DEVELOPMENT OF BIOPLASTIC AND LIGNOCELLULOSIC FOR GREEN COMPOSITES MATERIALS: INDUSTRIAL APPLICATION

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INTRODUCTION

Bioplastics are used in an increasing number of markets, from packaging, catering products, consumer electronics, automotive, agriculture/horticulture and toys to textiles and a number of other segments. Packaging remains the largest field of application for bioplastics with almost 60 percent (1.2 million tonnes) of the total bioplastics market in 2017. The increase in the use of bioplastics in all market segments is driven by the increasing demand for sustainable products by consumers and brands alike due to a growing awareness of the impact on the environment and the need to reduce the dependency on fossil resources as well as the continuous advancements and innovations of the bioplastics industry in new materials with improved properties and new functionalities. The budding bioplastics industry hast he potential to unfold an immense economic impact over the coming decades. According to a recent job market analysis conducted by (EuropaBio, 2016), the European bioplastics industry could realise a steep employment growth. In 2013, the bioplastics industry accounted for around 23,000 jobs in Europe.

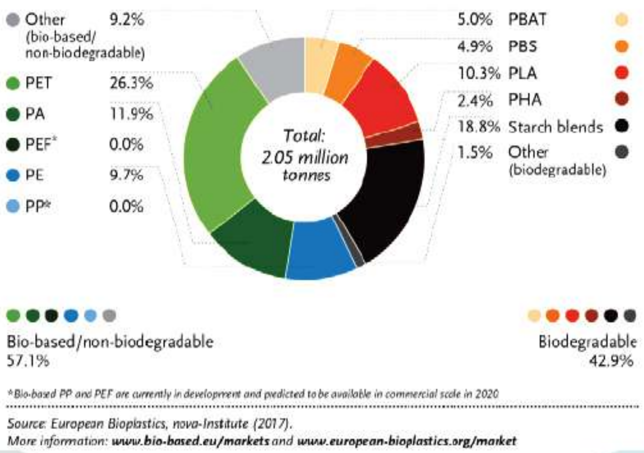

Fig. 1. Global production capacities of bioplastics in 2017 (by material type)

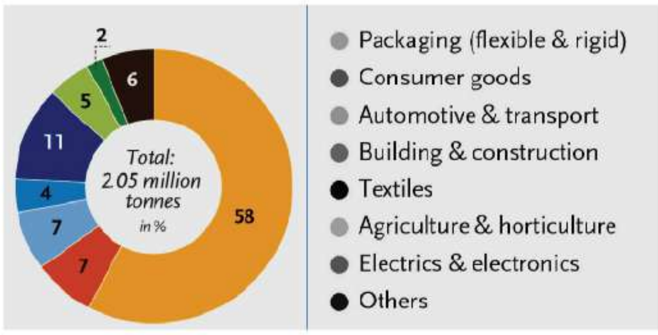

Fig.2. Global production capacities of bioplastics in 2017 (by market segment)

Bioplastics are used in an increasing number of markets, from packaging, catering products, consumer electronics, automotive, agriculture/horticulture and toys to textiles and a number of other segments. Packaging remains the largest field of application for bioplastics with almost 60 percent (1.2 million tonnes) of the total bioplastics market in 2017. Industrial uses of natural fibers increasingly gain attention from various manufacturing sectors. The use of natural fibers for polymer composites is growing rapidly to meet diverse end uses in transportation, low cost building, and other construction industries (Hao et al., 2013). Qualities of natural fibers are strongly influenced by growing environment, age of plant, species, temperature, humidity, and quality of soil. Various fields where natural fibers can be employed are: structural composites, automobile, non-structural composites, geotextiles, packaging, molded products, sorbents, filters, and in combinations with other materials. Apart from the plant-based fibers become other alternatives for producing biodegradable, biomedical and bio-resorbable composite materials for bioengineering and orthopaedic applications.

LIGNOCELLULOSIC FIBRES

Natural fiber is a type of renewable sources and a new generation of reinforcements and supplements for polymer based materials. The development of natural fiber composite materials or environmentally friendly composites has been a hot topic recently due to the increasing environmental awareness. Natural fibers are one such proficient material which replaces the synthetic materials and its related products for the less weight and energy conservation applications. The application of natural fiber reinforced polymer composites and natural-based resins for replacing existing synthetic polymer or glass fiber reinforced materials in huge.

Kenaf (*Hibiscus cannabinus* L. family Malvacea) has been found to be an important source of fiber for composites,and other industrial applications. Kenaf is well known as a cellulosic source with both economic and ecological advantages; in 3 month (after sowing the seeds), it is able to grow under a wide range of weather conditions, to a height of more than 3 m and a base diameter of 3 - 5 cm. The kenaf plant is composed of many useful components (e.g., stalks, leaves, and seeds) and within each of these there are various usable portions (e.g., fibers and fiber strands, proteins, oils, and allelopathic chemicals). The yield and composition of these plant components can be affected by many factors, including cultivar, planting date, photosensitivity, length of growing season, plant populations, and plant maturity. Kenaf filaments consist of discrete individual fibers, of generally 2 - 6 mm (Akil et al.,2011). Kenaf is presently being used in paper production on a very limited basis. Various uses of the bast fibers have been explored, such as in the making of industrial socks to absorb oil spills, as well as making woven and non-woven textiles. The kenaf bast fiber is known to have the potential as a reinforcing fiber in thermoplastic composites, because of its superior toughness and high aspect ratio in comparison to other fibers.


Kenaf Tree


Bast Kenaf Fibres

Oil palm (Elaeis guineensis Jacq.) is the highest yielding edible oil crop in the world. It is cultivated in 42 countries in 11 million ha worldwide. West Africa, South East Asian countries like Malaysia and Indonesia, Latin American countries and India are the major oil palm cultivating countries (Shinoj et al., 2011). Oil palm is the largest and important plantation crop in Malaysia. The oil palm trees generally could last between 25-30 years before the next replantation needs to be done. With this replantation cycle, the huge amount of available biomass is available and not being fully utilized and normally left to rot naturally. This readily available renewable resource could be used as a raw material for wood based industry. Empty Fruit Bunch (EFB) is one of the oil palm biomass material. The EFB amounting to 12.4 million t year–1 (fresh weight) and regularly discharged from oil palm refineries (Abdul Khalil et al., 2006). It is a lignocellulosic material and has potential as the natural fibre resource. Moisture content of fresh EFB is very high, about over 60% on a wet EFB basis. As EFB is readily available and abundance in Malaysia, converting them into composite boards can be a way to resolve the scarcity of wood sources.


Oil Palm Tree


Bamboo Fibres

APPLICATION OF LIGNOCELLULOSIC IN INDUSTRY

Automatives part

Natural fibers reinforced composites are emerging very rapidly as the potential substitute to the metal or ceramic based materials in applications that also include automotive, aerospace, marine, sporting goods and electronic industries (Thakur and Thakur, 2014). Natural fiber composites exhibit good specific properties, but there is high variability in their properties. Their weakness can and will be overcome with the development of more advanced processing of natural fiber and their composites. Their individual properties should be a solid base to generate new applications and opportunities for biocomposites or natural fiber composites in the 21st century "green" materials environment. The exploitation of natural fiber composites in various applications has opened up new avenues for both academicians as well as industries to manufacture a sustainable module for future application of natural fiber composites (Gurunathan et al., 2015).

The automobile industry is successfully applying composites reinforced with a variety of natural fiber to replace components such as interior panels and seat cushions originally made of glass mat PMC or polymeric foams (Monteiro et al., 2009). Many automotive components are already produced with natural composites, mainly based on polyester or Polypropylene and fibers like flax, hemp, or sisal. The adoption of natural fiber composites in this industry is led by motives of price, weight reduction, and marketing rather than technical demands (Saravan and Mohar, 2010). Germany is a eader in the use of natural fiber composites. The Germanauto-manufacturers, Mercedes, BMW, Audi and Volkswagen have taken the initiative to introduce natural fiber composites for interior and exterior applications.(Sanjay) The automobile industry is successfully applying composites reinforced with a variety of natural fiber to replace components such as interior panels and seat cushions originally made of glass mat PMC or polymeric foams (Monteiro et al., 2009).

Interior part: Dashboard

Interior part: Door frame

Wood Plastic Composites (WPC)

Thermoplastic green composites can be obtained only with limited fiber loading (maximum 50%w/w). This is due to techniques available for thermoplastic composite manufacturing that hinder good fiber dispersion in a high viscosity matrix when the fiber content is higher than 50%. Interestingly, thermoplastic green composites can be processed by means of the standard and economic equipments used for plastic manufacturing such as compounding and injection molding. However, these techniques have the limitation that only relatively short fibers (which impart limited reinforcing effect) can be used. If longer fibers are to be included, compression molding methods need to be used. In the automotive industry, for example, long natural fibers are generally mingled together with fibers of the thermoplastic polymer to form a nonwoven fleece, which is subsequently hot pressed in order to promote melting of the thermoplastic fibers (Fowler et al., 2006).

Food Packaging

Packaging is currently at the centre of intensive research among scientists concerning new technologies that include the development of environmental friendly packaging materials that interact well with foods in terms of preservation. To provide a positive impact on consumer health, the packaging is designed by integrating functional ingredients in the structure of the packaging with the packed food products (Chen, 2014). New developments in packaging technology have been fuelled by developments in materials engineering, electronics and processing technology which involve some key areas including high barrier materials, active packaging, intelligent packaging, nanotechnology, tagging applications and digital print for packaging that are important for the growth of packaging industry (Nomikos, 2005). Most challenging aspect of packaging research is to develop and promote the use of renewable and biodegradable "bio-plastic" which can commercially replace petroleum based plastics and thus help in reducing waste disposal problem. However, biopolymers based packaging has relatively poor mechanical and barrier properties than non-biodegradable counterparts which currently limit their industrial use.

Although extensive research is being undertaken, the nanotechnology approach for packaging applications is still in the development stage. The main focus is to examine the complete lifecycle of the packaging (raw material selection, production, analysis of interaction with food, use and disposal) while integrating and balancing cost, performance and impact on health and environment. Cellulose nanofibre has been considered as a remarkable engineering material because of its high abundance, low weight, high strength, stiffness and biodegradability (Khalil, 2014). The use of cellulose nanofibre adequately enhanced the mechanical and barrier properties of cellulosic fibre based products (e.g., papers, biocomposites). Cellulose nanofibres are derived from natural resources (wood or plant) thus they are almost inexhaustible, renewable and globally abundant (Kalia, 2011). Studies have demonstrated that the use of nanocellulosic based materials as reinfor-cing elements in various bio-based polymeric composites enhanced the mechanical and functional properties of the composite, such as their biodegradability, transparency, gas barrier properties,specific surface area and heat stability (Li, 2014). Beside improvement in properties of food packaging nanomaterials will also prevent the invasion of bacteria and microbes into packed food products through packaging. Polymers with cellulosic fibre/ nanoclay based hybrid materials would provide high barrier, short life, easy disposal and environmentally compatible properties for food packaging materials.

CONCLUSION

Natural fibers are one such proficient material which replaces the synthetic materials and its related products for the less weight and energy conservation applications. The application of natural fiber reinforced polymer composites and natural-based resins for replacing existing synthetic polymer or glass fiber reinforced materials in huge. Cellulose nanofibre neither interferes with the human food chain nor uses petrochemical components for its functionality. Therefore, nanocellulosic fibres have been utilized in a wide range of applications. Packaging sector could be one of the area were cellulose nanofibres can be used for sustainable and green packaging.

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