Research & Reviews: Journal of Material Sciences

DOI: 10.4172/2321-6212.1000154

e-ISSN: 2321-6212
p-ISSN: 2347-2278

Fabrication and Testing of Composite Powder Material from Prawns Shells

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Research Article

Received: 28/08/2016
Accepted: 05/10/2016
Published: 14/10/2016

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Keywords: Composite material, Prawn shell powder, MYK Laticrete - latapoxy resin and hardener, Strength of composite materials

ABSTRACT

Prawns are an extremely good source of protein, yet are very low in fat and calories, making them a very healthy choice of food. In this article, we have discussed the use of the bio-degradable wastes as a composite material. The discarded waste of the prawn shell wastes is used for making a composite material. Composite material consists of matrix and reinforcement. In this article the particulate reinforcement used is prawn shell powder and the matrix used is lapatoxy-SP 100 resin along with hardener (MYK Laticrete). The reinforcement used is prawn shell powder is mixed to the matrix taken in the fixed ratios. In this article, the composite material is fabricated and is tested for hardness. It is a discarded waste that can be easily available in the environment. And also it is bio-degradable, even during its decomposition; it releases nutrients into the environment that are used by trees. These composites cause no harm to nature and are eco-friendly. They don't require any site to grow the raw material used as the reinforcement. They possess high strength, toughness, can withstand loads, hardness etc. Composite materials are a substitute for conventional plastics and possess higher mechanical properties than those materials.

INTRODUCTION

Most of the man's inventions have come about because of his needs. At first, he used only the materials which surrounded him in nature like wood and stone for tools and animal skin for clothing. Then he learned to weave natural fibers like cotton and silk to make cloth. Slowly he discovered the use of iron and copper to make hunting implements. Later, he learned to use fire to make pots and pans from clay and to mix metals like copper and tin to produce the alloy bronze. In this way, he began to make new materials that are not found readily in nature. Another synthetic material that was first made in early times was glass, a compound of silica and soda ash. Man's scientific understanding has greatly increased in the last two centuries, which have witnessed a revolution in technology. Scientists have discovered how to make special synthetic materials like plastics. The word plastic is derived from the Greek word 'plastics' meaning 'fit for moulding'. It is quite a fitting word as plastics can be fabricated into rigid, tough, corrosion- resistant objects. It can be inorganic or organic, natural or synthetic. But increasingly, the word has come to denote synthetic organic plastics, essentially polymers. These polymers, meaning many (poly) parts (rneros) are composed of giant molecules or units called monomers. Each monomer is composed essentially of carbon and hydrogen. Most of the developments in plastics took place as a result of man's search to replace wood, cement and other materials with newer ones having better properties. Celluloid first made from cellulose and camphor was developed in a bid to find good billiard bans! Some developments were as a result of military needs during World War. The first synthetic plastic, Bakelite, was invented by Baekeland in 1906 by reacting phenol and formaldehyde. Polyvinyl chloride WVC1 and related Polymers were first manufactured in the late 1920's. Polystyrene, Lucite, and plexiglass (acrylic) were invented in the 1930's. Many plastics are made from other plastics; for example Acrilan, Orlon,

e-ISSN: 2321-6212
p-ISSN: 2347-2278

and Dyne are made from styrene. Some other plastics are nylon, polyethylene, Teflon, etc. Polymers are produced by complicated chemical processes but they involve basically two types of chemical reaction-addition polymerization and condensation polymerization. In the former, the individual monomers add to one another directly, without a change in composition. In the latter, two or more monomers react to form a chain eliminating a small part of themselves, usually water.

Plastics are generally classified as thermoplastics. They melt or soften when heated, and thus can be reprocessed, whereas the thermo set plastics remain hard after formation. At high temperatures, they do not melt but decompose. With the invention of plastics, the man started using this material to replace the conventional ones. Metals though tough have inherent drawbacks like heavyweight and loss of strength due to corrosion. However, many plastics though versatile are not strong or stiff enough as such for use in sophisticated applications. Of late, scientists have started mixing materials with different properties in a new way so as to make new materials which have the good properties of the constituent materials, without having the inherent weaknesses or disadvantages of the individual materials. These new materials are called composite materials.

Composite Materials

A composite material is made combining two or more dissimilar materials. They are combined in such a way that the resulting composite material or composite possesses superior properties .which are not obtainable with a single constituent material. So, in technical terms, we can define a composite as a multiphase material from a combination of Materials, differing in composition or form, which remain bonded together, but retain their identities and properties, without going into any chemical reactions. The components do not dissolve or completely merge. They maintain an interface between each other and add in concert to provide improved, specific or synergistic characteristics not obtainable by any component that acting singly.

Bone is a simple example of a natural composite material having the best properties of its constituents. The bone must be strong and rigid; yet flexible enough' to resist breaking under normal use. These require properties are contributed by its components. A mature bone is made up of two basic kinds of materials--organic and inorganic. The organic component, consisting mostly of proteins, carbohydrates, and fats make it pliable and give the required softness. The inorganic component, made up of calcium phosphate, gives it the required strength and rigidity. The most common synthetic composite material is Glass Fiber Reinforced Plastics (GRP) which is made out of plastics and glass fiber. The individual components have altogether different properties to that of the composite material, GRP. Plastics are light, durable, have excellent corrosion resistance and can be easily moulded to any complex shape. But they are not fit for load-bearing applications because of lack of sufficient strength, stiffness, and dimensional stability. Glass fiber, on the other hand, possesses very high strength and is sufficiently stiff and durable. Like plastics, it also cannot be used for load-bearing applications because of its brittleness and fibrous structure. But when both these are combined in the correct proportions and a particular glass fiber arrangement, we obtain GRP which has the improved mechanical and other properties suitable for load bearing applications.

Identification of the Problem

Composite materials have changed the world of materials revealing materials which are different from common heterogeneous materials. A composite material is a structural material that consists of two or more combined constituents which are combined at the macroscopic level and are not soluble in each other. It should be understood that the aforesaid composite material is not the by-product of any chemical reaction between two or more of its constituents. One of its constituents is called the reinforcing phase and the other one, in which the reinforcing phase material is embedded, is called the matrix.

The reinforcing phase material may be in the form of fibers, particles, or flakes (e.g. Glass fibers). The matrix phase materials are generally continuous (e.g. Epoxy resin). The matrix phase is light but weak. The reinforcing phase is strong and hard and may not be light in weight. For example, in concrete reinforced with steel, the matrix phase is concrete and the reinforcing phase is steel. In graphite/epoxy composites the graphite fibers are the reinforcing phase and the epoxy resin is the matrix phase. The components do not dissolve or completely merge. They maintain an interface between each other and a d in concert to provide improved, specific or synergistic characteristics not obtainable by any of the original components acting singly.

Preference of Prawn Shell Powder as Reinforcement

At present aquaculture is in focus as an answer to the growing demand for food. As production in this industry gains momentum, protein emerges as the most important and expensive input component. Since the cost of production keeps steadily increasing with declining natural resources, there is a compulsion to find a viable means to ease this problem. It is estimated that aquaculture feed accounts for 40-60% of the operational cost. Naturally our attention should turn to cost-effective and easily available feed ingredients.

The shellfish processing industry in India generates 8.5 million tons of shell waste per year [1]. About 35-45% by weight of shrimp raw material is discarded as waste when processed into headless shell-on products. The peeling process, which involves the removal of the shell from the tail of prawn, increases the total waste production up to 40-45%. On a global basis, the shrimp processing industry produces over 700000 million tons of waste shell. Although part of this is used for chitin/chitosan preparation, feed manufacture and as manure, a major portion still remains unused. Environmental implication of traditional disposal methods of such waste, coupled with the strengthening of environmental regulations in many countries, has created an interest in alternative methods of disposal/utilization of this waste.

METHODOLOGY

Reinforcement

In this article as discussed the project is made out of prawn shell powder. In daily use we use prawns for our diet and its shell is removed out as waste and dumped out. In an average of nearly 2,23,095 metric tons of prawn's are used a day in a country. And its waste is discarded out as waste. The prawn shell has a good strength and resistance regarding the composite material science. Already the discarded wastes of seashells, crab shells, fish shells are used as bio-degradable materials in composites. These organic bio-degradable materials are added with sustainable matrix and are made into a composite material.

As the free availability of the shells that are discarded as waste and which are biodegradable are used for making composites. Even the dried prawn shells have a good elastic modulus and ultimate strength. Since there is a sharp increase in the elastic moduli of prawn shell and isolated crab chitin on drying, as in other arthropod shells, it is concluded that under normal functional use during life, cuticular water considerably reduces the embrittling effects of the inorganic salt phase. It would appear then that a live wet cuticle is a composite material which exhibits both reasonable flexibility and adequate strength and toughness.

The mechanical properties of the plastic could be easily engineered to suit various strength, stiffness and weight requirements, simply by varying the combination of prawn shell and polymer content. The seafood-based product is completely renewable and sustainable, as prawn shells are derived from fishing industry waste. These have a much higher mechanical strength than conventional plastics [2].

The mechanical properties as the tough, transparent, and renewable material can be used to make large, 3-D objects with complex shapes. The new prawn shell material is entirely biodegradable. It breaks down completely within about two weeks after being discarded in the environment and even releases nutrients during its breakdown that plants can use. The prawn shell fiber is mixed with a reinforced matrix to form the polymer composite material. Cheap and easy to make on larger scales and wouldn't take up land like plant-based bioplastics. A suitable matrix is added to the prawn shell powder then the strength of the fiber increases to resist the composite material and withstand the circumstances of the environment as it is biodegradable.

Avail of Matrix-Latapoxy Resin

The matrix used in the article discussed is LATAPOXY SP- 100. LATAPOXY SP-100 Stain-free Grout is an epoxy grout specifically designed for use in applications of ceramic tile, vitrified tile, and stone where staining is expected.

Scientists have been aware of epoxy resins for many years but the first commercial exploration of their properties was undertaken in the 1930s. This was in Germany by the firm of I.G. Farben Industries. However, it was not until the 1950s that use of the compounds in a commercial way was introduced in North America. At about this time the founder of Industrial Formulators, Jim Peters B.Sc., began experimenting with them and over the years became one of the leading formulators in the world. Epoxies are among the thermoset family of resins, along with polyester, silicones, urethanes, melamine's, acrylics and phenolics. Once curing of epoxies has taken place they cannot be melted by heat. This makes epoxies the opposite of such other plastics (thermoplastics) like polyethylene, vinyl, polypropylene, etc., which can be melted and solidified over and over again.

The resin that is the basis for most of our epoxy formulations is the diglycidol ether of bisphenol A (DGEBA). Bisphenol A is produced by reacting phenol with acetone under suitable conditions. Bis means two, phenyl means phenol groups and the ÒAÓ stands for acetone. Thus, bisphenol A is the chemical product made from chemically combining two phenols with one acetone.

Unreacted acetone and phenol are stripped from the bisphenol A which is then reacted with a material called epichlorohydrin. This reaction sticks the two (di) glycidyl groups on ends of the bisphenol A molecule. The resultant product is the diglycidyl ether of bisphenyl-A or the basic epoxy resin. It is these glycidyl groups that react with the amine hydrogen atoms on to produce the cured epoxy resin. Epoxy resins can cause mild skin irritation and a form of dermatitis upon repeated contact. It is important to limit skin contact with any epoxy resin or hardener **(Figure 1)**.

Used in the epoxy resin is epichlorohydrin which with the expectation of cyclo-aliphatic resins is used as a precursor for every commercially available of epoxy resin LATAPOXY groups require routine cleaning with a neutral pH soap and water. All other LATICRETE and LATAPOXY materials require no maintenance but installation performance and durability may depend on properly maintaining products supplied Temperature will effect working properties of LATAPOXY® 300 Epoxy Adhesive. Warm temperatures will speed curing and shorten working time. Cool temperatures will slow curing and require a longer time to traffic. Store LATAPOXY 300 Epoxy Adhesive at 70°F (21°C) for 24 hours prior to use.

Hardener

In this project the product made is used by MYK LATICRETE, LATAPOXY RESIN, PART- A, 250 g. Part B, the hardener, is typically a polyamine or mixture of polyamines and has can have a strong ammonia-like smell. Most are considered DOT Corrosive materials and should be respected as such. They are typically light coloured to dark amber liquids. The hardener, like the resin, can be filled with metal or mineral fillers to improve the performance or lower costs. And just like the resin, these fillers may settle

e-ISSN: 2321-6212
p-ISSN: 2347-2278

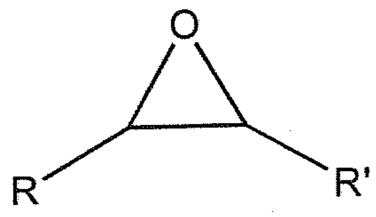

Figure 1. Basic chemical structure of epoxy group.

over time and must be stirred to a homogeneous consistency before mixing with the resin. Some epoxy hardeners are based on anhydrides rather than amines. These hardeners are more likely used in electrical potting and encapsulation applications and are likely to be heat cured in nature. Both polyamines and anhydrides are somewhat sensitive to moisture. Keep containers tightly sealed and when used in meter-mix-dispense equipment it is best to use a dry nitrogen purge or a desiccating air dryer on the vent [3].

Two part epoxy compounds are normally supplied in separate A-B containers, either both full or in a pre-measured kit. Under the Resin lab designation; Part A is the epoxy resin and Part B is the polyamine hardener, with some systems the Part B may be an anhydride. Epoxy resins are normally clear to slightly amber, high viscosity liquids which may be filled with mineral fillers to improve performance and lower cost. These sometimes can settle to the bottom of the container and must be stirred to a homogeneous consistency before adding the hardener. Epoxy resins can cause mild skin irritation and a form of dermatitis upon repeated contact. It is important to limit skin contact with any epoxy resin or hardener. Therefore, we recommend that you wear rubber gloves when mixing and using the epoxy compounds.

Mixing Ratios of Epoxy and Hardener

In general best case is a 1/1 ratio with even viscosity, worst case is a 10/1 ratio with a wide viscosity difference. The type of cartridge can also have a dramatic effect on dispense quality, especially when used in a pulsing mode. Larger and thin walled cartridges can induce a lead/lag effect where A and B show an extreme ratio change in a very short period due to the expansion and relaxation of the cartridge barrel. The thicker walled cartridges show much less tendency to produce this lead/lag effect which is a primary cause on intermittent tacky areas on small. Potting or castings.

Boiling range: IBP 432°F (222°C) (IBP=Initial Boiling Point)

Appearance and odor: Clear slight yellow, slightly viscous liquid with a slight ammonia-like odor.

Solubility in water: slight.

EXPERIMENTAL PROCEDURE

Production of prawn shell powder from prawn wastes. The prawn shells that are discarded as a waste are taken in a required quantity. These prawn shell wastes were thoroughly washed several times with cooled freshwater.

Prawn shell waste components (head, thoracic and abdominal shell, carapace, telson, appendages, antennae, maxillary case) were separated and washed again. These prawn shells were dried under the sun for 2-3 days along with using a drier. The complete moisture content is removed by drying the prawn shells under the sun and also using a drier as well. **Figure 2** shows the dried prawn shells.

Figure 2. Dried prawn shells.

Those dried prawn shell's which are completely dried and are ground into a powder using a blender for 3-4 times as shown in the figure below. The fine powder of prawn shells is collected as in required quantity.

The finely grounded prawn shell powder is again dried for a day long to remove any excess moisture content in the powder.

The powder must be clean and clear from dust and any other micro-organisms before processing.

The fiber that is used in the composite material is this completely dried powder which is mixed with the matrix suggested possessing the particulate reinforced matrix. This prawn shell powder will have good strength when compared to other biodegradable materials [4].

The reinforcement is processed for the prawn shell powder, as mentioned earlier the matrix that used is lapatoxy resin along with the hardener in the constant ratios as In general best case is a 1/1 ratio with even viscosity, worst case is a 10/1 ratio with a wide viscosity difference. The type of cartridge can also have a dramatic effect on dispense quality, especially when used in a pulsing mode. In this article the resin and hardener are taken by 75% and the prawn shell powder is taken by 25% for mixing the matrix and fiber as shown in the figure below the resin and hardener.

The prawn shell powder is a particulate reinforcement in the composite as it is taken in the powder form. The **Figures 3 and 4** below shows the blending and the dying of the prawn shell powder that is used as a reinforcement in making the composite material.

Figure 3. Blending of dried prawn shells.

Figure 4. Drying of prawn shell powder.

The general understanding of shell secretion is that it begins with the formation of periostracum extruded from the periostracal groove. Upon reaching the tip of the outer mantle lobe, it is reflected back and a calcareous outer layer initiates slightly within or immediately below the internal layer of the periostracum. However, some bivalves defy this model and can secrete calcareous matter before the shell layers are laid down. In these cases, the secreted matter protrudes from the periostracum in the form of needles or pins, which represent a highly organized and early phase of mineralization, differing from the normal shell secretion process.

Its structure is mostly an array of parallel prisms, polygonal in cross-section, straight, and elongated along the direction perpendicular to the shell's outer surface.

The part-A is the epoxy resin and the part- B is the hardener, Epoxy resins are normally clear to slightly amber, high viscosity liquids which may be filled with mineral fillers to improve performance and lower cost. These sometimes can settle to the bottom of the container and must be stirred to a homogeneous consistency before adding the hardener. Epoxy resins can cause mild skin irritation and a form of dermatitis upon repeated contact (**Figure 5**).

When hand mixing the epoxy resins and the hardeners, it is best to pour the resin, the Part A, into the mixing vessel first At

e-ISSN: 2321-6212
p-ISSN: 2347-2278

Figure 5. MYK Laticrete - latapoxy resin and hardener.

first in a container the resin and hardener are added in ratios and mixed in the container for a time until we get a good vertex in the middle of the solution in the container (**Figures 6 and 7**).

Figure 6. Mixing of the resin.

When a good vertex is obtained in the solution then the prawn's shell powder is added to the vertex of the matrix in the container. The powder mixed into the matrix is stirred using a stir stick until it forms a good mixture. This mixing of the particulate matrix s called stirring technique. It doesn't require any temperature or heat [5].

The mixture should be mixed without any bubbles and it must be clean and free room dust as well. It should be made a uniform distribution throughout the composition by scraping the sides and bottom of the mixing vessel frequently.

After the products have been thoroughly mixed, the mixture should be poured into the mould or used in the adhesive step. Often, the end product must be totally free of voids and bubbles. The prepared composite material is poured into the die of the required shape. The shape of the die is procured out as a composite material. The composite material procured out is hard and high in strength (**Figure 8**).

After the process, the composite material is taken out which is free from voids and that is tested for further investigations.

e-ISSN: 2321-6212
p-ISSN: 2347-2278

Figure 7. Powder mixed with matrix.

Figure 8: Composite material made out of different die

The composite made out of prawn shell powder is a bio-degradable material that can be easily discarded into the environment easy to use. It doesn't require any plants or sites to grow the raw materials [6,7].

The waste material that goes as waste is identified and used for good purpose. Instead of ceramic, plastic, these materials are used as a supplement. They will have good strength and are hard. They can be used as tiles, making articles, decorative items etc.

RESULTS AND DISCUSSION

The composite is made from the prawn shell powder by adding the matrix lapatoxy resin along with the hardener. The composite material is tested for hardness test. The results for composite material can be known both by testing and also by observing the composite during the experiment.

These results show that the composite material is hard and have high strength. The particulate powder shape taken for making the composite material is chosen as that it is apt for the project for making the composite material, we have chosen is by trial and error method.

Testing Method

Hardness test

The test piece that is to be tested is placed on the work table. Initially basic load is applied on the test piece, and the hardness number is noted for the load respectively. The load is increased gradually on the test piece and the corresponding hardness numbers are noted. The load on the test piece is increased until test piece breaks under the load applied.

That test piece gets a breaking point at a certain load. Until that load, the test piece can withstand. The Brinell hardness test is conducted on the test piece placing the load and using a circular ball indenter of 10 mm to take the readings on the test piece. Basing on the diameter of ball indenter, the values of the hardness numbers are noted regarding the diameter. The hardness number determines the strength of the particulate composite material (**Figures 9 and 10**).

Figure 9: Hardness test.

Figure 10. Hardness test equipment tests piece.

At a load of 750 kg, it has a hardness number of – 52.1

At a load of 1250 kg, it has a hardness number of – 96.3

At a load of 1500 kg, the test piece breaks and reaches its ultimate strength; at that applied load it has a hardness number of – 114.4

e-ISSN: 2321-6212
p-ISSN: 2347-2278

Comparison with other bio-degradable materials

Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, and Sri Lanka. Many works have been devoted to using of other natural fillers in composites in the recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties. Composites of high strength coconut filler can be used in the broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances. The objective of this paper is to study the tensile and flexural properties of epoxy composites based on coconut shell filler particles

The experiment started with the procurement of the coconut shell specimens, resin, hardener, mould, and roller. Coconut shells were procured from a local grocer. Six pieces of coconut shells were ground to form a powder with the diameters of 50 to 200 μm using a grinding machine. The density of coconut shell is 1.60 g/cm^2. Epoxy resin and hardener were procured from a local supplier in Cheras, Selangor, Malaysia. The resin used was epoxy resin 3554A with the density of 1.15 g/cm^3. The weight ratio of the resin and hardener was 100:25. Epoxy and hardener were mixed in a container and stirred well for 5–7 minutes. Before the mixture was placed inside the mould, the composite was hardened, and later it was removed from the mold and placed inside an oven for 12 hours at 40°C for curing.

Coconut filler particles strengthen the interface of the resin matrix and filler materials. The maximum tensile strength for 15% filler composite was higher (35.48 MPa). Stress at fracture from a bend or flexure test is known as flexural stress. He maximum flexural strength for 15% filler composite was higher (80.68 MPa). Mold has initially been polished with a release agent to prevent the composites from sticking onto the mold upon removal. Finally, the mixture was poured into the mold and left at room temperature for 24 hours [8-11].

CONCLUSION

When the matrix is added with the prawn shell powder, it's seen that it has a good uniform distribution throughout the surface. The reinforcement used in the composite material has a good interface with the matrix. When the load is applied on a composite material, the load is directly carried by the matrix and it is transferred to the reinforcement from the matrix through reinforcement–matrix interface. So, it is clear that the load transfer from the matrix to the fiber depends on the reinforcement matrix interface. This interface may be formed by chemical, mechanical, and reaction bonding. In most cases, more than one type of bonding occurs.

About 35-45% by weight of shrimp raw material is discarded as waste when processed into headless shell-on products. The peeling process, which involves the removal of the shel1 from the tail of prawn, increases the total waste production up to 40-45%. On a global basis, the shrimp processing industry produces over 700000 million tons of waste shell. Environmental implication of traditional disposal methods of such waste, coupled with the strengthening of environmental regulations in many countries, has created an interest in alternative methods of disposal/utilization of this waste.

Prawn exoskeleton is rich in protein (approximately 40%) besides chitin which may constitute about 14% of the dry weight. The shell composition of a prawn contains Chitin $(C_8H_{13}O_5N)n$ is a long-chain polymer of an N-acetyl glucosamine, a derivative of glucose. The mechanical properties as the tough, transparent, and renewable material can be used to make large, 3-D objects with complex shapes. The material is entirely biodegradable it breaks down completely within about two weeks after being discarded in the environment.

Prawn shell even releases nutrients during its breakdown into the environment that plants can use. The prawn shells have a much higher mechanical strength than the conventional plastics. The composite material has high strength, tough, and has a good hardness to withstand loads, water resistance, no reaction with chemicals, easy to get the raw material that is used as a fiber, no need of any mechanical processing equipment. It has the high ultimate strength and elastic modulus as well. The composite material prepared using the prawn shell as reinforcement and the matrix used is lapatoxy resin along with the hardener. The composite materials that are made out of biodegradable materials are discarded as a waste into the environment. The discarded waste into the environment is chosen as the fiber for making the composite materials which attain a high strength, toughness, wear resistance, hardness, ultimate strength and all the mechanical properties that are to be possessed generally.

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