins which are already established in the plant extracts having medicinal values and are environmental benign, yet chemically complex structures (Kulkarni and Muddapur, 2014). Since these methods eliminate the time-consuming process of microbial culture and maintenance, plant-mediated synthesis of silver nanoparticles has attracted more attention over other biological sources (Ahmed et al., 2015). A number of plants, including *Aloe vera*, *jatropha curcas*, *citrus aurantium* (orange blossom), *solanum melongena* (eggplant*), Trifolium resupinatum*, pine pollen, *Cassia tora*, *Fritillaria* flower, *Taxus baccata*, and *Laminaria japonica* have also been identified for their ability to produce silver nanoparticles (Hamedi and Shojaosadati,2019). In recent decades, green approaches based on employing biological entities such as bacteria, fungi, viruses, yeasts and plants have emerged as promising methods for nanoparticle synthesis (Gajbhiye et al., 2009; Kalishwaralal et al., 2010; Nayak et al., 2015; Eren, 2020). The protocol for the nanoparticle syntheses involves: the collection of the part of plant of interest from the available sites and then washing thoroughly twice/thrice with tap water to remove both epiphytes and necrotic plants; followed with sterile distilled water to remove associated debris if any. These; clean and fresh sources are shade-dried for 10–15 days and then powdered using domestic blender. For the plant broth preparation, around 10 g of the dried powder is boiled with 100 mL of deionized distilled water (hot percolation method). The resulting infusion is then filtered thoroughly until no insoluble material appeared in the broth. To 10^{-3} M $AgNO_3$ solution, on addition of few mL of plant extract follow the reduction of pure Ag(I) ions to Ag(0) which can be monitored by measuring the UV–visible spectra of the solution at regular intervals (Sahayaraj and Rajesh, 2011).

Antimicrobial Effects of Silver Nanoparticles

The combined use and misuse of antibiotics and other antimicrobial medicines has led to development of antimicrobial resistance (AMR). The overuse of antimicrobial agents against harmful pathogens has led to the rise of multidrug-resistant microorganisms (Fan et al., 2017). A person infected with a multidrug-resistant bacterium could not recover easily because it needed to be treated with broad-spectrum of antibiotics. Moreover, AMR property of varied pathogens is posing serious threat globally (Supraja et al., 2016). Therefore, development and modification of new antimicrobial compounds is especially focused in recent times. The multi-resistant pathogens due to antigenic shifts and/or drifts are ineffectively managed with current medications. This resistance to medication by pathogens has become a stern problem in public health; therefore, there is a strong requirement to develop new bactericides and virucides. Silver is having a long history of use as an antiseptic and disinfectant and is able to interact with disulphide bonds of the glycoprotein/ protein contents of microorganisms such as viruses, bacteria and fungi (Ahmed et al., 2016).

Silver is a potent antimicrobial agent which is used in the form of nanomaterial or as metal salts for antimicrobial applications. Antimicrobial agents have a major role in water treatment, chemical industries, food preservation, aquaculture ponds, agricultural productivity and biomedical applications (Anjali Das et al., 2020). The synthesis of AgNPs is a very promising technique because of its wide applicability, especially in the treatment against pathogen microorganisms. The antimicrobial activity from AgNP is mainly due to their large surface area, which results in greater interaction between the nanoparticles and the cells of the microorganisms, inhibiting their growth even at very low concentrations in the medium (Palanisamy et al., 2017). Antibacterial activity of the AgNPs can be exploited for disinfection in wastewater treatment plants, to prevent bacterial colonization and eliminate microorganisms on medical and silicone rubber gaskets to protect and transport food and textile fabrics among others (Panacek et al., 2006). Additionally, AgNPs demonstrate good antimicrobial properties against a wide range of microorganisms, including bacteria, yeast, and mould. Therefore, use of such materials in the food industry may be useful for extending the shelf life and improving safety of food products by preventing the growth of spoilage and pathogenic microflora (Krásniewska et. al., 2019).

AgNPs can easily penetrate microbial cell wall due to its small size and are also utilized in food industry in packaging to stop damage of food products by pathogens (Siddiqi et al., 2018). The mechanism of the bactericidal effect of silver colloid particles against bacteria is not very well known. It is possible that AgNPs act similarly to the antimicrobial agents used for the treatment of bacterial infections. Those agents show four different mechanisms of action; interference with cell wall synthesis, inhibition of protein synthesis, interference of nucleic acid synthesis, and inhibition of a metabolic pathway (Klueh et al., 2000; Yamanaka et al., 2005; Sondi et al., 2007).

For the syntheses of nanoparticles employing plants can be advantageous over other biological entities which can overcome the time consuming process of employing microbes and maintaining their culture which can lose their potential towards synthesis of nanoparticles. Hence in this regard; use of plant extract for synthesis can form an immense impact in coming decades (Ahmed et al., 2016). Some researches exhibited that the nanoparticles showed greater antibacterial activity compared to their precursor plant extracts. Biomaterials of edible and medicinal mushrooms were used as biofactors for the synthesis of nanoparticles. The importance of the mushroom is coming from the quantity and size of the produced fruit bodies and their bioactive materials which used as natural precursors to reduce silver ions into Ag atoms. *Pleurotus ostreatus*, *P. florida*, and *P. sajor caju* are the most widely used in the synthesis of AgNPs respectively and there are more than 70 other species that have not been studied in this regard (Owaid, 2019). The bio-synthesized AgNPs from *P. sajor caju* (oyster mushroom) had excellent antibacterial activity against *Escherichia coli* and *Pseudomonas aeruginosa* compared as *Staphylococcus aureus* (Nithya and Ragunathan, 2009). The antibacterial action of *P. ostreatus* AgNPs had also potent toward *K. pneumoniae*, *E. coli*, *S. aureus, Psuedomonas aeruginosa* and *Vibrio cholera* (Elumalai et al., 2012).

Guzman et al. (2012) prepared AgNPs from aqueous silver nitrate ($AgNO_3$) solution using a mixture of hydrazine hydrate and citrate of sodium as reductant and sodium dodecyl sulfate as a stabilizer. The antibacterial activity of these AgNPs against *E. coli*, *P. aeruginosa*, and *S. aureus* was tested with the Kirby-Bauer diffusion and Minimum Inhibition Concentration (MIC) dilution methods. The results of antibacterial activities against *E. coli*, *P. aeruginosa*, and *S. aureus* reported around 14.38 ppm, 6.74 ppm, and 14.38 ppm. Geetha et al. (2014) synthesized and characterized of AgNPs in lemon grass leaves and studied its antibacterial activity. Investigation on the antibacterial effect of nanoparticles against *Psuedomonas aeruginosa*, *P. mirabilis*, *E. coli*, *Shigella flexaneri*, *S. somenesis* and *Klebsiella pneumonia* reveals high efficacy of silver nanoparticles as a strong antibacterial agent. Elemike et al. (2017) evaluated the AgNPs for their antibacterial properties against Gram negative (*E. coli*, *K. pneumonia*, *P. aeruginosa*) and Gram positive (*Bacillus subtilis* and *S. aureus*) pathogens. The antibacterial results of the nanomaterial (CA-AgNPs) were compared to the metal free *Costus afer* extract and gentamycin (as a control drug). At a concentration of 100 μg/mL in DMSO (as a diluent), the CA-AgNPs were active to both the Gram negative and Gram positive pathogens used for the antibacterial screening. The nanoparticles exhibited better inhibition of the bacterial strains compared to the precursors (leaf extract of *Costus afer* and silver nitrate) and also compared favourably with the observed antibacterial activity of Gentamycin. In another study, a rapid green synthesis of the AgNPs using leaves extract of *Convolvulus arvensis* was investigated. It was found that the biosynthesized AgNPs have the antibacterial activity against human pathogen *E. coli*. Also, nanoparticles exhibit biofilm degrading activity against both bacterial strains of *S. aureus* and *P. aeruginosa* (Hamedi et al., 2017). Eren and Baran (2019) synthesized AgNPs by green synthesis methods using pistachio (*Pistacia vera* L.) plant extract and tested the antimicrobial effect of synthesized AgNPs on *S. aureus* ATCC 29213 MIC method. Effective concentrations of AgNPs for inhibition in *S. aureus*, *E. coli* and *C. albicans* were determined as 0.041, 0.662 and 0.165 μg mL-1, respectively. Obtained results showed that AgNPs prepared from 1 mM silver nitrate solution has more effective antibacterial activity compared to the commercial antibiotics.

Ravichandran et al. (2019) also used green synthesis of AgNPs by bio-reduction of $AgNO_3$ using *Parkia speciosa* leaf aqueous extract. The *petai leaf* aqueous extract based AgNPs exhibited fairly significant antibacterial action on *E. coli*, *S. aureus*, *P. aeruginosa* and *Bacillus subtilis*. However, when compared to AgNO3 and *petai leaf* aqueous extract alone, the synthesized silver nanoparticles showed better activity against *E. coli*. Hamedi and Shojaosadati (2019) determined the antibacterial properties of the AgNPs produced with the aqueous extract of *Diospyros lotus* leaves against *E. coli* strain. The silver nanoparticles' MIC against *E. coli* was obtained as 62.5 mg/mL. The nanoparticles' minimum bactericidal concentration (125 mg/mL) was estimated as twice their MIC.

Maciel et al. (2020) demonstrated a green synthesis of AgNPs using essential oils as an environmentally friendly alternative to the toxic chemical reducing agents. A trial screening was performed using the essential oils of oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), clove (*Syzygium aromaticum* L.), rosemary (*Rosmarinus officinalis* L.) and *Poiretia latifolia*. The developed AgNPs presented antimicrobial activity against *Staphylococcus aureus* in different concentrations (40–100 µL/mL), with a MIC of 40 µL/mL, thus considered bactericidal agents.

Odeniyi et. al. (2020) reported a simple, eco-friendly, and economic means to synthesis of AgNPs using aqueous extract of *Nauclea latifolia* (African peach) and The MIC of the biosynthesized SNPs as evaluated. Microbial growth inhibition increased with increasing concentration indicating that activity is dependent on concentration as endorsed by many researchers who believe that AgNPs have a dose dependent antibacterial activity (Suganya et al., 2015). At concentrations of 3.125 µg/mL, the AgNPs of the aqueous fruit extract visibly inhibited the growth of most of the tested pathogens; *Citrobacter fruendii* EC 35218, *E. coli* 11775*, S. aureus* 29213 and *E. coli*. At concentration of 1.565 µg/mL, it inhibited the growth of *E. coli* 25933 and *E. coli* 2348. *Candida albicans* and *Rhizopus* sp. were visibly inhibited at 12.5 µg/mL, while *S aureus* and *Klebsiella* sp. were inhibited at 25 µg/mL. The MIC of *Staphylococcus* sp. was recorded as 50 µg/mL. AgNPs synthesized with the methanol fruit extract visibly inhibited most of the organisms at MIC of 6.25 µg/mL. Exceptions are inhibition of *E. coli* 25933 and *Staphylococcus* sp. at 50 µg/mL, *S. aureus* 29213 at 3.125 µg/mL and *E. coli* 35218 at 6.25µg/mL. There was no observable activity against *Klebsiella* sp., *S. aureus, C. albicans* and *Rhizopus* sp. at concentrations of 50 µg/mL and below. The AgNPs had antimicrobial and antifungi activity against most of the tested pathogens. *Pseudomonas aeruginosa, E. coli* 700728*,* and *Aspergillus niger* are highly susceptible. Shu et. al. (2020) also determined that the AgNPs exhibited significant antibacterial activity in a concentration dependent manner against *E. coli*. The growth inhibition assay demonstrated a complete reduction in *E. coli* at concentrations of AgNPs above 20.0 µg/mL. The AgNPs in combination treatment with ampicillin exhibit superior antibacterial activity compared to ampicillin alone against ampicillin-resistant *E. coli.*

Kambale et al. (2020) were synthesized AgNPs using aqueous leaf extracts of three Congolese plant species, namely *Brillantaisia patula* (BR-PA), *Crossopteryx febrifuga* (CR-FE) and *Senna siamea* (SE-SI). The AgNPs derived from BR-PA, CR-FE and SE-SI exhibited higher antibacterial activity against *E. coli*, *P. aeruginosa* and *S. aureus* compared to their respective crude extracts and $AgNO_3$. Results indicated that the biomolecules covering the nanoparticles may enhance the biological activity of metal nanoparticles. Hence, their results support that biogenic synthesis of AgNPs from Congolese plants constitutes a potential area of interest for the therapeutic management of microbial diseases such as infectious skin diseases.

In another research, in addition to the bioavailability and cost-effective synthesis of silver nanoparticles using medicinal plant extracts (Allium rotundum l, Falcaria vulgaris Bernh, and Ferulago angulate Boiss), the antimicrobial and synergistic effects of these plants extracts alone, and in combination with silver nanoparticles synthesized by green chemistry were investigated against *P. aeruginosa* PAO1 and *S. aureus* ATCC 25923. The results of this study showed that increasing the concentration of the extract, the amount of no growth halo, also increased. The results showed that the lowest average inhibition zone of *S. aureus* with a diameter of 9 mm was related to 2.5 µg of Falcaria vulgaris Bernh., and the highest average of inhibition zone diameter (20 mm) was related to 10 µg of Ferulago angulate Boiss. Also, against the *P. aeruginosa*, the lowest mean inhibition zone diameter (13 mm)was related to a concentration on 2.5 µg of the plant Falcaria vulgaris Bernh., and the maximum average of the inhibition zone diameter (22 mm) with a concentration of 10 µg of the mixture of extracts of the two plants; Allium rotundum l., and Ferulago angulate Boiss. Also, against *P. aeruginosa*, the lowest mean inhibition zone diameter (16 mm)was related to a concentration of 0.5 ppm of silver nanoparticles and a triple mixture of plant extracts, and the highest mean inhibition zone diameter (23 mm) belonged to a concentration of 6 ppm of silver nanoparticles and Allium rotundum l.

Conclusion

In the coming years, AgNPs may have potential use due to their antimicrobial activity, in foods or as an alternative to antibiotics in the healthcare industry. AgNPs could play also an important role in designing polymeric materials used in the field of active food packaging. However, the major concern about the use of AgNPs is associated with insufficient knowledge about the safety and toxicity of silver nanoparticles. There is a contravercy among the previous studies conducted regarding safety and toxicity of nanomaterials. Some studies revealed have negative effects on health, whereas other studies reported no negative effects. The impacts of AgNPs in foods are not well known and the numbers of studies conducted on this matter are very limited. Therefore, the behavior of these nanomaterials in the digestive system, their effect on the human body and their interactions with food constituents should be investigated.

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Chapter-3

ADVANCES, RECENT TRENDS AND PROGRESSES IN POLYMERIC MEMBRANES

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1. INTRODUCTION

Membrane is used as selective barrier. Some molecules allow passage of small parts, such as ions, while blocking the passage of some parts. Membrane is a term used in many technical fields, which are used in medicine, construction and engineering fields.Membranes can be different types in the induustrial sector. For example, there are different types of membranes used in the building construction industry such as polymer, polyethylene, bituminous, modified, slate and liquid.

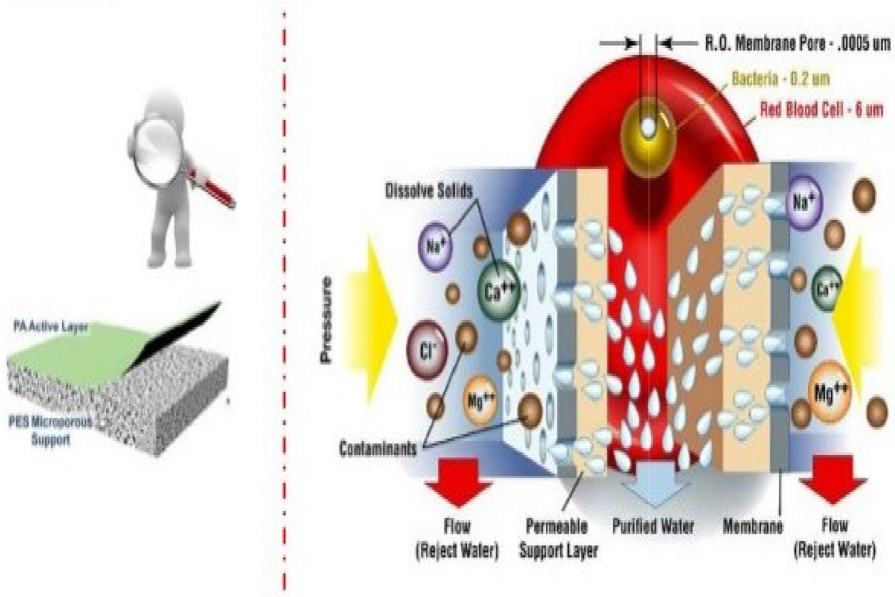

Figure 1 : Polymer Membrane((Briceno, 2017)

The use of membranes have advantages and disadvantages, which are given as

- The materials that make up the membrane are not harmful.
- Membrane treatment generally takes place in an atmospheric environment.
- There is no need for an additional chemical.
- It does not contain threats for the substances (protein etc.) It is easy to install and operate.
- Processing performance is high.
- It has a low cost.

In this chapter, advances, recent trends, progress in polymeric membranes have been reviewed.

2. RESULT and DISCUSSIONS

2.1 Polymer Membrane

Water shortage is a distress ringing danger bells. This water shortage should be eliminated. One of the eliminating ways of this problem is the use of membrane which is effective item in cleaning of waste water. Microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), reverse osmosis (RO) and membrane distillation (MD) are the most common techniques used for water treatment (Ajith J.Jose, 2018). With these techniques, waste substances can be removed from the water. Membranes can be classified in three groups:

- Organic(Polymeric) Membrane
- Inorganic(Ceramic) Membrane
- Biomedical Membrane

Organic materials are type of polymers made of cellulose-based or modified organic materials. Compared to other membranes, polymer membranes are less resistant to high temperatures and show strong chemical activity. This drawback may not be important in the use of polymer membranes due to its easy preparation, low cost, small size and low energy requirement This properties lead membrane to the use in wide area application.

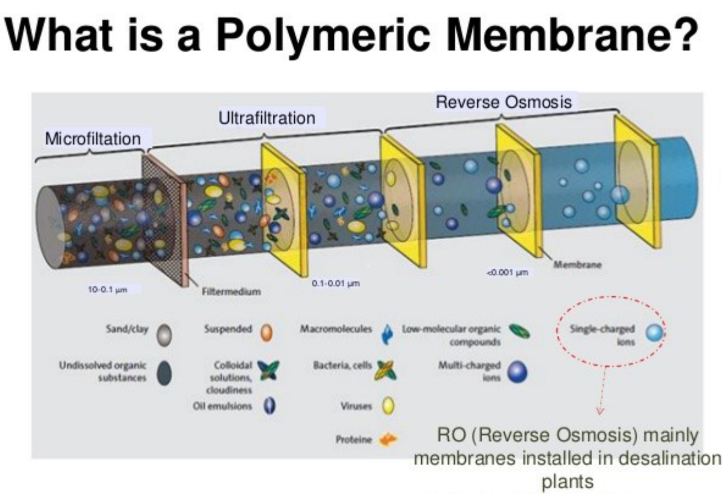

Figure 2. Polymer Membrane Modelling(Briceno, 2017)

Polymeric membranes are based on rubber and glass types. Glassy ones can be converted into rubber type by applying a certain temperature. Rubber membranes have higher permeability than glassy membranes. The performance of polymeric membranes can be improved by reducing the thickness of the membrane. Studies are still ongoing for more gas selective permeability.

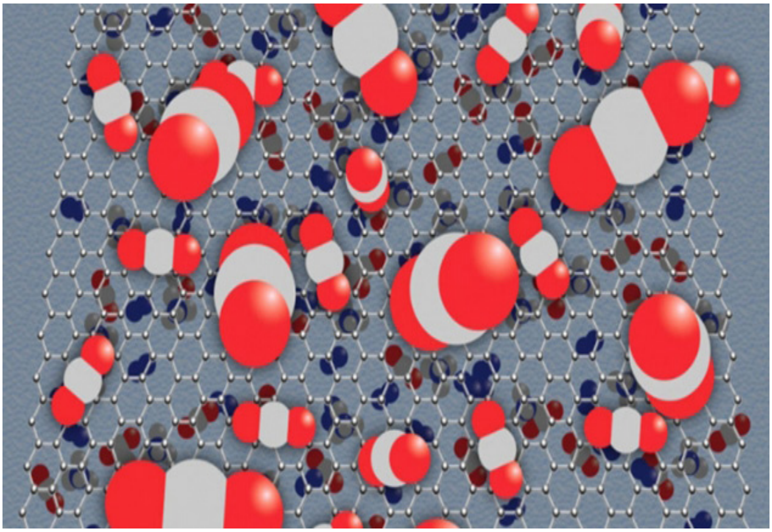

Figure 3. Selective-permeable properties of membranes (Plastikciyiz.biz, 2019)

Some factors can affect the gas permeability of polymer membranes, which shown as

- Mobility of polymer chains
- Glass or sub glass transition temperature
- Penetrant-polymer interactions

In general, polymer membranes with high permeability and low selectivity are rubber form under normal conditions. Polymer membranes with low permeability and high selectivity are glassy form under normal conditions.

Table 1: Some properties and usage area of given membranes.

MEMBRANES	PROPERTIES	USAGE AREA
Micro Filtration(MF)	It filters out particles with a diameter of ~ 0.01μm.	Sterilization Process
Ultra Filtration(UF)	It filters out dissolved substances and particles with a molecular weight ranging a few hundreds to several million.	Removal of tailings in fruit juice
Reverse Osmosis(RO)	It separates solutions and dissolved substances.	Desalination of sea water

Membranes should be selected according to the usage area. Before choosing them, the type of membrane that may be most effective in the usage area should be decided. For example, elestromeric membranes have high elasticity. It has a stable feature against stretching and tearing. Plastomeric membranes retain their structure for many years without deterioration. With this feature, it is used in residential and commercial buildings.

Polyesters,Polyethers,Polyamides,Polypropylene,Polytetrafluoroethylene(PTFE),Polysulfone(PS),Polyvinylchlorides(PVC),Polyacrylonitriles(PAN),Polyurea, Polysulfones, Polycarbonates, Polyvinylidenefluorides (PVDF), and Cellulosic Polymers can be given as membrane polymer.

2.2. Polymers Types in Membranes

The use of different polymers in polymer membrane production may have different properties. These properties can be an advantage or a disadvantage. For example, Cellulose Acetate (CA) polymer is inexpensive and resistant to chlorine. To mention its disadvantage, low chemical and thermal stability can be given. In Polysulfone (PS) polymer, the flow is sterile and has a wide pH range, but its resistance to hydrocarbons is poor. Polypropylene (PP) is a chemically resistant polymer, but may have hydrophobic properties. Polytetrafluoroethylene (PTFE) polymer is resistant and chemically stable but expensive. Finally, Polyamide (PA) has good chemical and thermal stability but is sensitive to chlorine. As can be seen, whatever polymer is desired to be used as a membrane, it will always have an advantage and disadvantage. Therefore, attantion should be taken to ensure that the material uses as a membrane material by ragarding ıts drawbacks and advanteges.

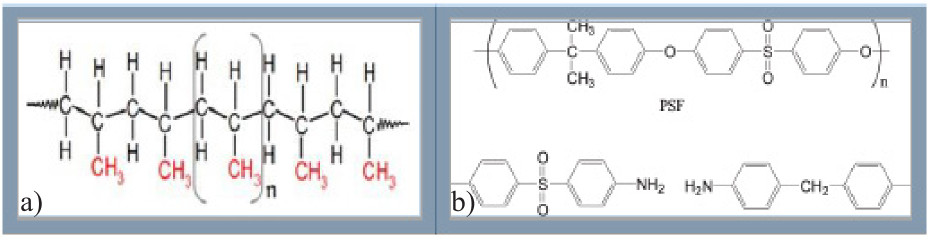

Figure 4. Chemical Structures of (a) Polypropylene and (b) Polysulfone

2.3 Production Techniques of Polymer Membrane

There are several advanced production methods for the production of polymer membranes. These can be categorized according to their various symmetrical / asymmetrically shapes, which are mainly stretching, track-etching, phase inversion and CVD techniques. Track-etching, casting + leaching, film stretching are the production steps in symmetrical membranes. Phase inversion and slip casting/ sintering steps are among the production steps of asymmetric membranes.

2.3.1 Streching Technique

The first process in stretching technique is extrusion process. In this process, polymers are melted into films. After this process, rolling is started. Meanwhile, it is very important to capture the best morphology. The second process is annealing. Annealing is necessary for the perfection of the phase. The last operation is stretching. In this section, the films are deformed to create pores. The Figure 5 shows the suummarization of the process.

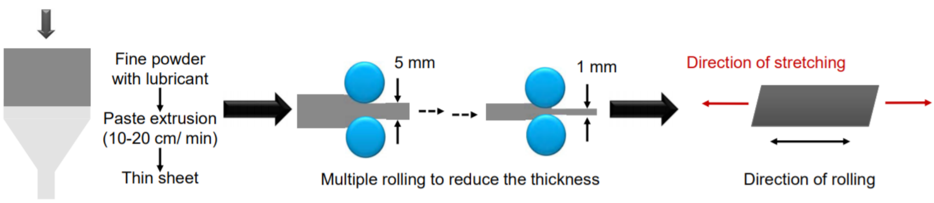

Figure 5 : Stretching Technique Modelling

2.3.2 Track-Etching Technique

In the Track-etching technique, a large number of ions are first sent to a polymer film by a radiation source. Damaged areas are identified using an etching bath. Alkaline solutions such as sodium hydroxide and potassium hydroxide are used as etching solution. This technique result can be examined in terms of pore size and shape. The different etching conditions affect the pore shape and size.

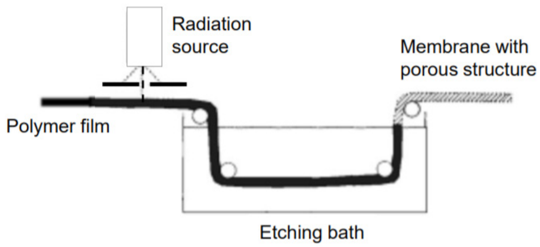

Figure 6 : Track-etching Technique Modelling

2.3.4 Phase Inversion Technique

Phase inversion is a fabrication type used in the production of artificial membranes. The membranes that will infiltrate in phase inversion are produced using artificial polymers. The phase inversion process can be performed by lowering the temperature of the solution, immersing the polymer solution in the solvent and facing the solution with an anti solvent vapor, or evaporating the solvent at high temperatures.

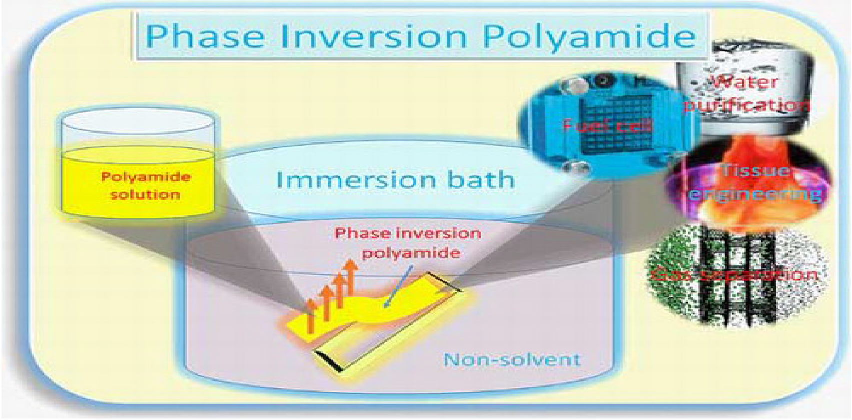

Figure 7: Phase Inversion Polyamide Modelling(Kausar, 2017)

2.3.5 Chemical Vapor Deposition (CVD) Technique

Polymeric membranes are usually prepared by the CVD method. In this technique, the polymer solution is poured into a thin film and its contents are immersed in the coagulation bath, which is a material that does not show solvent properties for the polymer. As the solvent moves out of the polymer film, the non-solvent moves inward. Phase separation takes place in the polymer film and the formed membrane collapses as a solid phase.

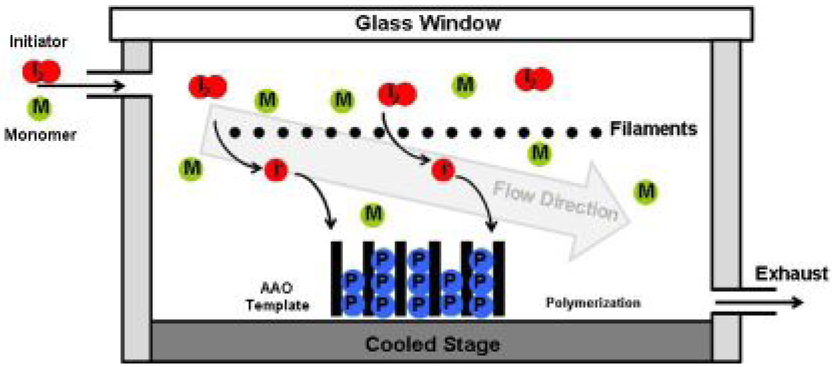

Figure 8. Polymer nanotube production by CVD method(Polymer CVD Lab)

2.4 Advances in Polymer Membranes

Nowadays, Polymer membranes are one of the most advanced membrane rings. One of the main reasons for the widespread usage of membranes is due to the increase of unwanted toxic substances in our daily life. As we mentioned at the beginning of our study, membranes are selective-permeable membranes. While it shows the feature of being under certain size according to the production types, this is not valid in the opposite case. This property has been used in many areas from water treatment to medical sector.

In 2019, a new development took place for polymer membranes. Some scientists at the Massachusetts Institute of Technology have developed a new polymer membrane that greatly benefits natural gas efficiency and is beneficial in reducing environmental pollution. Yuan He graduated from the MIT Chemistry department about this polymer membrane, published in Advanced Materials magazine, stated that "It has the potential to process natural gas much better than other traditional materials"(Plastikciyiz.biz, 2019).Again, according to a Science Daily report published in 2019, batteries were developed that use membranes included in the polymer class and enable energy storage.Versatile and affordable battery membranes were developed from the polymers used in this study.The name of this technology is AquaPIM membrane.(Lawrence Berkeley National Laboratory, 2019)

Figure 9 : Protective mask produced with the help of polymer membrane

One of the most important invention today is the electrospining device developed for the production of masks to save the COVID-19 virus, using polymer membranes. Inovenso companies in Yıldız Technopark in Turkey developed a nanofiber membrane producing elektrospining device. With this device, nanofiber membranes can be produced by spraying polymer solutions. These nano-sized fibers made of membranes can hold viruses efficiently and produce high-efficiency and comfortable medical masks. The mask produced with these membranes greatly prevents viruses, dust particles and bacteria from entering the mouth. The small diameter of the fibers in the masks produced with this designed electrospinning device provides a high rate of filtration.(Rakipoğlu, 2020)

3. CONCLUSION

In this study, Polymer membrane have been reviewed and some important isssues related to this membrane type were discussed. Furthermore, the production methods of polymeric membranes such as stretching, trace-burning, phase transformation and chemical vapor deposition techniques have been mentioned. The usage of polymeric membranes eliminates some problems affecting the world. One of these problems is water scarcity. Using membranes, dirty water into drinking water can be cleaned after the filtration process. Regarding this, the developments related to the polymer membranes keep their importance. Thus , polymeric membranes can be used in variety of applications, such as batteries, natural gas purification and the production of medical masks that prevent the current pandemic COVID-19 virus. In addition, it is possible to see Polymer Membranes in different areas.

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Chapter-4

ADVANCES, RECENT TRENDS AND PROGRESSES IN ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE

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Introduction:

Ultra-high molecular weight polyethylene (UHMWPE) is an advanced polymer with a very high molecule weight, long chains and contain a composition of unusual properties, such as shown in table 1. these wide range of properties and the low production cost Led to its application in several fields

Table 1. important properties of UHMWPE. Adapted from [1].

property	UHMWPE
Melting temperature (^oC)	125-138
Degree of crystallinity (%)	40-75
Tensile yield strength (MPa)	21-28
Tensile ultimate strength (MPa)	40-48
Tensile ultimate elongation (%)	350-525
Tensile modulus of elasticity (GPa)	0.8-1.6

Also, the chemical inert and non-toxicity of UHMWPE polymers addition to its properties allowed its application in the medical industry, such as the application as bearing material in human joints replacement. However, the debris of material wear after a joint motion led to untying problems when applying in human implant applications. So, several experiences done to improve the wear resistance and increase the biocompatibility of UHMWPE. One of the most important methods named by crosslinking. Crosslinking mean combined the carbon atoms in polymer together to produce a 3D carbon structure [2]. This combination between carbon atoms achieved by many different ways such as treating by argon plasma which effect on the mechanical properties of UHMWPE [3]. Another crosslinking method done by mixing with organic peroxide initiators (dicumly peroxide) that is led to produce UHMWPE sheets with suitable properties for knee replacement industry [4]. On the other hand, the technological development led to a great importance in UHMWPE electrical properties to use this material in electrical applications [5]. Ion bombing method led to confusion polymer chemical bonds and form a new carbon double bonds C=C [6]. This method applied on the UHMWPE polymer by helium ions to produce better electric properties polymers for electric device applications [7]. The aim of this paper is to determine the results of argon plasma, organic peroxide initiators and Ion bombardment on the properties of UHMWPE and determine the application field depending on the resulted properties.

UHWMPE Treated by Argon Plasma for Hip and Knee Total Joint Replacement:

polymers treatment by plasma have been a very important method to enhance polymers surfaces and improve the hardness and other properties of polymers [8]. An original UHMWPE sample were compared with UHMWPE treated by argon plasma applied by microwave electron cyclotron resonance to determine the effect of plasma treatment and the change in properties [3]. The FTIR spectroscope of the two different samples shown in fig. 1.

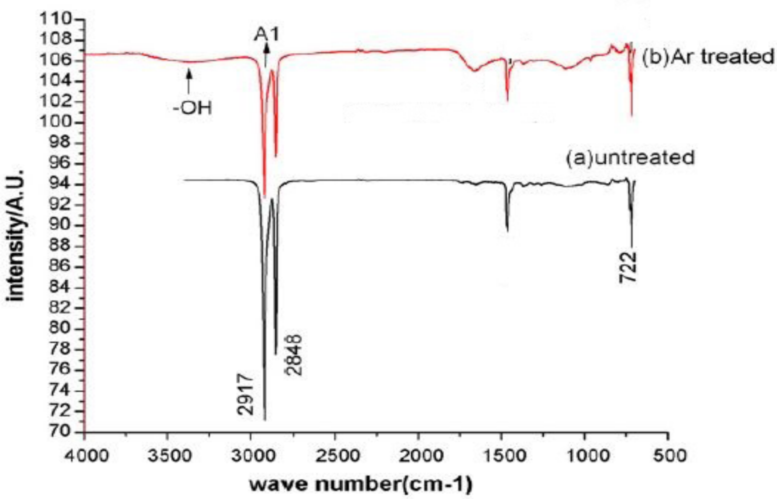

Fig. 1 FTIR results of untreated and treated UHMWPE samples. Adapted from [3]

The 2917 cm^{-1} absorbed peak refer to the stretching vibration of methylene which its area calculated in table 2, it shows decreasing in the calculated area A_1 which mean reducing the stretching vibration of methylene in argon plasma treated sample [9]

Table 2. the area of stretching vibration of methylene peak. Adapted from [3].

	position of the peak(cm^{-1})	calculated area(A_1)
untreated	2917	20183
treated	2848	17520

This reduction led to increase the crosslinking in molecular chains. These extra crosslinking improve the molecules action forces which led to improve the hardness of argon plasma treated sample and reduce the ability to scratch which reduce the materials loss in treated sample [10]. Also, elevation in the friction coefficient for the treated samples shown in the results of pin on disc test in fig. 2. This increasement refer to the increasing in crosslinking of molecule chains. All these reasons increase the ability to plastic deformations and reduce the wear rate of treated sample. Which allows to its application in hip and keen joints replacement as a bearing material.

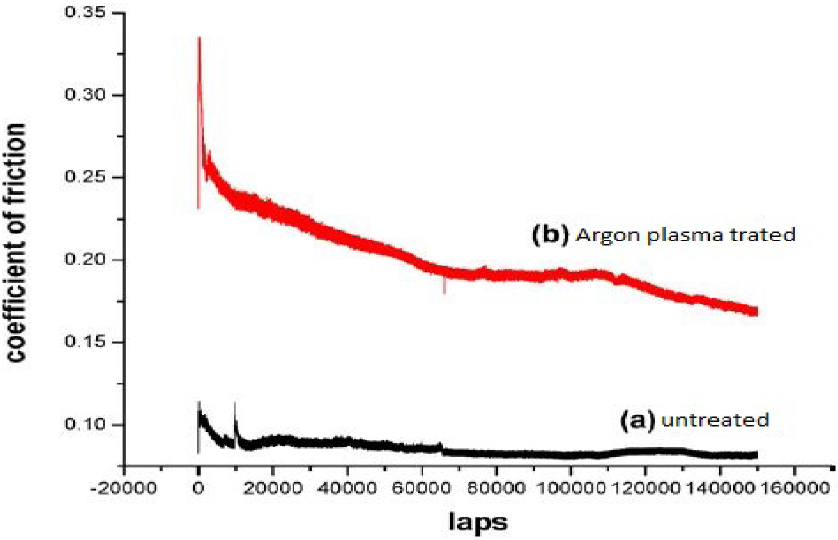

Fig.2 Friction coefficient of untreated and treated UHMWPE samples. Adapted from [3]

UHMWPE cross linked by organic peroxide for knee replacement applications:

Another method to increase the crosslinking of UHMWPE polymers was named by peroxide crosslinking method. In this process UHMWPE grains were mixed with dicumyl peroxide initiator and converted to sheets by compression molding process. To determine the effect of this method, three different sheets are prepared with a mass of 300 gram and different material compositions [4]. The first one didn't contain any dicumyl peroxide, the second sheet has a composite of 35% dicumyl peroxide and 65% UHMWPE, while the third sheet contain 65% dicumyl peroxide and 35% UHMWPE. Also, 0.4% of vitamin E were added to the UHMWPE polymers before the moulding to reduce the effect of oxidation [11]. The fig. (3a) shows the effect of using dicumyl peroxide as an initiator on the tensile strength of sheet, gradual increase in the value of tensile strength by increasing the dicumly peroxide ratio because the formation of new crosslinking [12]. also, the wear rate change for the three sheets were tested by pin on disc device, and the results plotted against the dicumyl peroxide percentage such as shown in fig.(3b). significant decrease in wear rate when increasing the percentage of dicumly peroxide. This decrease back to the forming of new free radicals that helps start the crosslinking process. These increasing in tensile strength value and wear rate produce suitable properties for use in knee preplacement application.

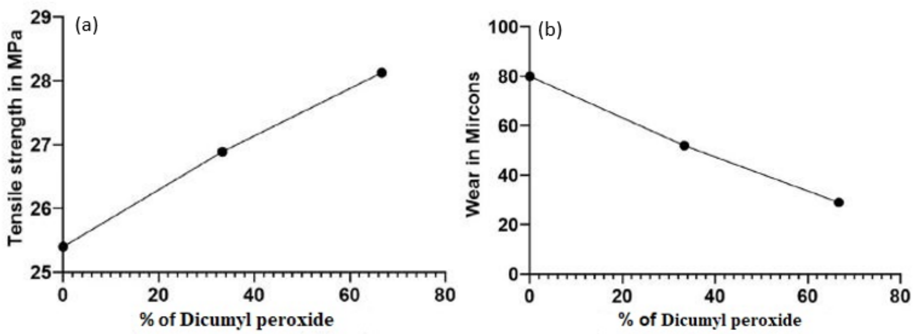

Fig. 3. The percentage of dicumyl peroxide against (a) tensile strength (b)wear rate. Adapted from [4].

Helium ion bombed UHMWPE for electronic devices:

The ion bombarding is a very good technique to refine the chemical and physical properties of polymer surfaces [13]. A sample of ultra-high molecule polyethylene with a molar mass of 120000 gram per mole, density of 0.95 gram per cm^3 and crystallinity of 65%, it was examined after bombing by 130 KeV Helium ions in the range of influences of (10^{14})to (2×10^{16}) cm^{-2} [7]. Increasing in the absorption of electromagnetic radiation happen because of two reasons. The first was because the reduction in the Photoluminescence intensity, while the second because the good harmony of helium ions to produce electronic levels in the band gab [14]. Also as shown in fig. (4a) increase the ion fluences led to gradually reduction in activation energy (Ea), which led to reduce the optical energy gap from 2.85 to 1.82 eV at the fluences of 10^{16} cm^{-2} for the bombarde sample which shown in fig. (4b). As a result of the decreasing the optical energy gap, formation of defects and increasing of the electric conductivity was observed [15], which allow the application of helium ion bombarde UHMWPE in electronic devices production.

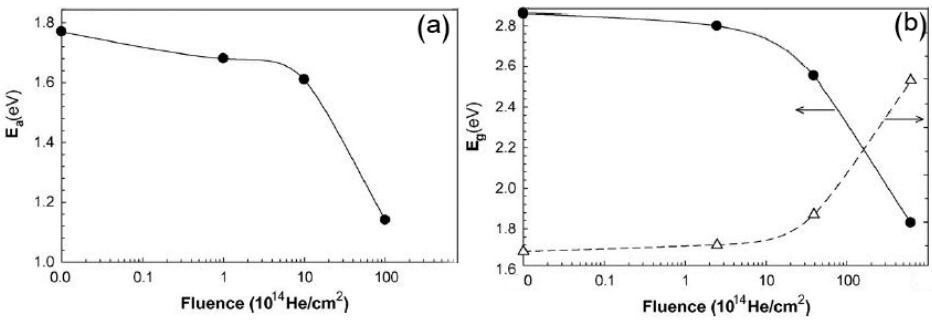

Fig. fig. 4. Hilum ion fluence against (a) activation energy (b) optical energy gab. Adapted from [7]

Conclusion:

The UHMWPE polymers were failed when applying in knee replacement applications due to the unsuitable wear resistance for this application. So, in this paper the effect of increase the crosslinking of polymers and how to applied were examined. The first way was by argon plasma treating which improve the wear and scratch resistance of the UHMWPE polymers, the second way was by mixing UHMWPE with dicumyl peroxides which produce a higher tensile strength and wear resistance UHMWPE polymers. The resulted properties of this methods allow its application as a bearing material in total knee joints replacement. on the other hand, ion bombardment method applied on the UHMWPE by using helium ions which led to increase the electrical conductivity depending on the formation of defects and allow the application of UHMWPE bombed by helium ions in the electric devices production industry.

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Chapter-5

PROPERTIES OF WASTE RUBBER ADDITIVE POLYMER CONCRETE

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ABSTRACT

Every year, hundreds of millions vehicle tires become waste due to their product (service) life. To prevent the global environment and healthcare problems these waste tires are used in concrete. The aim of the study is producing polymer concretes with waste rubber and polymer additives which have become so popular in recent years. In the study by replacing 0-4mm sieve range waste rubber aggregates in different ratios (0%, 5%, 10%, 15% and 20% by volume) instead of the fine aggregates, the rubber aggregate concrete (RAC) was obtained. In addition, polyester and styrene-butadiene (SBR) polymers were added in the ratio of %1 and %2 of the cement volume into the obtained RAC mixtures. From the obtained mixtures, 2 different types of concrete were produced. These concretes are Rubber Aggregated Polyester Concrete (RPC) and Rubber Aggregated Styrene Butadiene Concrete (RSC). Unit weight compressive strength (7 and 28 days) and freeze-thaw strength tests of the dry concrete and the unit volume weight and slump amount tests of the fresh obtained concrete were performed. As a result of the study, it was determined that the strength of rubber aggregate concrete samples containing %1 SBR gave better results compared to the other series.

1. INTRODUCTION

With the development of the transportation sector and the rising needs of human to the vehicles, the tire production demand has been raised. Increasing tire production has brought a lot of cons with itself such as waste rubber pollution. Disposing of these wastes or recycling them by utilizing them in different areas requires great efforts [1, 2]. Waste tires are generally tried to be disposed of by burning, shredding or storing. These facilities cause significant environmental problems [3-5].

Recently, waste tires have been tried to be used in the construction sector to protect the environment and nature. The use of tire grains obtained from the crushing of waste tires in concrete as aggregate and construction of crash barriers from these concretes can be shown as examples of these studies [6]. In some of these studies, it has been determined that the unit density of waste tire aggregate is lower than aggregate, which reduces the unit density of concrete [7]. Due to the low unit density of rubber aggregate concretes, it has been stated that light carrier concrete can be produced with the addition of 20% of the tire aggregate and light concrete with the addition of approximately 60% [8]. In this study, waste tire aggregate in the range of 0-4mm sieve was replaced by volume in different proportions (0%, 5%, 10%, 15% and 20%) instead of fine aggregate (0-4 mm). In addition, 1% and 2% styrene-butadiene polymer is added to the concretes where rubber aggregate is replaced and wasted rubber-reinforced polymer concretes were produced. Dry unit weight, compressive strength (7 and 28 days) and freeze-thaw resistance tests were performed for the fresh form concretes obtained, the unit volume weight and slump amount and hardened concretes.

2. MATERIAL AND METHOD

2.1 Material

Aggregate: In the study, as fine aggregate in the range of 0-4mm and as coarse aggregate between 4.0-11.2 mm and 11.2-22.4 mm, crushed stone taken from the quarry belonging to Tam Taş Yapı Malzemeleri Sanayi and Ticaret AŞ. İn Mamak Yakup Abdal, Central district of Ankara province aggregate is used. Physical properties of the aggregate are given in **Table 1**.

Table 1. Aggregate physical properties

Physical Properties		
Sieve Range *(mm)*	**Density** *(kg/m^3)*	**Wearing Loss** *(Los Angeles %)*
4 - 11.2	2.71	-
11.2 - 22.4	2.71	29.74
0 – 4	2.67	-

Waste Tire Aggregate: In this study, the waste tires purchased from Umut Soğuk Sistem Lastik Coating San. Tic. Ltd. Şti. was sieved (4mm sieve) and rubber aggregates with a 0-4 mm sieve were used. The physical properties of the waste tire aggregate are given in **Table 2**.

Table 2. Waste tire aggregate physical properties

Physical Properties	
Specific Gravity (kg/m^3)	1.16
Water Absorption (%)	2.56

Cement: In this study, CEM II/ 42.5 R Portland cement was used. The chemical, physical and mechanical properties of the cement used are given in **Table 3**.

Table 3. CEM II/42,5 R Portland cement

Component (%)	CEM I 42,5R	TS EN 197-1	Physical Properties		TS EN 197-1	
CaO	63.93	-	**Setting Time**	Start	141	min. 60
SiO_2	19.49	C+S≥%50	*(Min.)*	Finish	202	-
Al_2O_3	4.36	-	**Density** *(g/cm^3)*		3.10	-
Fe_2O_3	3.40	-	**Blain Thinness** *(cm^2/g)*		4012	-
MgO	1.72	Lim≤%5	**Expansion** *(mm)*		1	max. 10
SO_3	3.1	Lim≤%4	32µ Left in Sieve		13.3	-
Na_2O	0.37	-	90µ Left in Sieve		7.2	-
K_2O	0.67	-		2 Days	30.5	min. 20
Cl-	0.0089	Lim≤%0.10	**Compressive Strength** *(N/mm^2)*	7 Days	42.8	-
Loss on Ignition	2.91	Lim≤%5		28 Days	51.5	max. 62.5
Residue	0.32	Lim≤%5				

2.2. METHOD

2.2.1. Mixture Design

Calculations for rubber aggregated concrete, rubber aggregated concrete containing styrene butadiene and rubber aggregated concrete containing polyester were made in accordance with TS802 standard [9]. Details of abbreviations used in mixtures are given in **Table 4** and details of mixture calculations are given in **Table 5**.

Table 4. Abbreviations used in mixtures

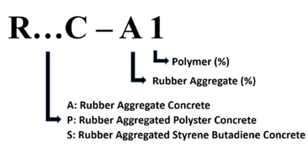
	Serial Code	**Rubber Aggregate Content** *(%)*	**Serial Number**	**Polymer Content** *(%)*
	A	0%	1 2	1% 2%
	B	5%		
	C	10%		
	D	15%		
	E	20%		

Table 5. Calculations of concrete mixtures

RAC (A-B-C-D-E) Mixture Group *(dm³)*						
Components	**Sieve Diameter**	**RAC-A**	**RAC-B**	**RAC-C**	**RAC-D**	**RAC-E**
Aggregate Sieve Range (mm)	11.2- 22.4	205.5	205.5	205.5	205.5	205.5
	4 – 11.2	62.3	62.3	62.3	62.3	62.3
	0 - 4	355	337.25	319.50	301.75	284
Water	~	222.4	222.4	222.4	222.4	222.4
Air	~	20.0	20.0	20.0	20.0	20.0
Cement	~	134.8	134.8	134.8	134.8	134.8
Rubber Ag-gregate	0-4	0	17.75	35.50	53.25	71.00
RPC (A1-B1-C1-D1-E1) Mixture Group *(dm³)*						
Components	**Sieve Diameter**	**RPC-A1**	**RPC -B1**	**RPC -C1**	**RPC -D1**	**RPC -E1**
Aggregate Sieve Range (mm)	11.2- 22.4	205.5	205.5	205.5	205.5	205.5
	4 – 11.2	62.3	62.3	62.3	62.3	62.3
	0 – 4	355	337.25	319.50	301.75	284
Water	~	222.4	222.4	222.4	222.4	222.4
Air	~	20.0	20.0	20.0	20.0	20.0
Cement	~	133.45	133.45	133.45	133.45	133.45
Rubber Ag-gregate	0-4	0	17.75	35.50	53.25	71.00
Polyester (1%)	~	1.35	1.35	1.35	1.35	1.35
RPC (A2-B2-C2-D2-E2) Mixture Group *(dm³)*						
Components	**Sieve Diameter**	**RPC-A2**	**RPC –B2**	**RPC –C2**	**RPC –D2**	**RPC –E2**
Aggregate Sieve Range (mm)	11.2- 22.4	205.5	205.5	205.5	205.5	205.5
	4 – 11.2	62.3	62.3	62.3	62.3	62.3
	0 – 4	355	337.25	319.50	301.75	284
Water	~	222.4	222.4	222.4	222.4	222.4
Air	~	20.0	20.0	20.0	20.0	20.0
Cement	~	132.1	132.1	132.1	132.1	132.1
Rubber Ag-gregate	0-4	0	17.75	35.50	53.25	71.00
Polyester (2%)	~	2.70	2.70	2.70	2.70	2.70
RSC (A1-B1-C1-D1-E1) Mixture Group*(dm³)*						
Components	**Sieve Diameter**	**RSC-A1**	**RSC-B1**	**RSC-C1**	**RSC-D1**	**RSC-E1**
Aggregate Sieven Range (mm)	11.2- 22.4	205.5	205.5	205.5	205.5	205.5
	4 – 11.2	62.3	62.3	62.3	62.3	62.3
	0 – 4	355	337.25	319.50	301.75	284
Water	~	222.4	222.4	222.4	222.4	222.4
Air	~	20.0	20.0	20.0	20.0	20.0

Cement	~	133.45	133.45	133.45	133.45	133.45
Rubber Aggregate	0-4	0	17.75	35.50	53.25	71.00
SBR (1%)	~	1.35	1.35	1.35	1.35	1.35

RSC (A2-B2-C2-D2-E2) Mixture Group *(dm³)*						
Components	**Sieve Diameter**	**RSC-A2**	**RSC-B2**	**RSC-C2**	**RSC-D2**	**RSC-E2**
Aggregate Sieve Range (mm)	11.2- 22.4	205.5	205.5	205.5	205.5	205.5
	4 – 11.2	62.3	62.3	62.3	62.3	62.3
	0 – 4	355	337.25	319.50	301.75	284
Water	~	222.4	222.4	222.4	222.4	222.4
Air	~	20.0	20.0	20.0	20.0	20.0
Cement	~	132.1	132.1	132.1	132.1	132.1
Rubber Aggregate	0-4	0	17.75	35.50	53.25	71.00
SBR (2%)	~	2.70	2.70	2.70	2.70	2.70

2.2.2. Fresh Concrete Experiment

In order to determine the unit weight tests according to TS EN 12350-6 [10] standard and the consistency tests in accordance with TS EN 12350–2 [11] standard, consistency tests were performed on the prepared fresh concrete mixtures.

2.2.3. Hardened Concrete Experiment

Unit weight test in accordance with TS EN 12390-7 [12] standard was performed on 100x100x100 mm sized cubes. In accordance with the. TS EN 12390-3 [13] standard, 225 cubic samples of 100x100x100 mm dimensions were produced and the pressure resistance test was performed on the produced samples samples at the end of the 7 and 28 days curing period. In addition, the freeze-thaw test was performed for 100 cycles according to ASTM -C666 [14] standard.

3. RESULTS AND DISCUSSIONS

3.1. Fresh Concrete Experiment Results

Unit weight and slump test results on fresh concrete mixtures are given in **Table 6.**

Table 6. Fresh concrete experiment results

Sample Code	Fresh Unit Volume Weight (kg/m³)	Slump Amount (mm)
RAC-A	2321	19.5
RAC-B	2183	19.5
RAC-C	2067	15.0
RAC-D	1999	15.0
RAC-E	1989	14.5
RPC-A1	2250	18.0
RPC-B1	2264	18.0
RPC-C1	2092	18.0
RPC-D1	1974	17.5
RPC-E1	1952	17.0
RPC-A2	2152	19.0
RPC-B2	2160	18.0
RPC-C2	2056	17.5
RPC-D2	1956	16.5
RPC-E2	1885	17.0
RSC-A1	2254	19.5
RSC-B1	2192	19.0
RSC-C1	2120	19.0
RSC-D1	2088	18.0
RSC-E1	1971	17.5
RSC-A2	2250	20.0
RSC-B2	2216	20.5
RSC-C2	2121	20.0
RSC-D2	2085	20.0
RSC-E2	1976	20.0

When the unit volume weights of fresh concretes were compared, the lowest fresh unit weight was obtained from RPC-E2 (1885 kg/m³) series and the highest RAC-A (2321 kg/m³) series. It was found that there is a decrease depending on the amount of polymer additive in the series without polymer additives and in all series containing waste rubber-added polymer. With the results obtained from the slump test, the flow classed of the concrete mixtures were determined as S1 according to TS-EN 206-1 [15].

3.2. Hardened Concrete Experiment Results

Unit weight and slump test results on hardened concrete mixtures are given in **Table 7**.

Table 7. Hardened concrete experiment results

Sample Code	Dry Unit Weight (kg/m³)	Freeze-Thaw Mass Loose *(%)*	7-Day Compressive Strength *(MPa)*	28-Day Compressive Strength *(MPa)*	Compressive Strength after Freezing-Thawing *(MPa)*
RAC-A	2321	0.3	37.15	44.50	41.9
RAC-B	2183	1.8	26.25	32.80	30.6
RAC-C	2067	0.6	19.15	24.60	24.0
RAC-D	1999	0.8	12.10	15.50	14.3
RAC-E	1999	0.7	12.15	14.40	14.1
RPC-A1	2250	0.4	30.90	37.90	26.4
RPC-B1	2264	2.5	25.50	30.90	25.7
RPC-C1	2092	0.8	19.00	25.60	21.6
RPC-D1	1974	0.3	12.30	16.60	13.4
RPC-E1	1952	0.9	8.75	12.80	11.0
RPC-A2	2152	0.5	22.60	29.00	24.9
RPC-B2	2160	0.8	21.95	28.60	26.5
RPC-C2	2056	0.9	16.60	21.90	15.4
RPC-D2	1956	1.3	14.25	18.80	17.2
RPC-E2	1885	1.4	9.80	12.70	11.5
RSC-A1	2254	2.0	26.85	37.10	34.9
RSC-B1	2192	0.8	22.30	29.60	25.7
RSC-C1	2120	0.6	18.50	23.00	21.7
RSC-D1	2088	0.8	14.40	17.80	17.3
RSC-E1	1971	0.9	11.00	15.30	13.3
RSC-A2	2250	0.8	25.85	35.40	34.0
RSC-B2	2216	1.5	22.70	31.20	26.2
RSC-C2	2121	0.8	18.75	25.70	23.8
RSC-D2	2085	1.2	14.70	19.70	17.3
RSC-E2	1976	2.4	11.65	14.80	14.4

According to the results stated in **Table 7**, it was determined that the dry unit volume weights of the concrete samples produced were the highest (2299 kg/m³) in the RAC-A series samples and the lowest (1957 kg/m³) in the RAC-E series samples. In all series, as the rate of waste rubber increases (0%, 5%, 10%, 15%, 20%), the dry unit volume weights decrease. It was determined that these values do not exceed the upper limit (2400 kg/m³) given in the literature. When mass losses after freezing-thawing are examined: It was observed that the lowest mass loss was from the RAC-A and RPC-D1 series and the highest loss was from the RPC-B1 series. In series without polymer additive: It was determined that the mass loss increased in parallel with the increase in the waste tire additive ratio, and the series with polyester and SBR additives changed, but there was no major contribution loss. According to the results of the compressive strength test, RAC-A (37.15 MPa) samples gave the highest value, while the lowest value was RPC-E1 (8.75 MPa). According to the results of the 28-day test, RAC-A (44.5 MPa), which does not contain waste tire aggregate gave the highest value, while the lowest value was given by RPC-E1 (12.70 MPa). In all series, it has been determined that as the rate of waste tire aggregate increases, the compressive strength decreases. In addition, according to the compressive strength results obtained after 100 cycles of frost resistance, RAC samples average 5%, 1% polyester containing 14%, 1% and 2% SBR 8% in RSC samples. There was a decrease in the rate. As a result of frost resistance, it has been determined that as the waste tire aggregate and polymer additive rate increases, concrete compressive strength decreases.

4. RESULTS

The results obtained in this study on the determination of the properties of polymer concrete with waste rubber additives are given below.

- There is a decrease in fresh unit volume weights depending on the amount of polymer additives in series without polymer additives and in all series containing waste rubber additive polymer.
- Flow classes of concrete mixtures are determined S1.
- As the waste tire aggregate ratio increases (0%, 5%, 10%, 15%, 20%) in all series, the dry unit volume weights decrease and these values do not exceed the upper limit given in the literature (2400 kg/m³).
- After the freeze-thaw test, the loss of mass increased in parallel with the increase in the waste tire additive rate, it showed changes in polyester and SBR-added series, but there was no major loss of additive.
- As the rate of waste tire aggregate increases in all series, the compressive strength decreases.
- As a result of frost resistance, it has been determined that as the waste tire aggregate and polymer additives rate increase, concrete compressive strength decreases.

As a result, it was determined that RSC-A1 samples gave better results than other series.

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Chapter-6

GLOSS OF PAPER

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INTRODUCTION

Whether the paper produced in the desired weight using suitable cellulose provides the expected optical and physical properties is determined as a result of the tests to be carried out. Properties of the final product paper;

General properties (thickness, unit weight, etc.)

Physical resistance properties (tensile, tear, double folding, burst, etc.)

Optical properties (brightness, opacity, gloss, whiteness, etc.)

Surface properties (surface smoothness, peeling, etc.)

Structural properties (porosity, etc. cellulose blend.) are classified as.

The standard methods used to determine the optical properties we will discuss in this study are;

Gloss ISO 8254-1 (standards vary depending on the surface to be measured (metal, plastic or paper)).

CIE whiteness ISO 11475:2004 (procedure SCAN P66)

Yellowness ASTM E 313

Opacity ISO 2471:2008

Color (CIE Lab) ISO 5631 (SCAN P72)

In this study, it has been tried to give information about the importance, methodology and test methods of gloss which is one of the optical properties of the paper.

IMPORTANCE OF GLOSS

Gloss is a property that expresses the ability of a surface to show the gloss appearance or gloss quality. Gloss, which is a qualitative property, is not a basic term (Ferwerda et al., 2001). Luster is associated with luster (luminosity-a sudden selective reflection of light) and glare (glare - unwanted reflection of extremely bright light). While gloss and luster indicate a pleasant effect in a psychological sense, glare indicates an unpleasant, blinding effect.

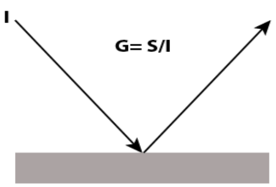


Figure 1: Reflection of incident light on the surface

Gloss is a combination of the following 3 factors:
1. The refractive index of the material
2. The angle of incidence of light
3. Surface topography

As you can see in Figure 1 above;

While some of the incident light is absorbed, some will be transmitted into the material; The remaining light will be reflected from the surface at different angles depending on the surface topography (the shape created by natural or artificial details).

Table 1: Gloss standards and applied materials

	20°	60°	85°	45°	75°
Applications	**Coatings, plastic and related materials**			**Ceramic, Film**	**Paper, Vinyl**
	High Gloss	**Semi Gloss**	**Low Gloss**	**Semi Gloss**	**Low Gloss**
DIN EN ISO 2813	x	x	x		
ASTM D 523	x	x	x		
ASTM D 2457	x	x	x	x	
DIN 67530	x	x	x		
JIS Z 8741	x	x	x	x	x
ASTM C 346				x	
TAPPI T 480					x
Brightened Metal					
EN ISO 7668	x	x	x	x	

Source:URL1

As you can read in Table 1 above, the numerical value is expressed as Gloss Unit (GU). This expressed value is the result of a scaling based on measuring mirror-like reflection at a given angle in 100 GU units in a highly polished black glass.

The foundations of this terminology are based on the standards established in the German BAM (URL2) Canadian NRC (URL3) and the British NPL (URL4) technology research centers. In Europe and America, there are industrial national standards precisely framed in numbers. For example, gloss levels are shown in figure 3 according to the Master Painter Institute (MPI) (Table 2).

Table 2: Gloss values measured at 60° and 85° according to the Painter Institute (MPI)

Gloss measured at 60°	Gloss measured at 85°	Gloss class
Up to 5 GU	Up to 5 GU	Traditional Matte
Up to 10 GU	10 – 25 GU	Velvetlike
10 – 25 GU	10 – 25 GU	Eggshell-likefinish
20 – 35 GU	Up to 35 GU	Satin-likefinish
35 – 70 GU		Semi-gloss
70 – 85 GU		Glossy
More than 85 GU		High Gloss

Source: URL1

Gloss, one of the optical properties, is important for the surface to be measured. The degree of light reflected from the surface is expressed with gloss. The gloss is measured by illuminating the surface of a beam of light coming at a certain angle to the surface. (Whitehouse et al., 1994). It reflects the beam of light coming onto the surface in different directions. The intensity of this reflected light is measured by the devices from different angles and the brightness value is determined. The intensity of the light varies according to the amount of light reflected in different directions. The gloss value and consequently the class also changes according to the measured angle (Leloup et al., 2019).

Another issue that should be considered in gloss measurements is that different angle values (20°, 60° or 85°) should be used in measurement devices for gloss measurements on surfaces with different degrees of gloss (such as Glossy, Semi-gloss and Matte). Because the sensitivity of the Glossmeter devices used to measure the gloss value varies according to the angle value selected.

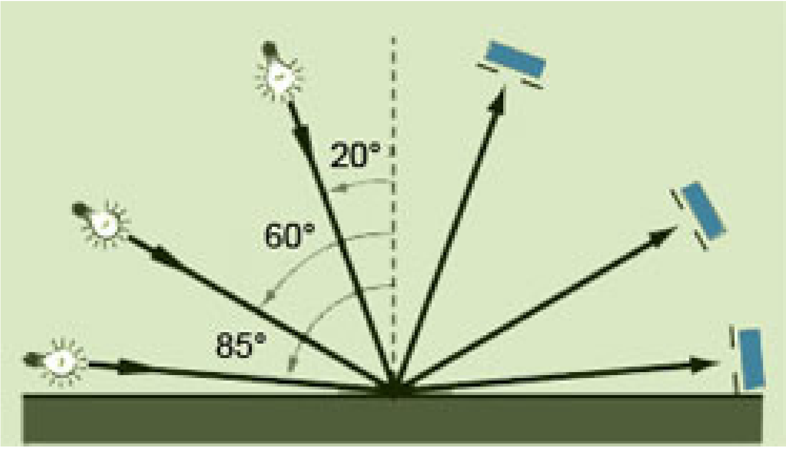
While low angles give more accurate results for higher gloss (> 70GU); For low gloss (<10GU) the device should be set to a higher angle value. Thus, the gloss values of the surfaces, especially those with a very matte or very shiny appearance, can be measured more sharply (Table 3).

Table 3: Gloss level and measurement angle

Gloss Level	Gloss measured at 60°	Measuring angle
Low Gloss	< 10 GU	85°
Semi-Gloss	10 – 70 GU	60°
High-Gloss	> 70 GU	20°

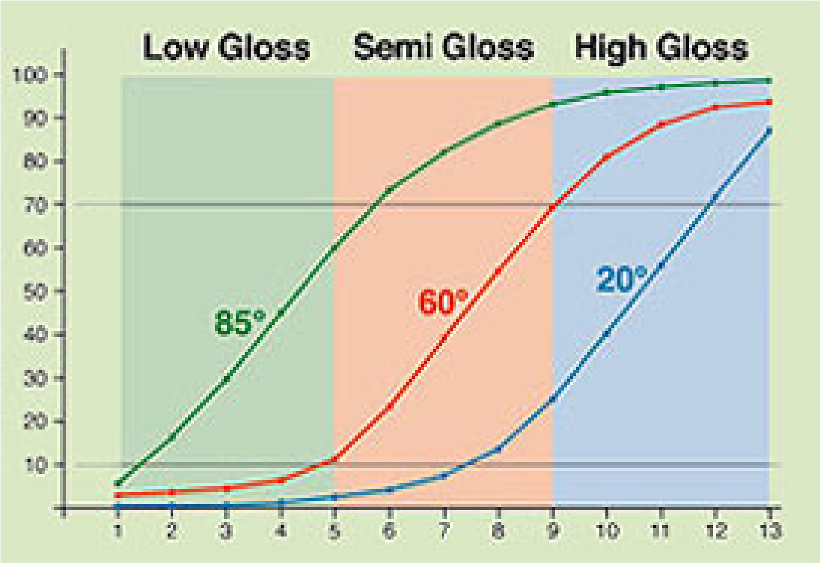
Source: URL1

As can be seen from the graphic below (Figure 2-3), values other than the angle specified in the table will show the gloss value with some deviation.



Source: URL1

Figure 2: Reflection of light coming at different angles from the surface



Source: URL1

Figure 3: Gloss levels at different angles

PAPER GLOSS AND TEST METHODS

Three different techniques are applied during the production of paper to give high gloss to the paper. The first is formed using a Yankee type dryer during drying of the paper (Hagiopol and Johnston, 2011). The Yankee dryer is a cylinder type dryer with a very shiny and smooth surface. In this drying form, the paper is dried by contacting with the metal surface. The paper produced in this way can be polished in the production of paper machine (glazed) or simply M.G. is called paper.

The second is the gloss achieved by coating the paper. The gloss in this type of paper will depend on the coating technique used, the base paper used, the type of filler, the particle size and shape, particle orientation, and the type and amount of adhesive (El-Sherif et al., 2017).

The third is the gloss obtained by calendering and super-calendering. Another method of producing extremely high gloss is by sticking the thin glossy plastic film to a paper surface (Özden and Sönmez, 2020).

Gloss is often preferred due to its visual and aesthetic appeal. High gloss cover papers are an example. Gloss can be differences in the appearance of the floor and elegance of a publication (Figure 4).

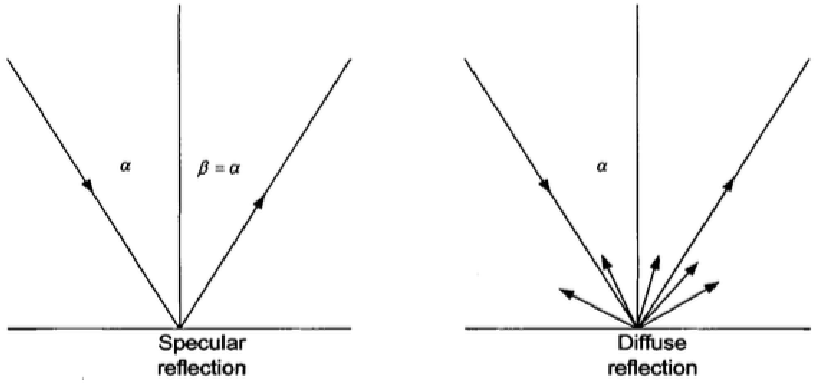


Figure 4: Specular (mirror-like) and diffuse reflection (scattering). α: incident angle, β: reflective angle (Jeon, 2002).

Printing operations are generally highly dependent on the paper surface. As with offset printing, smoothness and accompanying gloss are particularly important requirements in some other cases (Gloss of Paper, 75° (Technidyne)) (Figure 5).

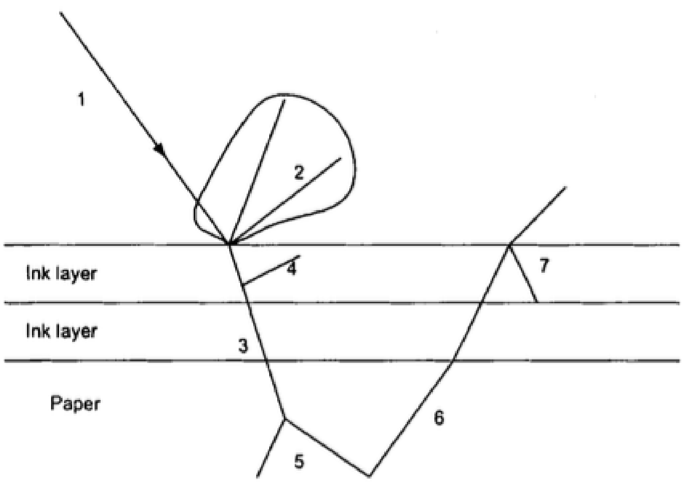


Figure 5: Reflection of light on the printed surface (1: Incoming light, 2: Reflection distribution of light from printing surface 3: Absorption of incident light in the ink layer on the printed surface, 4: Light refraction in the ink layer due to ink opacity, 5: Light refraction in the paper causes optical diffusion, 6: Reflection of incident light off the paper, 7: Inner surface reflection) (Jeon, 2002).

In the first luminance studies, considering luminosity as a physical property, studies were made on how to measure it objectivelyIn this process, gloss measurement, one of the optical properties of the paper, was first performed using a glarimeter. (Ingersoll, 1921). Luminosity is known as the amount of light reflected by scattering as well as a specular reflection amount of an incident light. Since Ingersoll found that specularly reflected light was almost completely polarized, he enabled the measurement to be carried out using a polarizing filter in the Glarimeter used to calculate the brightness. (Chadwick and Kentridge, 2015).

Glossmeter was used for gloss measurements in later years. Regardless of a gloss meter, the relationship between visual scale data and the measured gloss values can be defined with a three-part linear fit or a cubic function with a higher correlation (Ji et al., 2006).

Gloss, which is defined as the characteristic of the paper surface, is important for the paper surface feature (Elsayad et al., 2001). The quality of the paper is associated with its glossy appearance. When light hits the surface of the paper, the gloss of the paper depends on the direction of the incident light.

Gloss depends on the optical and physical properties of the paper's surface, the type of incident light, the angle of the light hitting the surface, and the perception of the reflected light by humans. (URL5).

Gloss of paper surface indicates the amount of light reflected from the surface at a specified angle. In order to determine this value, a light beam is sent to the paper surface at a certain angle with the help of a device and the paper surface is illuminated. The amount of light reflected from the paper is determined as the gloss value of the paper. In this process, depending on the physical structure of the paper surface, the light beam falling on the surface is reflected from the surface at different angles. Depending on the existing functions of the device, the intensity of the light reflected from the paper surface can be measured at different angles. The intensity of this beam, which is reflected at different angles due to the different physical properties of the surface, can be at different values at different angles. (Hubbe et al., 2008).

The angle between a conventional luminescence beam and the normal transition from the point of impact is 75º. The devices used for this gloss measurement are called glossmeters. Glossmeters measure the percentage of light reflected from the measured surface, and the unit is GU. There are gloss meters that measure different angles (20º, 60º and 85º) except 75º.

More accurate results can be obtained when measuring surfaces with glossy surfaces with instruments with higher reflection angles. While the gloss angle is measured with an incidence angle of 75° on the unprinted cardboard surfaces, the measurement is performed with 60° on the printed surfaces.

In Figure 6, the reflection of the light coming on the matte and glossy surface and the reflection of the cardboard surface with low illumination angle can be seen in Figure 7.

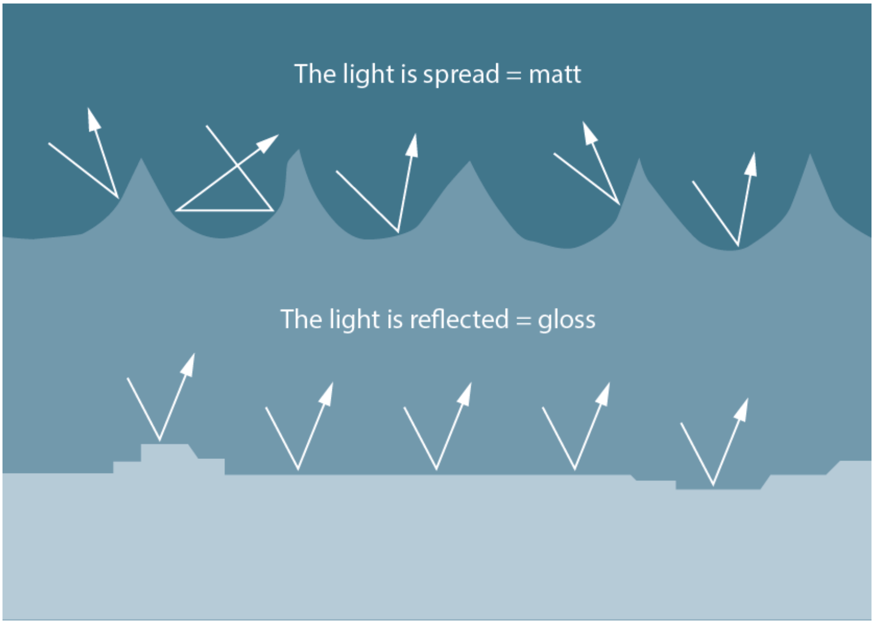
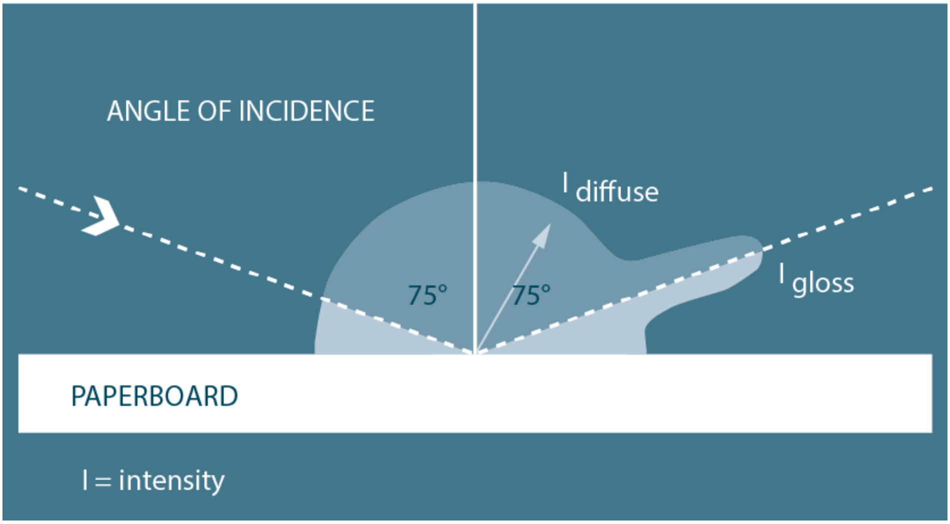


Figure 6: Reflection of incident light on matte and glossy surface



Source: URL5

Figure 7: Reflection of light at a low angle of illumination on a paperboard surface

As stated in ISO 2813 / ASTM D523, although 20/60/85 ° geometries are used for gloss measurement in many industries, different industries may use different industrial standards. Although GU is used as a standard bright unit; it can be used with standard units BAM in Germany, NRC in Canada and NPL in the UK (URL6).

The standards used during the measurement of gloss values of paper and paperboard products are given in Table 4.

Table 4: Standards of the used in the measure of the gloss values of papers

Standarts	Explanations
DIN 54502 1992	Testing of paper and board; reflectometer as means for gloss Assessment of paper and board
ASTM D1223 1998	Test method for specular gloss of paper and paperboard at 75°. Has unusual converging beam geometry. Specifies the primary standard as black glass of refractive index 1.540, not 1.567, at the sodium D-line having a defined gloss value of 100.
ASTM D1834 1995	Test method for 20° specular gloss of waxed paper. Another unusual converging beam geometry, different to the previous one.
TAPPI T480 OM-90 1990 (USA)	Specular gloss of paper and paperboard at 75° Same text as ASTM D 1223
TAPPI 653 1990	Specular gloss of waxed paper and paperboard at 20° Same text as ASTM D 1834
JIS - Z8142 1993 (Japan)	Testing method for 75° specular gloss

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