Journal of
Chemical Engineering & Process Technology

Chauhan and Chauhan, J Chem Eng Process Technol 2013, S6
DOI: 10.4172/2157-7048.S6-001

Review Article Open Access

Natural Fibers and Biopolymer

Ashish Chauhan[1]* and Priyanka Chauhan[2]

[1]*B. R. A. National Institute of Technology, Jalandhar (Pb), India*
[2]*Shikhar S. Sadan, Dhampur (U.P.), India*

Abstract

In recent years, there have been a tremendous increase in interest, research and development in the natural fiber, biopolymers and polymers materials for their use in bio-composite, packaging, agriculture, medicine etc. Many scientists are modifying traditional materials to more user-friendly and novel polymer composites out of naturally occurring materials. Low recycling rates and the high volume of non-degradable plastics have shortened dramatically the life expectancy of current commercial landfills and increased the demand of biodegradable plastic packaging materials. A number of biological materials may be incorporated into biodegradable polymer materials like cellulose, starch and fiber extracted from various plants. The aim behind these judicious and planned efforts are to procure and promote the biodegradable polymer materials that would reduce the need for the synthetic polymer production while reducing the pollution at a lower cost . This paper provides an insight to the progress in process in the field of the utilization of natural fiber and biodegradable polymer.

Keywords: Natural fiber; Polymer; Biodegradable; Biopolymer; Plastic

Introduction

There has been a tremendous increase in attention, research and development for the natural fiber, biopolymers and polymers materials for their use in bio-composite, packaging, agriculture, medicine etc. Many scientists are modifying traditional natural fibers and polymer to more user-friendly and novel polymer composites and advanced materials. Low recycling rates and the high volume of non-degradable plastics have shortened dramatically the life expectancy of current commercial landfills and increased the demand of biodegradable plastic packaging materials. Various biological and natural ingredients materials may be reinforced into biodegradable polymer materials like cellulose, starch, chitosan, chitin, protein and fiber extracted from various sources. The aim behind these judicious and planned efforts are to procure and promote the efficient and advanced biodegradable polymer materials that would decrease the need of synthetic polymer production and reduce the environmental pollution at a lower rate. This paper provides an insight to the progress in process in the field of the utilization of natural fiber and biodegradable polymer.

Natural Fiber

Natural Fiber and biopolymers play a key role in the advancement of technology through environment safety. Natural fiber serve various roles but most importantly as fillers. Natural filler, fibers and biological materials may be reinforced into the synthetic plastic matrices as degradable component. Macromolecules like starch may be added to polyethylene to improve its biodegradation property. It can be used in gelatinized form as well [1]. Heating of the starch in the presence of water during extrusion or injection moulding leads to the formation of a thermoplastic material that may be deformed during blending. This starch-based product is then blended with either natural or synthetic materials. Heating of starch above its glass transition temperature breaks its molecular structure that further leads to bonding. Glycerol may often be used as a plasticizer in starch blends, to increase softness and pliability. Starch granules that are plasticized with water and glycerol are referred as plasticized starches [2,3]. Plastic materials that are created from starch based blends may be easily either injection molded, extruded, blown or compression molded. Agricultural waste and biomass used for the biopolymer industry also includes fiber as reinforcing filler. This class also includes cellulose, flax and hemp fibers [4]. Natural cellulose fibers are economic, readily available, biodegradable, low weight and have effective tensile strength. These properties make cellulose fibers the preferred choice as natural fillers in plastic materials. Hornsby et al. [5] observed that the presence of cellulose fibers in a polypropylene matrix based materials causes a marked increase in its tensile modulus. Cellulose is the most abundant carbohydrate that has a very long molecular chain, which is insoluble in all solvents [6]. Therefore, it is most often converted into derivatives to enhance solubility that could further improve adhesion within

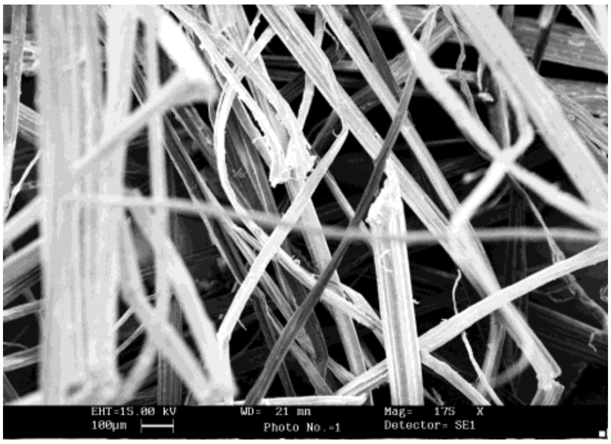

Figure 1: SEM of *H. sabdariffa* fiber.

***Corresponding author:** Ashish Chauhan, B. R. A. National Institute of Technology, Jalandhar (Pb), India, Tel: +91-9464616773; E-mail: aashishchauhan26@gmail.com

Received April 16, 2013; **Accepted** May 02, 2013; **Published** May 06, 2013

Citation: Chauhan A, Chauhan P (2013) Natural Fibers and Biopolymer. J Chem Eng Process Technol S6: 001. doi:10.4172/2157-7048.S6-001

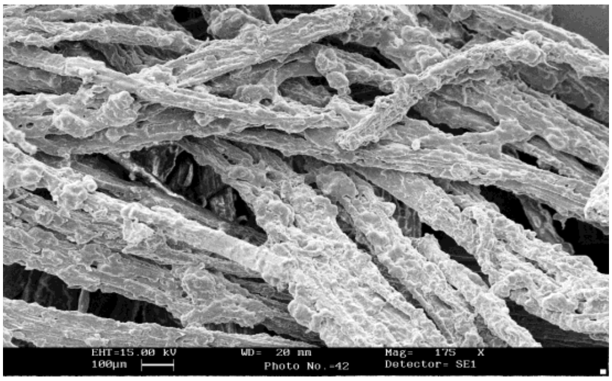

Figure 2: SEM of *Hs*-g-poly (Vinyl Monomers).

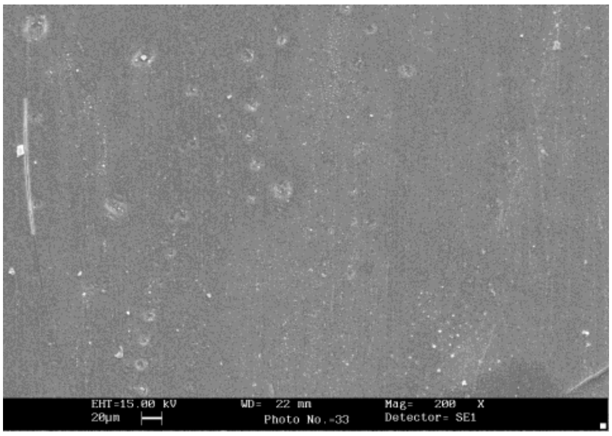

Figure 3: SEM of P-F resin.

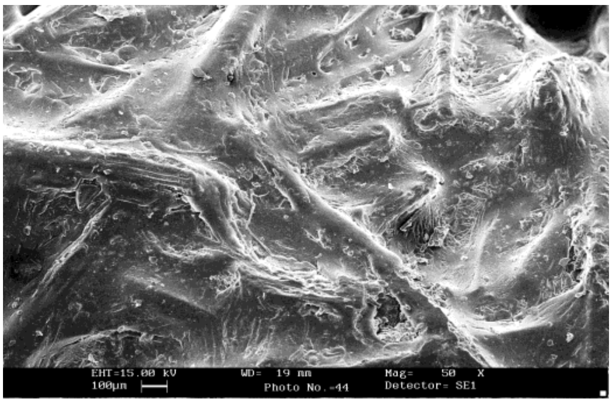

Figure 4: SEM of *Hs*-reinforced-PF composite.

the matrix. Researchers are keenly in expanding the area of fiber use in biopolymer products, as this would uplift the value added prospects and processing of local agricultural waste products. Flax and *Hibiscus* fibers are the centre of focus for the polymer scientists due to their mechanical strength and availability. Chemical treatment like silylation, benzoylation, acetylation of the fibers is performed in order to modify the surface properties, without changing its inherent traits, the fiber structure and morphology [7]. This modification decreases the degradation of the fibers and enhances the adhesion between the fiber and matrix interface. Bledzki et al. [8] reported that fibers that have been properly dried and dehydrated prior to their addition in the matrix show significantly improved adhesion as compared to fibers with higher moisture content. Chauhan et al. [9-15] used the *Hibiscus sabdariffa* stem fiber as backbone for graft copolymerization and procured novel materials. They further used the raw (Figure 1) and grafted fiber (Figure 2) as reinforcement in polymer matrix (Figure 3) based composite for use in various fields (Figure 4). However, many attempts are being made to utilize the natural fiber in the formation of advanced biomaterials, bio composites and green composites while keeping into consideration its biodegradation and environmental safety.

Biopolymers

Biopolymers have proved to be multi specialty entity for their diverse application in various fields. It has been reported that polyvinyl alcohol is an effective polymer for use as matrix in fiber reinforced composites, due to its highly polar and biodegradable character. Microbial biopolymer feedstocks produce biological polymers through microbial fermentation as these products easily decompose and are environment friendly materials [16,17]. It has been noticed that a number of bacteria accumulate polyhydroxy alkanoates (PHAs) as intracellular carbon reserves when nutrient deficiencies occur. It was observed that increasing the carbon to nitrogen (C:N) ratio in a chemically waste water treatment system elevated the growth of specific polymer yield that inculcated the production of PHA [16]. Researchers reinstate that any type of biomass can be converted into sugars through chemical or biological treatments and certain organisms convert these sugars to PHA. Waste food materials could also be converted into PHA PHA is brittle and expensive when used alone, so researchers opt to mix them with less expensive polymers that have complementary properties to get fruitful results. Polylactic acid is the next promising biopolymer that is obtained by microbial fermentation. It is achieved by condensation of lactic acid after fermentation [3]. The carbon content stored in the plant as starches could be converted to sugars. Fermentation and separation forms the PLA. PHA and PLA are both considered synthetic polymers as they are not found in nature but are fully biodegradable [18,19]. Wheat is rich source of starch and gluten that are employed by the biopolymer industry. Similarly, Canola derivatives have the potential both as polymers and plasticizers [20]. Chitosan that is obtained by the deacetylation of chitin that is found in marine environments. It is dissolved in acidic solutions prior to it's incorporated into biodegradable polymer films as it is insoluble in water. The soy proteins have immense potential for industrial applications in plastics and reinforced composite materials. Many naturally occurring organisms both plant and animal have the potential to be modified and employed as biopolymers [21].

Usefulness of Natural fiber and Polymer for Environment

Scientists are integrating environmental considerations prior to materials processing so as to meet an ever increasing awareness and urgent need to protect the environment [22,23]. When food packaging enters the municipal waste stream, it becomes a major source of household refuse which is disposed to landfill sites. When recycling or re-processing of these materials is not environmentally sound, composting of suitable packaging waste may be a viable alternative. Packaging waste can be collected directly from households with kitchen and garden waste and composted in municipal composting facilities, or could potentially be composted in home compost bins, provided that they are compostable under such conditions. Significant improvement has been seen in recycling pulp based packaging materials. The difficulties associated with collection, identification, sorting, transportation, cleaning and processing of plastic materials render the recycling for these materials to be time consuming, uneconomic whereas land filling is considered a convenient disposal method. Recycling of plastic waste is encouraged and well know technique, but all in vain. Currently, about 10% of plastic products are recycled after use [24]. Regeneration must be promoted as a disposal technique. In underdeveloped countries plastics are completely recycled as the return on investment is positive that makes it judicious and economic method. The emission of toxic gases during this recycling is now a challenge for scientists. The use of plastics based on renewable feed stocks that are biodegraded is a better choice than recycling plastics waste products, since the end products are organic matter that avoids toxic emissions to the surrounding. Therefore, we should strive to obtain plastics which are compostable or degraded must be encouraged. When biopolymers are disposed off in landfill environments, we hope that the necessary microorganisms will be present but this may not always be the case. Inoculation with bacteria, fungi and actinomycetes is effective in encouraging biopolymer degradation within soil [25,26]. Compostable plastics undergo biological degradation to give carbon dioxide, water, inorganic compounds and biomass at a rate consistent without leaving toxic residues [26]. The requirements of biopolymers in industrial composters are complete biodegradation and disintegration, such that there may be no effect on compost quality as a result of biopolymer degradation. It was observed that odor emissions from compost piles are reduced when biodegradable plastic is reinforced or mixed. Ammonia, a noxious gas, is produced by the decomposition of compost. The degradation of biodegradable plastics produces acidic intermediates neutralize the ammonia content and reduce the odor [27]. As the biopolymer and natural fiber based industry grows, problems associated with production are getting sorted out. Multilayer films containing starch and natural fibers face the challenge of adhesion problems [3,7]. The search for an ideal processing technique to circumvent this problem continues. Additional starch content in thermoplastic blends increases flexibility but decreases mechanical strength. There exists a direct co-relation between processing technique, structure and properties of starch based materials. ASTM and ISO elaborate the details on biodegradable plastic materials [28,29]. The industries based on utilization of natural fiber and polymers are striving for excellence and have bright future prospects, driven mainly by the environmental concerns of using renewable resource. The ultimate goal for these attempts in research and development are to pay a way to procure and inculcate these advanced material with optimum technical performance and full biodegradability [29].

Conclusions

There are a seemingly limitless number of areas where biodegradable polymer materials may find its use. The sectors of agriculture, automotives, medicine, and packaging all require environmentally friendly polymers. Environmental responsibility is constantly increasing in importance to both consumers and industry. Biopolymers limit carbon dioxide emissions during creation, and degrade to organic matter after disposal. Biodegradable plastics containing starch and/or cellulose fibers appear to be the most likely to experience continual growth in usage. We hope upcoming scientist and research could find better solutions to environmental challenges and give fruitful results in the form of efficacious and advanced green materials.

References

1. Verhoogt H, Truchon F, Favis B, St-Pierre N, Ramsay B (1995) Morphology and mechanical properties of blends containing thermoplastic starch and PHB.
2. Martin O, Schwach E, Averous L, Couturier Y (2001) Properties of biodegradable multilayer films based on plasticized wheat starch. Starch 53: 372-380.
3. Jopski T (1993) Biodegradable plastics. Starch 83: 17-20.
4. Bismarck A, Aranberri-Askargorta I, Springer J, Lampke T, Wielage B, et al. (2002) Surface characterization of flax, hemp, and cellulose fibers; Surface properties and the water uptake behavior. Polymer Composites 23: 872-894.
5. Hornsby P, Hinrichsen E, Tarverdi K (1997) Mechanical properties of polypropylene composites reinforced with wheat and flax straw fibers. Journal of Materials Science 32: 443-449.
6. Chandra R, Rustgi R (1998) Biodegradable polymers. Prog Polym Sci 23: 1273-1335.
7. Frisoni G, Baiardo M, Scandola M (2001) Natural cellulose fibers: Heterogeneous acetylation kinetics and biodegradation behavior. Biomacromolecules 2: 476-482.
8. Bledzki AK, Gassan J (1999) Composites reinforced with cellulose based fibers. Progress In Polymer Science 24: 221-274.
9. Chauhan A, Kaith B (2011) Synthesis, Characterization and Chemical studies of Hibiscus sabdariffa-g-copolymers. Fibers and Polymers 12: 1-7.
10. Kaith BS, Chauhan A, Singha AS, Pathania D (2009) Induction of the morphological changes in Hibiscus sabdariffa fiber on graft copolymerization with Binary vinyl monomer mixtures. Inter Jour Polym Anal Characterization 14: 246-258.
11. Chauhan A, Kaith B (2011) Thermal and Chemical studies of Hibiscus sabdariffa-graft-(Vinyl monomers). International Journal of Polymeric Materials 60: 837-851.
12. Chauhan A, Kaith B (2011) Development and Assessment of the Advanced Graft obtained from Hibiscus sabdariffa biomass. Journal of Applied Polymer Science 123: 1650-1657.
13. Chauhan A, Kaith B (2012) Versatile Roselle Graft-Copolymers : Xrd Studies and their Mechanical Evaluation After use as Reinforcement In Composites. J Chil Chem Soc 57: 1262-1266.
14. Chauhan A, Kaith B (2012) Exploring the viability of Modified Cellulosic Polymer and its use as reinforcement to obtain Green Composite by Advanced Analytical and Evaluation Techniques. J Anal Bioanal Techniques 3: 1-6.
15. Chauhan A, Kaith B (2013) Fabrication and Physico-chemico-thermo-mechanical Accreditation of Green Composite. J Bioremed Biodeg 4: 1-6.
16. Chau H, Yu PHF (1999) Production of biodegradable plastics from chemical wastewater – A novel method to reduce excess activated sludge generated from industrial waste water treatment. Water Science and Technology 39: 273-280.
17. Chiellini E, Cinelli P, Imam S, Mao L (2001) Composite films based on biorelated agro-industrial waste and Poly(Vinyl Alcohol). Preparation and mechanical properties characterization. Biomacromolecules 2: 1029-1037.
18. Stevens ES (2003) What makes green plastics green? Biocycle 44: 24-27.
19. Petkewich R (2003) Microbes manufacture plastic from food waste. Environ Sci Technol 5: 175A-176A.
20. Crawford C (2001) Developing Biobased Industries In Canada. Federal Biomass/Bioenergy Strategy Framework (AAFC & NRCan).
21. Park SY, Lee BI, Jung ST, Park JH (2001) Biopolymer composite films based on k-carrageenan and chitosan. Materials Research Bulletin 36: 511-519.
22. Thurston D, Lloyd S, Wallace J (1994) Considering consumer preferences for environmental protection in material selection. Materials & Design 15: 203-209.
23. Orhan Y, Buyukgungor H (2000) Enhancement of biodegradability of disposable polyethylene in controlled biological soil. International Bio deterioration and Biodegradation 45: 49-55.
24. Swift G (1998) Requirements for biodegradable water soluble polymers. Polymer Degradation and Stability 59: 19-24.
25. ASTM Subcommittee (1998) Standard Terminology Relating to Dynamic Mechanical Measurements on Plastics. American Society for Testing and Materials, USA.

26. Nakasaki K, Ohtaki A, Takano H (2000) Biodegradable plastic reduces ammonia emissions during composting. Polymer Degradation and Stability 70: 185-188.

27. Van Soest J, Kortleve P (1999) The influence of maltodextrins on the structure and properties of compression molded starch plastic sheets. Journal of Applied Polymer Science 74: 2207-2219.

28. Nechwatal A, Mieck K, Reubmann T (2003) Developments in the characteristics of naturalfiber properties and in the use of natural fibers for composites. Composites Science and Technology 63: 1273-1279.

29. Chauhan A, Kaith B (2012) UUsing the Advanced Analytical Techniques to Investigating the Versatile Cellulosic Graft copolymers. Journal of Analytical and Bio-Analytical Techniques 3: 7-14.

This article was originally published in a special issue, **Natural Fibers** handled by Editor(s). Dr. Ashish Chauhan, National Institute of Pharmaceutical Education and Research (NIPER), India