International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

Analyzation of Calcium Carbonate ($CaCO_3$) in Eggshells and their Applications

[1]Mr. Suraj Kolekar, [2]Mr. Saurabh Deshmukh, [3]Mr. Vandan Hiwale, [4]Mrs. Aastha Dutta

[1,2,3]Student, Department of Plastics and Polymer Engineering, Maharashtra Institute of Technology, Aurangabad, India

[4]Faculty, Department of Plastics and Polymer Engineering, Maharashtra Institute of Technology, Aurangabad, India

***Abstract* - This paper explores the detailed study of calcium carbonate ($CaCO_3$) and its different origins such as naturally derived calcium carbonate ($CaCO_3$), calcium carbonate ($CaCO_3$) obtained from different eggshells and their various extraction methods. In this work, attempt has been made to add the eggshell powder as filler to various polymer matrix and applications of eggshells in various sectors. A growing effort has emerged to use bio-fillers as a replacement for synthetic once in an attempt to reduce cost. Recently, eggshell filler (ESF) has raised tremendous attention in polymer industry due to its high calcium carbonate ($CaCO_3$) content, which shows a great potential to substitute conventional mineral filler like talk, calcium carbonate and china clay. Percentage of calcium carbonate content varies from different types of eggs. Hybrid hen eggshell can be utilized as it contains 95% by weight of calcium carbonate ($CaCO_3$) and 5% by weight of organic materials. Eggshell filler can be used as an alternative for commercial grade calcium carbonate filler. Also the various uses of eggshells in nutrition and medicine and it can be used for different purposes that minimize their effect on environmental pollution.**

Keywords: Eggshell, Calcium carbonate ($CaCO_3$), Eggshell filler, Fourier transform infrared spectroscopy.

I. INTRODUCTION

A study of calcium carbonate gives significant lessons about the history of the earth, since chalk, limestone and marble trace their origin to shallow water. Calcium carbonate appears as a white, odorless powder which is partially insoluble in water but will readily soluble in acid.

Calcium carbonate is a chemical compound with the formula $CaCO_3$. It is a common substance found in rocks as the minerals calcite and aragonite. Calcium carbonate is also occurred in the main component of pearls, shells of marine organisms, snails, and eggs also it is extracted by mining or quarrying. On other hand, calcium dioxide is also a source of calcium carbonate. Firstly calcium water is passed to produce calcium hydroxide then carbon dioxide is passed through the solution to precipitate the desired calcium carbonate. [2]

$$CaO + H_2O \rightarrow Ca(OH)_2$$

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$$

Calcium carbonate is mainly classified in two types, first one is precipitated calcium carbonate (PCC) which has very fine controlled particle size hence it is useful in production of paper and the second one is ground calcium carbonate (GCC), it is powdery form material which is produced from lime stones and mostly used in different pharmaceutical and industrial applications. [1]Many of us come across calcium carbonate for the first time in the school classroom, where we use blackboard chalk. Chalk is a fine, microcrystalline material. The composition of eggshell is very similar to our bones and teeth. It is also helpful for a recovery of bones. It is mainly used for industrial purposes like in polymer industries $CaCO_3$ is used as filler for many polymers.

1.1 Structure

The thermodynamically stable form of $CaCO_3$ under normal condition is hexagonal β-$CaCO_3$ (the mineral calcite). The other forms are orthorhombic λ-$CaCO_3$ occur the mineral aragonite which can be form by precipitation at temperatures above 85°C and hexagonal μ-$CaCO_3$, occurring as the mineral vaterite which can be form by precipitation at 60°C. [3]

1.2 Different sources of calcium carbonate

1.2.1 Geological sources

Aragonite, Calcite and Vaterite those are the pure calcium carbonate minerals. Industrially important source are rocks which are primarily calcium carbonate include limestone, marble, travertine, and chalk.

1.2.2 Biological sources

Eggshells, seashells and snail shells are mainly biological source of calcium carbonate and it also be used as industrial sources of that chemical. [4] Oyster shells have recently recognition as a source of dietary calcium, but are also a practical industrial source.[5] A green vegetables such as kale and broccoli contain dietarily significant amounts of calcium carbonate but they are not practical as an industrial source.[6]

© 2017-2020 IRJIET All Rights Reserved

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

1.2.3 Extraterrestrial

Apart from earth there is strong evidence suggests the presence of calcium carbonate on mars. [7, 8]

Figure 1: Calcium Carbonate

II. EGGSHELLS

2.1 Different origins of eggshells

2.1.1 Worm eggs

Nematode eggs have a three-layered structure: an external vitelline layer, a chitin layer that confers mechanical resistance and an internal Lipid-rich layer that makes an egg chamber impermeable. [9]

2.1.2 Insect eggs

Insects and other arthropods lay a large variety of styles and shapes of eggs. Some of them have soft shells which contain proteins and others have harder shell. Eggs which are survived in dry conditions usually have a hard shell, consist dehydrated or mineralized proteins with more pore system to allow respiration. The extensive ornamentation occurs in arthropod.

2.1.3 Fish, amphibian and reptile eggs

Fish and amphibians generally lay eggs which are surrounded by the extra embryonic membranes but they do not develop a shell around membrane. There are some fish and amphibian eggs have thick, leathery coats. The eggs of fish, amphibian and reptile are small in size also they are very fragile.

2.1.4 Mammal eggs

Monotremes lay soft-shelled eggs which are similar to reptile eggs. In the uterus the shell is deposited on the egg. The egg can take up fluids and growing in size during this process.

2.1.5 Bird's eggs

There are various types of eggshells were studied such as swift, hen, forest pigeon, lap wing etc. and their calcium content. Eggshells contain calcium, magnesium and small trace amount of other microelements. The major component of eggshell is calcium carbonate $CaCO_3$, the analysis of $CaCO_3$ done by volumetrically by using a characteristic reaction of carbonate compounds, namely their reaction with acids. [10]

According to the experimental analysis of eggshell samples, the swift eggshells contain lowest value of $CaCO_3$ content (% of $CaCO_3$ was 68.06) and lap wing eggshell contains highest value of $CaCO_3$ (% of $CaCO_3$ was 96.46). The calcium content in hybrid hen is greater than calcium content in local hen. Sometimes the calcium level is depending on birds' habits. Eggshell powder has been reported to increase bone mineral density in people and animals with osteoporosis, it is also used as fertilizers for plants to neutralize pH level of overly acidic soil. Sometimes in the hen calcium deficiency during the breeding period results in poor eggshell formation and even to egg binding. [10]

Table 1: Weight and percentage of $CaCO_3$ present in different bird's eggshell samples.[10]

Egg samples Hybrid	Weight of CaCO3 in grams	The % of CaCO3 in Eggshell
Hybrid hen	0.4764	95.28 %
Local hen	0.4	80 %
Domestic Pigeon	0.4344	87 %
Forest Pigeon	0.4554	91 %
Swift	0.3403	68.06 %
Lap wing	0.4823	96.46

2.2 Anatomy of an egg

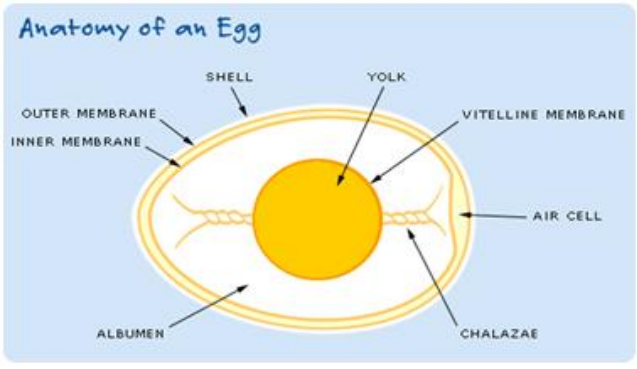

Figure 2: Anatomy of an egg

© 2017-2020 IRJIET All Rights Reserved

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

Shell

Texture with little bumps and grainy, this shell is covered with as many as 1600-1700 tiny pores. Eggshell is completely made up of calcium carbonate ($CaCo_3$) crystals, from its pores the air and the moisture can be pass because of its semi permeable membrane. Shell also has a thin outermost coating called cuticle or bloom and this shell helps tom keep out bacteria and dust.

Inner and Outer Membranes

These are two layers of membrane outer membrane is attached to egg shell and inner membrane is to albumen membranes are strong and contains keratin protein.

Air Cell

Inner membrane is warm firstly when it cools, the contents contract and both membranes get separated from each other and air cells forms.

Albumen

Albumen is the white part in the Egg, this white is clear liquid and contain albumin proteins.

Chalazae

Chalazae helps to suspend the yolk in the center of white, it Opaque ropes of egg white, they attach the yolk's casing to the membrane lining the eggshell.

Vitelline Membrane

It also called as Vitelline envelops which covers the yolk, its works like casing of yolk.

Yolk

Yolk is more proteinous than white, and as well as yolk has contained less water also. Yolk is the yellow internal part of egg having rich in protein, fats and vitamins. The yolk contains iron, phosphorus, calcium, thiamine, riboflavin and vitamins like vitamins A & vitamins D. the yellow color of yolk can varies according to the feed and breed of birds.

III. IDENTIFICATION OF PRESENCE OF CALCIUM CARBONATE

3.1 Fourier Transform Infrared Spectroscopy (FTIR)

Fourier transform infrared spectroscopy (FTIR) is a powerful tool for identifying the types of chemical bonds in organic and inorganic molecule by producing an infrared absorption spectrum that is like a molecular "fingerprint". It can be utilized to identify the components of an unknown mixture. FTIR is widely use for determination and analysis of polymer structures.

3.1.1 Principles of FTIR Spectrophotometry

FTIR relies on the fact that the most molecules absorb light in the infrared region of the electromagnetic spectrum. This absorption corresponds specifically to the bonds present in the molecule. The frequency range is measured as wave numbers typically over the range 4000 – 600 cm-1.

The background emission spectrum of the IR source is first recorded, followed by the emission spectrum of the IR source with the sample in place. The ratio of the sample spectrum to the background spectrum is directly related to the sample's absorption spectrum. The resultant absorption spectrum from the bond natural vibration frequencies indicates the presence of various chemical bonds and functional groups present in the sample. FTIR is particularly useful for identification of organic molecular groups and compounds due to the range of functional groups, side chains and cross-links involved, all of which will have characteristic vibrational frequencies in the infrared range.

3.1.2 Instrumentation

Fourier transform infrared spectroscope consists of a moving mirror, a fixed mirror and a beam splitter. Radiation from the infrared source is collimated by a mirror and the resultant beam is divided at the beam splitter, half of the beam is passes to a fixed mirror and half of the beam reflected to a moving mirror.

A liquid nitrogen cooled MCT detector enhances the sustainability of the instrument. After reflection, the both beams are combines at the beam splitter and for any particular wavelength, constructively or destructively interfere, depending on the difference in optical paths between the two arms of the interferometer. With a constant mirror velocity, the intensity of the emerging radiation at any particular respective wavelength modulates in a regular sinusoidal manner. In the case of broadband source, the emerging beam is a complex mixture of modulation frequencies, which passing through the sample compartment.

This detector signal is sampled at precise intervals during the mirror scan. Both the sampling rate and the mirror velocity are controlled by a reference signal incident upon a detector which is produced by the modulation of beam from a helium-neon laser.

© 2017-2020 IRJIET All Rights Reserved

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

3.1.3 FTIR result of hen eggshell

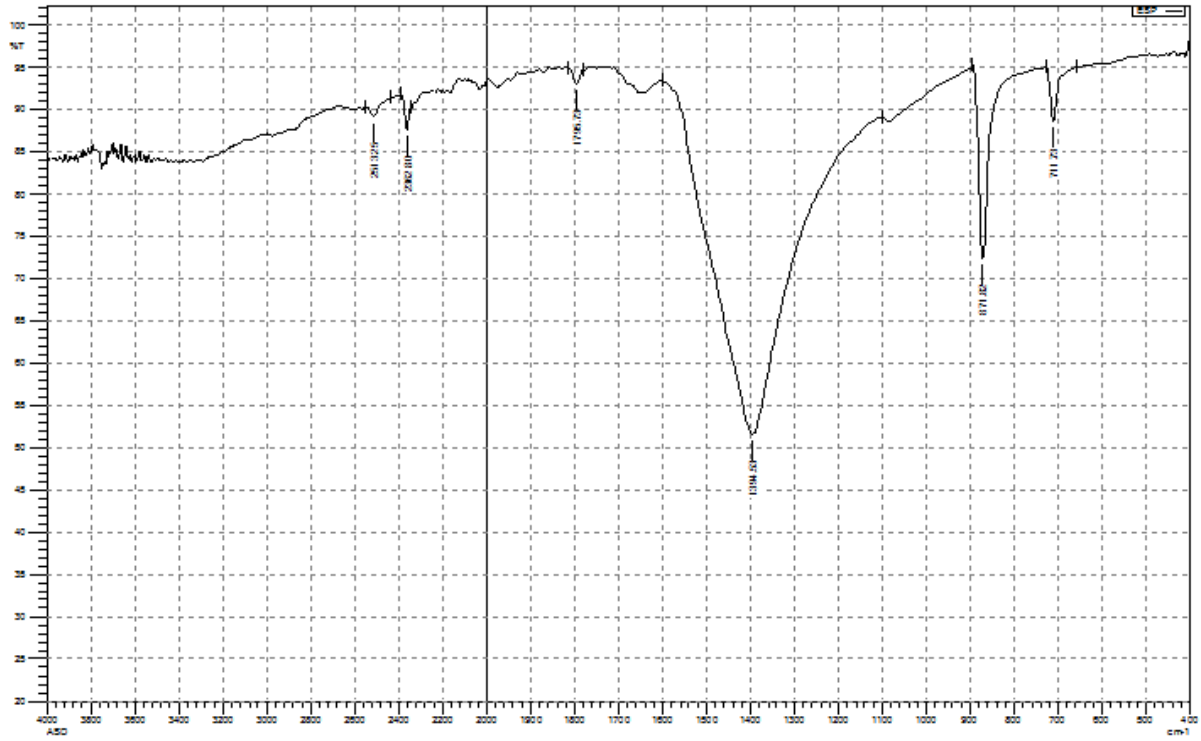

Figure 3: FTIR result of hen eggshell

Table 2: Result of hen eggshell

No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	711.73	88.62	6.44	727.16	657.73	466.215	123.418
2	871.82	72.46	22.92	894.97	727.16	1501.222	702.809
3	1394.53	51.62	40.03	1600.92	1101.35	12261.13	7905.241
4	1795.73	93.04	1.83	1815.02	1780.3	206.997	29.361
5	2362.8	87.61	3.32	2391.73	2347.37	448.705	56.271
6	2513.25	89.24	1.46	2549.89	2434.17	1114.462	64.043

According to above table, the bands at frequency 711.73 cm^{-1}, 871.82 cm^{-1}, 1394.53 cm^{-1}, 1795.73 cm^{-1}, 2362.8 cm^{-1} and 2513.25 cm^{-1} represents the characterization bands of eggshell filler. The band at 1394.53 cm^{-1}, 871.82 cm^{-1} and 711.73 cm^{-1} represents CO_3^{2-} vibration which shows the occurrence of carbonate group.

3.2 Identification of $CaCO_3$ by chemical reaction

In Analytical chemistry, we call it qualitative inorganic analysis which helps to find the elemental composition of inorganic compounds. It is mainly focused on detecting ions in an aqueous solution, therefore material in other forms may need to be bought to this state before using standard methods. The solution is then treated with various reagents to test for reactions characteristic of certain ions, which may cause color change, precipitation and other visible changes. [11]

The chicken eggshell contains 95-97 % CaCO3 that means, we can ignore the presence of another cation.

© 2017-2020 IRJIET All Rights Reserved

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

i. Dissolve the eggshell with HCL. (We use HCL, because chloride salt is lighter than Nitrate salt that means it is more volatile than other salt and chlorine atoms do not emit energy in the visible region)

$$CaCO_3(s) + 2HCL\ (aq) \rightarrow CaCl_2\ (aq) + CO_2\ (g) + H_2O\ (I)$$

ii. Use platinum string or Ni-Cr string (platinum is better than Ni-Cr, but very expensive), clean the string with HCL 4M to make sure that the string doesn't contain another cation.

iii. Put the string on the $CaCl_2$ solution that you have dissolved.

iv. Burn the string with Bunsen burner on low flame.

v. You can identify the Ca_2+ cation by see the color of the flame, the flame will appear the orange-red light.

For Carbonate ion

You can identify the carbonate ion with any string acid; the CO_2 will appear from the shell

$$CaCO_3(s) + 2HCL\ (aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(I)$$

You can identify the CO_2 with baryta-water or Ba (OH_2) solution in glass rod; it will appear white precipitation on the rod. [11]

IV. METHODOLOGY

Method 1

i. In this process first clean the eggshells properly with the help of water.
ii. The eggshells were thermally treated at temperature of 700˚C for 1-3 hrs.
iii. Eggshells were grounded in grinder and then converted into a powder form.
iv. The powder was sieved to get the fine powder filler particles.

Method 2

i. In this method the eggshell filler was extracted by means of chemical reaction.
ii. Chicken eggshells were treated with sodium chloride (NaCl) solution for removing the layer of membrane from inner wall of shell.
iii. Then the eggshells were placed in the oven.
iv. The eggshells were pulverized and then sieved to get a fine particle size.

Method 3

i. First the eggshells were introduced to the high air pressure at a room temperature.
ii. Then eggshells were pulverized to get a fine particle size or powder form.
iii. Because of the high-pressure air ultimately the inner membrane components were removed.
iv. Also, this process avoids the usage of high temperature and other harsh chemicals therefore there was no harm to eggshell composition and we get the original chemical formula.

Method 4

i. In this method firstly, the eggshells were gently washed by water.
ii. After that the eggshells were boiled in water for a specific time.
iii. When boiling was completed dry the eggshells at room temperature after that put it into the hot air oven at a temperature of 120-140˚C for 30 minutes to remove the moisture from it.
iv. After complete drying of eggshells, it was pulverized to get a powdered form.
v. Then they obtained powdered form eggshells were sieved to get a required particle size.

Method 5

i. Firstly, collect the eggshells then eggshells were stored in the iced water.
ii. After that the membrane of the eggshell was manually separate out from eggshells.
iii. Cleaning was done to remove the contaminations from eggshell.
iv. The eggshells were immersed in aqueous acetic acid (70%) for minimum 2 days to get dissolve.
v. Eggshells were rinsing with deionized water to reduce the acidity.
vi. After washing eggshells were put into the oven at a temperature of 50˚C for complete 2 days for removing moisture and drying purpose.
vii. After drying eggshells were grounded and then sieved to required particle size.

Method 6

i. In this method the eggshells were cleaned with water and left in open air at a room temperature for 24 hours.
ii. Then eggshells were put in chamber furnace for calcinations purpose at a temperature of nearly 800˚C for 3 hours.
iii. The eggshells were kept in furnace until the temperature is reached to room temperature.

© 2017-2020 IRJIET All Rights Reserved

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

iv. Then the eggshells were grounded by using a ball mill to reduce the particle size.
v. The powders were sieved as per required particle size.

V. EGGSHELL COMPOSITES

5.1 Composite of eggshell with high density polyethylene (HDPE)

In this study they designed composite of high-density polyethylene with calcinated eggshell powder. The commercial injection grade HDPE is used which has melt flow index (MFI) of 14gm/10min and a melting temperature (Tm) of 131˚C. The eggshell powder was calcinated at a temperature of 800˚C for 3 hours and then ground for 12 hours using ball mill. Calcinated eggshell powder was sieved with 230 and 325 mesh sieves. The eggshell/HDPE composite test specimen was prepared by using compression molding machine.

Result and observation: Here we observed that calcinated eggshell filler used as good functional filler for HDPE. As eggshell filler loading percentage increase in composite as compare to HDPE matrix is results increase in young's modulus and ultimate stress of the filled HDPE. The addition of filler was not significantly influenced the yield strength and decomposition temperature of the composite. As eggshell filler loading percentage decrease it decrease in tensile strength, modulus of elasticity, hardness (shore-D) and also increase in elongation at break and impact strength. [12]

5.2 Composite of eggshell with low density polyethylene (LDPE)

For this composite industrial grade low density polyethylene was used and the eggshells were obtained from local market. Firstly, the egg shells were washed, dried and ground to a powder using the blender. A sieve was used to obtain an average particle size of 63 µm. The egg shell powder was dried in a vacuum oven at 80oC until a constant weight was observed. The composites of LDPE-eggshell are prepared by using a Z-blade mixer or blender. While making a composite first charge LDPE in mixer when it getting melt at that time add eggshell filler, mixing is continued till homogeneous mixing is obtain.

Result and observation: In observation it is seen that tensile strength of composite and elongation at break decreases with increase in the eggshell filler loading. As a filler loading percentage increases in LDPE matrix it results increase in stiffening, hardening of composite, young's modulus and water absorption. [13]

5.3 Composite of eggshell with polyvinyl chloride (PVC)

For this composite PVC resin was used and the chicken eggshells were collected from local shop and canteen etc. The eggshell filler was prepared by the extraction of CaCO3 from eggshells METHOD 4 as mentioned above. The PVC-eggshell composite is prepared by using rheomix mixture at the temperature of 180 ˚C. The composite test specimen was made by using compression molding machine.

Results and observation: The result shows that as eggshell filler loading percentage increases tensile modulus increases and tensile strength, elongation at break decreases. The composite of 10% filler loading exhibits better strength and elongation at break as compare to composite having 40% filler loading. [14]

5.4 Composite of eggshell with polypropylene (PP)

For this composite the eggshell filler was prepared by using the extraction of CaCO3 from eggshells METHOD 3 as mentioned above and injection grade polypropylene was used. The eggshell/PP composite test specimen was prepared by using compression molding machine.

Result and observation: In PP-ESP composite it is observed that as the eggshell filler loading percentage increase the stabilization torque also increases. It shows higher tensile strength and thermal stability as compare to neat PP. Also, is shows higher stiffness due to decrease in segmental mobility and higher tensile modulus. As filler loading percentage increases the elongation at break decreases. [15]

5.5 Composite of eggshell with polylactic acid (PLA)

In this study PLA was dissolved in chloroform to make 10 %wt. solution and then add 1-5 %wt. eggshell filler in solution. The eggshell filler was prepared by the extraction of CaCO3 from eggshells METHOD 4 as mentioned above. The whole solution stirred with the mechanical stirrer. Now the film of PLA-eggshell composite is made by film casting process.

Result and observation: In the observation it is seen that tensile strength and modulus is increased with the filler content up to 4%wt. filler loading percentage. But after that loading %wt. both tensile strength and modulus will decrease gradually. The X-ray spectra graph of the composite shows that crystallinity of PLA-eggshell composite is increases with increasing eggshell filler loading percentage. [16]

© 2017-2020 IRJIET All Rights Reserved

ISSN (online): 2581-3048
Volume 4, Issue 8, pp 37-46, August-2020
https://doi.org/10.47001/IRJIET/2020.408007

5.6 Composite of eggshell with polyester

In this study polyester resin was used. The eggshell filler was load at different %wt. in polyester resin to make a composite. The eggshell filler was prepared by the extraction of CaCO3 from eggshells METHOD 4 as mentioned above.

Results and observation: As per observation the density of composite increase by increase in filler loading percentage. The tensile strength of composite increased up to 40 %wt. of filler loading but after that it decreases steadily. The compressive strength and hardness also increase as eggshell filler loading percentage increased. [17]

5.7 Composite of eggshell with epichlorohydrin

In this study they designed epichlorohydrin-eggshell filler composite by phase inversion method. The eggshell filler was prepared by the extraction of CaCO3 from eggshells METHOD 4 as mentioned above. The film test specimen is used. In observation it shows that tensile strength of the composite is increased by increase in eggshell filler loading percentage. [18]

5.8 Composite of eggshell with E-GLASS/EPOXY

In this study they designed a composite of E-glass/epoxy with eggshell filler. In this chicken eggshells were treated with sodium chloride solution to remove the layer of membrane on inner wall. Treated eggshells were dried, powdered, pulverized and sieved. Add eggshell filler in E-glass/epoxy at different loading percentages like 0%, 3% and 6% wt. by hand lay-up technique. [19]

Result and observation: It is observed that as eggshell filler loading percentage increases tensile strength decrease, however tensile modulus and impact strength increases. At 3%wt. filler in composite, tensile strength dropped by 15%. As the filler content is increased to 6%wt. tensile strength will further reduced by about 15%. On the other hand, tensile modulus increased by 24% and 8% for composite specimens with 3%wt. and 6%wt. filler content respectively. Reduction in tensile strength incorporation of fillers is mainly due to poor interfacial adhesion with the matrix. Adding a suitable coupling agent may improve the interaction between fillers and the epoxy resin resulting in a positive effect on tensile strength.[19]

VI. APPLICATIONS

Chicken eggshell are used in various application in order to reduce their effects on environmental pollution. It is almost certainly the natural source of Calcium. The ES usually employed in the form of powder. Chicken ES is inexpensive, abundant and good characteristic for many potential applications such as medical and cosmetic applications.

Chicken eggshells can be used as an alternative soil stabilizer like lime since they have the same chemical composition. Such stabilized soil can be used as subgrade materials in road construction works. Eggshell membrane consists of collagen as a component. [18]

Waste eggshells are unwanted unusable material are many times used as a plant fertilizer and are effective liming sources.[18] This is because eggshells contain calcium that raises, or neutralizes and maintain the pH level of overly acidic soil. Chicken eggshells can be used as an alternative soil stabilizer like lime because they have the same chemical composition and then that stabilized soil can be used as a base in road construction works. [18]

Eggshell membrane is primarily composed of fibrous proteins and it can be consisting of collagen as a component. Collagen is a type of protein, fibrous in nature that connects and supports other bodily tissues, such as skin, bone, tendons, muscles and cartilage. Collagen has been isolated mainly from bovine and swine skins and bones Collagen used in medicine, biochemical, pharmaceutical, food and cosmetic's industries. [19]

Used of this Eggshell membrane collagen is extremely low in autoimmune and allergic reactions as well as in bio-safety it can be highly use. [19] The waste water from the wet flue gas desulphurization the chicken eggshell is used as substitute of clay limestone in removal of heavy metals from waste water. [20] It can be used in paper industry as a filler as well as pigment for coating. It can also use in the food industry as a hardener and food dye. In the agriculture sector for the different types of fertilizers, in metallurgy as a flux in ladle desulphurization, in construction, chemical, cosmetic's and pharmaceuticals application its used. [21] In the agriculture sector for the different types of fertilizers, in metallurgy as a flux in ladle desulphurization, in construction, chemical, cosmetic's and pharmaceuticals application its used. [21]

For the lactose isomerization and the dimethyl carbonate synthesis and in the water treatment process eggshell used as a sorbent and after the great achievement of the successful use of eggshell as a biological sorbent it's important to characterize the feature such as particle size, shape and porosity. [22] In the variety of Nano technology applications eggshell membrane can be used as natural solid phase support for biomimetic chemical processing. Various core sizes metal nanoparticles are synthesis by using the eggshell membranes which have many applications for catalysis, medical imagine and optics. [18] Removing of Co2 and the immobilization of heavy metals in soil eggshell used. In the recent years the

© 2017-2020 IRJIET All Rights Reserved

ISSN (online): 2581-3048
Volume 4, Issue 8, pp 37-46, August-2020
https://doi.org/10.47001/IRJIET/2020.408007

research and studies has been done that eggshells can be also used as catalyst in the biodiesel production.

Waste eggshell in triglyceride Trans esterification with a view to determine its viability as a solid catalyst for use in biodiesel synthesis. Effect of calcination temperature on structure and activity of eggshell catalysts was investigated. Reusability of eggshell catalysts was also examined. It was found that high active, reusable solid catalyst was obtained by just calcining eggshell. Utilization of chicken eggshell as a catalyst for biodiesel production not only provides a cost-effective but also environmentally friendly way of recycling this solid eggshell waste, significantly reducing its environmental effects, but also reduces the price of biodiesel to make biodiesel competitive with petroleum diesel. [21]

It can be possible to use the $CaCo_3$ from chicken eggshell waste as to starting material for synthesizing calcium niobate (Ca4Nb2O9) powder via conventional solid-state reaction. [23] Eggshell membranes are a positive source of bioactive proteins proteoglycans and glycosaminoglycan's which associates with the fibrous are composed of collagen type. In many emulsion, cold cream and powder makeup the collagen, hyaluronic acid, chondroitin sulfate is the main component of cosmetics. [18]

Water soluble bio cream and lotion which activates skin can be produced by the combination of chitosan, treated powder eggshell and the lactic acid. [18] Eggshell is a large source of dietary calcium. It is composed of 39% elemental Ca which also contains useful amounts of large number microelements considers the strontium (Sr), fluorine (F) and selenium (Se). [18] We can also consume eggshell powder as a calcium supplement health beneficial and this supplement have shown significant and beneficial result for reducing bone loss. [18]

As a calcium source for the piglets in animal feed eggshell membrane powder compare to purified calcium carbonate. Using eggshell mono-calcium and di-calcium phosphate were produced and it can be used as a calcium and phosphate supplement for farm animal feed. Eggshell membrane holds two layers prepared by a thick network of fibrous proteins. These proteins are highly insoluble of large variety of solvents, but their composition makes them suitable for a broad range of applications. [18] A Solubilized protein yield close to 100% of the eggshell membrane protein was obtained. Ultrasound favors the detachment of big clumps of proteins from the eggshell membrane, facilitating the solubilization of its compounds. The ultrasound had no effect on the protein properties. [24]

Dis-carded eggshells remain largely unutilized and un-transformed. Eggshells consist of calcium carbonate as a useful material to produce Hap, which is the major inorganic part in bones used in bone and dental therapy. A calcium phosphate ceramics material was found to be crucial as a biomaterial because of its osteophytic nature and its incorporation into bone tissues.

Moreover, the use of eggshell to produce Hap will help reduce the pollution effect of the waste and the subsequent conversion of the waste into a highly valuable product as a good chance of reducing the cost of treatment in bone repair or replacement with little impact to the environment. The process of transforming eggshell into Hap and nano-HAp is an environmentally-friendly process. [25]

VII. CONCLUSION

This paper discusses various types of calcium carbonate sources and its origins, also in this paper we discussed about calcium carbonate percentage in different type of eggshells and their extraction processes. The calcium carbonate which is extracted from eggshell can be used in polymer industries, pharmaceutical industries, biodiesel production and biological uses.

REFERENCES

[1] Ropp, R. C. (6 March 2013). Encyclopedia of the Alkaline Earth Compounds. *Elsevier*. pp. 359–370.
[2] Horne, Francis (23 October 2006). "How are seashells created?". *Scientific American*. Retrieved 25 April 2012.
[3] Oyster Shell Calcium Carbonate". Caltron Clays & Chemicals. *Archived from the original* on 10 September 2013.
[4] Mangels, Ann Reed (4 June 2014). "Bone nutrients for vegetarians". *The American Journal of Clinical Nutrition*. 100 (1): 469S–475S.
[5] Boynton, W. V.; Ming, D. W.; Knave's, S. P.; et al. (2009). "Evidence for Calcium Carbonate at the Mars Phoenix Landing Site" *(PDF). Science*. 325 (5936): 61–64.
[6] Clark, B. C., III; Arvidson, R. E.; Gellert, R.; et al. (2007). "Evidence for montmorillonite or its compositional equivalent in Columbia Hills, Mars" (PDF). *Journal of Geophysical Research*.
[7] Benenati G, Penkov S, Müller-Reichert T, Entchev EV, Kurzchalia TV (May–Jun 2009). "Two cytochrome P450s in Caenorhabditis elegans are essential for the organization of eggshell, correct execution of meiosis and the polarization of embryo". *Mech Dev*. 126 (5–6): 382–93. *doi:10.1016/j.mod.2009.02.001. PMID 19368796.*
[8] Sahyadri, J. (2018). Comparative study on calcium content in egg shells of different birds 1-4. 31–33.

© 2017-2020 IRJIET All Rights Reserved

ISSN (online): 2581-3048
Volume 4, Issue 8, pp 37-46, August-2020
https://doi.org/10.47001/IRJIET/2020.408007

[9] Analysis. Q. i. (n.d.). Testing of presence of calcium carbonate by chemical reaction. Retrieved from *https://en.m.wikipedia.org/wiki/Qualitative_inorganic_analysis.*

[10] Technology, P., Sutapun, W., Suppakarn, N., &Ruksakulpiwat, Y. (2013). Application of Calcined Eggshell Powder as Functional Filler for High Density Application of Calcined Eggshell Powder as Functional Filler for High Density Polyethylene. August. *https://doi.org/10.1080/03602559.2013.769578*

[11] I, C. L. E. S. P. (2009). LDPE-Isophthalic Acid-Modified Egg Shell Powder. 20(1), 87-98.

[12] Farahana, R. N., Supri, A. G., &Teh, P. L. (2015). AkademiaBaru Effect of PVC-MA Coupling Agent on Tensile, Water Absorption and Morphological Properties of Recycled High Density Polyethylene / Ethylene Vinyl Acetate / Eggshell Powder Composites AkademiaBaru. 10(1), 1–11.

[13] Development Polypropylene (PP)-Modified Chicken Eggshell Composites Chai. (2016). May 2016.

[14] Ashok, B., Naresh, S., Reddy, K. O., Madhukar, K., Cai, J., Zhang, L., &Rajulu, A. V. (2014). Tensile and Thermal Properties of Poly (lactic acid)/Eggshell Powder Composite Films. *International Journal of Polymer Analysis and Characterization*, 19(3), 245–255. *https://doi.org/10.1080/1023666X.2014.879633*

[15] Hassan, S. B., Aigbodion, V. S., & Patrick, S. N. (2012). Tribology in Industry Development of Polyester / Eggshell Particulate Composites. 34(4), 217–225.

[16] International, A., Free, O., & Reviewed, P. (2017). Effect of Eggshell on Mechanical Properties of Epichlorohydrin Cross-linked Chitosan / Eggshell Composites.

[17] Nayak, S. Y., H, S. S., Sharma, P., Aman, I., & Dey, S. (2015). Use of egg shell particulate as fillers in e-glass / epoxy composites. 21–25.

[18] Jia, J., Duan, Y. Y., Yu, J., & Lu, J. W. (2008). Preparation and immobilization of soluble eggshell membrane protein on the electrospun nanofibers to enhance cell adhesion and growth. *Journal of Biomedical Materials Research - Part A*, 86(2), 364–373. *https://doi.org/10.1002/jbm.a.31606*

[19] King'ori A.M. 2011. A review of the uses of poultry eggshells and shell membranes. *International Journal of Poultry Science*, 10(11):908-912, *https://thepoultrysite.com/articles/a-review-of-the-uses-of-poultry-eggshells-and-shell-membranes*

[20] Makuchowska-Fryc, J. (2019). Use of the Eggshells in Removing Heavy Metals from Waste Water - The Process Kinetics and Efficiency. *Ecological Chemistry and Engineering S*, 26(1), 165–174. *https://doi.org/10.1515/eces-2019-0012*

[21] Z. Wei, C. Xu, B. Li, Application of waste eggshell as low-cost solid catalyst for bio-diesel production, *Bioresour. Technol.* 100 (11) (2009) 2883–2885. *https://doi.org/10.1016/j.biortech.2008.12.039*

[22] Mittal, A., Teotia, M., Soni, R. K., & Mittal, J. (2016). Applications of egg shell and egg shell membrane as adsorbents: *A review. Journal of Molecular Liquids*, 223(June 2018), 376–387. *https://doi.org/10.1016/j.molliq.2016.08.065*

[23] P. Kamkum, et al., Application of chicken eggshell waste as a starting material for synthesizing calcium neobate (Ca4Nb2O9) powder, *Ceramics International* (2015), *http://dx.doi.org/10.1016/j.ceramint.2015.03.189*

[24] Eggshell membrane biomaterial as a platform for applications in materials science, *Acta Biomaterial* (2014), *http://dx.doi.org/10.1016/j.actbio.2014.03.020*

[25] Arabhosseini A., Faridi H. (2018): Application of eggshell wastes as valuable and utilizable products: A review. *Res. Agr. Eng.*, 64: 104–114. *https://doi.org/10.17221/6/2017-RAE*

AUTHOR'S BIOGRAPHIES

Prof. Aastha Dutta
Prof. of plastic and polymer engineering department, Maharashtra institute of technology, Aurangabad, India.

Suraj Sanjay Kolekar
Student of plastic and polymer department, Maharashtra institute of technology, Aurangabad, India.

Saurabh Shamkant Deshmukh
Student of plastic and polymer department, Maharashtra institute of technology, Aurangabad, India.

Vandan Santosh Hiwale
Student of plastic and polymer department, Maharashtra institute of technology, Aurangabad, India.

© 2017-2020 IRJIET All Rights Reserved

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 4, Issue 8, pp 37-46, August-2020

https://doi.org/10.47001/IRJIET/2020.408007

Citation of this Article:

Mr. Suraj Kolekar, Mr. Saurabh Deshmukh, Mr. Vandan Hiwale, Mrs. Aastha Dutta, "Analyzation of Calcium Carbonate ($CaCO_3$) in Eggshells and their Applications" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 4, Issue 8, pp 37-46, August 2020. https://doi.org/10.47001/IRJIET/2020.408007

****

© 2017-2020 IRJIET All Rights Reserved