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BIO-SOURCE COMPOSITE MATERIALS USED IN AUTOMOTIVE INDUSTRY

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Abstract: *The current paper is a review of bio-source composite used in automotive industry. It presents the vehicle parts made of bio-source composite and the main advantages that are obtained from the use of them. Studies indicate that a vehicle weight reduction of 10% leads to a benefit of 3% to 7% of fuel consumption and a reduction of 100 kg ensures a decrees of CO_2 emission with 10g/km. Bio-source materials help in weight reduction and in respecting European norms of Vehicle End of Life Directive. Flax and hemp are used in the interior door panels, back set shell, armrests and floor panels.*
Key words: *Bio-source material, composite, automotive, flax fibers, weight reduction*

INTRODUCTION

Weight reduction of the vehicle is a strategy well known for improving the fuel consumption of motor vehicles and represents a significant opportunity to reduce the consumption of fuel in the transport sector. By reducing the mass of the vehicle, the forces of inertia on which the engine must overcome are smaller, and the power required moving the vehicle is thus reduced.
Studies indicate that a weight reduction of 10% leads to a benefit of 3% to 7% of fuel consumption per type of car and driving type used. This effect is stronger in the case of engines of smaller size. On average, a weight reduction of 100 kg ensures a decrease in the emission of CO_2 by 10g/km [1].
A key material, lightweight, used widely to reduce the weight of vehicles is plastic. The front bumper, the cover of the engine and fuel tanks, are 1,4 kg, 2 kg and 5 kg, lighter when compared to traditional materials. In 2005, the automotive industry in Europe has increased the use of plastic materials up to approximately 140kg [2]. Plastic materials and polymeric composites currently constitute about 10% of a vehicle by weight and 50% by volume, and these numbers are expected to grow slowly. The main factors restricting the growth of polymeric composites in vehicles today are in production time and the cost of fibers. The most widely used type of composite in auto industry is thermoplastic, polypropylene, reinforced with glass fibers, which is applied to the rear hatch, roof, interior door panels, structural door and dashboard. Other types include laminated thermoplastics, laminated compounds made from glass fiber and polyester. Polymeric composites reinforced with carbon fibers (CFRP) are more expensive and less popular, although they offer significant resistance and weight-saving benefits. In their concept car of mid-size the Rocky Mountain Institute has used CFRP to achieve a car body lighter with 60% than that of a conventional steel car. However, carbon fibers price is higher than glass fibers (carbon fiber price: 13-22$ per kilogram, compared to 1-11$ per kg for glass fibers). Their use is usually restricted to low-volume applications in luxury vehicles. A successful application in mass production of vehicles is the crankshaft made of carbon fiber.
In 2010 Mazda Design America team participated in a challenge to the Auto Show from Los Angeles using a design concept to reduce weight for MX-0 range from 900 kg to less than 500 kg, using materials supplied by Bayer MaterialScience SRL (polyurethane composite materials). The idea was to present a design for the future path for vehicle weight reduction using materials that can be mass-produced today.

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Composite reinforced with natural fibers and/or biopolymers have developed significantly over the past years because of their significant processing advantages, biodegradability, low cost, low relative density, high specific strength and renewable nature. These composites are predestined to find more and more application in the near future, especially in Europe, where pressure from both legislation and the public is rising. Interfacial adhesion between natural fibers and matrix will remain the key issue in terms of overall performance, since it dictates the final properties of the composites.

BIOMATERIALS

There are many examples of use of bio-source materials in automotive components. Beyond traditional uses, such as wood, cotton, textile and leather seats there are two main uses: as reinforcement fibers or filling, or to create polymers.
Bio-based composites are reinforced or filled with natural fibers, including bast fibers, originating from the stem of plants (such as hemp, flax and jute).
Bio-polymers can be obtained from a variety of sources, including soybean, castor oil plant, corn or sugar cane. These raw materials are, usually, fermented and passes through a series of conversions to produce polymers that can be used in plastic composites. Just like conventional polymers, bio-polymers can be extruded, molded, injected, expanded or thermoformed.
Flax and hemp are used in the interior door panels, back set shell, armrests and floor panels. Coconut fibers and bio-foams have been used for making chairs, headrests and headrest. Cotton and other natural fibers have been shown to provide superior soundproofing properties and are used in interior components.
Composite materials based on bio-degradable sources generally are used in two ways: as a replacement for petroleum-based polymer or as a replacement for synthetic fibers (such as glass fibers). When using a locally sourced product, bio-degradable, it appears a carbon emission reduction, due to the removal of transportation of petroleum-based materials.
Because bio-source fibers tend to be less dense than traditional fibers (such as glass), components that use these materials are lighter than conventional ones.
Bio-composite materials tend to absorb the impact energy, as opposed to composite materials based on mineral fibers, which tend to break, making them safer for the occupants of the vehicle in case of an accident.
Some authors highlight that natural fibers require less energy consumption during production process (11.4 MJ/kg) compared to glass fibers (48.3 MJ/kg). This leads to reducing environmental impact with 23% [4].
It was demonstrated that absorption of water drops, permanently, the resistance of parts made from bio-source materials, which limits their use in outdoor applications. Therefore, class A surfaces (areas inside the machine), are likely to use a bio-source composite.
On August 14, 1941, at the 15th Annual Dearborn Michigan Homecoming Day celebration, Henry Ford unveiled his biological car. Seventy percent of the body of the cream-colored automobile consisted of a mat of long and short fibers from field straw, cotton linters, hemp, flax, ramie and slash pine. The other 30 percent consisted of a filler of soymeal and a liquid bioresin [8].
Ford Headrests have a content of soybeans between 13% and 26% in volume. Reinforced polypropylene composite with hemp fiber, used by Chrysler is composed of 25% hemp and 25% jute. Some Ford vehicles contain doors with interior door panels with 50% flax fiber, while the BMW inner door panel is composed of an acrylic polymer with 70% hemp fiber (tab. 1).
Cooling tank for the heat sink used by Toyota and the fuel pipes of Fiat diesel engine has bio-source content of 40-60%.
Innovations in bio-source composites:

- Ford Motor Co., 2010 FordFlexCUV - trim (PP reinforced with wheat straw);
- BMW 2008 MY BMW 7 Series Sedan - door panel (prepreg of natural fibers with acrylic polymer);
- Rilsan® HT, a polyamide in the polyphthalamides (PPA) family, also partially bio-based, combining for the first time "ultra flexibility" and resistance to high temperatures. These characteristics allow it to replace metal and rubber used in tubular applications in car engines. It

thus helps to reduce the weight of vehicles and reduce fuel consumption [9]. Produced from castor oil, Rilsan® PA11 is a polymer of 100% renewable origin. This bio-based feature is another major asset for Rilsan®.

Table 1. Percentage of reinforcement for various applications of the bio-source composite.

Model	Fibers	Material	Application	reinforcement (Bio-source)
BMW 7 series	Hemp	Acrylic polymer	Interior door panel	70%
Chrysler Sebring	Hemp, Jute	Polypropilena	Interior door panel	50%
Ford Fiesta and Focus	Jute	Polypropilena	Interior door panel	50%
The Ford Fusion and Lincoln MKZ	Soy	Polyuretan	Headrests	13-26%
Nissan Leaf	Corn	Sorona	Rugs/Mats	20-35%
Toyota	-	Nylon bio-source	Cooling vessel	40-60%

A few years ago, Ford introduced the U model, which included several bio-source components, including chairs of soy-based foam, door panels, corn-based mats, sealing material (tissue). Ford uses in the current vehicles produced for North America chairs of soy-based foam in vehicles.
Mercedes-Benz has incorporated a wide variety of natural fibers in its vehicles, including flax, hemp, jute, wool and cotton. They were used for various components such as: covers, seat backs, caps, lids, shelves, rear doors panels.
At the end of 2009, Faurecia has introduced *Clean* range of products focused on an approach which is cleaner and easier for the automotive industry. This leads to a relief of the vehicle with about 30 kg, wanting in the near future a reduction in vehicle weight up to 60 kg through the use of natural fibers and biomaterials in parts for future models. New technology *Lignolight* allows mixing of 70% wood fibers with 30% resin within the door panels. They become lighter by about 40%.
Similarly the company Toyota has developed an environment-friendly material used in their third generation model of Toyota Prius. Using the manufacturing process *Ingeo* to reduce the use of fossil fuels by up to 65%, reducing the emission of CO_2 by up to 95%.
Natural fiber producers from North America already supplies for automobile producing firms bio-source materials for use in components such as door panels or dashboard.
An outside the car use of flax fibers shows at Toyota, which uses these fibers to replace asbestos fibers used in brake discs.
AFT Plasturgie produces compounds of PP reinforced with hemp fiber in a percentage of 20 to 40% for the automotive parts manufacturing (valves, rear view mirror support, battery box, sealing profiles, air intake system-Figure 1) [5].

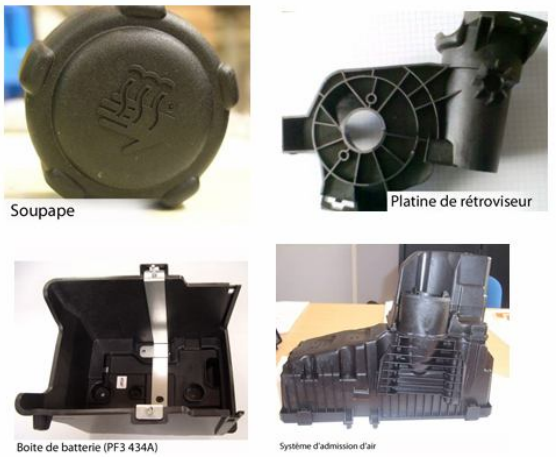

Figure 1. Bio-source fiber reinforced parts produced by AFT Plasturgie [5].

The European Industrial Hemp Association [6] concluded in their report, that all plastic reinforced with hemp fiber has advantages like: low level of energy required to produce them, and also a low level of greenhouse gas emissions at the end of life, in comparison with plastic reinforced with glass fibers. An example of a part obtained from bio-source composite is shown in Fig. 2.

Figure 2. Door panel made of hemp fibers and epoxy resin [6].

Recent work on the composites reinforced with flax fiber, have shown that the mechanical properties of composites reinforced with flax fibers are comparable to those of composites reinforced with glass fibers.
In terms of their long-term use, as a substitute for synthetic fibers, natural fibers requires further studies that focus on improving the adhesion between fiber and matrix and the dimensional stability improvement of fiber.
Most automobile manufacturers have not specified what percentage of plastic parts reinforced with synthetic fibers will replace with composite bio-source or bio-composite. Toyota is one of those that have announced that they plan to change 20% of the plastic parts with bio-source parts by 2015.

CONCLUSIONS

The current paper is a review of bio-source composite used in automotive industry. It presents the vehicle parts made of bio-source composite and the main advantages that are obtained from the use of them.
Weight reduction of the vehicle is a strategy well known for improving the fuel consumption of motor vehicles and represents a significant opportunity to reduce the consumption of fuel in the transport sector.
There are many examples of use of bio-source materials in automotive components. Beyond traditional uses, such as wood, cotton, textile and leather seats there are two main uses: as reinforcement fibers or filling, or to create polymers.
An objective of the research world is to integrate the biodegradables reinforcements in composite materials as much as possible. The vegetable fibers are a renewable and recyclable source, fully combustible and the fabrication process requires less energy consumption then for elaboration of mineral fibers. Especially, some biodegradables fibers (i.e. flax and hemp) can offer specific mechanical properties (mechanical properties divided to the density of the fiber) comparable with those of glass fibers because of their low density.
Composite reinforced with natural fibers and/or biopolymers have developed significantly over the past years because of their significant processing advantages, biodegradability, low cost, low relative density, high specific strength and renewable nature. These composites are predestined to find more and more application in the near future, especially in Europe, where pressure from both legislation and the public is rising. Interfacial adhesion between natural fibers and matrix will remain the key issue in terms of overall performance, since it dictates the final properties of the composites.

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