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# Natural fiber for green technology in automotive industry: A brief review

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**Abstract.** Fiber reinforced polymeric composites have been known and widely used because of their high specific strength and modulus compared to metals. In the last few years, biomaterials listed as a demand technology to be exploring by researchers especially in industrial purpose. This is push by environmental awareness and the over use of petrol resources lead to the development of new materials, called biocomposites, which will maintain a better future. This paper will be discussing about a brief review of natural fibers, use in automotive industry to achieve a green technology target in manufacturing of cars specifically. It's a fact that, related to weight reduction, the automotive industry can take advantages of using these materials, not only because of extinction of oil reserve, but because of high ability and importance of these materials itself in automobiles. Currently, most composites in the market are focused with long-term durability design while using nondegradable polymeric resins such as epoxies and high-strength fiber such as glass. All these materials prove to be a good characteristic of composite but still lack in environmental concern. This polymer and fiber are derived from petroleum, a nonreplenishable commodity. The momentum is to use biocomposites in common plastics to improve performance. Since the main purpose of this paper is to show a bio-composite which is suitable to replace the existing interior of automotive design, the work has focused on obtaining that bio-composite, taking account into the raw-materials cost reduction and the maintenance of the manufacturing process based on current scenario. The automotive industry is in their way to expand green technology in composites because the need is greatest. But producing the composites is energy intensive and polluting, while the durability of conventional composites, often seen as an advantage, is also their biggest challenge. Current fibers use in industry right now is difficult to dispose. They do not degrade naturally and could linger for generations.

## 1. Introduction

"The most environmentally friendly thing you can do for a car that burns gasoline is to make lighter bodies" (Henry Ford). Waste indiscriminate had been remind to us since school which is in early age. The concept of reducing, reusing and recycling activity is for decreasing rubbish in a landfill. Unfortunately this habit cannot be practicing because of attitude. Day by day it leads to a rise in health cases and environmental degradation problem. Regarding this matter, any solution crossed will be taken seriously to ensure action is louder than speaks. This will be including automotive industry because at the end life of automotive part will be landed in a landfill. Issues on recycling car components, is forcing the automotive industry to look at ways to lower the environmental impact of cars over their entire life cycle. Researchers do more studies aiming to help, by improving technologies to enhance the performance of plant fibre, a 'greener' alternative to glass fibre, for use in thermoplastic composite automotive parts. Natural fibres offer technical and environmental benefits when used to reinforce plastics [1].

At the end of 2010, total number of vehicles in Malaysia had reached amount of 21.25 million vehicles with an average of 12% increase of vehicle registration each year over the period of 5 years. If the estimation was to be continued, Malaysia will have as much as 31 million vehicles in the year 2020. As the automotive industry develops, its impact to the environment also increases. Thus, a proper solution of managing waste is needed to sustain the environment and reduce human impact towards nature [1]. Environmental concern as well as government legislation has motivated manufacturers in many countries to consider product life cycle issues and deal with product recovery at the end of the product life cycle. The automotive industry is one of the leading industries in this environmentally conscious manufacturing and product recovery [2].

## 2. Green technology to overcome waste disposal of car component

There is a dramatically surge in interest of eco-friendly materials and technology in industrial sectors and hybrid biocomposite from natural resources. All products have environmental impacts. It is either small or huge depending on the root causes and raw materials used in the production process. These will be including process or services which may involve energy consumption, natural resource depletion, solid waste generation, air pollution, land degradation and global warming issue. However, previous research stated that these impacts can be minimized by practicing sustainable design which helps to promote product quality and reduce cost while environmental degradation will be in a very minimum level to occur. Sustainable development is important, it plays huge role in industry sector as well as in our daily lives. This is to ensure both present and future needs fulfill with good quality of environment and preservation of natural resources can be well manage.

In addition, the biggest concern is on the end destination of automotive products where end-of-life of vehicle recycling is widely exploited over the world. The goal is to ensure the amount of waste generated from disposal process can be decreasing which lead to reduce environmental degradation. Therefore, end-of-life recycling is an important factor which must be included in product application for every product and material design. According to auto recycling statistics [3], most of car produced nowadays will be a good source of recyclable material. In fact, around 80 percent of a car can be recycled.

However, there are two major issues occurred for the current materials for internal car component. Both are high in cost and currently high of weight. Designing a combination of lightweight and strong biomaterials are strategies to develop advanced lightweight composite that can replace the traditional synthetic structures or metals which made as part of automotive components. Heavy composite panel structure will significantly influence the fuel consumption of a car and subsequently increase the carbon dioxide emission in air. In addition, composite made of glass fiber form sharp edges upon deformation and increase the concern related to safety issue.

The increasing demand for greener and biodegradable materials leading to the satisfaction of society requires a compelling towards the advancement of nano-materials science. The biodegradability of the natural fibers is considered as the most important and interesting aspects of their utilization in polymeric materials [4]. Designing a combination of lightweight and strong biomaterials are strategies to develop advanced lightweight composite that can replace the traditional synthetic structures or metals which made as part of automotive components. Heavy composite panel structure will significantly influence the fuel consumption of a car and subsequently increase the carbon dioxide emission in air.

Natural fibers have been exploited for various purposes as reinforcing fillers for aircraft, automotive and construction materials. The most common natural fiber used in composites is bast fiber, such as hemp, jute, sisal and kenaf [5]. Natural fiber has high specific strength than glass fiber while it has a similar specific modulus. Another point of worthy consideration is the source available in our country and these natural fibers theoretically offer desirable specific strengths and modulus at a lower cost [6]. Kenaf is one of the natural fibers that can be used as reinforcement in making Polymer Matrix Fiber Composites (PMFC). This cellulosic source is known with both economic and ecological advantages as it can grows under a wide range of weather conditions. The strength and stiffness of kenaf fibers are provided by the cellulose components via hydrogen bonds and other linkages. It was reported that hybridized kenaf fiber potentially improved the damping property of the composite [6]. Natural fibers also offer remedy in neutralizing the discomfort generated from engines, exhaust systems, gears and wheels which is produced in form of noise, heat and electrostatic charges. The nonabrasive properties of natural fibres make it a good choice in term of safety as natural fibers do not form sharp edges upon deformation like glass fibers [7].

## 3. Natural fiber replacing polymer's function.

Recently, production of synthetic polymers based petrochemicals quite popular but it is not biodegradable and harmful. Polymers such as polyethylene and polypropylene can be prolonged in the environment for many years after their disposal [8]. Last two decades, significant advances in the development of biodegradable polymers have been study [9]. Basically, production of polymers which can biodegrade generally obtained via polymerization of agricultural-based raw materials. Variety forms of biodegradable polymer materials have been implemented and thus proven to have potential uses in industries. Many of these polymers are well suited for adhesive applications such as environmentally friendly packaging, recyclable envelope adhesives, carpet backing, and many other products that are eventually destined for the municipal waste disposal facility.

Flax and hemp which can be the source for biofibers have potential as a raw material which are of great importance for the production of various types of composites use in automotives, building materials, packaging, papers and furniture industries [10]. Biofibres as viable alternative to synthetic fibre as reinforcement in plastics because of low cost, lightweight, good mechanical performance and biodegradable properties. In fact, a better performance can be creating use biofibre with biodegradable resins. While in automotive industry, biocomposites found a vast number of applications [11]. Basically, applications for a car included doorpanels, seat backs, dashboards and package trays, head restraints and seatback linings. For example, Mercedes [12] used jute-based composites, applied for the door panels of the E-class, banana-fibre as composites for the A-class and other bio-composites for the S-class. The Araco Corporation in Japan present another way in 2003, created the Grasshopper as a fully electric vehicle. This vehicles totally made from plant-based composites mainly kenaf for its body [13].

In the last few decades, the use of natural fibers gained considerable attention like from both resources, renewable and non-renewable such as oil palm, sisal, flax, and jute to produce composite materials. The plants, which produce cellulose fibers can be classified into bast fibers (flax, hemp, jute, kenaf, and ramie), seed fibers (kapok, coir, and cotton), leaf fibers (abaca, pineapple, and sisal), grass and reed fibers (wheat, rice, and corn), and core fibers (hemp, jute, and kenaf) as well as all other kinds (roots and woot) [14]. As far as the concern, benefits of natural fibers are beyond compare to synthetic fibers where in term of its relatively renewable resources, biodegradability, low cost, less damage to processing equipment, low weight, improved surface finish of molded parts composite, being abundant flexibility during processing, good relative mechanical properties such as tensile modulus and flexural modulus, and minimal health hazards [15]. Thus, natural fibers widely use because of those specific properties which can give more advatages to the users and even the producers.

Currently, automotive components produce from natural composites are already exist in manufacturing industry. In facts, those composites mainly based on polyester or Polypropylene and fibers like flax, hemp or sisal. The main reasons why natural composites were using are the highlight of weight reduction, and marketing rather than technical demands [16]. Germany stated as a leader in the use of natural fiber composites. The German auto-manufacturers, Mercedes, BMW, Audi and Volkswagen introduce natural fiber composites for interior and exterior applications. The first attraction is the inner door panel in the 1999 of the S-Class MercedesBenz, made in Germany, of 35% Baypreg F semi-rigid (PUR) elastomer from Bayer and 65% of a blend of flax, hemp and sisal. Eventhough this luxury automotive manufacturers are on board, that is not because they need to lower cost, in facts with the use of natural fiber composite, could be seen as evidence that industry need to do any initiative for environmental needs [17]. Back in 1996, Mercedes-Benz used an epoxy matrix with the addition of jute in the door panels in its E-class vehicles. Another paradigm of natural fiber composites' application appeared commercially in 2000, when Audi launched the A2 midrange car: the door trim panels were made of polyurethane reinforced with a mixed flax/sisal material. Toyota developed an eco-plastic made from sugar cane and will use it to line the interiors of the cars [18].

Volvo has started to use soya-based foam linings in its C70 and V70 models for their seats with natural fibers. To improve the quality of noise reduction they have also produced a cellulose-based cargo floor tray. In Western Europe, the yearly production of cars is up to 16 million vehicles that equate to an including usage of 80 000160 000 tons of natural fibers per year. German automobile companies like Daimler-Chrysler are continuing to lead the way, having a global natural fiber initiative program that benefits third nations by developing products made from natural fibers. One of the recent developments within the automotive industry has been the release of the Lotus Eco Elise. Another development was announced in 2008 at the EcoInnovAsia 2008 event held in Bangkok, Thailand, related to the Mazda 5. In this application, the manufacturer is using polylactic acid (PLA) in the interior consoles along with kenaf and PLA in the seat covers [19].

Sisal fibre is used traditionally to produce twine, ropes, carpets and bags. Natural fibres such as sisal are also increasingly used in composites in the automotive and construction sectors. About 5% of the composites manufactured in Europe incorporated natural fibres in 2012, the remainder mainly consisting of glass fibre composites [20]. The environmental benefits of biocomposites can be balance by the technologies while improving their thermal and dimensional performance provide an opportunity for their use in under the hood automotive applications [21]. In Japan, company of Hitachi Automotive Systems last year announced that it will produce a composite carbon/fiber drive shafts for the company Alfa Romeo, which will be built into the new Alfa Romeo Giulia car. These shafts are reduced by the noise of the central bearing by using carbon fibers which leads to greater comfort during the ride. In UK, door panels of the car Ford Mondeo are made of a mixture of kenaf fiber and polypropylene resins. The mass of the door is reduced from 5 to 10% by this way. The ability of fiber to absorb a large amount of moisture leads to greater comfort compared with synthetic materials. In Germany, higher performance applications are achieved with the inside panels of the Mercedes Benz E Class. Flax fibers were used in combination with epoxy resins. The biggest disadvantage of plant fibers are too large oscillations in quality, which depends on the growth rate, and absorption of moisture, which complicates the application [21].

## 4. Mechanical Properties

Mechanical properties of natural fibers will be depending on the factors like size, maturity as well as processing methods adopted for the extraction of fibers. Previous study stated that several properties such as density, tensile strength, modulus and other properties depend on the internal structure and chemical composition of fibers. It is known from the research that modulus of natural fiber decreases with increase of its diameter [23-24]. Regarding in the tabulated data from previous data collections, the strength of natural fiber is below the line, less value compare to glass fiber as can see in Table 5.1, while stiffness is on the same level. However, there is something special about natural fibers where it has low densities, which are up to 2 times lighter than glass, the resulting specific stiffness of natural fibers is substantially higher than the same parameter of glass fibers. Flax, hemp and jute fibers are particularly have better value of specific stiffness. Those factors are good explanation to be used as reinforcement in composites for automotive applications. Sisal, coir cotton and ramie are only useful if the price is cheaper and reasonable to buy in bulk condition. Wood fibers in the form of short fibers or flour are also used in composites processing, but mainly as filler. The properties of natural fibers presented in Table 1 are mostly for those fibers extracted by using dew-retting process, and could be regarded as conservative.

**Table 1** Properties of some synthetic and natural fibers (Adapted from kavelin, 2005).

| **Fibers** | **Tensile strength, MPa** | **Tensile modulus, GPa** | **Specific gravity** | **Specific strength** | **Specific stiffness** | **Failure strain, %** | **Price, Euro/kg** |
|---|---|---|---|---|---|---|---|
| E-glass | 2500-3500 | 70-73 | 2.56 | 27 | 29 | 2.5-3.0 | 1.5-2.5 |
| Carbon | 2500-6000 | 220-700 | 1.75-1.9 | 116 | 400 | 1.4-2 | 30-50 |
| Flax | 500-900 | 50-70 | 1.4-1.5 | 33 | 50 | 1.3-3.3 | 0.5-1 |
| Sisal | 80-840 | 9-22 | 1.3-1.45 | 6 | 17 | 3-7 | 0.3 |
| Jute | 200-450 | 20-55 | 1.3-1.4 | 14 | 42 | 1.16-1.5 | 0.12-0.5 |
| Hemp | 310-750 | 30-60 | 1.48 | 20 | 41 | 2-4 | 0.5-1 |
| Banana | 530-750 | 7-20 | 1.4 | 5 | 14 | 1-4 | 0.5 |
| Coir | 130-175 | 4-6 | 1.15 | 3 | 5 | 15-40 | 0.25 |
| Cotton | 300-600 | 6-10 | 1.5 | 4 | 7 | 7.0-8.0 | 1.6-4.6 |
| Silk | - | - | 1.34 | - | - | - | 18.3-36.7 |
| Wool | 125-200 | - | 1.31 | - | - | - | Up to 15.4 |

Natural fiber composites are often poorer in properties, mostly mechanical, compared to synthetic fiber composites. A possible solution to this issue is the use of natural fiber/synthetic fiber combination in polymer hybrid composites. Although the biodegradability of the composites is compromised by synthetic fibers, this is compensated by the improvement in their mechanical and physical properties. Hybrid composites use more than one kind of fibers in the same matrix and the idea is to get the synergistic effect of the properties of both fibers on the overall properties of composites. There has been a significant increase in research on natural fiber/synthetic fiber hybrid composites in recent years. Natural fibers are mostly hybridized with glass fibers because of their comparable properties and low cost. Some studies, however, have been done on hybridization of natural fibers with the more expensive carbon and aramid fibers. There is a considerable improvement in mechanical properties of these composites following hybridization, especially when synthetic fiber plies are used as skin and natural fiber plies are used as core. Various natural fiber surface treatments have been used to improve their interfacial adhesion with the matrices and, hence, their mechanical properties.

## 5. Future Prospective of Natural Fiber in Automotive Industry

Natural fiber give a lot of benefits to environmental advantages such as: reduced dependence on non-renewable energy/material sources, lower pollutant emissions, lower greenhouse gas emissions [25] increase energy recovery and end of life biodegradability of components [26]. Eventhough the advantages of natural fibers give specific benefit to environment, all these properties should be supported by quantitative analysis. In this regard, Joshia et al. mentioned three comparative Life Cycle assessment (LCA) studies to assess the overall environmental performances. This research lead to specific applications, analyzed in the study, natural fiber composites are environmentally suit to glass fiber composites on most midpoint indicators [27].

Drivers of superior environmental performance show from the comparative analyses are as follows

[25]:
- Less environmental impacts of natural fiber production compared to glass fiber production
- Substitution of matrix (synthetic polymer) by higher content of natural fiber in the composite
- Improvement of fuel efficiency and lower use phase emissions due to weight reduction
- Energy and carbon credits from end of life incineration of natural fibers [26].

## 6. Conclusion

The preservation of our environment requires that we stop developing materials that will, like many plastics, last indefinitely. Yet nature's way, to accept rapid degradation because there is continual renewal, is not an option. Industry, especially the automotive sector, which is an enormous user of bulk materials, would like a halfway house of reasonably long-lived materials that nevertheless degrade back into the environment when they are no longer needed. Reinforced plastics based on natural, mainly plantderived substances show promise of providing this and may turn out to be one of the material revolutions of this century.

The automotive industry is in the driving seat of 'green' composites because it is here that the need is greatest. Faced with pressures to produce fuel efficient, low-polluting vehicles, the industry has used fiber reinforced plastic composites to make its products lighter. But producing the composites is energy intensive and polluting, while the durability of conventional composites, often seen as an advantage, is also their Achilles' heel. Glass, carbon, and aramid fiber reinforced polyester, epoxy, and other similar resins are difficult to recycle and hard to dispose of. They do not degrade naturally and could linger for generations.

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