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E-MAGAZINE

CHEMQUEST

UNDER DBT STAR COLLEGE STRENGTHENING SCHEME 2019

World of Glass

CELEBRATION OF INTERNATIONAL YEAR OF GLASS (2021)

DEPARTMENT OF CHEMISTRY

SURENDRANATH COLLEGE

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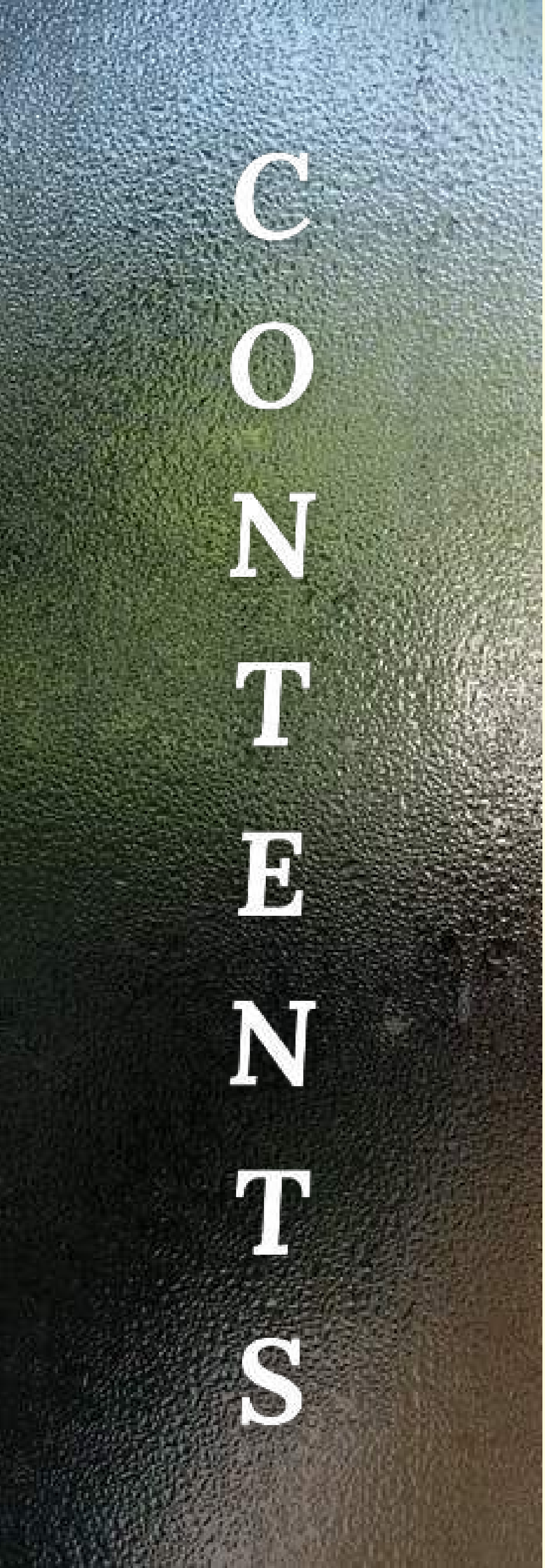

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Editor's Note

We feel really proud and excited to acclaim that we are ready with all the new hopes and hues to bring out the **2nd issue of the 2nd volume** of our e-magazine **CHEMQUEST** on the festive occasion of **New Year 2022** on a seemingly interesting topic **WORLD OF GLASS** to celebrate the **International Year of Glass (2021).**

We have put in persistent efforts to bring excellence to this treasure trove. The extraordinary task of editing this issue would not have been possible without sincere support of all the executive members of the Editorial Board, who sorted out the articles from the writings we obtained from our enthusiastic and inquisitive students, edited them sincerely, and finally made a fair and presentable draft.

We are thankful to them who literally dipped their oars into the turbulence of Covid-19 pandemic and have sailed it to the shore of publication within a truly short tenure despite all their usual college and university duties. We are grateful to our respected Principal Sir, Dr. Indranil Kar, for his inspirations in all our unique ventures like this. We also take this opportunity to thank all the members of Surendranath College family for their sincere support and best wishes.

Finally, we heartily wish all the readers, Merry Christmas and Happy New Year and hope this issue would enjoy critical acclaim and play a vital role in the all-around development of scientific mindset of all the reader like its previous issues.

All stay safe, stay healthy. Happy Reading!!!

Editors in Chief

31st December’2021

Principal's Message

“The mind is not a vessel to be filled, but a fire to be kindled.” **CHEMQUEST** the biannual E-Magazine published by the **Department of Chemistry** literally kindles the imagination of its students. I am happy to notice that swaying from serious thinking to playful inventiveness, they are brimming with a zeal for life, empowering themselves with skills and creativity under able leadership of their enthusiastic faculty members.

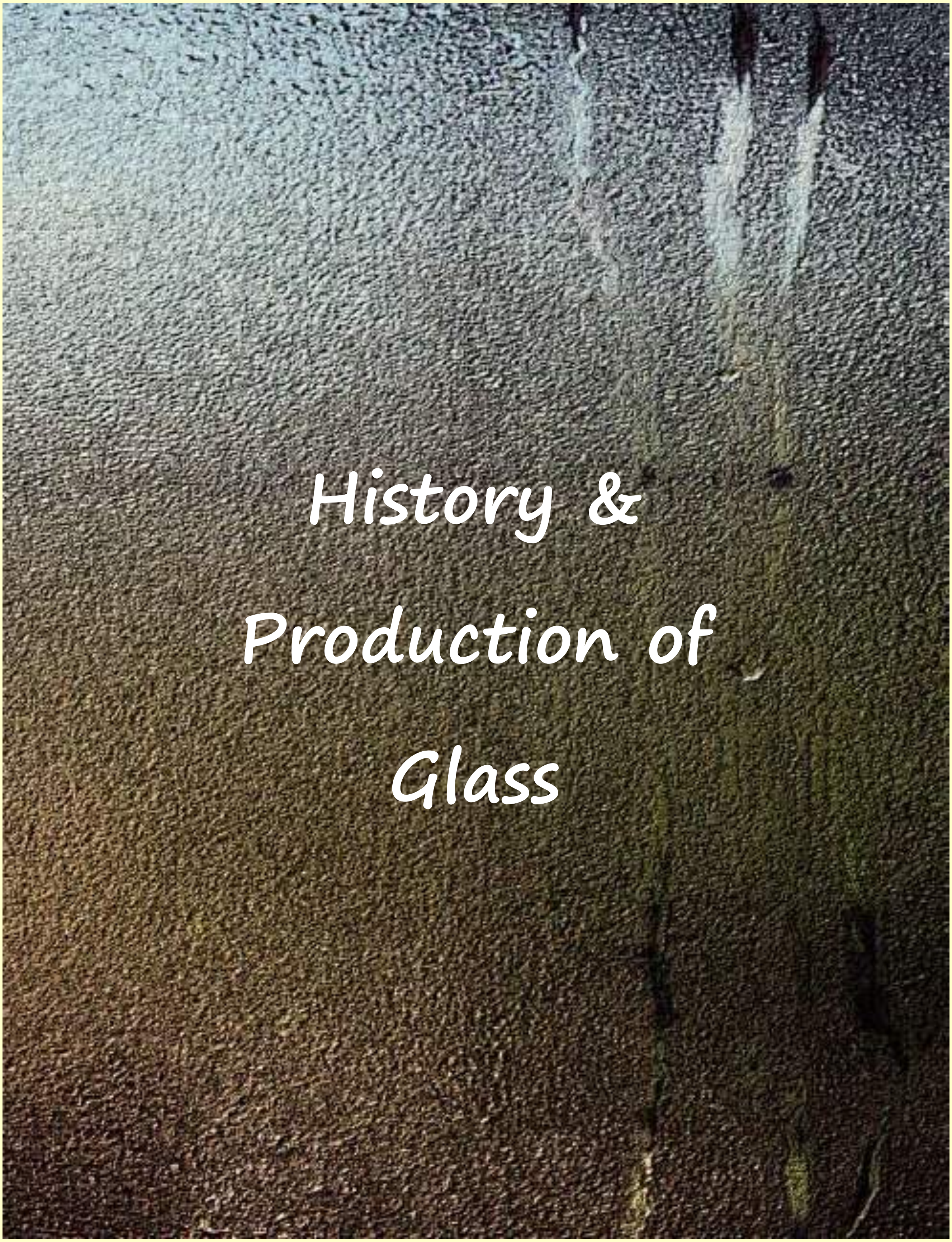
I congratulate all the faculty members and students of the department who have used various mediums of expression to present their ideas. As long as our ideas are expressed and thoughts are kindled, we can be sure of learning, as everything begins with an idea. I appreciate all of them who have shared the joy of participation in publishing this e-magazine along with their commitment to curriculum and regular duties.

Hope this **2nd issue of Volume 2** of **CHEMQUEST** published on **New Year’s Eve (2022)** on a popular topic **“World of Glass”** will enable the students to give and get a little more of learning and would be able to satisfy its general readers too.

Happy new year to all the readers. Happy Reading!

Dr. Indranil Kar
Principal,
Surendranath College, Kolkata

WORLD OF GLASS


History &
Production of
Glass

GLASS AND HISTORY BEHIND

Krishnendu Chatterjee
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Saumik mal
Boijoyanta Howlader
Semester v

Glass

Glass is a silica-based, non-crystalline amorphous solid material. It has broad practical and technological properties as well as a longstanding function in decorative applications such as windows, tableware, and household appliances. All qualities of glasses can be enhanced through cutting and polishing for use in optical lenses, prisms, fine glassware.

Raw Materials

Silica (70 to 72%)

Lime (10%)

Soda (14%)

Oxide/alumina/magnesia (5%)

The substances are introduced in the form of quartz sand, soda, and lime. 5% oxides such as magnesium and aluminium oxide are added to this mixture. These additives improve the physical and chemical properties of the glass.

Basically, all amorphous bodies that are obtained by lowering temperature of a melt, are given the name glass. The lowering of temperature cause solidification which results the gradual increase of viscosity adopts, the mechanical properties of a solid body.

The temperature range for a glass to melt is in between 1000 to 2000 degree Celsius. The microscopic structure of a glass is very much comparable to that of a liquid in which the individual constituents from an irregular network, without a long-range order. While a broad array of different silica-based glass exists, the most ordinary glazing and container glass is referred to as soda-lime glass. For colourful glass making, some metal salts are added or painted and printed as enamelled glass. The reflective, refractive and transmission properties of a glass, make the glass suitable for the making of optical lenses prisms and optoelectronics materials.

History Behind

One of the famous ancient Roman historian Pliny proposed that Phoenician merchants had made the first glass in the region of the Syria around 5000 BC and When people did not the utility of glass, they especially used the naturally occurring glass, Obsidian. It is a one kind the of volcanic glass.

On that time, it was to produce the knives, arrowheads, Jewry and money. Some of archaeological data claim the first man made glass was made in eastern Mesopotamia and Egypt around 3500 BC and the first glass vessels were made about 1500 BC in Egypt and Mesopotamia. The next 300 years, the glass industry was increased rapidly and then declined.

In the beginning it was very difficult and manufacturing process was very slow. Glass melting furnaces were small and the heat they produced was hardly enough to melt glass. But in the 1st century BC, Syrian craftsmen invented the blow pipe. This revolutionary discovery bought change in glass production, that why the production of glass was easier, faster, and cheaper. Glass production flourished in the Roman Empire and spread from Italy to all countries under its rule.

In 1000 AD the Egyptian city of Alexandria was the most important centre of glass manufacture. Throughout Europe the miraculous art of making stained glass on churches and cathedrals across the continent reached its height in the finest Chartres and Canterbury cathedral windows produced in the 13th and 14th centuries.

The Man behind

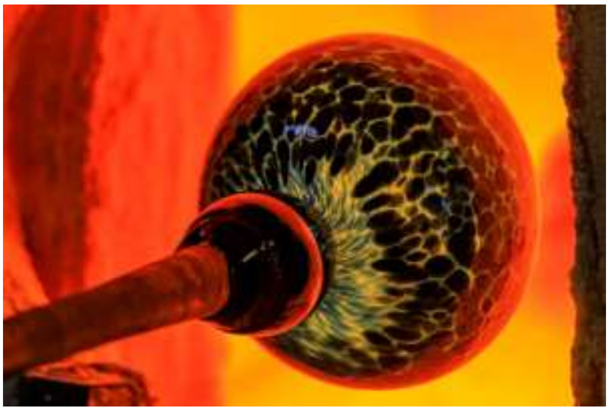
Basically, naturally occurring glasses are used to produce weapons, money, and ornaments by the Stone Age man, naturally occurring glass such as volcanic glass obsidian is a very useful Raw material for them at that time. Till now, the actual place and date of glass manufacturer action is not known though, according to the ancient Roman historian and piny the Elder, the actual credit of glass discovery deserves the phoencial merchants.

It is said that glass is first manufactured in the region of Syria. The story is that a merchant ship Laden with nitrum being moved at this place and the group of merchants We're preparing their meal on the beach. They have no stones with them to prop up their pots. So, they used nitrum lumps from the ship. This lump of nitrum fused with the sand of the shore and there a new translucent liquid flowed, thus was the origin of glass.

This history may or may not be true, But Syria was one of the places or the centre of origin of glassmaking. Phenician traders sold glass wear all through the Mediterranean countries. Another place where glassmaking was known in early time was Egypt. It is said that in Egypt, the earliest glass object is Created around 3500 BC.

The oldest specimens of glass are from Egypt. Glass industry in Egypt was well established in around 1500 BC. Egyptians where learn how to prepare glass models in around 1200

BC. Syrian Craftsman discovered glass blowing in the first century.



Natural Glass

In those times volcanic eruptions, we're less rare than they are in the present day. In present time, the natural glass compounds obsidian produced more regularly. Obsidian is a volcanic glass which are Created from molten lava. This molten lava containing a large amount of silica sand, Coles.

Obsidian forms When molten lava reaching the Earth's surface. Usually when molten lava comes into the contact of water, it forms obsidian glass. This obsidian is still used in modern days in surgical blades.

Artificial Glass

Glass was first made in the ancient world, but we don't know much about man's first efforts to make glass. Amulets and solid beads were made in Mesopotamia around 2500 BC. After that time glass making was further so much developed in Egypt specially around 1500 BC.

Glass Manufacturing

From the time of Crusades, glass manufacturing was developed in Venice. Venice became glassmaking centre of whole the western world. Glassmaking equipment was transferred to the island of Murano in 1291. During 15th century Venetian glass blower, crated Cristillo, nearly colourless, transparent glass. By the seeking of getting better life, many Venetians went to northern Europe in late 1500s. There they established factories and brought the art of Venetian glassblowing.

English glassmakers made glasses in Venetian fashion in 1575. In 1674, famous English glassmaker George Ravenscroft made an invention by making lead glass. In the United States the first glass factory was built in James town, Virginia in 1608. In the early 1800's, there was a great and rising demand for window glass, which was commonly known as crown glass. In the 1820s, the age of blowing individual bottles, glasses and flasks was ended by the invention of a hand-operated machine. In the 1870s, for the first time semi-automatic bottle machine was introduced. After 1890, glass use, manufacture and development began to increase rapidly. New modern machinery has been developed for precise, continuous manufacture of a host of products. In 1902, Irving W. Colburn invented the sheet glass drawing machine a milestone in this industry. By this invention it made possible the mass production of window glass. In 1904, the American engineer Michael Owens patented automatic bottle blowing machine. In 1959 new revolutionary float glass production was introduced by Sir Alastair Pilkington by which 90% of flat glass is still manufactured today.,

Safety glass

Safety glass has been in use since the early 20th century. It is used as alternative to regular glass in situations where heat would cause problems with regular glass or where it would be hazardous if the glass broke. Safety glass used in windows in public buildings, automobile windows, glass cookware, oven doors and safety glasses.

Safety glass was discovered accidentally by a French scientist, Edouard Benedictus in 1903, when he dropped a glass flask while he was working in his laboratory. In that flask had contained cellulose nitrate, a liquid plastic, which enabled it to keep its original shape when it had been dropped.

Two famous scientist Rudolf Seiden and Austrian chemist developed tempered glass in early 1900s. John Crew invented type of safety glass using tree resin between two layers of glass in 1905. Benedictus patented "Triplex" in 1909. This new safety glass was strengthened with a layer of polyvinyl butyral between two layers of glass.

Safety glass found its first practical use in World War I. Safety glass was used in the lenses for gas masks that time. After the proven high performance of the new glass under the extreme conditions of battle, safety glasses began to be used hugely in car windshields. In 1960s regulations for use and strength of safety glass were developed. It drove the development of the safety glass industry so far.

HISTORICAL DEVELOPMENT OF GLASS

Sovan Maity,
Sk. Golam Mostak,
Tamal Das
Semester III

It is believed that the earlier glass object was created around 3500 B.C in Egypt and Eastern Mesopotamia .The oldest specimens of glass are from Egypt and date back to 2000 B.C. After 1200 B.C the Egyptians learned to press glass into molds. The very first glass known the stone age people which was used for making weapons and decorative objects, was obsidian, black volcanic glass.

In all likelihood, the Egyptians learned glass making from their Asiatic neighbors, possibly from captives taken during Egyptian military campaigns in the East under the eighteenth-dynasty pharaoh Thutmosis III (1490–1436 B.C.). The glass industry, once transplanted to Egypt, grew vigorously, fueled in part by the abundance of the raw materials required to manufacture glass. Egyptian workshops exported large quantities of raw glass. The few glass beads of the Old Kingdom (about2613-2160B.C), made a thousand year earlier. Glass was produced by heating quartz sand and natron until they were molten, adding a color agent such as a copper compound for blue and green. To prepare a glass vessel, a core of sandy clay was molded over the end of a metal rod to form the interior shape. The rod was dipped into the molten glass and spun to coat the core. The craftsman also added details such as handles and bases using pincers, while the glass was still hot. The color of this vessel probably imitates turquoise, the yellow and white represents gold and silver. The tamarisk trees, dots and scales, and the name of the king are enameled, the earliest known example of this technique in Egypt.

Development of glass technology in India may have begun in 1700BC. In Ancient China glass making had a later start compared to ceramics and metal.

Invention

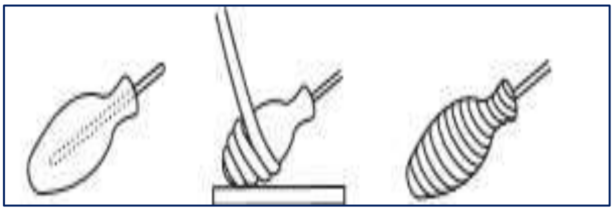
Scholars believed that the ability to make glass developed over a long period of time from experiments with a mixture of silica-sand or ground quartz pebbles and an alkali in 1861 Friedrich Sicmens introduced a technical innovation which speeded up the industrialization of glass production. Safety glass was discovered accidentally by Fdouard Benedietus, a French scientist in 1903 when he dropped a glass flask while he was working in his laboratory. This flask had contented cellulose nitrate, a liquid plastic, which enabled it to keep more or less its original shape when it had been dropped. In the early 1900s, Austrian chemist, Rudolf Seiden, developed tempered glass. Most of the glasses were produced from soda-lime glass because it was very stable and reasonable, hardness. Soda-lime glass was also easily made. Most of the mechanization in glass forming began during the late 19th century.

Ancient Egyptian Glass

Ancient Egyptian glass is made up of sodium and calcium silicate, which looks like modern ordinary glass in nature. The glass industry generally requires a fusion process at a temperature between 1400 and 1500 degree

Technique

Core-Forming: The manufacture of vessels or objects by trailing molten glass around a core of clay, mud, sand, and organic material is made in the shape of the desired vessel. Threads of colored glass are usually trailed onto the surface for decoration. The external surface of the vessel is smoothed by marveling while the glass remains hot and pliable. Finally, the core is removed after the vessel has been given spacious time to burn.



Casting Techniques: Casting glass into molds was only of minor importance in the New Kingdom but continued to at least a small extent after core-forming had been abandoned due to the introduction of **glass blowing** under the Romans. Casting is a technique of pouring hot glass into a mold. After the glass cools, glassmakers use various grinding and cutting techniques to refine the vessel's form and decoration.

Ancient Roman Glass

It wasn't until around 300 BC that the Syrians invented the blowpipe which formed the foundation for the craft of glass blowing. During the Roman Empire, new techniques and experimentation began and these techniques are still used in glass blowing today.

Roman craftsmen often used molds in conjunction with glass blowing to form new shapes and vessels. They also experimented with colors and adding gold and silver inlays to glass objects. Glass enameling later perfected by the glass blowers in the Middle East and Egypt began during the time of the

Roman Empire.

Chemical Composition

Ancient Roman glass can be classified as soda-lime glass. It was made from silicon, sodium, and calcium oxides, with the addition of potassium, magnesium, and aluminum oxides. In some Roman glass there's a characteristic pale blue-green color caused by iron oxide; an impurity, Roman glass has also been shown to contain around 1% to 2% chlorine, this is thought to have originated either in the addition of salt (NaCl) to reduce the melting temperature and viscosity of the glass, or as a contaminant in the natron.

Technique

Although glassmaking was invented around 3000 B.C. in the eastern Mediterranean region, glass was not widely available until the Roman period. Glass is made by melting a mixture of sand, soda or potash, and lime at approximately 700°C (1292°F). Liquid, or molten, glass is difficult to work with because

it is so hot.

Core-Formation: Vessels were usually small and most often used to hold perfume. This method was most expensive because it was very time-consuming and complex. The technique was first developed around 1500 B.C., though abandoned by 150 B.C.

Glass Casting: Like core-forming, was a process developed before the Roman period. It was invented around 1400 B.C. In this process, powdered glass is placed into a hollow mold and heated in the furnace until it fuses together. After cooling, the mold is opened and an object in the shape of the mold emerges. The Romans used this technique to create ribbed bowls. These were the first mass-produced tableware.

Glass Blowing: The invention of glassblowing in about 40 B.C. was the most important innovation in Roman glassmaking technology using a blowpipe. The technique was quick and easy compared to earlier processes, and glass became cheaper and more commonplace.

Mold-Blowing: Shortly after the invention of glassblowing, the Romans realized that if they inflated a glass bubble directly into a wooden or clay mold, vessels could be shaped and decorated in a single step. This technique allowed for the figural decoration.

Islamic Glass

The influence of the Islamic world to the history of glass is reflected by its distribution around the world, from Europe to China, and from Russia to East Africa. Islamic glass developed a unique expression that was characterized by the introduction of new techniques and the innovation of old traditions. Islamic glass did not begin to develop a recognizable expression until the late 8th or early 9th century AD, despite Islam spreading across the Middle East and North Africa during the mid-7th century AD.

Roman glassmaking traditions that are important in the Islamic period include the application of glass trails as a surface embellishment, while stylistic techniques adopted from the Sassanian Empire include various styles of glass cutting. This may have developed out of the long standing hard stone traditions in Persia and Mesopotamia.

Chemical Composition

Most of the glass finds are soda-lime-silica glass. As a result of the chemical analysis, they have been classified into two groups by the rate of potassium content: 4 groups show a low content of potassium and strontium, and group B shows a high content of potassium and strontium. This distinction was presumably caused by the cases in which either natron or plant-ash was used as the supply source of alkali (potash). There is also some high lead glass. As for the color of the glass from Raya, the most popular is transparent pale bluish green, which comprises about sixty percent of the whole. The second most is colorless, which is about twenty percent. Besides these, there is pale colored glass of green, blue, or dark brown caused by impurities, and colored glass of deep blue, purple, or brown which is mainly in the decorative glass group.

Soda-Ash Lead Glass & Plant Ash Glass

Soda ash lead glass from Piscinas Municipals have a very uniform composition. This glass consists mainly of lead ($PbO \approx 44\%$), silica ($SiO_2 \approx 41\%$) and soda ($Na_2O \approx 6.6\%$), with some lime ($CaO \approx 2\%$), magnesia ($MgO \approx 1\%$) and alumina ($Al_2O_3 \approx 1\%$). All other elements remain below 1%, except for chlorine that is exceptionally high, ranging from about 1.3% to 2.2%. Plant ash glass is characterized by high soda ($Na_2O > 10\%$) and elevated magnesia and potash contents (> 1.5%). It is a diverse set of samples, indicating the use of different raw materials and production technologies. Alkali and alkaline earth metals (Li, B, Na, Mg, P, K, and Ca) reflect the plant ash component. Together with elements associated with the silica source (Al_2O_3, TiO_2, Zr, La, Th); the plant ash glass from Piscinas Municipals can be separated into at least four distinct compositional groups

Technique

In the 10th and 11th centuries, casting and cutting techniques reached an even higher level of achievement. And from the 12th through 14th centuries, gilded and enameled vessels took on a hitherto unseen brilliance. Glass artists created imaginative and highly schematic scenes with animals, geometric patterns, and enamels. Islamic glassmakers inherited a long tradition of cold working: decorating an object by cutting, grinding, and polishing with a rotating wheel and abrasives, and by using hand-held tools. As early as the second half of the first century Islamic successors also made facet-cut objects, but in the ninth century they began to create vessels with linear decoration that included vegetal motifs, animals, birds, and inscriptions. The decorative glass makes up a little more than ten percent of all the registered glass. In the order of quantity, the excavated glass is given as follows: tooled and impressed decoration (38%); molded (14%); stained (13%); wheel cut (9%); incised (8%); stamped (3%); threaded (3%); and imbedded (2%).

Conclusion

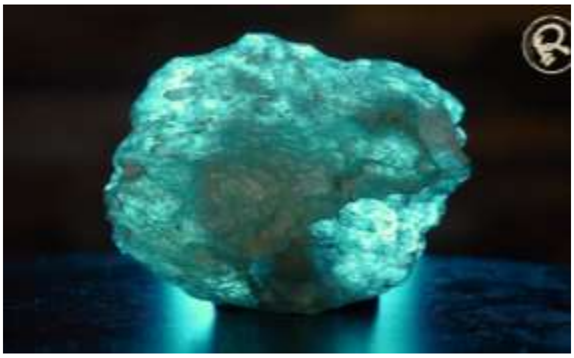
Ancient Egyptians are one of the earliest who produced glass, The material which was intervention in the industry until late era is sand quartz and calcium carbonate and Natron or ashes of the girls and a small number of colored materials. Roman glass industry sprang from almost nothing and developed to full maturity over a couple of generations during the first half of the first century A.D. Roman industry roughly coincided with the invention of glassblowing. This invention revolutionized ancient glass production, putting it on a par with the other major industries. Islamic art improved glass surface with different decorative techniques enamel, gilded, luster and cut, mamluk developing techniques from different parts of the Islamic world.

RESOURCES AND OCCURRENCE OF GLASS

Susmita Banik
Arindam Gayen
Semester-III

Resources from Ancient era

The naturally occurring glass is known as obsidian glass which is form naturally from volcanic magma with high silica content. In central and eastern Europe another type of natural glass that is impactite formed by the impact of meteorite. In the **Sahara** Desert, Lybyan desert glass is found which also found in Western Egypt.



Silica that is actually Silicon dioxide is an oxide of silicon ((SiO_2) which is the major natural resource in nature as quartz, which is a major part of glass. So naturally Desert side or geographical area mainly produce natural glass.

Some other examples of natural glass, Pumice, which is considered a glass because it has no crystal structure, Apache tears, a kind of nodular obsidian, Tachylyte, a basaltic glass with relatively low silica content, Sideromelane, a less common form of tachylyte, Palagonite, a basaltic glass with relatively low silica content, Hyaloclastite, a hydrated tuff-like breccia of sideromelane and palagonite, Pele's hair, threads or fibers of volcanic glass, usually basaltic, Pele's tears, tear-like drops of volcanic glass, usually basaltic.

Manmade Resources

It is believed that glass was made by Mesopotamian about 3,600 years ago but some people also claim Mesopotamian have been making copies of glass object from Egypt. Evidence from the archaeological view that first true glass was made by North Syria or Egypt. The glass named 'obsidian' that was made by the immense heat produced from the eruption melting sands. This obsidian was used as tips for spears. Natural glass had been used by ancient people, particularly volcanic glass (the obsidian glass) before they learned the way to create glass. Volcanic glass was used for production of knives, jewellery, arrowheads and even cash. The ancient Roman historiographer Pliny advised that Phoenician merchants had created the primary encloses the region of Syrian Arab Republic around 5000BC.

However as per the archeologic proof, the first artificial glass was made in Japanese geographical area and Egypt around 3500BC, and the first glass vessels were made regarding 1500BC in Egypt and Mesopotamia area. For future three hundred years, the glass business was highly increase so declined. In geographical area it had been revived within the 700BC and in Egypt within the 500's BC. For future five hundred years, Egypt, Syrian Arab Republic and the alternative countries on the Japanese coast of the Mediterranean were centres for glass producing.

Evidence of artificial glasses was discovered by the archaeologists throughout 4000 B.C. and from there it's conjointly been illustrious however those were utilised as glazes to create the coating of stone beads. This provides the data however till 1500 B.C. the hollow glass was created with the assistance of sand core and liquified glass. From these lines, it may be expressed that 'this' means that semisynthetic glass and also the 'coating' means that covering the stone beads. It was not till 1500 B.C., however, that the primary hollow glass instrumentality was created by covering a sand core with a layer of liquid glass." it absolutely was within the initial century B.C. that tumbler processing for creating glass containers initial came into existence. The glass containers were coloured because the raw materials employed in the creating were impure. Therefore, the solution is properly chosen because it is all due to the impurities that the colour of the glass instrumentation changes.

The first glass vessels appeared within the late sixteenth century B.C. Glassmakers in Mesopotamia region were once more the innovators, developing the core-forming technique, within which hot glass is trailed around a core within the form of the specified vessel as an alternative, crushed granular glass is applied to the core and heated till it melts and fuses. Core-formed vessels were typically tiny and used as containers for cosmetics, perfumes, and medicines. As early because the third millennium B.C., craftsmen in Mesopotamia discovered a way to glaze jewellery and little objects with coloured glass.

Probably, the Egyptians learned glassmaking from their Asiatic neighbours, presumably from captives taken throughout Egyptian military campaigns within the East underneath the eighteenth-dynasty swayer Thutmosis III (1490–1436 B.C.).

The glass business, once transplanted to Egypt, grew vigorously, burning partly by the abundance of the raw materials required to manufacture glass. Egyptian workshops not only made a range of wares for consumption by the royal court and aristocrats, World Health Organization might afford such luxuries, but additionally exported giant quantities of raw glass. Despite Associate in attention nearly total halt of glass production throughout the questionable Middle Ages of Mediterranean civilization between 1200 and 900 B.C., a replacement generation of craftsmen cultivated the core-forming technique within the ninth century B.C., and workshops began once more to manufacture tiny vessels to satisfy the strain of a rejuvenated marketplace for luxury merchandise. In between the sixth and fourth centuries B.C. witnessed Associate in treatment growth of the glass trade, as core-forming technology unfold throughout the Mediterranean. Though the technique remained for the most part an equivalent, the design of vessels modified over time to satisfy the shifting tastes of patrons that, by the sixth century B.C., were progressively influenced by Greek pottery. The amphoriskos, for example, may be a miniature version of the jar, a widely known Greek pottery type used primarily for storage. This tiny vessel most likely once command perfumed oil.

After core-forming technique several casting techniques followed by the Northeast and Egypt dating to the fifteenth Century B.C. Despite the invention of casting techniques there was a limited use until the Hellenistic period.

Again, it was increase with the high demand for luxury goods during period of the Alexander the Great. Most important cast glass is Mosaic glass formed by melting sections of preformed cane, mostly featuring colourful patterns. Another popular cast glass vessel is known as Ribbed bowls in the late Hellenistic and early Roman periods. Glass manufacturer made ribbed bowls out of both polychrome and monochrome glass

The conversion of the emperor Constantine to Christianity after A.D. 312 promoted a change of the spiritual constitution of the traditional world. By the center of the fourth century A.D., Christianity, once a persecuted cult centered in Palestine and therefore the urban centers of the Roman Empire, had developed into the accepted state faith.

In the first century A.D., glass vessels are using in different shape like imitation of various types of Fruits, animals etc. made by Mold-blowing techniques near Syros-Palestinian coast to look to food for inspiration. The figure describes the shape of a bunch of grapes of the late first to third century A.D.

Some decorated trailed spiral glass indicates date in the third century A.D. also particular shape of cup vessels in the second century A.D. made by the Roman empire. Ultimately, by the time of Crusades, Venice city became glass producing developed centre for glassmaking of the western world. In 1291 glassmaking instrumentation was transferred to the island of Murano. Throughout fifteenth century Venetian glass blower, Angelo Barovier, crated cristallo, nearly colorless, clear glass. By the late 1500's, several Venetians visited geographical area seeking higher life wherever they established factories and brought the art of Venetian glassblowing.

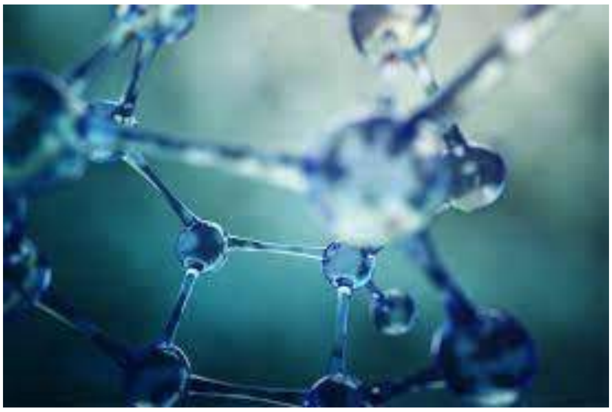
In 1608, the first glass factory was built in Jamestown in USA, Virginia. In the early 1800's, there was an excellent demand for sheet glass that was referred to as crown glass. Within the decade, the age of processing individual bottles, glasses and flasks was concluded by the invention of a manual machine. Within the decennary, the primary semi-automatic bottle machine was introduced.

PRODUCTION OF GLASS (MECHANISM)

Sneha Sen
Sajal Halder
Semester III

Glasses are disordered materials that lack the periodicity of crystals but behave mechanically like solids. Glass is neither a liquid—supercooled nor a solid. It is an amorphous solid—a state somewhere between those two states of matter.

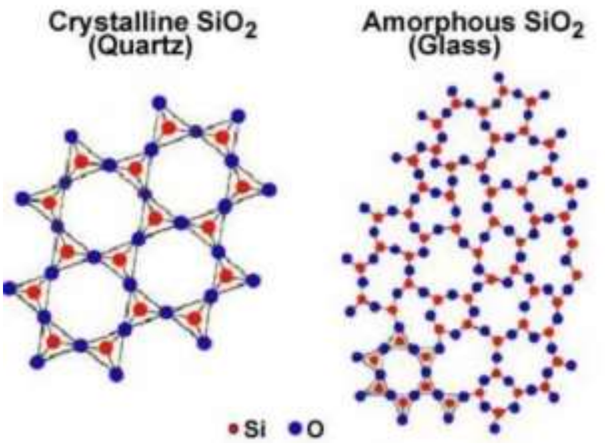
And yet glass's liquidlike properties are not enough to explain the thicker-bottomed windows, because glass atoms move too slowly for changes to be visible. So, to understand the structure of the glass a term **Supercooling** must be known.



Super cooling is the process of lowering the temperature of a liquid or a gas below its freezing point without it become a solid. It achieves this in the absence of a nucleus around which a crystal structure can form. An example of this phenomenon is found every day in meteorology: clouds in high altitude are an accumulation of supercooled droplets of water below their freezing point. In cumulus cloud water remains in supercooled state.

Preparation of Super Cooled Liquid

When glass is made, the material (often containing silica) is quickly cooled from its liquid state but does not solidify when its temperature drops below its melting point. At this stage, the material is a supercooled liquid, an intermediate state between liquid and glass. A liquid below its freezing point will crystallize in the presence of a seed crystal or nucleus around which a crystal structure can form. However, lacking any such nucleus, the liquid phase can be maintained all the way down to the temperature at which crystal homogeneous nucleation occurs. The homogeneous nucleation can occur above the glass transition where the system is an amorphous that is non-crystalline solid.



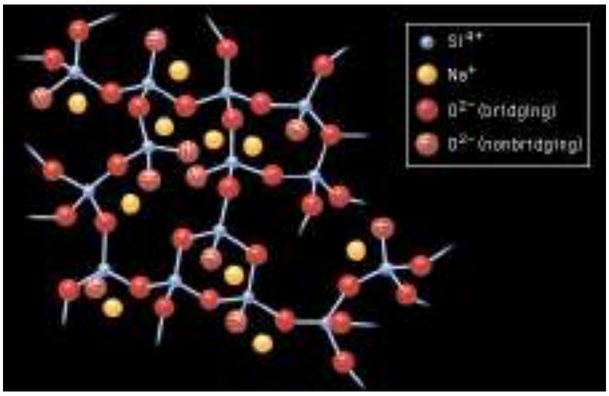
Thermodynamics of Glass Formation

Nuclear system of glass arrangement of a supercooled basic monatomic fluid with Lennard-Jones–Gauss (LJG) interatomic potential is examined by sub-atomic elements (MD) reproduction. Supercooled and smooth states are gotten by cooling from the dissolve. Polished state got at low temperatures is strengthened for extremely significant timeframe, on the request for microsecond, and we observe that smooth state stays unaltered and that the enduring lustrous condition of a straightforward monatomic framework in three aspects is figured it out.

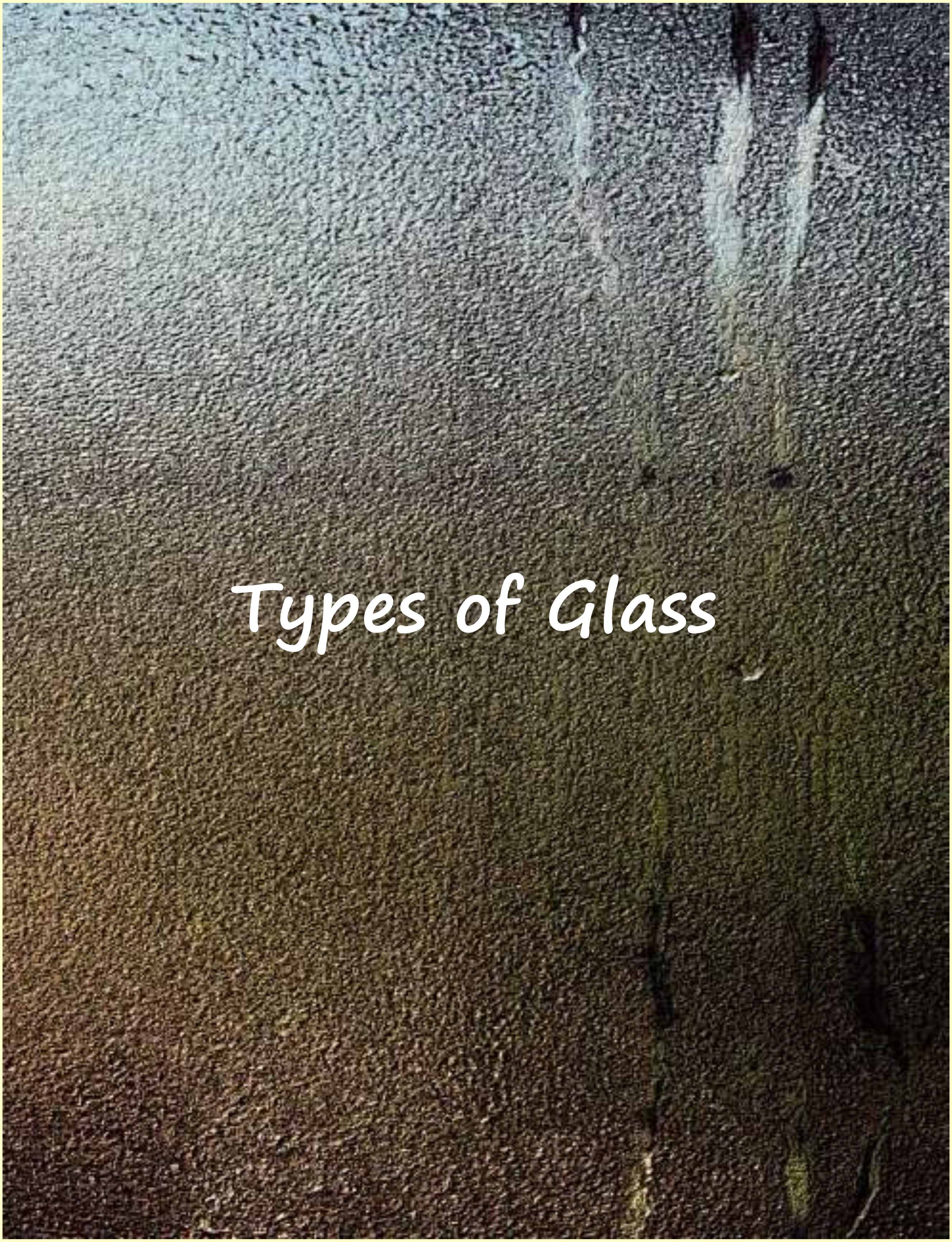
Transition Temperature Tg

Diverse functional meanings of the glass change temperature Tg are being used, and a few of them are supported as acknowledged logical principles. By the by, all definitions are self-assertive, and all yield distinctive numeric outcomes, best case scenario, upsides of Tg for a given substance concur inside a couple of kelvins. One definition alludes to the thickness, fixing Tg at a worth of 1013 balance.

Kauzmann's Paradox: As a fluid is supercooled, the distinction in entropy between the fluid and strong stage diminishes. By extrapolating the hotness limit of the supercooled fluid beneath its glass progress temperature, it is feasible to compute the temperature at which the distinction in entropies becomes zero. This temperature has been named the Kauzmann temperature. Assuming a fluid could be supercooled beneath its Kauzmann temperature, and it did for sure show a lower entropy than the gem stage, the outcomes would be confusing. This Kauzmann oddity has been the subject of much discussion and numerous distributions since it was first advanced by Walter Kauzmann in 1948. The impact of warm phonons and their collaboration with electronic design is a point that was properly presented in a conversation of the obstruction of fluid metals. Lindemann's hypothesis of dissolving is referred to, and it is recommended that the drop in conductivity in going from the glasslike to the fluid state is because of the expanded dispersing of conduction electrons because of the expanded sufficiency of nuclear vibration. Such hypotheses of limitation have been applied to move in metallic glasses, where the mean freeway of the electrons is tiny. Assuming that the electrical conductivity is low, the mean freeway of the electrons is exceptionally short. The electrons might be touchy to the short-range request in the glass since they don't get an opportunity to dissipate from molecules divided at large distances. Since the short-range request is comparative in glasses and gems, the electronic energies ought to be comparable in these two states. For composites with lower resistivity and longer electronic mean freeways, the electrons could start to sense that there is jumble in the glass, and this would raise their energies and undermine the glass as for crystallization.



Accordingly, the glass development propensities of certain composites may in this way be expected to some extent to the way that the electron mean freeways are exceptionally short, so just the short-range request is ever significant for the energy of the electrons. Thus, the glass is produced from supercooled fluid.


Types of Glass

TYPES OF GLASS

Rajdeep Chakraborty
Semester V

Glass is a non-crystalline, often transparent amorphous solid. It has a widespread use in practical, technological, and in decoration. Glass is formed by the quenching (rapid cooling) of the molten form. Historically, the oldest form of manufactured glass is silicate glass. It is based on the chemical compound silica, the main component of sand. Soda-lime glass contains around 70% silica. There are many other forms/types of glass which are manufactured. Some of these are mentioned below.

Silicate

Silicon dioxide (SiO_2) is the most common ingredient in the process of making glass. Fused quartz is a glass which is made from pure silica. It has relatively low thermal expansion and shows an excellent resistance to thermal shock. It's being able to survive an immersion in water while the glass is red hot. It can resist very high temperatures (1000-1500°C) and chemical damage and is very hard. For a wider spectral range, it appears transparent. It is further visible into both the UV and IR ranges. Thus, it is sometimes used where transparency to these wavelengths is necessary. Fused quartz is used for high temperature applications such as furnace tubes, lighting tubes, melting crucibles, etc. However, due to its high melting point (1723°C) and viscosity make it very difficult to workers to work. Therefore, other substances (fluxes) are added to lower the melting temperature and make the process of glass making simple. Quartz sand (silica) is the main raw material in commercial glass production

Soda-lime

Sodium carbonate (Na_2CO_3, 'soda') is a very common additive on glass. It is added to lower the temperature of glass-transition. Sodium silicate is highly soluble in water.

Soda-lime glass

So, some other compounds are added to the glass, which improves the chemical durability, which are lime (CaO, calcium oxide, obtained from limestone), magnesium oxide (MgO)and aluminium oxide (Al_2O_3). In the world, 75% of the manufactured glass is soda-lime glasses [sodium silicate + lime (CaO) + magnesia (MgO) + alumina (Al2O3)], containing about 70 to 74% by weight. Soda-lime-silicate glass is transparent, it is formed easily. On the above, it has a high thermal expansion and poor resistance to heat. It is typically used for window glass, light bulbs and tableware.

Borosilicate Glass

Borosilicate glasses (e.g., Pyrex, Duran) which contain 5 to 13% boron trioxide (B_2O_3). It has low coefficient of thermal expansion, about one-third of typical soda-lime glass. They are less subject to stress caused by thermal expansion. The type of glass is less vulnerable to cracking from thermal shock. They are commonly used as the glassware used in laboratory, household cookware and sealed beam car head lamps.

Lead Glass

When lead (II) oxide is added into silicate glas,s it lowers the melting point and viscosity of the melt. The density of lead glass (silica + lead oxide (PbO) + potassium oxide (K_2O) + soda (Na_2O) + zinc oxide (ZnO) + alumina) is high, which results in a high electron density. High refractive index of lead glass is responsible to make the look of glassware more brilliant and causing noticeably more specular reflection and increased optical dispersion. The glassware is more workable and produces a clear "ring" sound when struck because lead glass has a high elasticity. However, lead glass cannot withstand high temperatures well. Lead oxide also facilitates solubility of other metal oxides and is used in coloured glass.

The viscosity decreases of lead glass melt which is very
significant; this allows easier removal of bubbles and working at lower temperatures, hence it is frequently use as an additive in enamels and glass solders. The high ionic radius of the Pb^{2+} ion renders it highly immobile and hinders the movement of other ions; therefore, lead glasses have high electrical resistance.

Aluminosilicate Glass

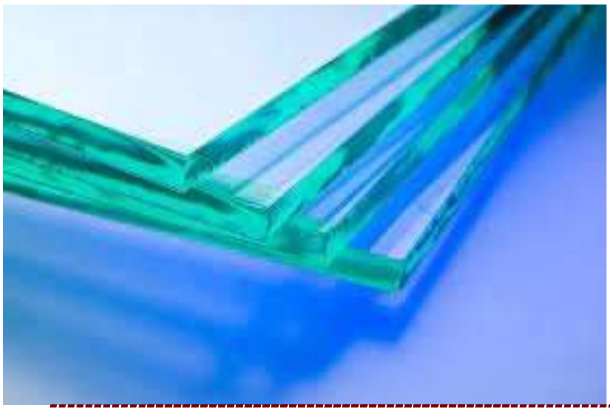
Aluminosilicate glass contains about 5-10% alumina (Al_2O_3). Compared to borosilicate glass, aluminosilicate glass tends to be more difficult to melt and shape. It has excellent thermal resistance and durability. Aluminosilicate glass is used for the making of fiberglass, used for making glass-reinforced plastics (boats, fishing rods, etc.), top-of-stove cookware, and halogen bulb glass.

Other Oxide Additives

The addition of Barium oxide increases the refractive index of glass. Thorium oxide gives glass a high refractive index and low dispersion and was formerly used in producing high-quality lenses. Thorium has radioactivity so it has been replaced by lanthanum oxide in modern eyeglasses. Iron can be incorporated into glass to absorb infrared radiation. For example, in heat-absorbing filters for movie projectors. while cerium (IV) oxide can be used for glass that absorbs ultraviolet wavelengths. Fluorine lowers the dielectric constant of glass. Fluorine is highly electronegative and lowers the polarizability of the material. Fluoride silicate glasses are used in manufacture of integrated circuits as an insulator.

Glass-Ceramics

Glass-ceramic materials contain both crystalline ceramic phases and non-crystalline



glass. They are formed by controlled nucleation and partial crystallisation of a base glass by heat treatment. Crystalline grains are often embedded within a non-crystalline intergranular phase of grain boundaries. Glass-ceramics exhibit advantageous thermal, chemical, biological, and dielectric properties as compared to metals or organic polymers. The most commercially important property of glass-ceramics is their imperviousness to thermal shock. Thus, glass-ceramics have become extremely useful for countertop cooking and industrial processes. Glass ceramics exhibits excellent mechanical properties and can sustain repeated and quick temperature changes up to 1000 °C.

Fibre Glass

Fibreglass (also called glass fibre reinforced plastic, GRP) is a composite material made by reinforcing a plastic resin with glass fibres. It is made by melting glass and stretching the

glass into fibres. These fibres are woven together into a cloth and left to set in a plastic resin. Fibreglass has the properties of being lightweight and corrosion resistant, and is a good insulator enabling its use as building insulation material and for electronic housing for consumer products. Fibreglass was originally used in the United Kingdom and United States during World War II. Uses of fibreglass include building and construction materials, boat hulls, car body parts, and aerospace composite materials. Glass-fibre wool is an excellent thermal and sound insulation material, commonly used in buildings (e.g. attic and cavity wall insulation), and plumbing (e.g. Pipe insulation), and sound proofing. It is produced by forcing molten glass through a fine mesh by centripetal force, and breaking the extruded glass fibres into short lengths using a stream of high-velocity air. The fibres are bonded with an adhesive spray and the resulting wool mat is cut and packed in rolls or panels.

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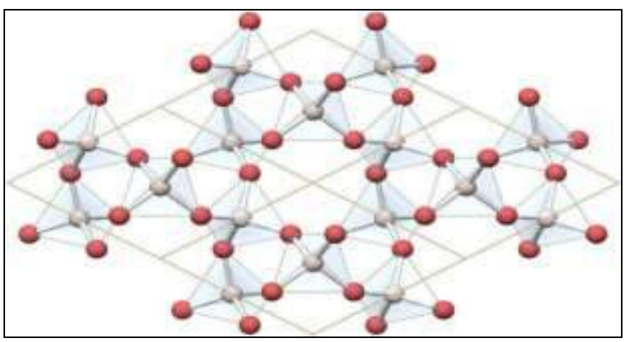
SODA LIME GLASS

Pradipta Pal

Semester III

Soda-lime glass, also called soda-lime-silica glass. It is most commonly available and largely manufactured glass. This is most prevalent type of glass. This type of glass mostly use for windowpanes and glass containers. Soda-lime glass is relatively inexpensive, chemically stable, reasonably hard and extremely workable. It is capable of being re-softened a number of times if needed, to manufacture and finish a product. This is makes it versatile and suitable for diverse applications.



Chemical Structure

It is composed of about 70% silica (silica dioxide) 15% soda(Sodium oxide) and 9% limes (calcium oxide) with much smaller amounts of various other compounds. Soda-lime glass is made by heating its raw materials in a glass furnace at temperatures up to 1675 degree centigrade. The temperatures are only limited by the quality of the furnace structure, material and by the glass composition. Relatively inexpensive minerals such as trona, sand and feldspar are usually used instead of pure chemicals. Soda-lime glass is divided technically into glass used for windows, called flat glass, and glass for containers, called container glass. The two types differ in the application, production method (float process for windows, blowing and pressing for containers), and chemical composition. Flat glass has a higher magnesium oxide and sodium oxide content than containers glass, and lower silica, calcium oxide, and aluminium oxide content. From the lower content of highly water-soluble ions (sodium and magnesium) in container durability against water, this is required especially for storage of beverages and food. Soda-lime glass is called soda-lime glass because it is prepared from soda ash or sodium carbonate. It is also called soft glass because it becomes soft after heating.

Stability The atoms in soda lime glass have strong atomic bonding and they are strongly connected so it makes it difficult for other substance to affect its structure and corrode the glass. This makes it good for use any purpose. Soda lime glass is not entirely Immune top, however other more specialized glasses can be more resistance.

Hardness Soda lime glass is a 6-7 on the Mohs hardness scale, which measured how resistant to abrasion material is. This highest score on this scale is ten and includes materials like diamond. Chemical tempering gives it more mechanical strength, making it harder and more scratch resistant. Heat strengthening also provides the glass with mechanical strength, with the bonus of making it more resistance to sudden changes in temperature. Soda lime glass can be softened and resoftened many times without quality loss. This attribute makes it good materials for recycling.

It's vulnerable to thermal shocks. Sudden temperature changes can shatter soda lime glass. This can be reduced by heat tempering, which gives these materials added strength. It is an electrical insulator. Glass does not transmit electricity and low dielectric constant. That makes it useful for insulating electrical products. It transmits visible light. Soda lime glass's refractive index is roughly 1.5, which means only about 4% of the light that hits it is reflected. It makes an excellent material for applications where light transmission is important. Due to its popularity and commonness, soda lime glass can be found across a wide range of industries. It shows up in architectural and construction applications as windows, in the packaging and food and beverage industries as bottle and containers and in electrical field as a high voltage insulator. Soda lime glass is also used in scientific applications for supplies like Petri dishes and a cheaper alternative to borosilicate glass products for its increased strength and chemical resistance. It also makes appearances in consumer goods such as decor, while the tempered version of it is used in consumer bake ware.

Soda lime glass in its pure form has no color. However, small impurities of iron glass can tint the glass green, and this tint can be especially visible in thicker glass pieces. To make colored glass, powdered metal oxides, sulfides or other molten compounds are added to the molten glass mixture. Hence, enhancing its aesthetic appeal. Example of coloring ions used to change the color of this soda lime glass includes:

Sulphur Together with iron and carbon salts, Sulphur forms iron polysulfide which is used to make amber glass. The concentration, redox state and nature of the compound used are significant factors that defined the color of the glass. Iron pyrite is a good source of Sulphur to produce amber glass.

Iron (II) oxide: Iron (II) oxide can be added to glass to produce a bluish green coloring. The sort of glass is what is commonly used for beer bottles. When chromium is further added to the mix, it produces a more vibrant green color, widely used for wine bottles.

Chromium: It is known to be a potent colonizing agent. It produces dark green or even black when used in higher concentrations. When used in a mixture with the combination of arsenic and tin oxide, it yields emerald-green glass. A good example in this application is chrome flour.

Copper Oxide: 2 to 3% of copper oxide added to molten glass produces a turquoise colour. It is also used in the production of black glass which involves a heat strike.

Titanium: It produces a yellowish-brown glass.

Didymium: It is used in addition with glass to produce a green or lilac red color.

Uranium: When added to glass, it yields a green or fluorescent yellow color.

Manganese dioxide: This additive which has a black color, is used to remove green color from glass.

In this way different colored glasses are made using different metal oxides.

Chemistry of Coloured Soda Lime Glass

The color of glass can be more than aesthetic, however. For example, beer bottles are colored green or brown to cut out specific wavelength of UV light which can otherwise contribute to beer spoilage and a 'skunky' flavor. It's also used in some chemical bottles for a similar purpose.

Pink glass is most valuable, followed by blue and green. Rear colors such as tangerine and lavender are also worth more than common color like yellow and amber. This should not be forgotten that the soda lime glass how much safe to us.

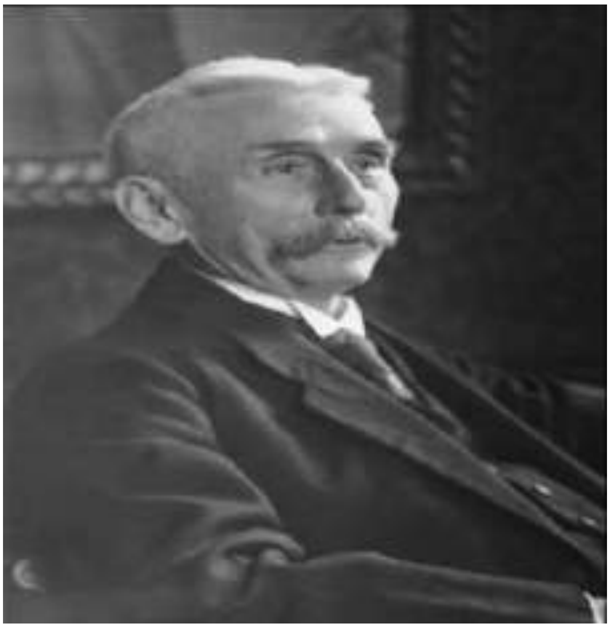
Soda lime glass is classified as Type i, Type ii and Type iii which are all considered to be food safe, or in the terms of the FDA, GRAS (generally regarded as safe). For this reason, soda lime bottles are very often chosen as the packaging of choice for most food and beverage products. In science and industry, glass act as an essential role. It has various ornamental and industrial applications, starting from small microscope to huge buildings. Soda lime glass was produced throughout much of Europe for hundreds of years. Silica, in the form of sand, and limestone were abundant nearly everywhere. Soda ash was readily obtained from hardwood forests. Now days Soda lime glass is used for various purposes, and it is very popular.

BOROSILICATE GLASS

Susmita Jana
Semester III

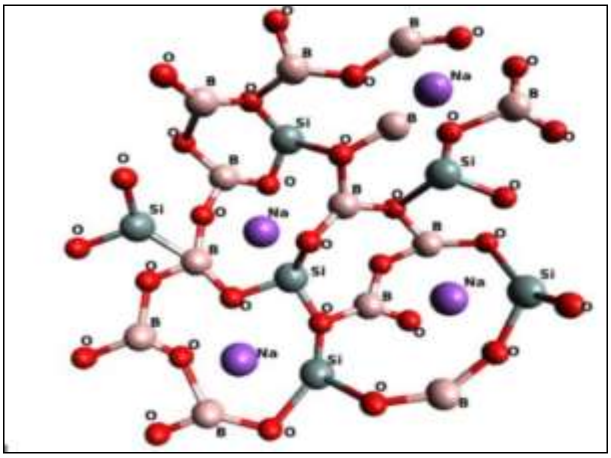
Borosilicate glass is a type of glass with silica and boron tri oxide as the main glass forming constituents.

Properties: Borosilicate glasses are known for having very low coefficients of thermal expansion making the more resistant to thermal shock than any other common glass. It also has very high electrical resistivity and dielectric strength, high chemical stability withstands high applied torque loads and visible to near infrared transmission



Inventor: In the 1880's, a German scientist OHO Schott, developed a low expansion glass, called borosilicate glass. It is also known as Jena Glass.

Chemical Formula: The chemical composition of Borosilicate glass typically consists of around 81% silicon dioxide (sio2) and 13% boron trioxide (B_2O_3) with lesser concentrations of sodium oxide and Aluminium oxide. Borosilicate glass is created by combining and melting boric oxide, silica sand, soda ash and alumina. Silicon is the main glass forming element in a borosilicate waste glass and its basic elements are SiO_4 tetrahedra, which comprise bridging or cross-linking and non-bridging atoms of oxygen



Chemical Stability: Borosilicate glass can withstand corrosion and breaking when exposed to acidic environments.

Production And Processing: This special type of glass is produced from melting the following substances – silica sand (59.5%), boric acid (21.5%), potassium oxide (14.4%), zinc oxide (2.3%) and trace amount of Cao and Al2O3.

The melting process requires an exceedingly higher temperature than traditional glass production, owing to the material's high transition temperature of up to 56^{o}degree C. Once the substrate has been produced, Borosilicate glass may be processed in a no of ways depending on the application for the material. This glass material may be molded or drawn into tubes and processed into custom shapes and size.

Physical Properties:

Composition: SiO2 (65-68%), B2O3 (8-15%), Na2O (3-9%), Al2O3 (1-5%), K2O – (max 2%)

Density 2.23gm/cm^{3}

Thermal Properties:

Melting Point – 1252 Degree C

Softening Temperature – 821 Degree C

Thermal Conductivity – 1.15 w/Mk

Shock Resistance – 300 Degree C

Mechanical Properties:

Hardness = Mohs 6, Knoop 420-52

Poisson's Ratio = 0.20

Young's Modulus = 64GPa

Compressive Strength = 9327KG/Cm^{2}

Tensile Strength = 832KG/Cm^{2}

Electrical Properties:

Volume Resistivity = 10^{15} ohmmeter

Optical Properties:

Refractive index = 1.47 nanometre

Magnetic Properties:

Relative magnetic permeability = Di-Magnetic

Common Uses for Borosilicate Glass:

1. Laboratory glassware
2. Scientific tenses and hot mirrors
3. Bakeware & cookware
4. Thermal insulation
5. High intensity lighting products
6. Sight glass
7. Aircraft exterior tenses
8. Aquarium heater

LEAD GLASS

Indrajit Saha
Semester III

Lead glass is well known as a crystal. There are some varieties of calcium content of some potash glass is replaced by lead. Lead Oxide is present in Lead glass in a typical amount 18-40%.The name of ‘flint glass’ is awarded to modern lead glass due to the presence of original silica source. This glass contains minimum 24% PbO. The clarity of the lead glass often attracts to us for using.

The term ‘crystal’ is technically not correct use for lead glass. The structure of lead Glass is not proper crystalline. Amorphous solid is the real structure of lead glass.

The 'Crystal’ of the Lead is popular due to historical and commercial reasons. Lead sounds becomes toxic to the consumers. The naming convention has been maintained to present day to describe decorative hollow ware.

General Uses

Lead glass is commonly employed to serve and to store drinks. Glassware of lead crystal is commonly used. But the use of it gives dangerous and risks to our health. Lead Glass has a dispersive power. So, the use of these types of lead glass becomes rare. To avoid dangerous side effects, few steps are taken. It would be helpful for all the mankind. Crystal glass is selected as an alternative use.

Which contains barium oxide, Zinc oxide or K_2O Lead free crystal has a similar refractive index to lead crystal.

But it is lighter, and it has less dispersive power. Labelling of 'Crystal' products is controlled by Council Directive 69/493/EEC in the European Union.

This Union defines four categories of this material depending on the chemical composition and properties. Glass products with other metal, oxides are used in place of Lead Oxide, must be labeled "Crystalline or Crystal Glass".

Historical Development

Most common stories on the lead Glass are depicted here. Mesopotamia is known as brith place of glass. Those glasses contained some PbO content. Blue glass fragment from Nippur also contained 3.66% PbO dated to 1400 BC, is the earliest known example. A red sealing wax cake found in the Burnt Palaces at Nimrud, from the early 6th century BC, contains 10% PbO.

This low value suggest that lead oxide may not have been consciously added and was certainly not used as the primary fluxing agent in ancient glasses. Lead Glass was also produced in Han-period China (206 BC220AD).

It was cast to imitate jade, both for ritual objects such as big and small figures, as well as jewelry and a limited range vessel.

An autonomous development between Western silica-natron glass and the unique Chinese Lead glass. This difference had depending on fundamental composition.

Conclusion: Lead Glass is most important for the daily life using. But Lead Glass has some harmful effects on human health.

So, Lead Glass is used to modified it. We see that the crystal lead glasses are employed to use for home decoration making, various to store and drinking glass.

From the historical background of Lead Glass, it is seen that lead glass commonly used. So modified lead glass is heavily utilized in Chemical Industries, Homeopathy medicine sector, various types of office using slab etc.

ALUMINOSILICATE GLASS

Arijit Banerjee
Semester V

We all know that glass is an inflexible material which is formed by heating a mixture of dry solid materials until it reaches a semi-solid state. Then the mixture is cooled quickly to prevent it from forming the crystalline structure that most solid materials have. As the glass cools, the atoms are locked in a disordered state similar to that of a liquid before they can form the crystalline state of a solid. We know glass is neither a liquid nor a solid, but instead it has the qualities of both, glass exist as a separate type of matter. Glass comes in many different varieties, and one of the less common types is aluminosilicate.

Now we need to know about the aluminosilicate glasses. Aluminosilicate is a glass of aluminum oxide, usually at between 20% and 40%. There are different types of Aluminosilicate glass; they depend on their chemical compositions, with focus on the oxide composition. Aluminosilicate glasses have comparable properties to borosilicate glass but are more heat resistant, tolerating temperatures that can be up to 800 degrees Celsius, and it has a better chemical resistance. Its softening temperature is at 1010 degrees Celsius. Aluminosilicate is a naturally occurring compound; aluminosilicate is now mass-produced due to much increasing demand.

Because of the heat resistance, aluminosilicate glasses are much more difficult to melt and therefore more fabricate.

It also undergoes an ionization process after it's created to make it more scratch resistant.

Aluminosilicate glass has a high resistance to thermal shock, so it is used as a sealing material for hot systems. It is often coated with an electrically conducted film and then used as resistors for electronic circuitry. Its lightweight lends to its use as for touch screens and touch screen protectors.

Now we should know about types of aluminosilicate glasses.

Alkaline earth aluminosilicate glass contains 15-25% aluminum oxide (Al_2O_3), 52-60% silicon dioxide (SiO_2), and approximately 15% alkaline earth. They are mainly used for glass bulbs for halogen lamps, high-temperature thermometers.

Alkali aluminosilicate glass is typically 10-25% aluminum oxide (Al_2O_3) and up to 10% alkali. The high alkali content prepares the glass for ion exchange with bigger alkali ions in order to improve the surface compressive strength. Due to this feature, it is especially suitable for use in touch displays, solar cells. High transformation temperatures and outstanding mechanical properties, as hardness and scratch behavior, are characteristics of alkali aluminosilicate glasses.

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GLASS CERAMICS

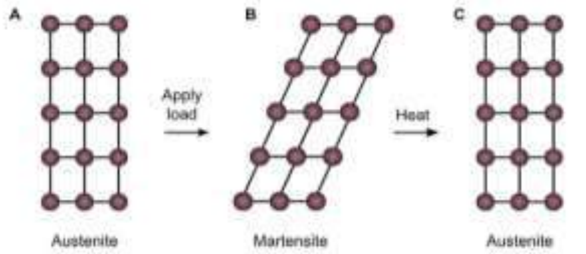
Suman Mahato
Semester V

Glass-ceramics are polycrystalline materials produced through controlled crystallization of base glass. To obtain a glassy state for materials, the non-crystalline structure is obtained. Glass-ceramics, basically glass that has a crystalline structure. The chemical composition of glass-ceramics is the same as conventional glass generally. This crystalline structure of glass-ceramics gives very specific properties to that material. Because of that crystalline structure, glass ceramics have opaque structure.

As we know that, if a material has a very fine crystalline structure, the strength of that material is high. Glass ceramics have a very fine crystalline structure compared with ceramics. Because of that, glass ceramics are very high in strength.

Preparation

i) General heating and forming operations that are used in glass working.



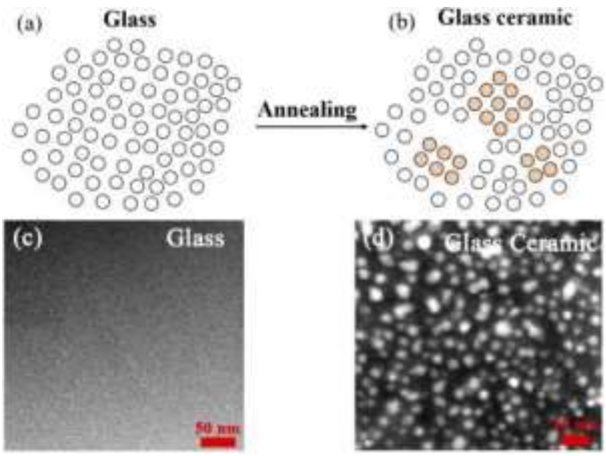
ii) Cooling of shaped glass-ceramic materials reheating of produced shape to create high-density crystallization nuclei zones. These high-density nuclei zones inhibit grain growth which will lead to obtaining finer grains. Some agents of nucleation are added such as P_2O_5, ZrO_2, and TiO_2.

iii) Heat treatment application to the glass-ceramic product after initiation of nucleation.

Glass ceramic material is very high in strength and temperature resistance.

Properties

Glass-ceramics can range from highly crystalline to containing a more substantial glassy phase. As they contain crystalline phases and, therefore, also grain boundaries, glass-ceramics can range from transparent to opaque. Depending on the microstructure and the chemical composition of glass-ceramics, their properties can be tuned to meet demanding requirements.



In general, glass-ceramics exhibit almost zero thermal expansion and high toughness. In addition, they are resistant to thermal shock and have a high impact resistance. Glass-ceramics have very good mechanical and physical properties compared to conventional glasses. There is absence of porosity, and this kind of glass has good thermal resistance.

Uses

With their thermal and mechanical characteristics, glass-ceramics have a range of applications, including Cook tops (which we find in most modern kitchens)

Household appliances including toasters, clothes irons, hair straighteners

Grills and BBQs

Smartphone protective screens

Infrared applications, such as in infrared heating elements.

In high-temperature furnaces as an insulation material, particularly due to their high thermal robustness.

FIBRE GLASS

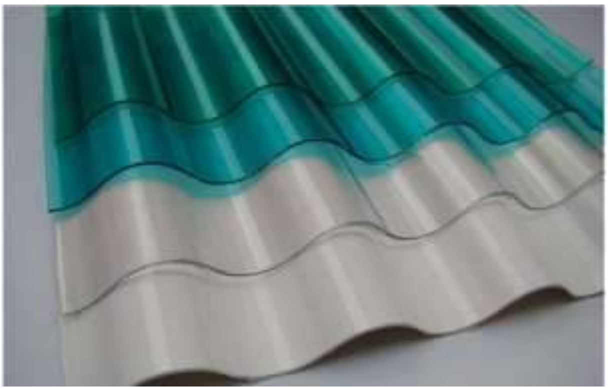
Subhadeep Sengupta
Semester V

Fiberglass composites are widely used in different applications of aerospace, automotive, sports, ships, and constructional work due to having higher demands.

These are having many advantages due to their low cost of production, easy to fabricate, light weight, higher strength to weight ratio. The objective of the work is to study the mechanical properties of fiberglass without filler at different fiberglass loading, and the effect of different fibre loading and filler content on the mechanical properties like hardness, flexural property, tensile strength, and impact property etc and the mechanical and abrasive behaviour of coated and uncoated E-glass fibre reinforced epoxy-based composites. A study is also performed to study the effect of various factors on the sliding wear behaviour of the composites and the surface morphology of composites before and after the tensile test was studied by optical microscope.

When dissimilar composition with divergent properties from each other are mixed, or a system fabricated from two or a lot of physically different stages by a distinct interface whose mixture creates versatile properties that are in a higher grade in many ways to its every material. Composite materials are very elastic and are used in a variety of applications. Composite parts give a very pure strength and structure become lighter in weight and can be molded in any shape. The main use of fiberglass is to make sheet and cover. It is mainly used in the aerospace industry, automobile industry etc. Generally, fiberglass is used with polyester using to make it fiberglass.

Polyester Fibre Glass Sheet



A system constituting of two or more phases is separated by a categorical platform whose mixture results in the production of summed up properties that square measure outstanding in many ways so that to its individual components. The properties can be made by combining the material, two constituents' mainly primary constituents and the epoxy. The system that is regular in nature and it is gifted in a big amount is called as primary constituents. The primary constituents hold and bind the fibre together distribute the load regularly within the fibres and save it from mechanical and environmental disaster. While the constituent is called as reinforcement, and it is used to increase the mechanical properties like the stiffness and strength of the material etc. We also know that fiberglass is a special type of synthetic fibre. Its strength is generally more than other fibre. The main property of fiberglass is that it is fireproof, waterproof, and today it is used in the fabrication of bodies of the sports car.

Primary Constituent:

The commonly used material is polymer matrices, and it has many advantages such as easy availability, low cost, it can be moulded to any desired shape and size, it is easily fabricated.

One of the most important properties of the material is that it is light in weight to body ratio as the overall weight is very less as compared to the other material. The primary constituent that area unit utilized in gift paperwork is fiberglass epoxy which is a category of a thermosetting material that will contain epoxide cluster as its main function is that it will be bonded to the one oxygen atom by two carbon atoms. As compared to the other resin of thermo set epoxy resin is used in much industrial application due to the different advantages as it forms three-dimensional cross-link compounds that undergo the chemical reaction that is irreversible in nature while comparing with the thermostat resin.

It has a super quality like high mechanical strength, good bonding between the secondary constituent molecule, that is the fibre of both the particle is tightly attached. It has a good resistance against chemical reactions, and it has low shrinkage ratio, therefore we must choose the epoxy resin LY-556 as it contains all the quality which are required to bind the fiberglass with our secondary constituents.

Fibre Material:

Fiberglass is commonly used for reinforcing agents among different intermixing material. Fiberglasses are available in different forms like woven fabric, non-ending fibre, chopped fibre, and short discontinuous fibre.

In this work, fiberglass is mainly used as a reinforcing agent because of the concerned length of fibre that is 6 mm, it contains the salt glass which contains alkali chemical compound of one chronicle.

Filler Material

For the study, we concluded that different constituent is used because the filler material in the chemical compound composite usually is silica carbide (SiC), Titania (TiO_2) is widely used for standard filler material.

During this work, we have a capability to take aluminium as a filler material as it has different advantages that is its property related to mechanical, chemical, and physical. It is very good as it has light in weight, strength, high hardness, and low cost which made it the right filler material to be used it enhanced the properties of the reinforcing constituents.

Mechanical Testing

In this work, fiberglass is taken as reinforcing agent epoxy and aluminium filler material of particle size 80 to 100 m. The aluminium filler is converted to powder form of particle size smaller than that of fiberglass so it can easily mix with it. If the particle size of the aluminium filler is large, then the binding of aluminium filler and fiberglass is difficult. That is why for ideal bonding, we need fine particle size. In this process fiberglass is taken in the mould after that layer of aluminium filler material is sprinkled. Now epoxy is poured into it and the sheet is ready now we must apply pressure for remoulding the sheet. For enhanced bonding of fiberglass particles and aluminium filler, we must apply a pressure of 25 kgs at a temperature of 270°C. Two types of fiberglass are made, one is with filler material and the other is without filler material for comparing the results while testing. The filler material quantity varies in different specimens so that we can conclude the good strength and surface quality after completion of all the tests. For performing various tests, we must cut the sheet in different shapes and sizes and perform the required test on it.

Conclusion

The work done is based on the experimental result of fiberglass which will be tested at various stages, with or without filler material. Various mechanical tests can be done on the workpiece to check the different properties at different stages. The following conclusions are made

•By the help of a pressurized method, we can fabricate fibre glasses of different composites.

•Aluminium coated fiberglass (coating thickness is not more than 0.30 μm) will lead to the removal of filler material in form of chips. A coating is done by thermal evaporation technique due to which it will be converted into one material.

•Aluminium additives are used as a filler material due which properties of fiberglass resin will be enhanced due to which properties enhanced are hardness, toughness, and tensile strength. Impact strength and flexure strength of the fabric is also improved due to the addition of filler content

•There is a mass change in the properties of the material before and after the addition of filler content. Properties which are fluctuated are hardness, flexural and tensile properties. The objective of adding filler material is to increase the wear property of fiberglass composites.

•The study shows that the thickness of the coating, aluminium filler, loading condition, and sliding distance plays an important role in the effect of the wear rate of the fiberglass composite.

COLOURED GLASSES

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Semester III

The recipe for producing coloured glass usually followed a process. where a metal is added with glass body. This is often accomplished by adding some powdered oxide, sulphide or other component .

Colouring Agents

Some of the colouring agents of glass and the colour they produce are listed below-
Cobalt Oxide: blue violet, Cadmium Sulfide: yellow, Gold Chloride: red, Antimony Oxide: white, Sulfur: yellow amber, Uranium Oxide: fluorescent yellow, green, Chromic Oxide: emerald, green.

There are also certain compounds, such as Manganese dioxide and Sodium nitrate, which can be used with certain types of molten glass to remove other impurities to create clear glass.

Method of Preparation

Glass Making

Glass starts out as a ground mixture of sand and scraps of broken or waste glass. It is called cullet. It is created when glass is recycled. The sand and cullet must be heated to their melting point to make glass. It means the glass makers need a furnace that can produce temperatures over 2,900°F.

These glass making materials are put into a furnace with a variety of other materials, depending upon type of glass is being made. When the sand and cullet melt, a red-hot glowing liquid is formed.

This is glass in its purest form. Although coloured glass can be produced in a number of ways, there are three main methods to produce it. Those are:

1. Introduction of transition metal or rare earth metal oxides to the glass. This can be achieved by the addition of metal oxides to the glass. The metal ions absorb certain wavelengths of light, depending on the metal, leading to the appearance of colour.
2. Formation of colloidal particles. This means particles of a substance that are suspended throughout the glass. These particles are

formed as the result of treatment with heat, forming this known as 'striking colours'. The colloidal particles scatter light of frequencies as it passes through the glass, causing colouration. Examples of these colloidal particles include gold, which imparts a ruby red colour, and selenium, which offer shades from pink to intense red.

3. Addition of already coloured particles to the glass. Examples of this type of colouration include milk glass and smoked glass; milk glass is achieved by adding tin oxide.

Application

Glass is already considered a superior product in many applications. Its resistance to chemical reactions and tampering make glass the perfect container for food, beverages, and pharmaceuticals. Glass does not affect the taste of food or drinks and won't deteriorate. Coloured glass finds obvious usage for decorative purposes – for instance, stained glass windows take advantage of the colouring effect of metal ions. However, the colour of glass can be more than just aesthetic.

Beverages like beer that are highly sensitive to light can generally be found in amber bottles that protect from virtually all UV radiation. Amber or brown glass absorbs nearly 100% of ultraviolet light at wavelengths shorter than 450 nanometers.

This is the best available protection from damaging UV light. Pharmaceutical companies and essential oil bottlers also usually prefer amber coloured glass for their containers because of its high level of protection. Various shades of green glass are used for less sensitive oils, like olive oil.

Amber glass is often seen in windows of facilities that house sensitive materials like antiques and artwork.

Cobalt blue is widely used for decorative purposes because and to contain less sensitive health and wellness products. Cobalt glass absorbs slightly less UV light, but still provides significant protection, allowing only blue light through.

Certain shades of green offer the lightest UV protection and are perfect for applications that involve only minimal sensitivity towards light.

MYSTERY OF COLOURED GLASSES

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Alumni 2021

We all know that glass is made from sand, soda and limestone and ordinary soda-lime glasses are totally colorless to our naked eye whether glass can be coloured in various colours by adding metal oxides or metal powders to molten glass. Depending on that metal, the glass takes on a unique color.

What to Add for Colour?

Transition metals with their unfilled or half-filled d - orbitals are the reason behind these colouration. In the process of electronic transition from lower orbital to higher orbital, an electron absorbs light but when that electron comes back to the ground state, it releases specific wavelength and intensity of light and gives rise to the coloration.

Iron(II) oxide is added to molten glass resulting in bluish green coloured glass, while Chromium and Iron oxide together can generate a richer green colour to glass.

Cobalt oxide produces a blue violet colour, small concentration of Cobalt (0.025-1%) yields blue glass. Copper oxides also do the same.

Chromium gives a dark green or black colour, while a mixture of Cobalt with Chromium will produce a blue green coloured glass.

Arsenic (As) provides a rather different shade of green i.e., emerald-green colour.

Titanium (Ti) generates a yellowish-brown whereas sulfur (s) gives a yellow amber colour.

The red color of glass is raised by Selenium (Se).

Nickel (Ni), depending on its' concentration, produces blue, violet, or black coloured glass.

A cranberry or ruby color is originated from Gold (Au).

Manganese is usually added in small amounts with glass to get rid of the green tint given by Iron but at higher concentration manganese will originate an amethyst color.

Uses:

Green colored glass is mainly used in beer bottles and wine bottles.

Blue glasses are mainly found as wine, champagne bottles but intense blue glasses (generated by Chromium) are used to make home ornaments.

Turquoise glasses are used to prepare fancy vases, lamps, and home ornaments.

Amber absorbs harmful UV radiation, so yellow amber glasses are often used to make lenses, sunglasses, medicine, and essential oil bottles.

Conclusion:

From the realm of industrial needs to our home ornaments, uses of colorued glass are everywhere. It seems magical how different metal elements originate different colors to normal glass. Colouration of glass not only just provides brightness simultaneously it provides hardness, more protection from various radiations, transparency and can both fully reflect sunlight and partially absorb it. So, day by day the use of colored glass is running towards a promising future.

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NON-SILICATE GLASSES

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Semester V

The primary benefits of the glass-ceramics incorporate- (1) Quick creation utilizing glass framing methods. (2) Pore free stone monuments. (3) Worked on mechanical and warm properties. (4) Advancement of glasslike stages and properties impractical by customary combination or strong state sintering. While these benefits have been broadly taken advantage of in silicates in the course of recent years, prompting a few business items, they are not exceptional to silicate frameworks.

Non-silicate glass-ceramics have been less broadly concentrated however business items truly do exist help in the beyond 25 years interest in non-silicates, and surprisingly non-oxide frameworks has consistently expanded. The current writing surveys a portion of the improvements in oxide glass-ceramics in which silica is either absent or in which it is added as a minor part, and in halide and chalcogenide-based frameworks. The audit isn't expected to be finished. It will zero in on frameworks in which remarkable properties and additionally structures of the subsequent glass-pottery are gotten.

Phosphate based Glass-Ceramics:

Most phosphate glasses experience the ill effects of helpless synthetic solidness, and low break sturdiness. Then again, their high warm development makes them alluring for fixing into metals. A large part of the early interest in phosphate glass-pottery can be followed to the need to work on the mechanical and synthetic properties of such seals. Extra interest in phosphates infers from requests for new biocompatible materials for bone replacement. Abe and colleagues were among quick to research phosphate-based glass-ceramics . The early investigations on parallel $CaO-P_2O_5$

glasses close to the $Ca(PO_3)_2$, stoichiometric creation prompted a few fascinating revelations.

1. Crystallization was seen at temperatures up to 50°C beneath Tg.

2. Situated, sinewy translucent b-$Ca(PO_3)_2$, filled in glass bars if the poles were framed by pulling while in a profoundly gooey condition. Gems were adjusted corresponding to the length of the pole.

3. Arranged precious stone development could likewise be created by unidirectional crystallization in a temperature angle by moving a preformed pole through this slope at speeds at or underneath the pace of gem development.

The exceptional crystallization conduct prompts a few possibly valuable properties. Bowing qualities (preabraded by 120 coarseness SiC paper) of the coming about materials were up to 640 +/ - 110 MPa. This ought to be looked at with that for the base glass (35 MPa) and for haphazardly solidified glass clay (50 MPa). Consequently, the qualities were moderately unfeeling toward scraped spot. True to form from these outcomes, the crack energy was expanded generously. Also break was not devastating as displayed schematically in Figure 1. Conduct is like that saw in glass network; fiber supported composites. Breaks spread along the framework stage ($2CaO$-$3P_2O_5$ with a limited quantity of remaining glass) corresponding to the filaments for some distance, trailed by crack of extra fiber "packs".

While the outcomes are great, a few issues remain.

1. Development rates are on the request for 20 mm/min., which restricts the pace of creation (1.2 meters/hr). Development rates are expanded at higher temperatures however the development turns out to be more irregular.

2. Without the temperature slope crystallization is surface nucleated in the twofold framework, and qualities are just marginally improved over the parent glass.

3. In surface nucleated material the volume change upon crystallization makes voids structure in the example. The voids can be haphazardly scattered or can combine to shape a huge void close to the focal point of the piece.

An intriguing likely answer for this issue has as of late been accounted for Substitution of 10 mol % Al_2O_3 for CaO, causes crystallization of some $AIPO_4$ notwithstanding the B-$Ca(PO_3)_2$ which has a lower thickness than the parent glass and lessens the volume change and the inclination to frame voids. Tragically Al_2O_3 and most different added substances decrease the capacity to shape arranged glass-earthenware production. Then again, ongoing work by James and coworkers has shown that Al_2O_3 related to TiO_2 and SiO2 improves mass nucleation and precious stone development in the CaO-P_2O_5 framework. A glass arrangement of around 40 moles% $Ca(PO_3)_2$ with 7-8% SiO2, 7-8% Al2O3 and 5-6% TIO, created around 75% crystallinity. A few gem stages were available, including AIPO, a Ti-phosphate, and B-$CaPO_3$ as the significant stage. A possibly intriguing element of these glasses is that they are both biocompatible and "machinable", having the option to be bored and strung utilizing traditional hardware, or dental drills. James credits the machinability to the slender molded gems which redirect engendering breaks in a way like that in business machinable glass-pottery.

Ternary $CaO-Al_2O_3$- P_2O_5 glass-earthenware production have been utilized in shaping hot squeezed glass-artistic lattice particulate composites with metallic titanium), cobalt-chromium, and 316 tempered steel particles. The mixes have sensible matches of warm development coefficients over the shaping. range, yet increments in K_{IC} are baffling. Full or incomplete debonding between particles the glass-ceramic network happened. A contributor to the issue might be expected to the a-ß change of AlO_4 in the 150-200°C area which, similar to that in quartz, prompts a volume decrease on cooling and exceptionally high nearby burdens.
$CaO-B_2O_3$- P_2O_5 based glass-earthenware production have been considered by James and Shi .Bulk crystallization was acquired in various organizations. Indented shaft crack sturdiness esteems (K_{IC}) expanded from around 0.9 to 1.3 MPa-$m^{0.5}$ for the best organizations. The expanded strength was credited to "microcrack toughenin" instead of breaking avoidance. Here, the warm extension confuses between the glasslike and lustrous stages makes numerous little breaks structure on cooling. Spread of many such breaks a little distance, rather than a solitary defect proliferating an enormous distance, in the parent glass, retains impressive energy without generous loss of solidarity, and prompts hardening. A comparable system has been proposed for canasite glass-ceramics.

Seals and Coatings

Glass-artistic materials are currently acknowledged choices for electronic seals and binds, in metals joining and defensive coatings. Comparative with their smooth rivalry, glass-pottery offer the benefit of expanded use temperature, a more extensive scope of warm development coefficients, (counting different non-straight extension practices) worked on synthetic solidness, and higher sturdiness. By and large the cycles utilize glass frits which are intended to solidify during arrangement of the seal or covering, yet later complete progression of the frit has happened. Most glass-ceramics utilized for these objects are silicate based however various phosphate frameworks have been produced for fixing to high development/low liquefying metals like aluminum and copper. Wilder et al. framed Pt catalyzed phosphate glass-earthenware production in the Na_2O- $CaO-P_2O_5$ and Na_2O-$BaO-P_2O_5$ frameworks, with the essential accentuation on acquiring materials with adequately high warm developments to match Al, and with fixing and crystallization temperatures lower than the softening place of

Al (660°C). Durability esteems were ordinarily 20-30% higher than the comparing glasses. The greater part of the glass-earthenware production, with developments sufficiently high to be utilized with Al, were peripheral in their compound toughness. The issue is by all accounts that the structures of the lingering glass stages are dissolvable, so the issue might have the option to be tackled by prudent decision of the parent glass arrangement. A few creations with OK extensions, durability and handling temperatures were appropriate for Cu and treated steel applications.

Porous Materials

The glass-earthenware course to valuable permeable constructions has as of late gotten significant consideration and a few novel non-silicates have been developed. Glasses in the Li_2O-CaO-TiO_2-Al_2O_3-P_2O_5 framework can be solidified by controlled nucleation and development to shape a glass-earthenware with B-$Ca_3(PO_4)_2$ and $Li_{1+x}T_{2-x}Al_x$ $(PO_4)_3$ strong arrangement. These glass-ceramics would then be able to be drained in HCl answers for eliminate any lingering glass and the B-$Ca_3(PO_4)_2$ leaving a permeable design of glasslike $Li_{1+x}T_{2-x}Al_x(PO_4)_3$ along with $Ti(OH)PO_4$. The $Ti(OH)PO_4$ comes about because of filtering of the Li during the disintegration step. Treatment of the permeable material by inundation in 7M $LiNO_3$ essentially to some extent reestablishes the lost Li. The electrical conductivity of the mass glass-artistic just as the filtered, permeable material is significant degrees more noteworthy than the relating guardian glass and is in the reach that makes the materials of interest as terminal materials for Li quick particle leading frameworks like batteries. The permeable idea of the drained glass artistic makes them intrigue for various different applications, including. Moistness sensors, particle trade layers and supports for immobilization of compounds in bioreactors.

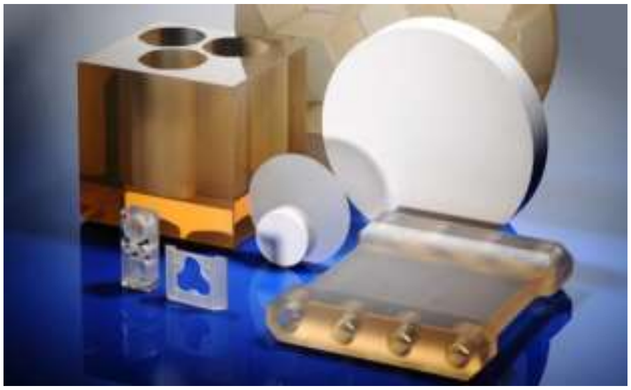
Other permeable glass-ceramics have been shaped by an interaction wherein the crystallization some of the time happens later leaching. Here, sodium borate glasses with Ta_2O_5 ,HfO_2 ,CeO_2, and additionally La_2O_3 are first framed as a glass, then, at that point, heat treated to foster interconnected polished stages like those in the Vycor type permeable borosilicate.

One of the stages (borate rich) is solvent and corrosive draining prompts a material with interconnected pores. Resulting heat-treatment at higher. Temperatures prompt improvement of translucent stages. Pore volumes in the scope of 0.03-0.5 ml/g. surface regions somewhere in the range of 10 and 150 m^2/g and pore radii from 1.5-4.0 nm are conceivable. Chemical opposition and temperature steadiness can be better than business permeable glasses.

Low Expansion Glass-Ceramics

An enormous number of glass-ceramics with glasslike stages which are isostructural with

$NaZr_2(PO_4)_3$ have been accounted for by Aitken2. These materials have the overall recipe $X_{0-4}Y_2(ZO_4)_3$ where X is a mono or divalent particle, Y is an octahedrally organized tri-, tetra-, or pentavalent cation and Z is a tetrahedrally planned cation. Blends of cations are likewise utilized. In this manner, Y might be a mix of Fe^{3+}, Ti, Al and additionally Nb and X might be a blend of Na, K, Zn, Mn, Fe^{2+}, Cd, and so on A portion of the subsequent materials have high ionic conductivities, while others have low or even bad warm extension coefficients, which prompts high warm shock opposition and dimensional strength.



A few syntheses were found to have a close to no extension north of 25-200°C.

Other low extension glass-earthenware production (a_{25-300} = 6 to 23 x 10^{-7}°C^{-1}) have been accounted for in the twofold Ca, Sr, and Ba-aluminoborate frameworks . Also, a portion of the materials have magnificent hardness, crack durability (>2.0 MPa.$m^{0.5}$) and qualities. A significant issue with these materials is that the extension coefficients are exceptionally temperature reliant, expanding quickly above around 200°C. While the substance solidness isn't quite as high as soft drink lime silicate glasses (1.0 versus 0.01x10^{-6} g/cm^2/min at 95°C in water.) it could be adequate for some applications. The creators pin the helpless toughness on the lingering glass stage, which might have the option to be improved by reasonable decision of the beginning structure.

Miscellaneous Non-silicates

The craving to frame ceaseless fibers of artistic superconductors has prompted the examination of the glass-ceramics process for creation of such shapes.

Non-Oxide Glass-Ceramics

Chalcogenide Glass-Ceramics

Chalcogenide glasses, those dependent on mixtures of S, Se and Te, are of interest for various applications.

Initial interest started in the 1950's when As_2S_3 was utilized as an infrared window/focal point. A few multicomponent infrared sending arrangements were created in the 1960's and 70's. Extra interest in these materials started from the disclosure of electrical exchanging and memory impacts.

Infrared Windows

Beginning interest in chalcogenide glass-pottery came about because of a longing to build the upper use temperature of the optical parts and to work on the mechanical properties.

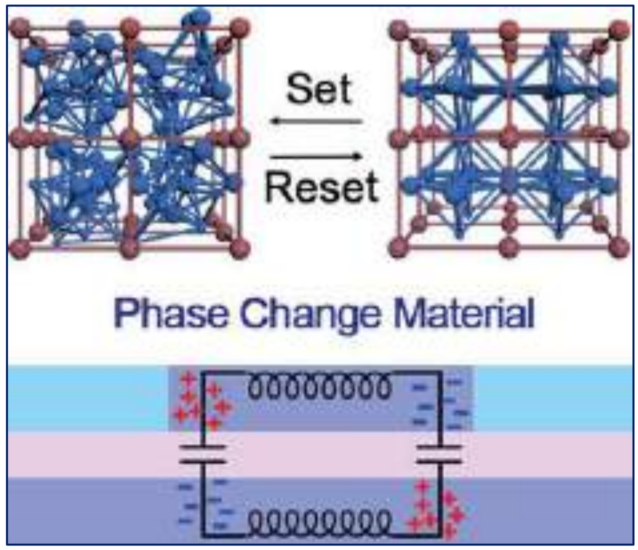
The soonest report of such a review is that of Mecholsky et al. PbSe augmentations to a Ge-As-Se sythesis advances stage division, which in this manner prompts crystallization of PbSe, $PbSe_2$, and $GeSe_2$. While the mechanical properties, for example, hardness, strength, and sturdiness and Tg were expanded, the necessary infrared transmission diminished in the significant 3-12 mm locale, apparently because of dispersing from the connection points delivered by crystallization. Tilloca and Zarzycki concentrated on a comparable framework however with CdSe as the nucleant. A few frameworks somewhat solidified without diminishing transmission in the 8-10 mm locale. Boehm and Assaf performed comparative examinations in the Ge-As-S and The Ge-Se-Te framework. Diminished transmission was likewise seen here however the decrease was genuinely uniform over the full range, proposing that assimilation changes, potentially because of free electrons, was usable. Long crystallization times prompted dissipating misfortunes.

By and large, chalcogenide glass-pottery has not demonstrated helpful because of the helpless transmission. Potential enhancements may be acknowledged by fitting the lingering smooth stage to such an extent that there is a nearby match of the refractive records of the different stages. This has been cultivated in some oxide glasses, yet it's anything but a minor undertaking in the chalcogenides.

Electrical Properties

A fascinating component of chalcogenides is the sensational distinction between the electronic conductivities of the glass and relating glasslike stage. It isn't remarkable for the distinction to be a few significant degrees. This reality prompts fascinating electrical conduct of some chalcogenide framework. Dey and LaCourse have created glass earthenware production in which the current differs in a non-straight style with the voltage. The conduct is like that seeing in ZnO varistors, despite the fact that it isn't certain that the component is something similar. The glass-ceramics can be shaped in the As-Sb-Se framework. Mass nucleation is catalyzed by stage partition of Sb_2Se_3 rich drops. Both Sb_2Se_3 (conductive) and now and then AsSe, take shape leaving a Se rich lustrous stage. (protecting) The current-voltage qualities of the subsequent material are displayed in Figure 2. As noticed, the basic voltage increments and the extent of the current increment diminishes with diminishing Sb content, predictable with a more modest glasslike content. The current increment is in excess of 6 significant degrees for the most elevated Sb content. While these outcomes are fascinating no extra reports of the electrical properties of comparable chalcogenide glass-ceramics have been distributed and it isn't known whether comparative practices can be created in different frameworks.

Optically Induced Phase Changes



Extra instances of novel material by controlled crystallization of chalcogenides are the business "phase change" optical recollections. These gadgets depend on the capacity of some chalcogenides to be reversibly exchanged between the translucent and nebulous states by utilization of laser energy. The reflectivity of the translucent and nebulous areas is unique, so it is feasible to recognize these districts optically. Accordingly, the frameworks have "read", "write" and "erase" capacities. It may likewise be referenced that the substance draw paces of translucent and undefined areas are distinctive, so it is additionally conceivable to deliver high goal photoresists.

Conclusion

Glass-ceramic handling of non-silicate frameworks offers new freedoms for creating materials with novel and valuable properties.

High ionic conductivity permeable materials have been framed in the phosphate frameworks. Arranged microstructures with profoundly strange mechanical properties have been shaped from twofold calcium phosphates. Chalcogenide glass-earthenware production with novel electrical practices has additionally been created.

These improvements have come regardless of a generally short history, and low degree of exploration. Almost certainly, extra significant advances will be made throughout the following quite a long while.

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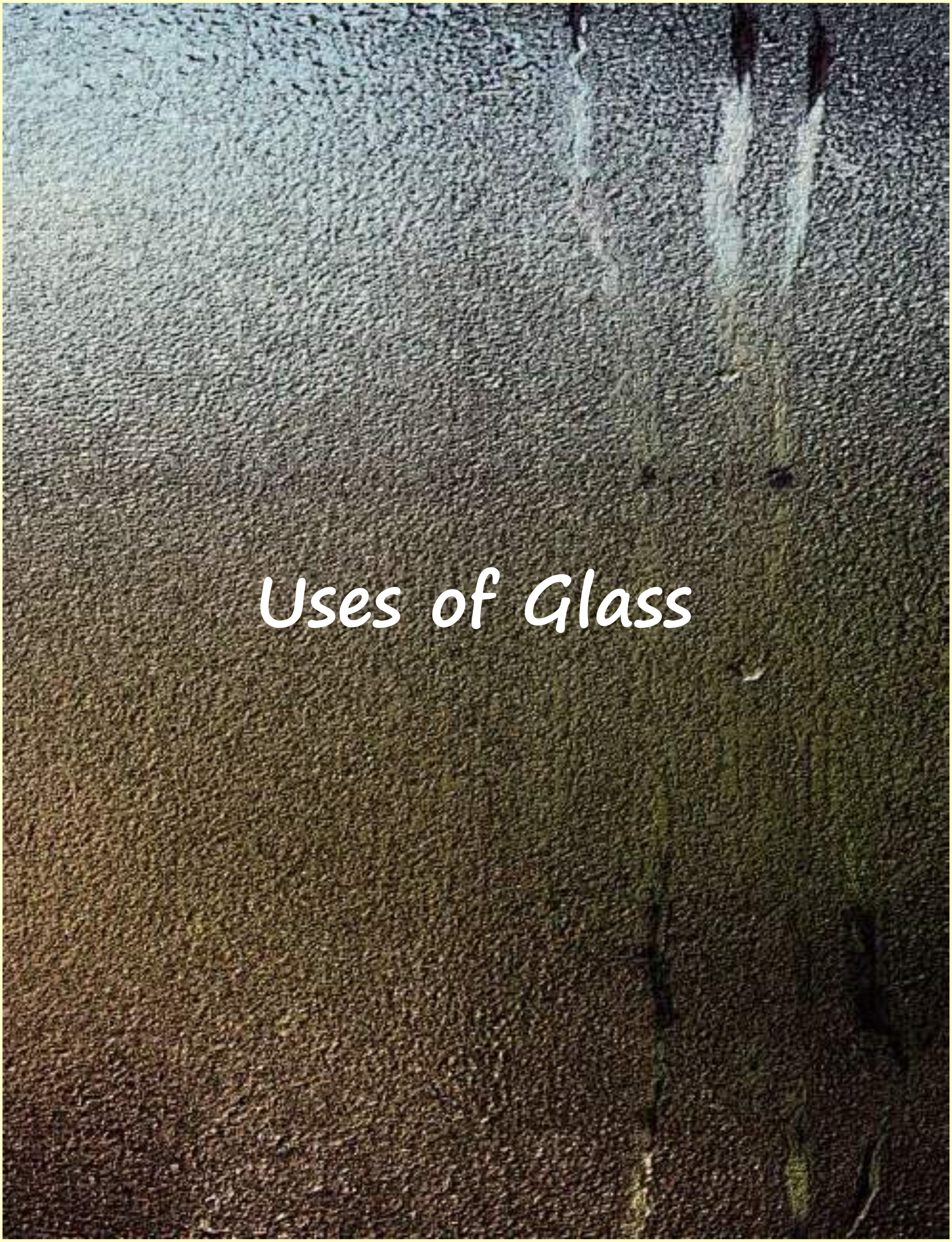

Uses of Glass

GLASS AS AN ARCHITECTURAL MATERIAL

Prince Saha
Semester V

Glass is one among the oldest man-made materials used. The exact period of invention is unknown however the oldest glass is found nearly 7000 B.C ago. Egyptians were the first used the glasses before 3000 B.C for decorative purposes as a colored glaze, pottery, and beads but Romans were the first to use the glass as windows. From the 17th century lead glass made major step for windows preparation in buildings like exhibition halls, railway stations and other public places. Until 1851 glass was considered as luxury goods which gradually diminished during industrial revolution. At that time iron and steel were also running parallel with glass which made advancements in metal framing technology, thus making an important part in modern architecture.

Crystal palace 1851

In 1851 construction of crystal palace by Paxton in London transformed the opaqueness of architecture’s traditional buildings by creating transparency through glass. To use the daylight as the only source of light was major objective for this crystal palace. To calm the intense sunlight and glare created by this transparent glasses, translucent screens of calico were hung externally in-between the ridge beams of the roof glazing and the cover the entire surface of the highly exposed horizontal section of the roof. The transparent wall arrived with Paxton’s Crystal palace and was carried forward as glass curtain wall experiment in 1864 in Oriel Chambers, Liverpool by Peter Ellis where glazing walls and iron frame used to maximize light and minimize solid wall.

Oriel Chambers, Liverpool 1864

Properties of Glass

Transparency

Transparency is the main property of glass which allows the light to enter through it prevent the use of electricity 24/7. Transparency of glass either can be of one side or both sides. Here one side transparency in glass behaves like a mirror.

Strength

Glass's strength depends on its young's modulus value. Though glass is brittle material but by adding admixture and laminates its strength can be improved

Recyclability

Any glass can be fully recyclable and can be used in any construction industries.

Types of Architectural Glass

Various types of glass used in the constructions for different purpose. Since the 1950s during the development of float glass three most attractive traits has been focused: the ability to transmit light, block heat and safety issues. These significant advances starting from the introduction of uncoated spectrally selective glass to the rise of multi-cavity insulating glass units has improved the quality of glass. Safety issues have a high importance on glass applications, because of potential life safety hazard to eco-life and us. Now, majority of new windows, curtain walls and skylights for commercial building construction have insulating glazing for energy efficiency and comfort. Architectural glasses mainly have three different strength categories.

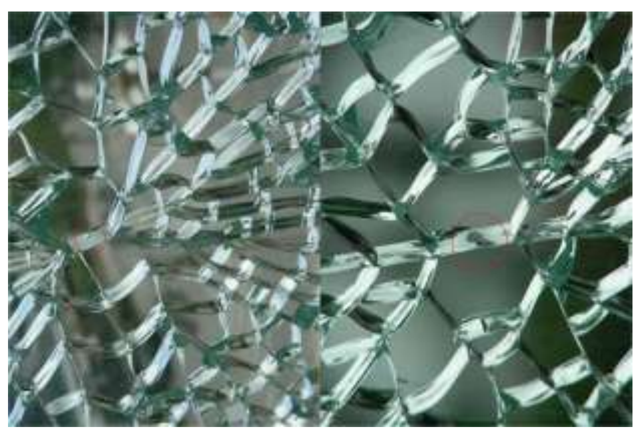
Annealed Glass

Most commonly used architectural glass. It has good surface flatness because it's not heattreated and does not distortion during glass tempering.

On the contrary, annealed glass breaks into sharp, dangerous shards. Heat-strengthened and fully tempered glass are thermally treated glass products, heated and quenched in such how to make residual surface compression within the glass. The surface compression gives the glass generally higher resistance to breakage than annealed glass.

Heat-Strengthened Glass

It has at least twice the strength and resistance to breakage from wind loads or thermal stresses comparing to annealed glass.



The necessary heat treatment generally leads to some distortion compared to annealed glass.

Like annealed glass, heat-strengthened glass can break into large pieces.

Fully Tempered Glass

It has four times the strength of annealed glass, which gives it superior resistance to glass breakage. It is float or sheet glass that has been heated and rapidly cooled, increasing its inherent strength and ductility.

Similar to heat-strengthened glass, the heat-treatment generally leads to some distortion. Fully tempered glass breaks into many small fragments, which makes it suitable as safety glazing under certain conditions. It is used for windows that are exposed to higher wind pressure or extreme heat or cold.

Float Glass

They are made from sodium silicate and calcium silicate, because if it they are also called soda-lime glass. . When molten glass is poured onto a molten tin bath. The glass floats on the tin, and levels out because it spread along the surface of container giving a smooth face to each side. It is clean and flat, so it causes glare. This glass thickness is 2mm to 20mm, and its weight range from 6 to 36kg/m^2. Floats glasses are used in shop fronts, public places.

Laminated Glass

It involves combination of layers of transparent sheet of polymer, such as polyvinyl butryal, between two or more layers of flat glass using an adhesive.

It is used as safety glazing and as overhead glazing in skylights. It is a long-lasting and versatile glass with plastic interlayer which provides protection from ultraviolet rays and gives laminated glass good acoustical characteristics.

Extra Clear Glass

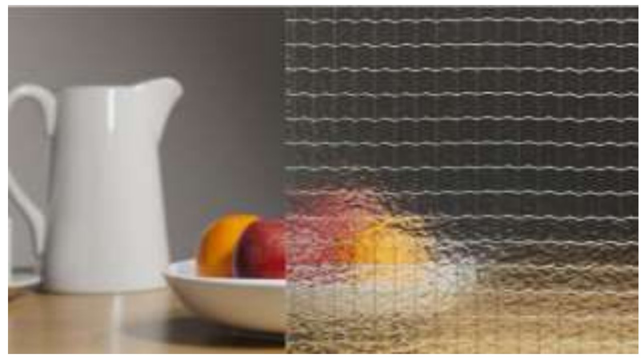
Extra clear glass has two unique properties, photolytic and hydrophilic. It acts as attain proof.

Tinted Glass

It is coloured glass. A Colour producing ingredients is mixed to the normal glass which does not affect other properties of glass such as iron oxide (green), Sulphur (blue), manganese dioxide (black), cobalt (blue), chromium (dark green), titanium (yellowish brown), uranium (yellow).

Wire Glass

It involves steel wires rolled into sheets of glass. A wire network is inserted during the manufacturing of sheet glass, allowing the glass to stick together when cracked.



Glass Wool

It is made of fibers of glass and acts as an insulating filler. It is fire-resistant glass.

Insulating Glass

It consists of two or more layers of glass separated by a hermetically sealed space for thermal insulation and condensation control.

The airspace between the glass layers can be filled during the manufacturing process with either dry air or a low-conductivity gas, such as sulfur hexafluoride or argon.

The thermal performance of double-glazed or triple-glazed windows can be further improved by the addition of double-glazed or triple-glazed windows can be further improved by the addition of a low-emissivity coating on one or all of the layers of glass. The air space also reduces heat gain and loss, as well as sound transmission, which gives the insulating glass superior thermal performance and acoustical characteristics compared to single glazing. Most commercial windows, curtain walls, and skylights contain insulating glass

Self-Cleaning Glass

It uses titanium dioxide coatings as a catalyst to break up organic deposits.

It requires direct sunlight to sustain the chemical reaction and rainwater to wash off the residue.

Chromatic Glass

It controls the transparent efficiency of glass and prevents daylight from entering inside. The chromatic glass may be photochromic which has light sensitive lamination, thermochromic which has heat sensitive lamination and electrochromic which has electric lamination over it.

There are three different types of chromatic glass

Photochromic Glass

Organic photochromic dyes produce self-shading glass.

Originally developed for sunglasses, these coatings are self-adjusting to ambient light and reduce visible light transmission through the glass.

They provide a more evenly (in terms of time) distributed illumination of interior space regardless of exterior variations and they are typically used to provide shading.

Electrochromic Glass

It uses electricity to adjust the shading and light visibility. Upon switching off the power, they retain the same degree of dimming.

Thermochromic Glass

It enables to regulate daylight, automatically adapting dynamically to the continuously changing climatic conditions, aids in reducing the energy needs of a building and providing thermal comfort. Here electrical power is not required. The polymeric interlayer is doped with complexes of transition metals, which change their coordination and transmission or color of the film under influence of light and heat.in winter they are favorable for regulating the interior temperature.

GLASS USE IN ART: ART GLASS AND STUDIO GLASS MOVEMENT

Srijita Bhowmik
Semester V

In the mid twentieth century, most glass creation occurred in manufacturing plants. Indeed, even individual glassblowers making their own customized plans would take care of their responsibilities in those enormous common structures. The possibility of "art glass", little enlivening works made of workmanship, frequently with plans or items inside, prospered. Pieces delivered in little creation runs, for example, the lamp work figures of Stanislav Brychta, are by and large called workmanship glass.

By the 1970s, there were great plans for more modest heaters, and in the United States, this led to the "studio glass" development of glassblowers who blew their glass outside of industrial facilities, regularly in their own studios. This agreed with a move towards more modest creation runs of specific styles. This development spread to different regions of the planet also.

Glass Panels

Joining a significant number of the above methods yet zeroing in on craftsmanship addressed in the glass rather than its shape, glass boards or dividers can arrive at colossal sizes. These might be introduced as dividers or on top of dividers or swung from a roof.

Enormous boards can be found as a component of outside establishment pieces or for inside use. Committed lighting is frequently essential for the work of art. Strategies utilized incorporate stained glass, cutting (wheel cutting, etching, or corrosive carving), frosting, plating, and overlaying (counting Angel plating). A craftsman might consolidate procedures through covering or silk-screening. Glass boards or dividers may likewise be supplemented by running water or dynamic lights.

Glass Paperweights

The soonest glass craftsmanship paperweights were created as utilitarian items during the 1800s in Europe.

Current specialists have raised the specialty to artistic work. Glass craftsmanship paperweights can consolidate a few glass methods however the most widely recognized procedures found are millefiori and lamp work—the two strategies that had been around well before the coming of paperweights. In paperweights, the millefiori or sculptural lamp work components are epitomized in clear strong precious stone making a totally strong sculptural structure. During the twentieth century there was a resurgence of interest in paperweight making and a few craftsmen tried to relearn the art. In the US, Charles Kaziun began in 1940 to create buttons, paperweights, inkwells, and different jugs, utilizing lamp work of exquisite effortlessness.

In Scotland, the spearheading work of Paul Ysart from the 1930s forward went before another age of specialists like William Manson, Peter McDougall, Peter Holmes, and John Deacons.

A further impulse to resuscitating interest in paperweights was the distribution of Evangiline Bergstrom's book, Old Glass Paperweights, the first of another classification. Glass boards Glass paperweights Imperfect for You, weaved glass via Carol Milne Kiln-framed glass form "Joined Earth" by Tomasz Urbanowicz various little studios showed up in the centre twentieth century, especially in the US. These might have a few to somewhere in the range of many specialists with different degrees of expertise coordinating to create their own particular "line". Outstanding models are Lundberg Studios, Orient and Flume, Correia Art Glass, St.Clair, Lotton, and Parabelle Glass. Starting in the last part of the 1960s and mid-70s, craftsmen like Francis Whittemore, Paul Stankard, Jim D'Onofrio, Chris Buzzini, DelmDebbie Tarsitano, Victor Trabucco, Gordon Smith, Rick Ayotte and his little girl Melissa, the dad and child group of Bob and Ray Banford, and Ken Rosenfeld started kicking off something new and had the option to create fine paperweights matching anything delivered in the exemplary period.

Glass fashion

Jewellery

The first employments of glass were in quite a while and other little bits of gems and enhancement. Dabs and adornments are still among the most widely recognized employments of glass in craftsmanship and can be worked without a heater.

It later became in vogue to wear practical adornments with glass components, for example, pocket watches and monocles.

Wearables and Couture

Beginning in the late twentieth century, glass couture alludes to the formation of restrictive custom-fitted dress produced using etched glass. These are specially made for the body of the wearer. They are mostly or totally made of glass with outrageous consideration regarding fit and adaptability. The outcome is generally sensitive, and not planned for ordinary use.

GLASS USE IN LABORATORY

Arghadeep Sarkar
Semester V

Glass is an inorganic solid material whose lustre and transparency serves variety of applications in construction of buildings, tableware, art, laboratories, telecommunications, etc. It is a supercooled liquid which resembles a solid due to the great increase in its viscosity when it is cooled rapidly. It is composed of several substances like silica, bleaching powder, oxides of alkaline metals, calcium oxide (lime) etc. and is obtained by fusing these materials in their molten states and then rapidly cooling. The history of manufacture of glasses is as old as 3500 BC and is known to have been first made in Egypt. It is believed that glass was formed by a natural process where it is formed on cooling of molten magma from the entrails of the earth. It is an important component of several products that are used in our day to day to life, most often without noticing it.

Application of Glass in laboratories

Glass is an essential material used for manufacturing several laboratory equipment because it can be obtained in various shapes and sizes by blowing, bending, or cutting. Glassware in the form of beakers, petri dishes, vials, burettes, and cylinders are mainly found in the laboratories. The relative inertness and considerable heat resistance of glass enables it to make space for nearly every type of reactions within glass container. Also, the transparency in glass helps to monitor the reactions easily. There are many types of glasses such as borosilicate, quartz or fritted glasses that are used in manufacture of laboratory glassware. Although in present times glass vessels are substituted for more durable, affordable, and less breakable plastic materials, there are yet some substances and experiments or applications still require the use of glassware.

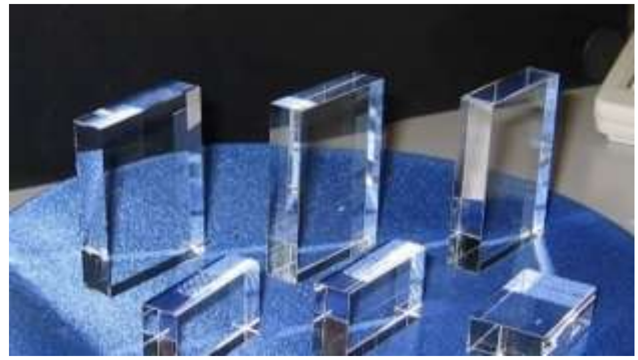
Borosilicate glass

This is one of the most common and affordable form of glass found in laboratories essentially used in test tubes, flasks, beakers etc.

It has a very low coefficient of expansion which makes it an ideal substance for the preparation of apparatus in which volume measurements are carried out. It offers high resistance to chemical attacks. However, this glass material is not inert to some substances that mainly includes Hydrofluoric acid (even at mild concentrations it affects the glass material), Strong Caustic solution and Phosphoric acid (It affects the glass material at higher ranges of temperature).

Quartz glass

This kind of glass is obtained by melting silica grains either by gas or electrical heating at temperature around 2000˚C. It supports experiments of wide temperature ranges and can withstand heat up to about 15000˚C. Silica glass is chemically pure, and no reaction takes place between the glass material and the reagent it holds. This material is used in manufacturing different types of laboratory-equipment including joints, tubes, flasks, beakers, cuvettes, and crucibles. It has extremely low coefficient of thermal expansion and that is why it is used for the manufacture of volumetric measuring apparatus to give proper results. It is also inert to chemical attacks. The apparatus made from quartz glass are employed in lab processes such as spectrophotometry, chromatography, and distillation.



This glass enables passage of broad range of light wavelengths which makes it useful for experiments involving infrared and UV radiation. This form of glass is more expensive than the others.

Actinic Glass

This type of glass does not allow UV light to pass through them.

The apparatus made with this glass material has a reflective or absorbing material that is coated or laminated to the surface or in between layers of the glass which makes it highly sensitive to light although inert to chemicals. It is thereby used to store light-sensitive chemicals that may undergo alternation from infrared radiation, visible light, or ultraviolet radiation. The glass material has tinted dark brown or amber colour. Amber glass is generally used for light sensitive applications. Tinted glass is used in manufacturing bottles that contain chemicals in solution or powder form.

Soda Lime Glass

This form of glass is brittle and has a low melting point. It does not have a high thermal shock resistance. It is easily available which make it the cheapest glass material.

Hence, it is used in manufacturing the most common lab equipment such as pipettes, measuring cylinders, disposable test tubes and volumetric flasks which are used for volumetric glassware that does not require heating.

Different Types of Laboratory Glassware

Some most common laboratory glassware are:

Beakers: These are used to contain samples and reagents.

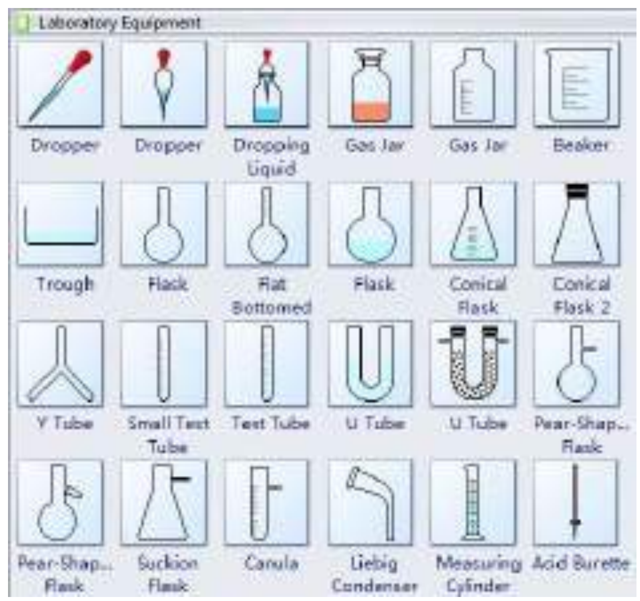
Funnels: These allow easy pouring of a liquid through a narrow passage.

Burettes: These are used to transport exact quantities of liquid into another vessel.

Pipettes: These are used to transfer specific amounts of fluids from one place to another.

Volumetric Flasks: These are like beakers and are also used to hold samples. These flasks are available in different shapes with a tapering neck.

Graduated Cylinders: These cylindrical vessels are like beakers and have volumetric markings on them for monitoring volume.



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APPLICATION OF GLASS IN OPTICS

Supriya Mondal
Semester V

Glass is a ubiquitous material in optics by virtue of its ability to reflect, refract and transmit light. In the present time we can use glass in different ways.

Eyesight Correction

The firs wearable eyeglasses were invented around 1284 in Italy. It is thought that Salvino D' Armate was inventor. Using eyeglass, we solved many eyes related problems.

Concave glass is used to correct nearsightedness(myopia), so that the rays of light are diverged. Convex lenses are used to aid the correction of farsightedness (hyperopia), so that the light rays are converged. Sunglasses as we know them today was invented in 1929 by Sam Foster. various types of colored glasses for protecting the eyes from glare and from injurious amounts of ultraviolet, luminous, and infrared radiant energy. A number of few glasses have been developed during the past decade for use in new and old industries to prepare protective glasses for use in industrial operations where the workers operate or are in close proximity with furnaces, cutting and welding apparatus, etc. that emit injurious amounts of ultraviolet, luminous, or infrared radiant energy.

Telescope

Telescopes that use lenses are called refracting telescopes. The other type uses mirrors to focus the light of the image. These telescopes are called reflecting telescopes. Refracting telescopes use lenses to bend the light to a specific focal point such that the object will be magnified to the viewer we use lenses to gather more amount of light than the human eye could collect on its own.

The Reflecting Telescope or Reflector uses a concave mirror to collect and focus the light on the eyepiece. Mirrors are lighter than lenses and they are also easier to shape into a smooth and perfect surface. If there are any flaws in a telescope's optics, then the image created will appear warped or out-of-focus and blurry.

Microscope

Microscopeuse mirrors and lenses are used to to reflect and refract light and form images. The light microscope and telescope use convex lenses and mirrors to make enlarged images of very tiny or distant objects. Concave mirror or plane concave mirror are used in microscope.

The combination of lenses and mirrors used in making the microscope helps in obtaining magnified and sharp image of the objects.

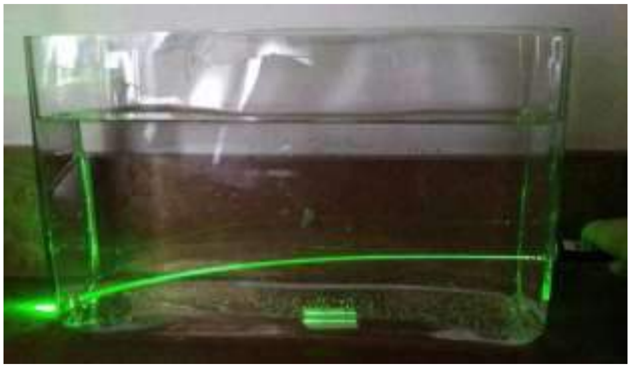
Fiberoptics

Fiber optics are simple strands of flexible glass as thin as human hair that is used for communications. These strands carry digital signals in form of light rays. Glass optical fibers have higher information transmission capacity with lower loss. They are ideal in corrosive environments or extreme temperatures. Glass optical fibers are almost always made from silica.

If you use silica glass for the core, it must be high purity in order to allow the light to be transmitted along the core with minimal loss.

Gradient-Index Optics

Depending on the chemical composition of the glass, different wavelengths of light, both visible and invisible, can be absorbed, transmitted, or refracted to achieve the desirable optical effect for a given application. The two most common types of optical glass are flint glass and crown glass. The rate of change of refractive index with respect to distance in a material, i.e., the slope of the refractive-index profile at any point. The way a Gradient Index (GRIN) lens works may be explained best by considering a conventional lens.



An incoming light ray is first refracted when it enters the shaped lens surface because of the abrupt change of the refractive index from air to the homogeneous material.

Laser diode

Glass lasers are commonly used in extremely high power, high energy multiple beam systems for inertial confinement fusion.

Generally, these lasers are frequency tripled to the third harmonic at 351 nm in laser fusion devices. Some of the other applications of Nd: glass lasers include: Optical communication. Laser diodes are the most common type of lasers produced, with a wide range of uses that include fiber optic communications, barcode readers, laser-pointers, CD/DVD/Blu-ray-disc reading and recording, laser printing, laser scanning and light beam illumination.

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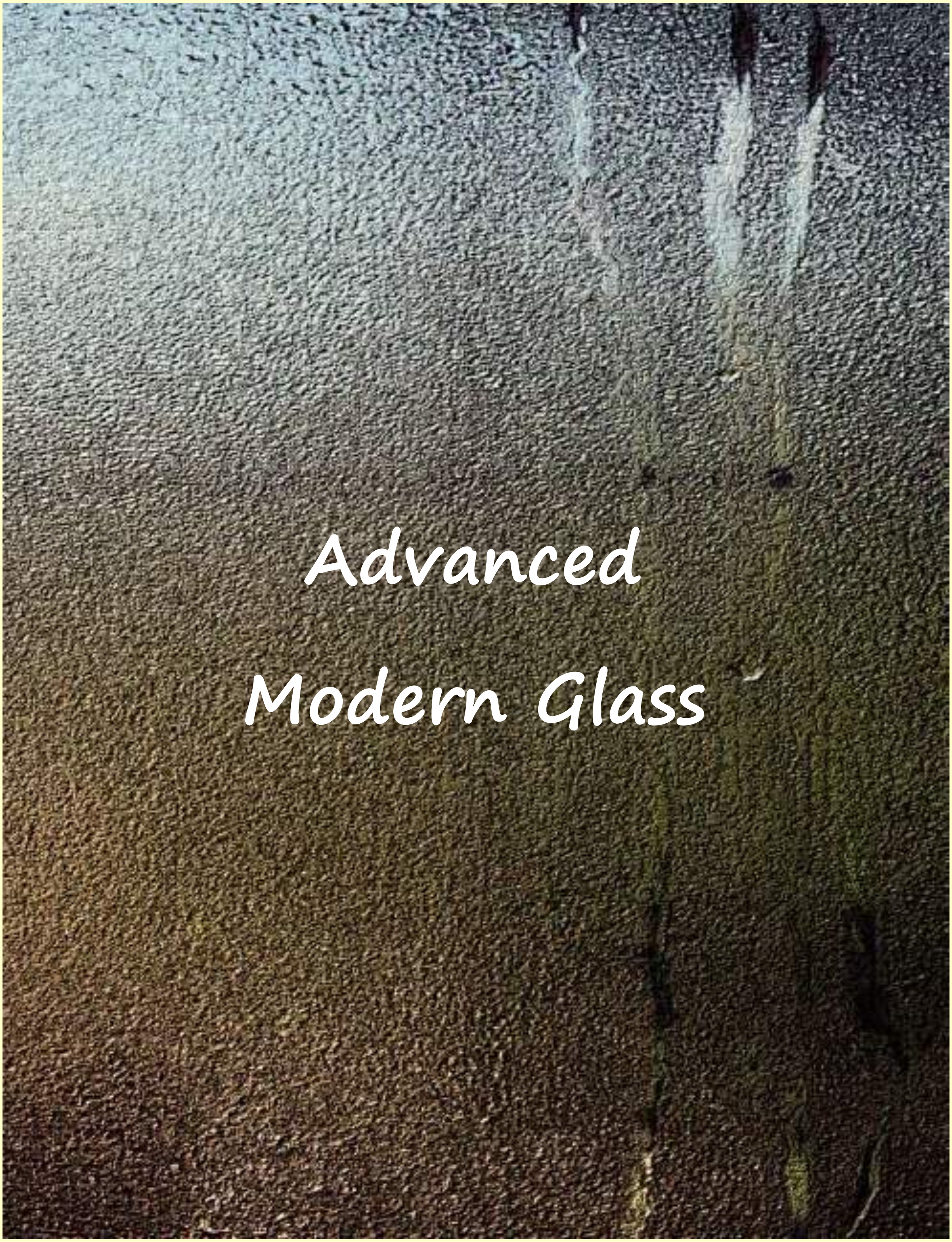
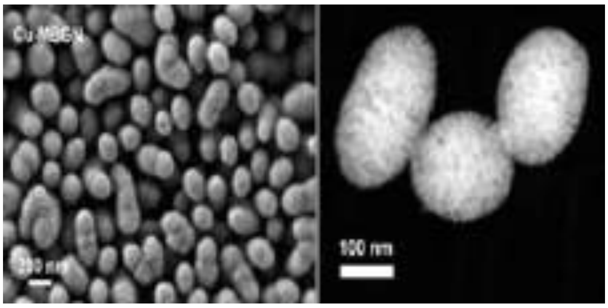

Advanced
Modern Glass

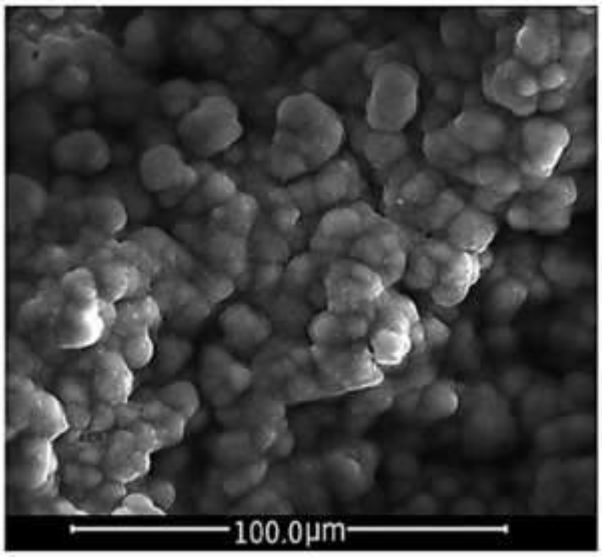
ADVANCED MODERN GLASS: II BIOACTIVE GLASS

Shobhondeb Giri
Semester III
Dr. Noor Salam
Faculty

Metallic glass nanoparticles (MGNs) with a small size and high surface-volume ratio are relatively easy to be synthesized by traditional powder metallurgy and sputtering and have attracted increasing attention for applications in additive manufacturing, composite reinforcement, catalysis, and biomedicine.

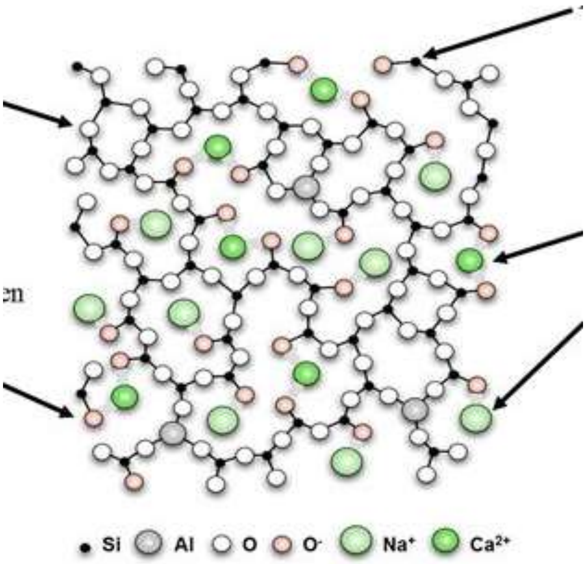


In these applications, nanoparticle coarsening is essential in the sintering kinetics and structural and functional retention. Moreover, bioactive glasses are promising materials for tissue engineering due to their controlled degradability and capability to stimulate new tissue formation. It's especially attractive for orthopaedic for orthopaedic and dental applications. In this regard, one of the major ambitions of today's biomaterials science is to obtain porous scaffolds able to effectively drive self-regeneration of tissues. In this regard, it is very important to take into consideration the hierarchical porosity found in Nature.



Upon mimicking hierarchically pore-structured natural materials, the resulting 3D scaffolds could perform a similar role. In the design of bioactive glasses, and biomaterials in general, it is therefore necessary to identify the biological environment that they will find and/or replace once implanted, as scaffolds are needed to support cells in tissue engineering applications.

When a bioactive glass is implanted, it dissolves gradually, and the ions released promote the growth of a carbonated hydroxyapatite layer at its surface. It has a low connectivity of the SiO_2 network.



The presence of network is modified like sodium and calcium, leading to the formation of non-bridging (Si-O) bonds. So, the surface Na and Ca cations are first exchanged with H^+ from the biological fluid and creating Si-OH bond. If present initially, phosphate ions can also be released. Due to increase pH, Si-OH bonds are more formed through the hydrolysis of Si-O-Si bonds, and they have re-polymerized. Moreover, the migration of Ca^{2+} and PO_4^{3-} ions to the surface follows, inducing the formation of an amorphous calcium phosphate layer, which then crystallizes into biomimetic hydroxyapatite the incorporation of hydroxide and carbonate ions from the biological fluid. It will also be dependent on its morphology because bioactivity is directly related to the glass dissolution rate.

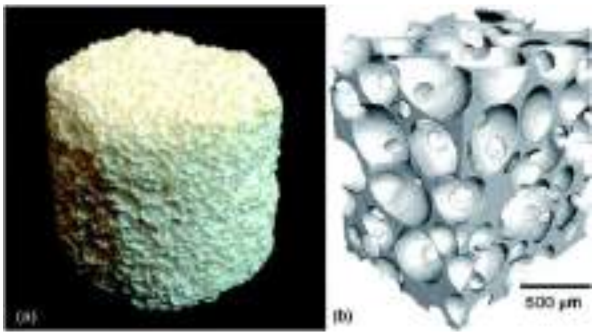
Bioactive nanoparticles can be dispersed in a polymer scaffold, used to create a bioactive coating on implants, dispersed or even to be directly injected. If well controlled and oriented, this could be very interesting for also drug delivery and cancer treatment. Therefore, bioactive glass nanoparticles mainly have been synthesized by melting or sol-gel route. So, sol-gel glass scaffolds can be considered the precursors of hierarchically structured macro/mesoporous glass scaffold. However, although sol-gel glass foams exhibit pores at both macro- and nanoscale, their mesoporous texture is arranged randomly instead of being ordered according to a well-defined symmetry since it is inherent to the sol-gel process.

Composition and Properties

Bioactive glass nanoparticles with a nominal composition of 45% SiO_2, 24.5% Na_2O, 24.5% CaO and 6% P_2O_5 and has been prepared through a conventional high temperature melting process, i.e., through the melting of oxides mixed at more than 1300°C followed by a quenching step. This temperature quenching allowed the formation of 20–80 nm amorphous particles. It has also been confirmed for SiO_2-CaO-(Na_2O)-P_2O_5 bioactive glasses (the role of Na_2O being to reduce the glass fusion temperature. Sol-gel-derived particles present a pore volume and a specific surface area two orders of magnitude higher than the melt-derived ones. This makes them highly attractive in the biomaterial fields because bioactivity is linked to the specific surface area of the materials.

Production: Sol-Gel Strategy

To produce bioactive glass sol-gel nanoparticles, groups have modified the classical Stöber process to introduce Calcium ion and sometimes PO_4^{3-} ions into the silica network. Obviously, it is also possible through a specific step to obtain nanoparticles from a silica monolith, but the particles are neither homogeneous in size nor in shape. Common precursors for calcium nor phosphorous are respectively Ca $(NO_3)_2$ and Et_3PO_4 or $(NH_4)_2HPO_4$. From investigating the literature, two trends emerge.



1. The first one involves the synthesis of silica nanoparticles followed by Ca^{2+} and PO_4^{3-} absorption onto their surface.

2. The second one introduces calcium and phosphate ions along with the silica precursor prior to increase the pH to form the particles.

(i) (TEOS/Ca^{2+}/PO_4^{3-}) acidic mixture is sometimes added to an ammonia solution.

(ii) and sometimes concentrated NH_4OH is dropped inside the (TEOS/Ca^{2+}/PO_4^{3-}) acidic mixture.

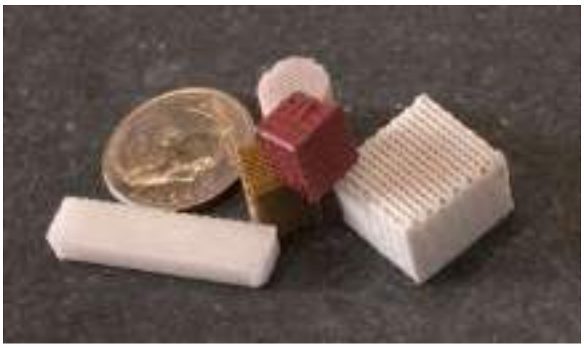
Phosphate-based glasses belong to the group of unique materials owing to their fully controllable bioresorbable nature and easy doping with a wide variety of ions. In recent years, various glasses have been developed with chemical compositions like the mineral phase of bone making. Phosphate-based glasses are promising candidates for the development of implantable biomaterials for repair and regeneration of hard tissues. Like silicate and phosphate-based glasses, calcium phosphates (CaP) based ceramics also exhibit natural components found in the human body. A few selected biotherapeutic ions that can be released from CaP glasses thereby playing a key role in bone repair and regeneration.

Conclusion

Bioactive glasses have been traditionally used in the clinical practice to fill and restore osseous defects due to their unique ability to bond to host bone and stimulate new bone growth. A broad range of bioactive glass nanoparticles-based materials have been presented on their biomedical advantages compared to bulk or micro-sized-based materials.

Most of their advantages lie in their superior specific surface area, leading to higher dissolution rate and thus faster apatite formation and ions/drugs release.

The sol–gel derived porous bioactive glasses have drawn worldwide attention by virtue of the convenience and flexibility of this versatile synthesis method. The different types of sol–gel derived bioactive glasses namely silica, phosphate, and silica–titania-based glasses along with organic–inorganic hybrids materials have drawn worldwide attention which presents future research perspectives.



ADVANCED MODERN GLASS: I SMART GLASS

Moumita Sadhukhan
Sonu Kumar
Surajit Sannigrahi
Semester III

What is smart Glass?

Smart Glass or switchable glass also called smart windows in those applications is a glass or glazing whose light transmission properties are altered when voltage, light or heat is applied. It is dynamic, allowing a traditionally static material to become alive and Multifunctional. This technology allows for the control of various forms of lights (UV, IR, and visible light). In general, the glass changes from transparent to translucent and vice versa, changing from letting light pass through to blocking some wavelength of light and vice versa. The technology can be integrated into windows, partitions, and other transparent surfaces in various sectors including architecture and interior design.

The term smart glass mainly refers to active technologies in which privacy glass films and coating, activated by an electrical charge, change the appearance and functionality of the glass. There are two types of primary smart glasses:

1. Active Switchable Smart Glass

Polymer Dispersed Liquid Crystal (PDCL): Seen in privacy partitions in various industries.

Suspended Particle Device (SPD): A glass used for windows that tint to shade as seen in automotive and buildings.

Electrochromic Glass: Coated windows for slow shedding.

2. Passive Switchable Smart Glass

Photochromic Glass: Eyeglasses with coating that automatically tint in sunlight.

Thermochromic Glass: A coated windows that changes in response to temperature.

PRODUCTION OF SMART GLASS

Manufacturing Process

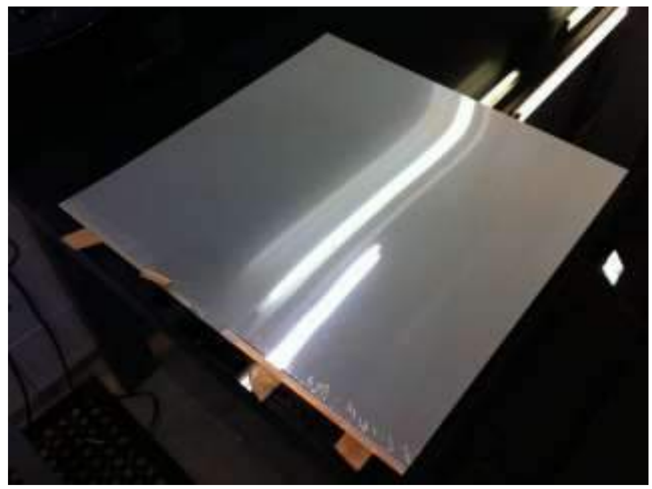
On demand of various products of smart glasses there are different manufacturing processes to create them. In absence of electric current, the natural state of the film is frosted. The liquid crystals in the PDLC are naturally arranged in a way that blocks out a lot of the light that would pass through it. When light is switched on where we can see that almost all the light is able to permeate through the films as the product presents. Smart Glass technology comes in two main forms:

Standard PDLC Technology

It is a technology that can adjust light transmission through the application of **AC** power sources. The active components are in switchable films (Polymer Dispersed Liquid Crystal) consist of liquid crystal microdroplets which are suspended in polymer. The nature state of the film sees the PDCL molecules arranged in a way that causes light waves to refract through and reflect away from the surface, distorting the state of the glass to present as frosted when an electric current is passed through the PDLC layer the liquid crystal molecules polarise allowing light to pass through. Standard PDLC technology is composed of multiple layers to create this incredible product. The outer layer is an optically clear protective coating of a polyethylene terephthalate (PET) film. Glasses made by this technology are of the following forms:

Switchable Glass/Film

It is designed for application to glass or plexiglass and recent years have given rise to the development of numerous switchable products that make most out of the substance being used. One of the most common uses of PDLC films in production of switchable glass.



Switchable Laminated Glass

Laminated safety glass ideal for high traffic areas, bathrooms, and hospitals. The switchable layer is fully encased between the two pieces of glass.

Toughened Switchable Glass

The switchable optical layer is factory coated using UV light to any thickness of glass. Ideally suited for projection application.

Switchable Double-Glazing Glass

Energy efficient double-glazed units with integral switchable films layer. Ideal for both external and internal windows.

Next Generation PDLC Technology

Designated specifically to retrofit existing transparent surfaces like glass or plexiglass. Self-Adhesive Switchable film prepared by intelligent glass provides a simple and cost-effective modern way in Smart Glass Production.

In absence of electric current, the natural state of the film gets frosted. The liquid crystals present in the PDLC are naturally arranged in a way that blocks out a lot of light that would pass through it. However, when light is switched on, almost all the light become able to permeate through the films and the glass becomes transparent.

USES OF SMART GLASS

Usually, smart glasses focus to provide life mentoring services as well as creating a platform for handling more authentic photos and video clips. Over the past few years, the market for smart glass has been growing slowly because of the rising demand for energy efficiency, light and heat control, privacy, automated shading, and design innovation. Smart glasses are called electronically switchable glass, which opens an classification of possibilities for architects and interior designers upper concern make it perfect for places like restaurants , bars and business counter. Here, we have listed some common application of this smart glass technology.

(a) Windows and Doors: The capability of controlling the amount of light and solitude makes smart glasses an ideal choice for Windows and skylights. It permits one to enjoy clear view or privacy as per the required of the person.

(b) Hotels and Restaurants: Hotels universally use this smart glass technology for taking privacy screen between guest bedrooms and bathrooms, external doors and windows, toilets, shower cubicles etc.

Smart glass from top glass manufactures help hoteliers design their interiors better and thus offer a luxurious experience to their customers.

(c) Hospital Interiors: Privacy is the prime importance in places like hospitals. Hospital provider often use switchable glass for areas like patient's rooms , testing laboratories, operation theaters, external doors, and windows. It not only makes sure privacy of patients but also allows the hospital staff to safely review the wall being of patients.

Smart glass is suitable not only for classic installation but also for indoor installation for the real, affective zoning of the officer or leaving room. Switchable glass will significantly reduce the heat loss of the room and significantly reduce the cost of lightning or air conditioning.

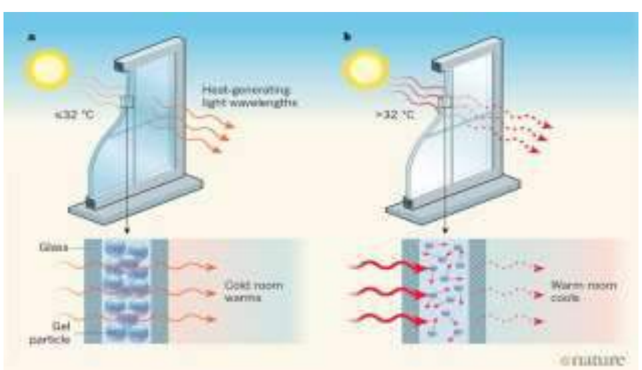
In addition, smart glass serves as an excellent alternative to mechanical screens, shaded screens, or blinds. In a transparent state, electrochemical or liquid crystal smart glass will not emit ultraviolet ray. But smart glass will need special extra coating to block ultraviolet radiation on suspended particles.

ADVANTAGES OF SMART GLASS

Recently we are seeing more demand for our Switchable Smart Glass than ever. As one of the world's leading manufacturers of Smart Glass technology, we come across some incredible applications of our products that leave even us impressed. The advantages of using these glasses are:

a) Control of Light and Temperature

Smart windows can dynamically change the tinting of glass to control the amount of heat and light that's enters a building. As a result, it will help to keep buildings cool during the summer and warm during the winter. Around 4% of all energy consumed in the United States is used to cool or warm buildings to compensate for heat transfer through windows, according to the US department of energy.



b) Future potential

The current use of smart glasses is convincing more and more forward-thinking businesses to hop on board. Although the widespread public usage is still pending, smart glasses have found valuable areas to operate, develop, and grow. So helpful that it is not surprising to hear that tech giants like Apple, Facebook, and Samsung are working on their AR-powered smart glasses.

c) Privacy

It preserves your privacy by protecting you from looks from the outside. Smart glass windows can transform an entire building or structure, by offering us the much-needed privacy that we want and need. This is made possible by using the liquid crystal technology that allows the privacy glass to go from clear to transparent in a matter of seconds.

d) Protect UV Rays

It blocks harmful UV Rays by tinting windows to create a shaded space or allowing light in when it is transparent.

This also help protect our paintings and other furniture in our home and/or office.

e) Projection Screen

Smart glass can be used as a very good projection screen. This expands the possibilities for creating an exclusive, individual design of the room. Perfectly suited for use in conjunction with video projectors designed to watch movies on a separate screen.

f) Ease of Use and Maintenance

Smart glass or switchable glass once it is installed, they are requiring almost no maintenance and it is very easy to use.


Future of
Glass

Glass & Its future

From previous discussion it is clear that glass is everywhere and meets various societal needs. Almost no other man-made material provides so many possibilities across so many industries and disciplines.

It

- Is preferred for serving food and beverages
- Plays important role in transportation
- Is a key element in architecture & buildings
- Is a part of renewable energy strategy
- Is crucial in modern communications
- Has many pharmaceutical, health and science applications.

Some areas of further Research and Development for the future of glass:

Special coatings for buildings: Smart mirrors and highly insulating glass windows for photosensitive, switchable, or electrochromic glazing. **Anti-reflection properties and technologies for clean energy generation.**

Strength: If glass of any type were available at 50 times its current strength, new products and opportunities could emerge in the marketplace, like ultra-thin and light container glass and lighter flat glass and fibreglass for composites. Some applications already render glass stronger by 2 to 6 times

Functional integration in glass that can then become an ideal substrate for OLED lighting, touch screens, audio-visual displays, etc. **and also, bendable glass, scratch resistance, audio glass, thinner glass and much more.**

To further increase glass properties, fundamental research is required, on the structure of the glass surface, the chemical reactions on its sites and how these reactive sites interact with molecules. Hard science and breakthrough in our understanding of the glass substance are needed. Though it requires substantial investments, but positive research outcome could open unlimited opportunities.

The future of glass could translate in unlimited opportunities

The outcome of research in all different fields could open tremendous opportunities for the development of future glass products and the way we currently use glass in various applications. Just imagine:

Smart glass bottles and containers whose colour changes depending on the liquid temperature (medicines, wines, perishable products, etc.)

Interactive drinking glass

Photovoltaic sunroof to provide electricity to hybrid and electric vehicles

LED light sources in jewellery

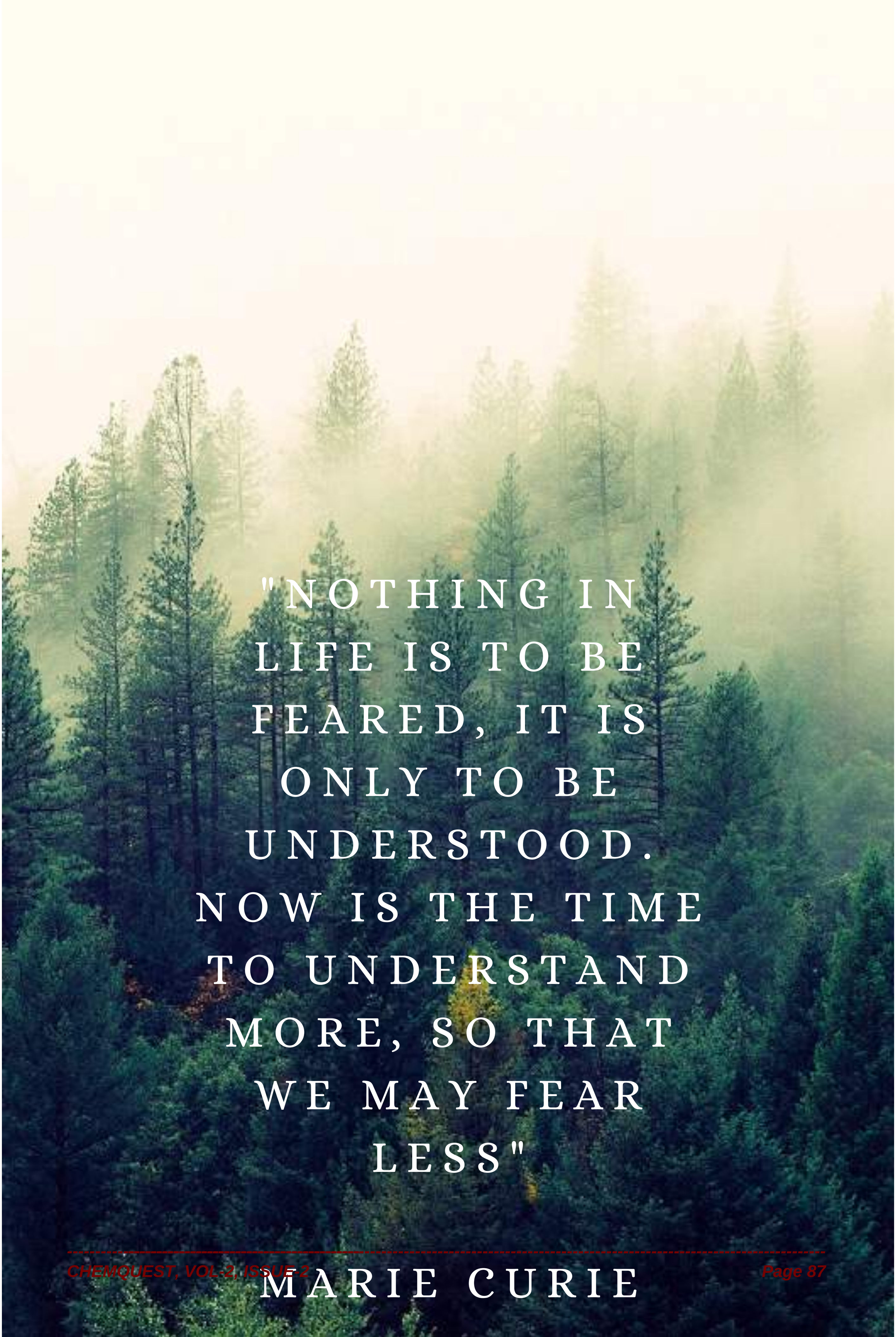
Mirrors assessing the health condition of the person standing in front of it

Jewellery assessing the cardiac rhythm and body temperature

More **complex glass shapes and further improved insulation** properties to free architects from constraints

Smaller and best performing **photovoltaic and wind energy electricity generation equipment** whose integration would become easier to fulfil most of world's energy needs.

So, glass does altogether have a really promising future.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MARIE CURIE