บรรณาธิการปริทัศน์/Editorial Corner

โอกาสของอุตสาหกรรมกระบวนการกลั่นชีวภาพในการก้าวไปสู่เศรษฐกิจหมุนเวียน: กรณีศึกษาของคอมโพสิตชีวภาพ

Opportunity of Biorefinery Industry towards Circular Economy: Bio-composites Case Study

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ภาควิชาวิศวกรรมวัสดุและการผลิต บัณฑิตวิทยาลัยวิศวกรรมศาสตร์ไทย-เยอรมันนานาชาติสิรินธร มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าพระนครเหนือ

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Bio-composites, also known as green composites, produced from renewable resources are an encouraging solution for sustainable development. These materials have several social, economic, and environmental advantages over conventional petroleum-based composites. Recent studies aim to enhance the durability, performance, and ecological footprint of biocomposites, with the ultimate goal of less carbon emissions. [1]. Bio-composites are created by combining two essential materials: natural fibers and a biopolymer matrix. Natural fibers as a reinforcing part play an important role as they can withstand stress and high load. In general, composites are usually made with synthetic fibers

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such as glass, carbon, and aramid. However, bio-composites are made from natural eco-friendly fibers like lignocellulosic biomass combined with natural biopolymers or bioresins [2]. The composition of these fibers depends upon their resources, but lignocellulosic fibers mainly contain cellulose, hemicelluloses and lignin [3]. The other part of the composite is the matrix that supports the reinforcement and distributes the load. There are three categories of renewable polymers that are used including 1) natural polymers (e.g. thermoplastic starch (TPS), cellulose, protein, etc.), 2) synthetic polymers from natural biomass feedstocks (e.g. poly(lactic acid) (PLA), etc.), and 3) synthetic polymers from microbial fermentation (e.g. poly(- hydroxy alkanoate) (PHA), poly(3-hydroxybutyrate-co-3- hydroxyvalerate) (PHBV), etc.) [4].

Bio-composites can be fabricated through compression molding, injection molding by injecting molten material into molds, and extrusion by forcing material through dies. The fabrication methods of bio-composites vary according to their applications. Moreover, techniques, such as solvent mixing, melt blending, and in situ polymerization have been investigated for the creation of polymer/graphene bio-composites for tissue engineering. For low-performance continuous fiber reinforced composites, hand layup and spray layup methods are favored due to their cost-effectiveness and ease of implementation. On the other hand, high-performance fiber-reinforced composites rely on resin vacuum bagging, compression molding, and resin transfer molding techniques to guarantee exceptional strength, stability, and suitability for high-volume production. In the case of mass production of short fiber composites, extrusion and injection molding are the primary methods utilized [5]. Improving bio-composite's mechanical qualities to either equal or surpass those of conventional materials is a major obstacle to their wider use. Through creative material compositions, fiber treatments, and manufacturing processes, research efforts have been directed at enhancing the strength, stiffness, impact resistance, and durability of bio-composites. To ensure the lifespan and dependability of bio-composites in real-world applications, it is essential to comprehend the aging mechanisms and long-term performance of these materials under diverse environmental circumstances [4].

The utilization of bio-composites has become prevalent across various sectors, including automotive, aerospace, construction, packaging, and biomedicine. Due to their reduced weight, these materials find application in the automotive and aerospace sectors, hence enhancing fuel efficiency. The utilization of bio-composite materials has the potential to enhance the fuel efficiency of the Boeing 787 by 20% [6]. The packaging industry is increasingly utilizing starch-based plastics because of their biodegradability. According to a market research report, the composite market is projected to reach a value of 112 billion USD by 2027 (6.88% CAGR during 2020-2027) [7]. Bio-composites find applications in tissue engineering, bandages, and drug delivery within the field of medicine. According to a report, the use of bio-composites-based materials can accelerate the healing process by 1.5 times [6].

Regardless of its benefits, the implementation

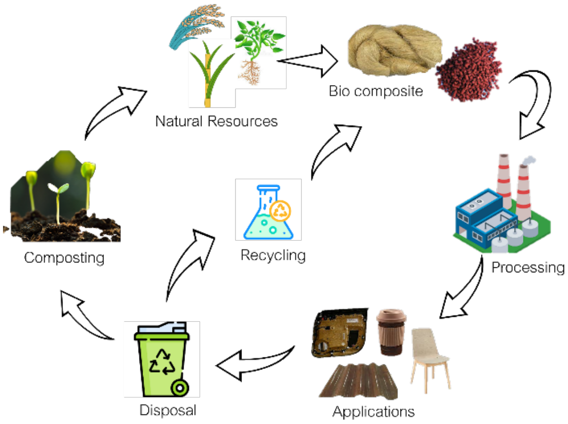

Figure 1: Circular Economy Life cycle assessment of bio-composites [8].

of the circular economy of bio-composites (Figure 1) presents certain problems. The concept of a circular economy has garnered considerable attention as a sustainable alternative to the conventional linear economy. Bio-composites, notwithstanding their promise for many uses, encounter challenges that necessitate resolution to align them with the principles of the circular economy framework. The primary concerns are around the inefficiency of trash collection and transportation systems, challenges associated with dismantling and segregating various components, the substantial energy demand for recycling processes, and the subsequent decline in mechanical qualities of materials during recycling. In order to address these difficulties, it is imperative for the government to unite academia and industry on a single platform to identify a more effective solution and enact legislation to promote an efficient circular economy [8].

In summary, bio-composites exhibit considerable potential as sustainable materials for future applications. Ongoing research is being conducted to better the performance and durability of these materials, hence expanding their range of uses. An efficient strategy is required to address all the obstacles associated with the circular economy framework of bio-composites, in order to develop a sustainable society in the future.

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