Universiti Malaysia PAHANG

BMM4893: Mechanics of Composite Materials

Chapter 5: Composite Materials in the Future

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Learning Outcomes

By the end of the topic, students shall be able to:

1. Discuss the synthetic fibre for future
2. Discuss the natural fibre for future
3. Limitation of Composites in Future

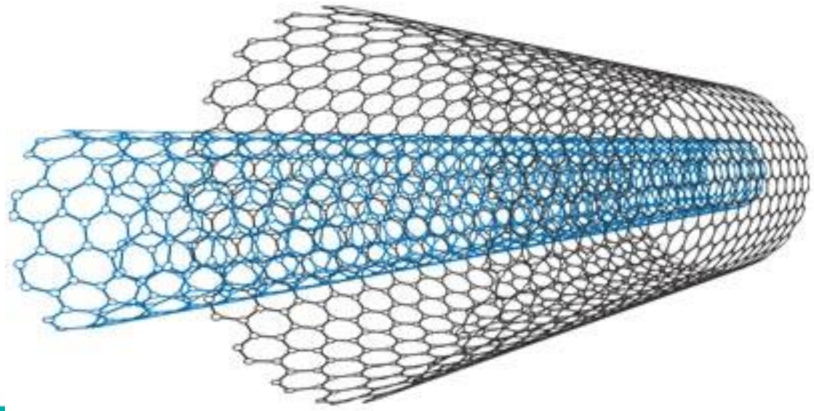
Market Survey

1. The market's growth is due to the development of emerging countries, particularly in Asia. It is directly related to the health of the economy. These countries are in the equipping phase and the demand for a variety of goods is high there.
2. Thermoplastic composites are growing faster than thermosets.
3. According to some experts, carbon composite would be ready to be introduced into the mass applications, via automobiles in particular. But the current uncertainty on the user markets leaves the question open.
4. "Eco" or "organic" composites are receiving interest and the use of natural fibres is becoming more professional. Few "fully organic" products, however, are reinforced with long, natural fibres. This market is expected to grow significantly in the next decade.

Market Survey

5. Reinforcement architectures are increasingly complex and "intelligent": 2.5D or 3D, triaxial or multiaxial. Solutions are proposed to obtain structural reinforcements that are much more deformable. 3D preforms are needed.

6. Carbon nanotubes are spreading. They are added to epoxy prepregs or laminating resins to improve the ultimate strength and dimensional stability or change conductivities.



Market Survey

7. Production is becoming highly automated. The composites industry is moving towards low volume mass applications; automation is essential and is accompanied by an acceleration in cycle time.

8. Out-of-autoclave (OOA) systems are taking off. They make it possible to produce composite parts faster, more efficiently and with an excellent surface finish in a non-autoclave environment. The technique is more flexible, requires less expensive tools, much less investment and is more energy efficient. Resin injection techniques (RTM and others) are growing.

9. The need to solve the problems of recycling composites is increasingly urgent with the advent of mass applications. Little progress has been made in recent years, but the issue remains on the agenda.

Market Survey

10. Integrated composite structures, designed and manufactured in a single step, are one of the strong trends at the moment. The combination of multiple processes allows manufacturing with low power consumption and advanced automation. An interesting implementation technique involves thermoforming reinforced sheets of continuous fibres and moulding them from a casting by conventional injection with a short fibre reinforced polymer.

11. The aeronautical, automotive and wind industries are innovative sectors. Composites in the first niche are growing (11%/year) thanks to on-going efforts to produce lighter aircraft. The automotive industry remains creative and is investing in carbon composite, but this sector is very sensitive to the economic situation. The wind power industry is using an increasing amount of composites (16% growth/year), but its future is linked to politics, which are rather uncertain today, and the authorities.

Composites in Automotive Industry

Composites in Automotive Industry

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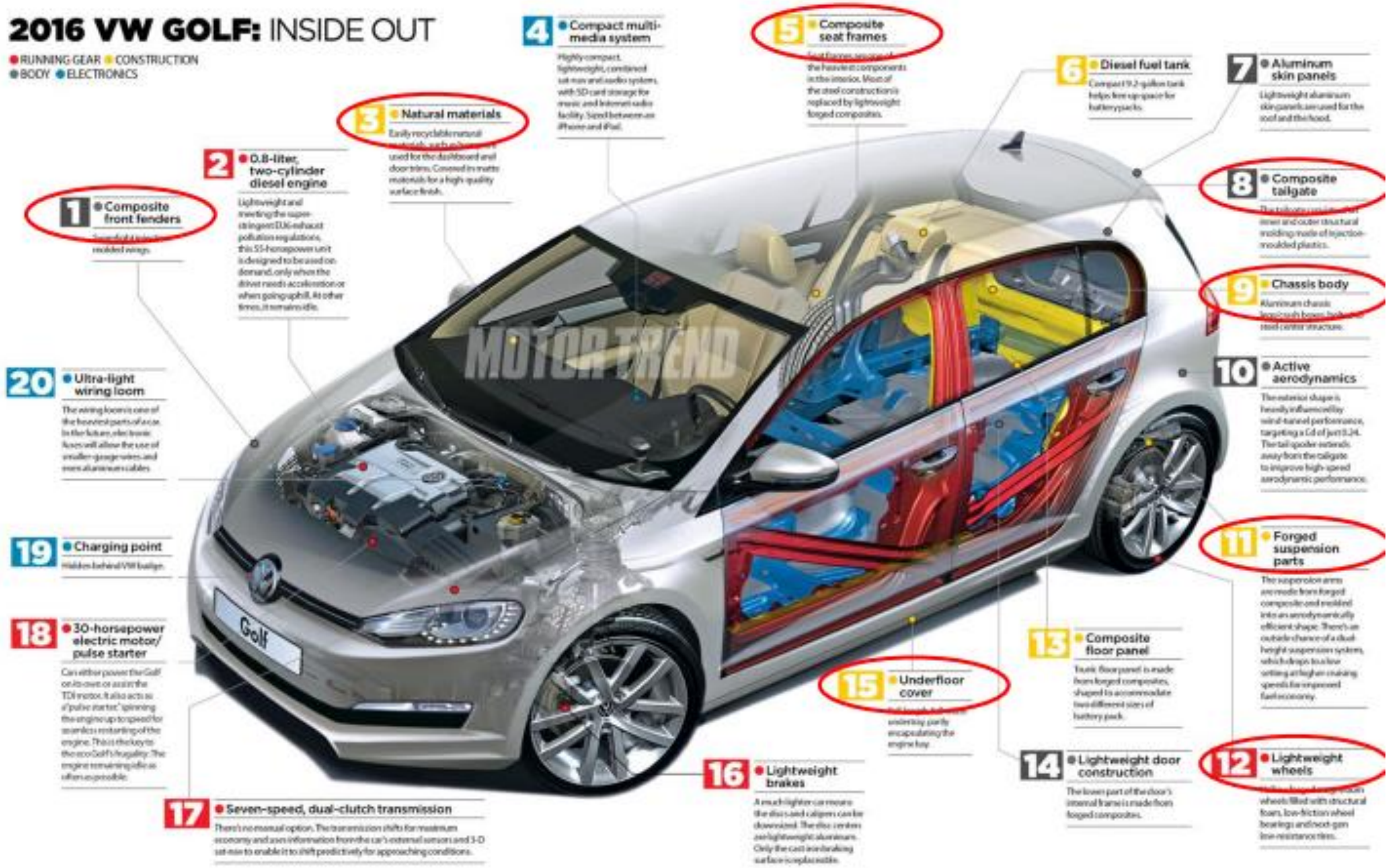
Multiple Composite Materials



Composites in Automotive Industry

Composite Fibers in Automotive Applications

COMPOSITE FIBER REINFORCED PLASTICS (CFRP)

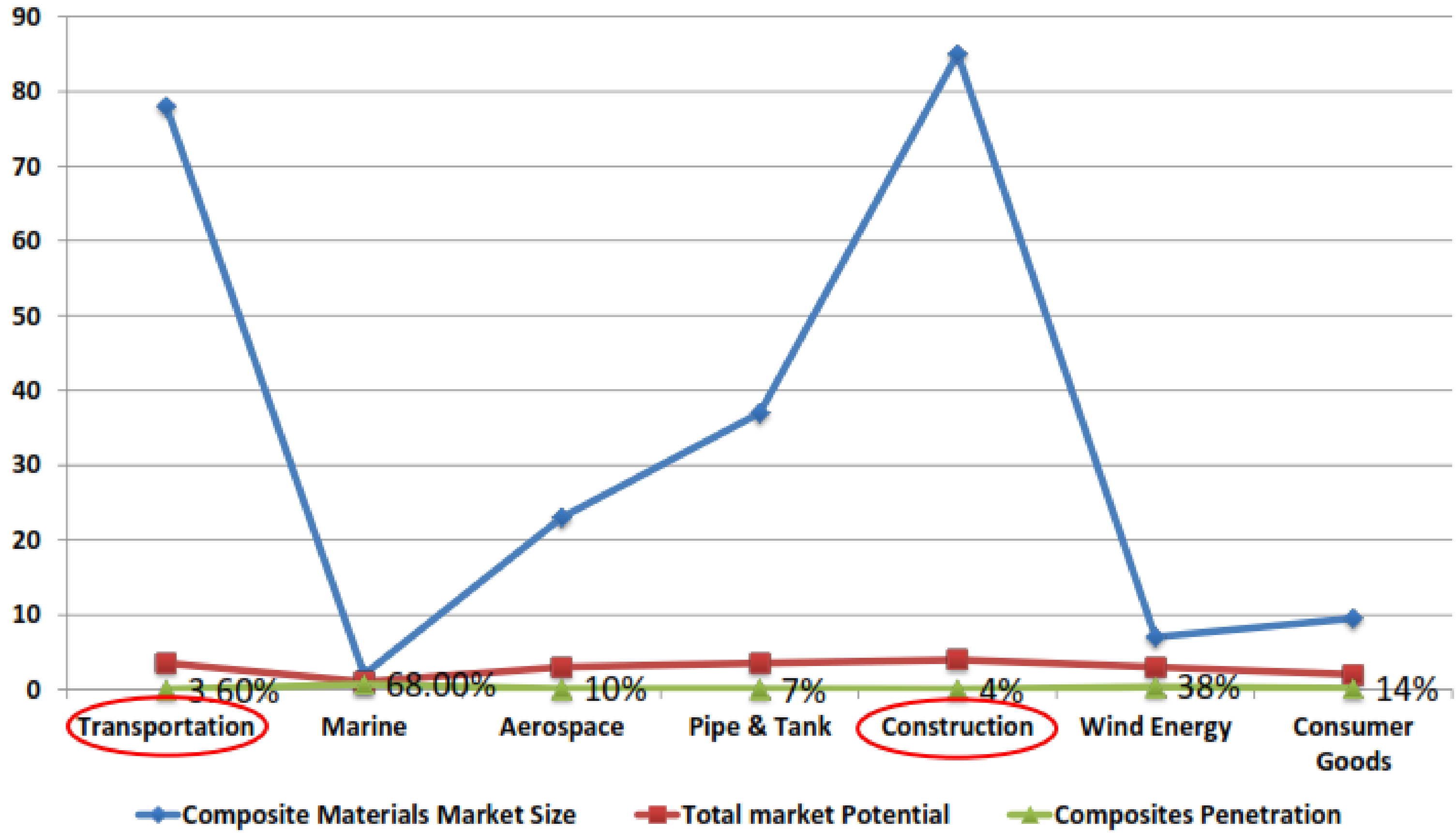
- NATURAL FIBERS
  - WOOD
  - NON-WOOD
    - SEED / FRUIT
    - BAST
    - LEAF
    - STEM
- GLASS FIBER
- CARBON FIBER

Non-structural Facia panels & Acoustic applications

Structural, light-weight strength & reduced number of parts

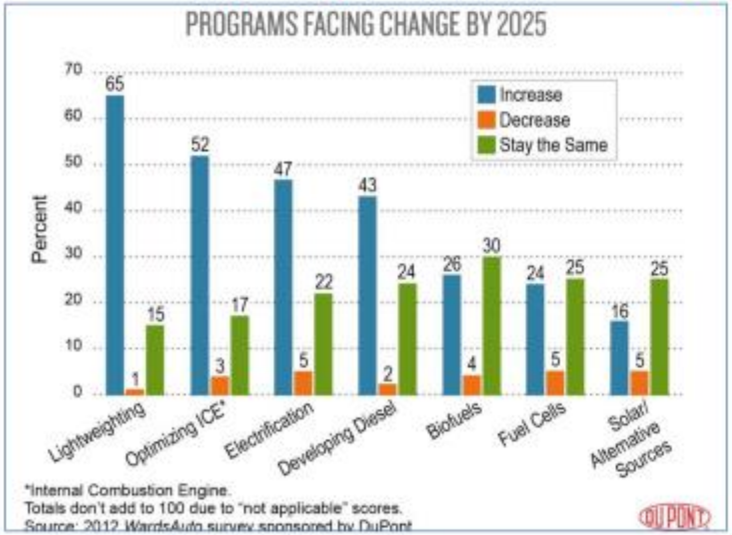
Composites in Automotive Industry

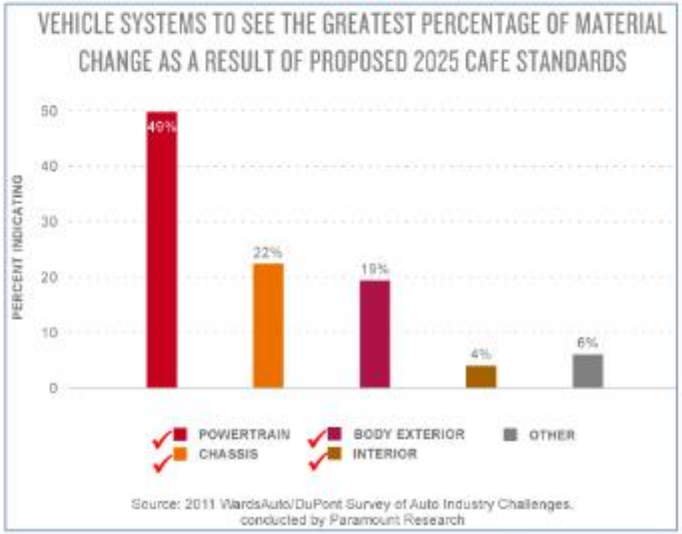
Composites Penetration in Market Segments

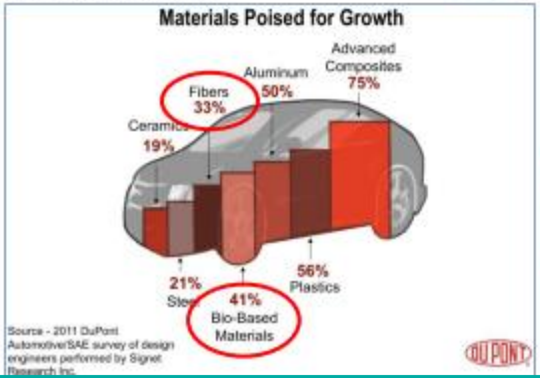


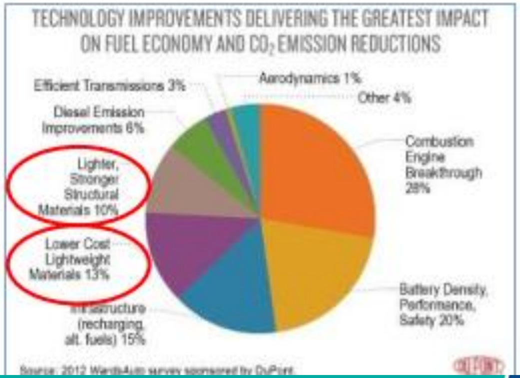
Composites in Automotive Industry

Challenges Associated With Meeting 2025 CAFE (Corporate Average Fuel Economy) Standards









Composites in Automotive Industry

Natural Composites

Composites in Automotive Industry

Lotus Eco Elise Concept

The materials incorporated include :

- hemp - used on the car's composite body panels, spoiler and seats,
- eco wool for the upholstery and
- sisal for the carpet.

The Eco Elise's hemp hard top incorporates a set of solar panels to provide power for the car's electrical systems.

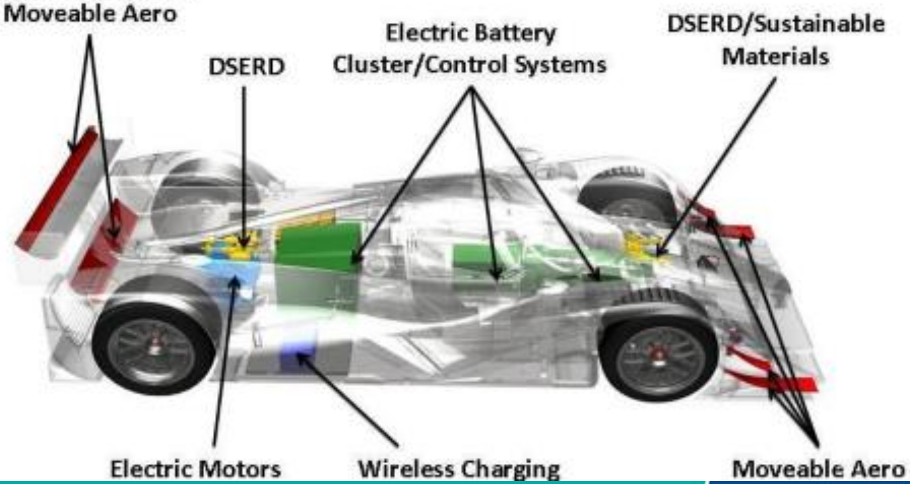
Composites in Automotive Industry

Lola-Drayson Electric Race Car : 'Green' Composites

The Lola-Drayson B12/69EV demonstrates the potential of sustainable 'green' technologies in the motorsport industry, using –

- Recycled Carbon fiber composites (structural parts)
- flax reinforced composites

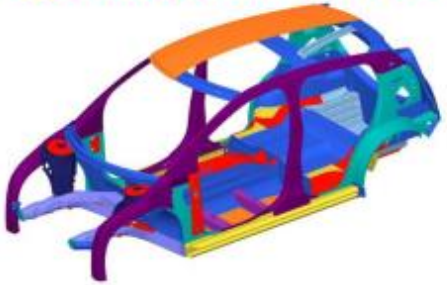
The Lola-Drayson B12/69EV

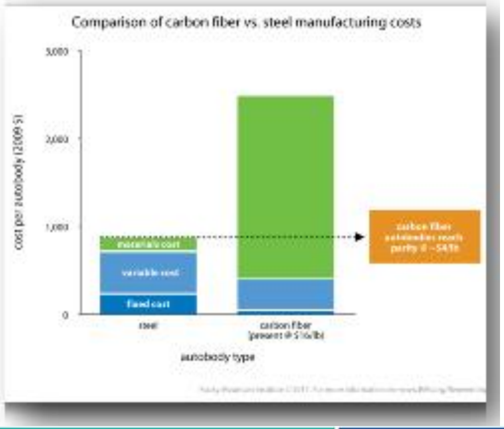


Composites in Automotive Industry

Potential Lightweighting Materials

Lightweighting Material	Material Replaced	Mass Reduction (%)
Magnesium	Steel, Cast Iron	60 – 75
Carbon Fiber Composites	**Steel , Aluminum, Cast Iron**	**50 – 60**
Aluminum Matrix Composites	Steel, Cast Iron	40 – 60
Aluminum	Steel, Cast Iron	40 – 60
Titanium	Alloy Steel	40 – 55
Glass Fiber Composites	Steel	25 – 35
Advanced High Strength Steel	Mild Steel, Carbon Steel	15 – 25
High Strength Steel	Mild Steel	10 – 15

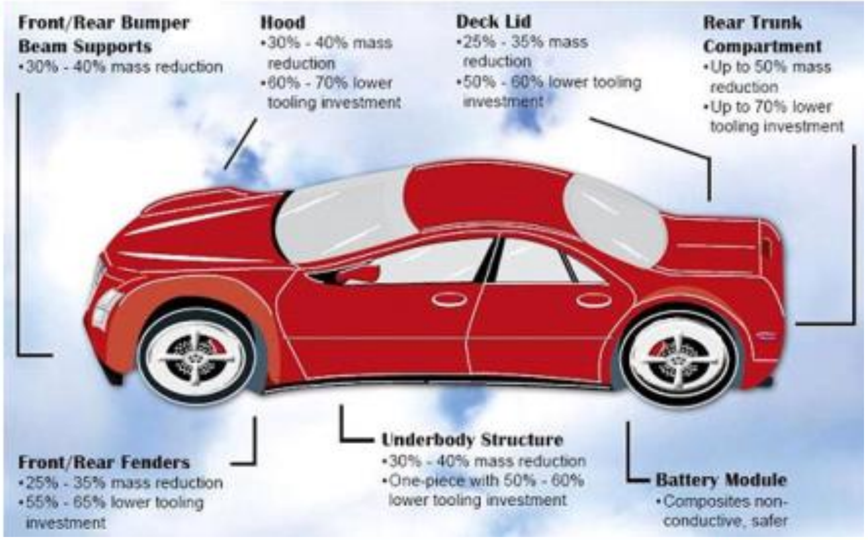




Composites in Automotive Industry

Why use carbon composites?

	Carbon Fiber	UD Carbon Composite	Steel	Aluminum
Strength (MPa)	4150	~ 2200	~ 690	~ 415
Modulus (GPa)	245	~ 132	~ 207	~ 69
Density (g/cc)	1.81	~ 1.54	~ 7.8	~ 2.7



What is needed for broader automotive use of Carbon Fiber Composites?

- Lower cost carbon fiber & intermediate products
- High throughput / low cost manufacturing technologies

Composites in Automotive Industry

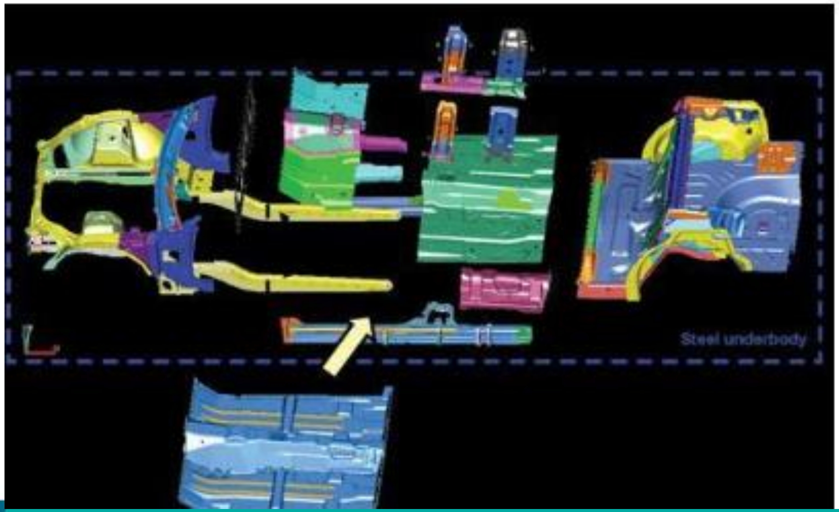
Opel Insignia OPC Seats

- Opel teamed up with Recaro & BASF to create a state-of-the-art **slim seat design**.
- Recaro was able to create a seat with **minimal components**, ultimately **reducing assembly time and cost**.
- Design criteria included **low weight**, **high mechanical strength**, **high level of comfort** and **sporty look** - without the use of large metal springs or excessive amounts of foam, which also creates more interior room for cargo or passenger legroom.

Composites in Automotive Industry

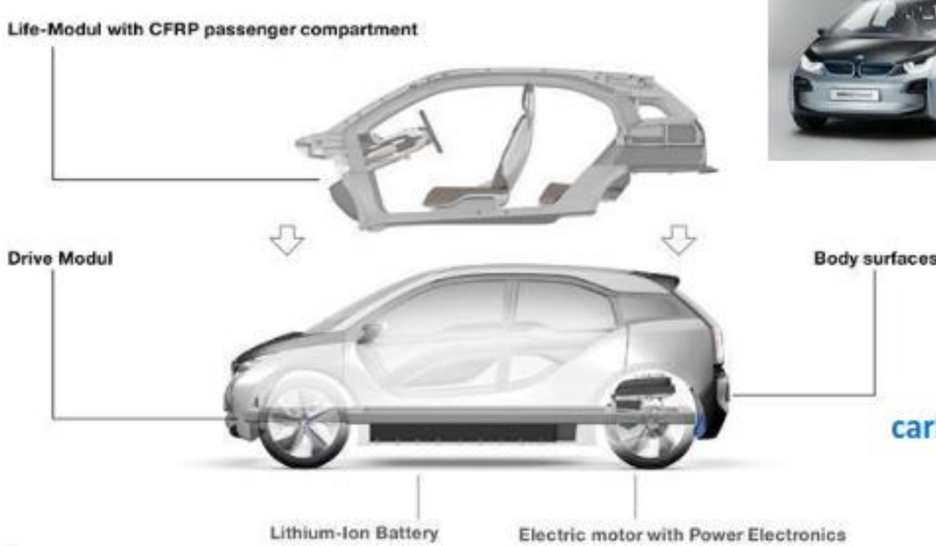
Structural Underbody

The United States Council For Automotive Research LLC (USCAR) have patented a composite underbody for a full-size, rear-wheel-drive passenger car.



Composites in Automotive Industry

BMW Carbon Fiber Cars i3 and i8 : Harder Than Steel



BMW is building its own carbon fiber factory, to secure supply of the lightweight material and refine the production processes.

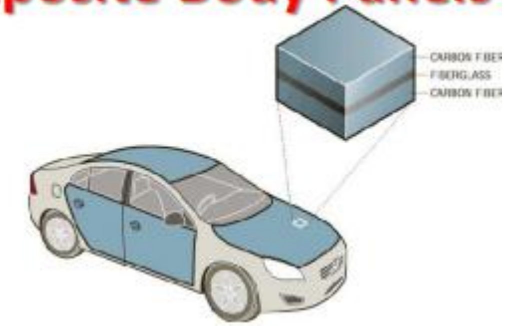
Composites in Automotive Industry

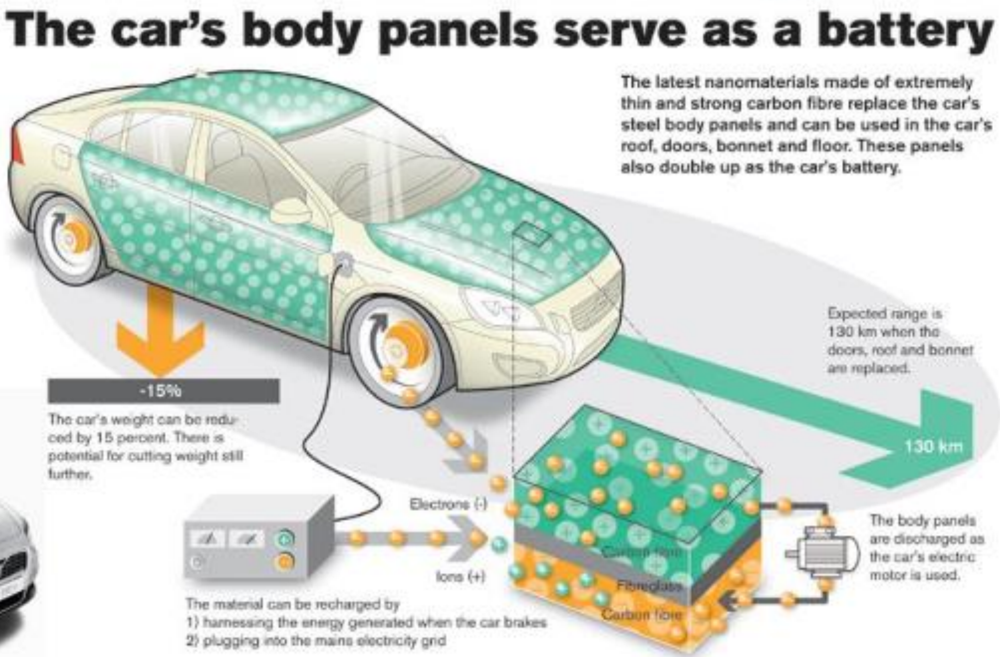
Composites in Automotive Industry

VOLVO : Batteries in Composite Body Panels

Volvo is developing a special composite material consisting of carbon fiber and polymer resin which will be –

- capable of storing and discharging electrical energy
- holding enough charge for 81 miles of electric driving
- and will recharge faster than the conventional EV batteries used today.





Composites in Automotive Industry

Carbon Fiber Wheels

- Japanese company **Weds Sport** came up with the first full carbon fiber wheel -unveiled at the 2008 Tokyo Auto Salon show, using the Dry Carbon Fiber process.
- One wheel weighs just 2.76kg.

- In 2009, Australian company **Carbon Revolution** introduced it's <u>CR-9</u> as a one-piece carbon fiber wheel
- Each wheel weighs 50% less than a aluminum wheel of comparative size.

Composites in Automotive Industry

The Final Frontier : CFRP Engine Block

- Created by Florida engineer **Matti Holtzberg** in 2011
- A carbon-fiber-reinforced engine block with strategic use of inserts to handle the heat and concentrated loads
- Constructed out of a six-piece aluminum mold with a removable core

Composites in Automotive Industry

Lamborgini *"Sesto Elemento"* 2011

Lamborghini's **Sesto Elemento** - was a technology demonstrator :

- 80 % of the car is CRPF
- Featuring a skin one-third the thickness of previous CFRP sports car body panels, the car's monocoque achieves the required rigidity via integrated stiffeners
- Uses one-shot Forged Composites technology
- Achieved its designers' objectives –
  - reduced the weight by 40 percent
  - cut acceleration from 0 - 100 kmh to 2.5 seconds from 3.4 seconds
  - increased the power-to-weight ratio, and the car's handling and performance

Lamborghini is the only automaker to have mastered the complete CFRP design-to-production process in-house

Composites in Automotive Industry

Lamborgini + Callaway : “Forged Composites”

Driving Technology

The photo above shows part of a Callaway club using traditional weave (left) versus one using Forged Composite. In the latter case, fiber chips are mashed together like composite hash browns and formed in a mold so accurate that even part numbers can be stamped into the piece.

- Forged Composite uses a **paste of fibers** mixed with resin that is squeezed out to make almost any shape
- Since the fibers aren’t oriented in any particular direction, the finished part is **strong all around**, while remaining light
- Reduce **press cycle times** to four minutes for vinyl ester and 10 minutes for epoxy
- Forged Composites can **mint 10,000 parts per year**

Composites in Automotive Industry

Lamborgini "CarbonSkin"

- A new version of carbon fiber material developed for the Aventador J. called "Carbonskin"
- Made of **woven carbon fibers soaked with a special epoxy resin** that stabilizes and keeps the material soft
- Like a hi-tech fabric, the carbon fiber mats fit perfectly to every shape
- In the Aventador J, the **complete cockpit** and **parts of the seats** are clad in this material

Composites in Automotive Industry

Toyota Lexus LFA

Carbon Fiber : from Key-to-Chassis

The LFA consists of 65 % CF and 35 % Al

Composites in Automotive Industry

Toray Teewave AR1 Concept

- TEEWAVE uses a range of Toray CFRP products
- Its body weighs 846 kg, including the battery
- It features Carbon Fibre composite monocoque chassis, crash structures, body, interior and seats
- The parts use a **process time of less than 10 minutes**.

Composites in Automotive Industry

Smart Forvision Concept Car

- Weight = 942 Kg
- The carbon fiber extra-thin door-skins with **strengthening surface features to add strength**
- CF bodycage & wheels
- Natural composite fiber interiors

Prospect for Future

REPAIR - SELF-HEALING

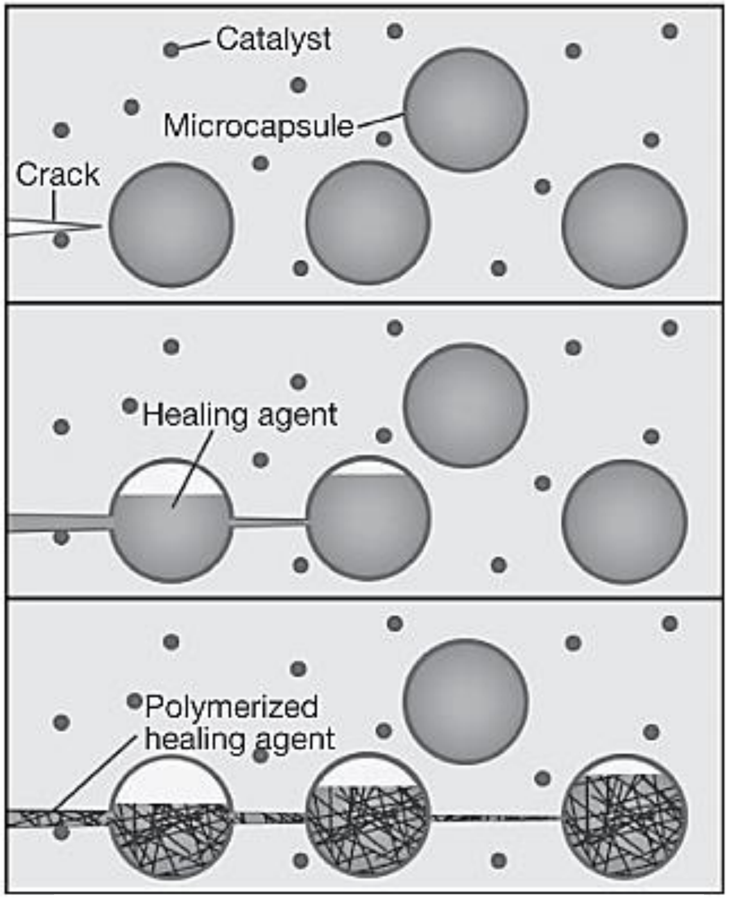


Figure 1. Schematic of a microcapsule-based self-healing epoxy [3].

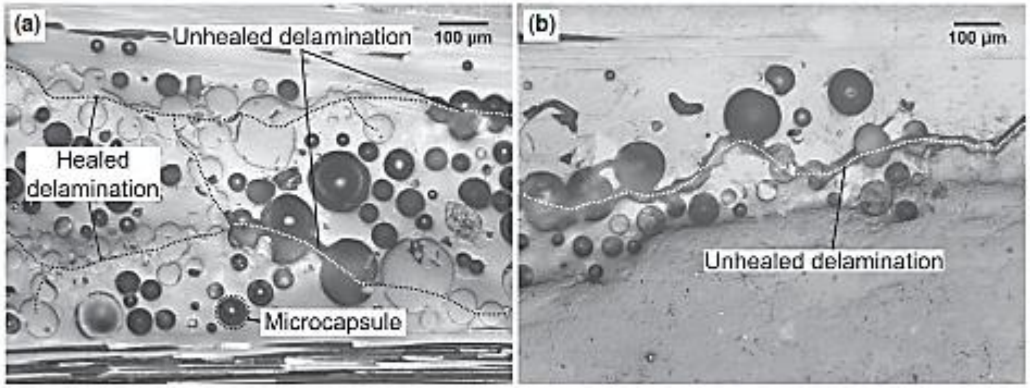
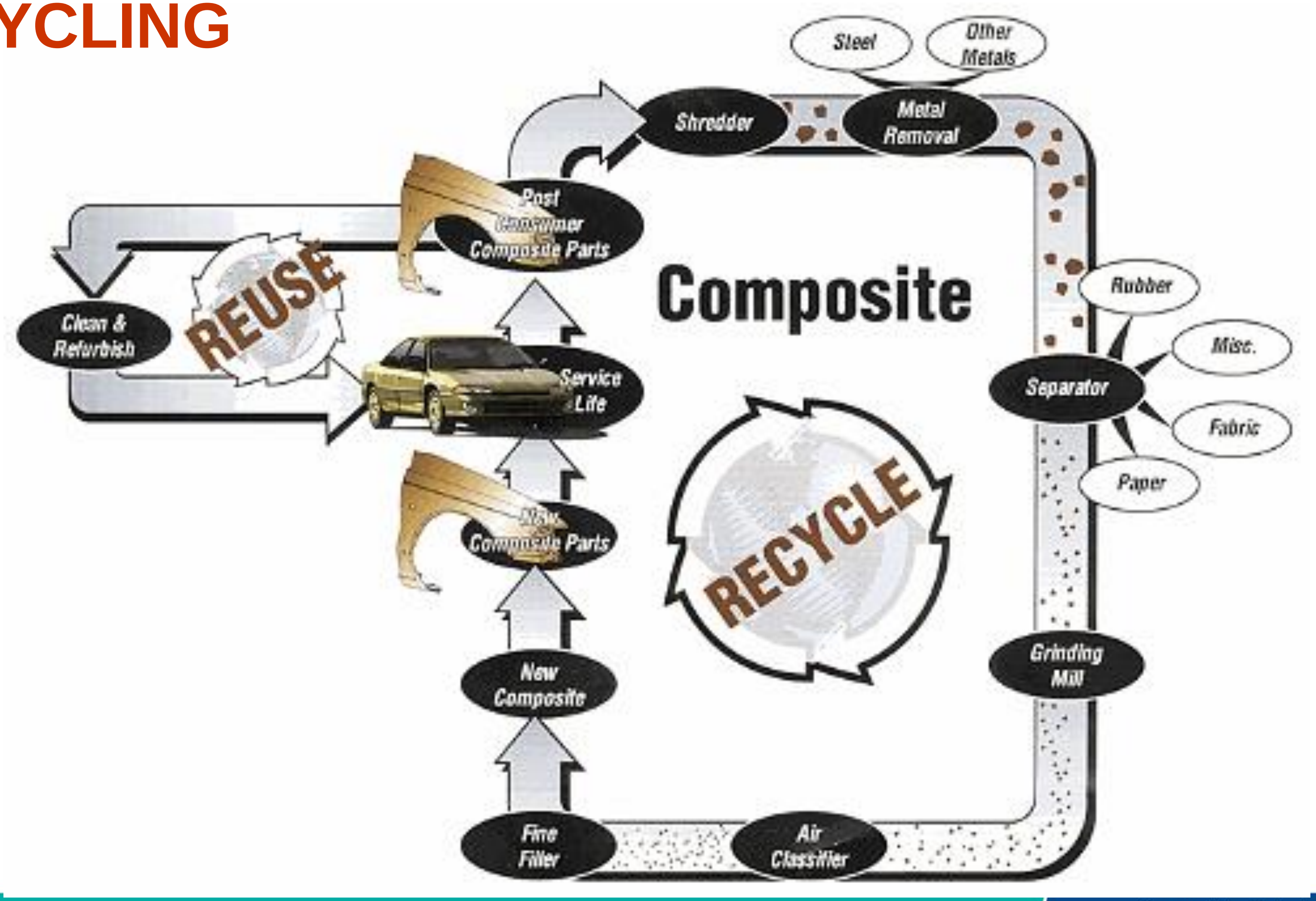


Figure 2. Optical micrographs of cross-section of two self-healing composite panels. (a) a fully self-healing composite showing the two capsule diameters as well as healed damage. (b) A nonhealing control showing unhealed delaminations. Impact energy for both specimens was 45 J [15].

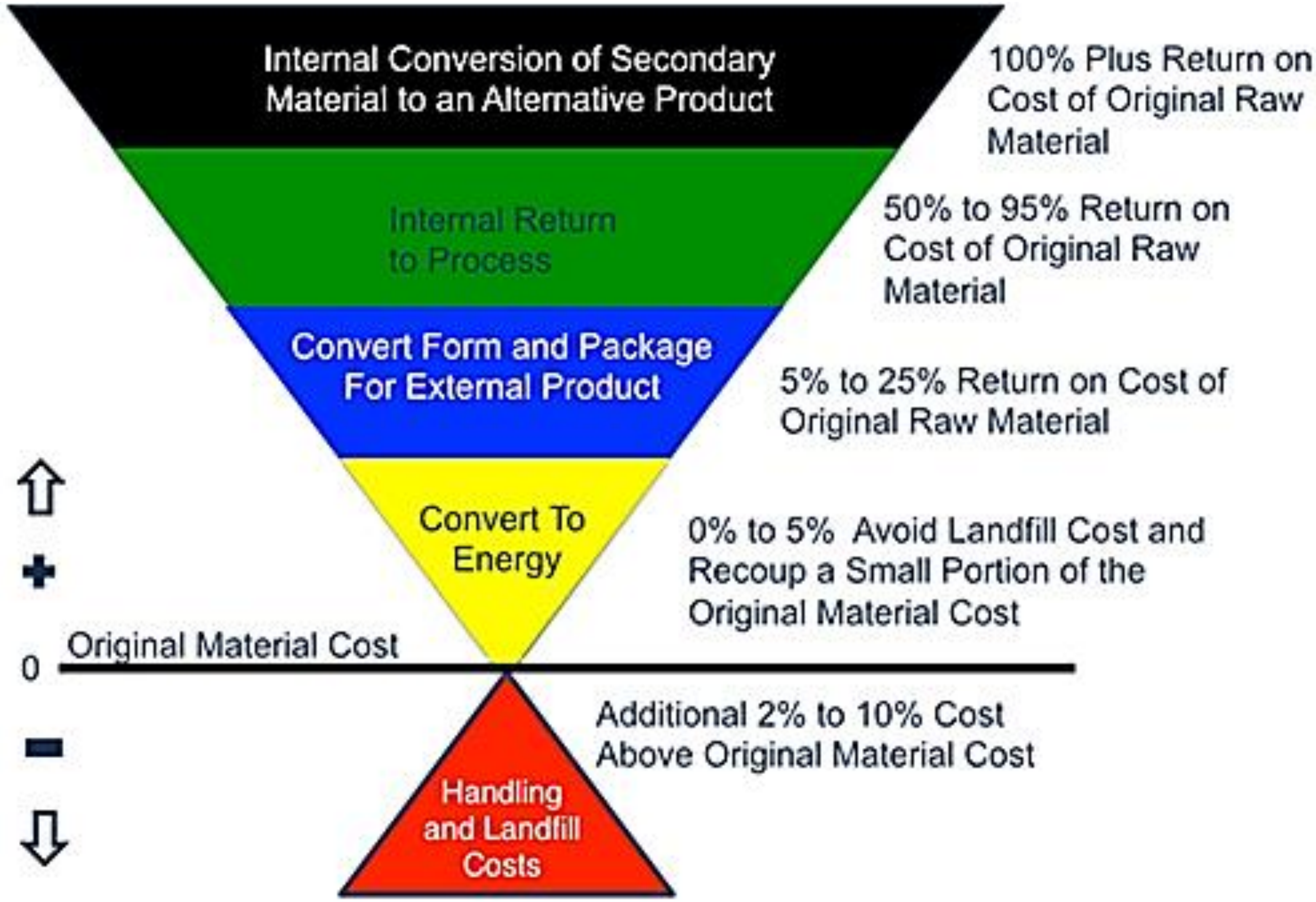
Prospect for Future

RECYCLING



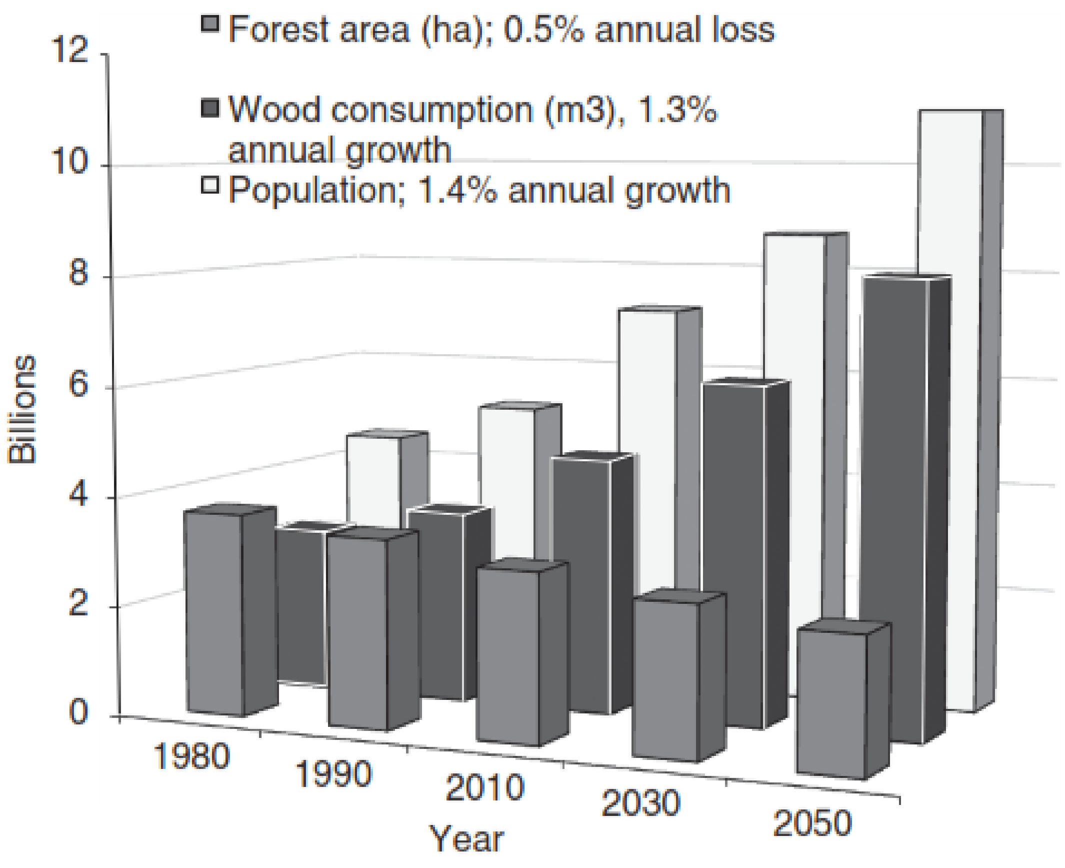
Prospect for Future

RECYCLING



Prospect for Future

Natural Fibres



Prospect for Future

Natural Fibres

- Natural fibers
  - Plant
    - Bast fibers
      - Flax
      - Hemp
      - Kenaf
      - Jute
      - Ramie
      - Isora
      - Nettle
      - Toina
    - Leaf fibers
      - Pineapple
      - Sisal
      - Abaca
      - Curaua
      - Palm
        - African palm
        - Chambira
        - Chiquichiqui
        - Moriche
      - Cabuya
      - Opuntia
      - Paja toquilla
      - Yucca
      - Pita
    - Seed fibers
      - Cotton
      - Coir
      - Kapok
      - Poplar
      - Calotropis
    - Fruit fibers
      - Coir
      - Luffa
    - Grasses and reeds fibers
      - Bamboo
      - Totora
    - Wood fibers
      - Hardwood
      - Softwood
  - Animal
    - Wool, Hair, Leather
      - Sheep (merino)
      - Llama
        - Guanaco
        - Llama
        - Alpaca
        - Vicuna
      - Camel
      - Goat
        - Angora goat
        - Cashmere goat
        - Common goat
      - Goose (feather)
      - Rabbit
      - Bristle
    - Silk
      - Silk
      - Spider silk
  - Mineral
    - Asbestos

Source: Institute of natural fibres and textile terms and definitions, textile institute

Prospect for Future

Natural Fibres

28 • RENCANA

Potensi kenaf komoditi eksport baharu negara

Gentian berkualiti dapat permintaan tinggi untuk industri automotif, pembuatan

MOHD ZULKIFLI ZAINUDDIN
bhkb@bh.com.my

Kecanggihan teknologi yang membawa banyak kemajuan dalam industri pertanian termasuk pokok kenaf, membuka satu lagi ruang kepada industri biokomposit negara.

Pokok kenaf atau nama saintifiknya *Hibiscus Cannabinus* adalah tanaman yang berasal dari Afrika dan sudah wujud sejak 4,000 tahun lalu. Tumbuhan ini bukan sahaja mampu menghasilkan gentian yang berkualiti, malah turut dapat menampung beberapa sektor pembuatan lain seperti tilam dan perabot, serta bertindak sebagai gentian penguat industri komponen plastik selain boleh dijadikan sumber makanan haiwan ternakan.

Malah kelebihan tumbuhan yang mencapai tempoh matang hanya empat bulan itu, mampu tumbuh dengan pantas dan boleh menjangkau ketinggian antara 3.7 hingga 4.3 meter dalam masa empat minggu. Selepas matang, kenaf akan diproses kepada gentian sebelum dijadikan produk seperti tali, guni, bahan binaan, plastik serta beg tangan.

Melihat akan potensi kenaf yang amat besar, Lembaga Kenaf dan Tembakau Negara (LKTN) dipertanggungjawab untuk menerokai potensi tumbuhan itu sebagai komoditi eksport baharu Malaysia.

Ketua Pengarah LKTN, Samsudin Noor, berkata pihaknya mengenal pasti potensi kenaf sejak tahun 2000 dan kajian sudah dilakukan sehingga tahun 2005 sebelum menggalakkan kenaf menggantikan tembakau dari tahun 2006 hingga tahun 2009. Usaha diperhebat dengan penubuhan LKTN pada tahun 2010.

Penanaman secara komersial sejak dua tahun lalu

Beliau berkata, penanaman kenaf secara komersial di negara ini sudah bermula sejak dua tahun lalu, dan permintaan bagi produk gentian kenaf adalah tinggi khususnya dalam industri automotif dan pembinaan.

"Sehingga kini, penanaman kenaf sudah dijalankan oleh kira-kira 1,300 pengusaha

*"Gentian kelapa dan palma tidak sesuai digunakan bagi menghasilkan produk bayi yang kami usahakan. **Hanya gentian kenaf dari Malaysia lebih sesuai digunakan kerana ia tidak berbau serta lembut"***

Ling Qing Pu,
Pengarah Shenzhen Laswell Trading Co Ltd dari China

jelang 2020," katanya kepada pemberita selepas perjumpaan dengan pembeli dan bakal pembeli tanaman kenaf, di Pulau Pinang, baru-baru ini.

Kemajuan dan potensi tanaman kenaf di negara ini terbukti apabila gentian menerima permintaan tinggi dari China, iaitu sebanyak 200 tan sebulan.

Kejayaan itu dicapai apabila gentian kenaf di negara ini menunjukkan kualiti lebih baik berbanding negara lain memandangkan iklimnya sesuai dengan pertumbuhan tanaman berkenaan.

Malah gentian daripada kenaf ini juga sudah diiktiraf oleh pakar persijilan global, TUV SUD, selain diuji Institut Piawaian dan Penyelidikan Perindustrian Malaysia (SIRIM) serta Institut Penyelidikan Perhuta-

Prospect for Future

What else?

1. Biocomposites
2. Nanocomposites
3. Aerospaces

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Thank you