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Biopolymer and derivatives industry during till after the COVID-19 pandemic

FROM THE EDITOR

Welcome to the issue 23 (July-Dec 2021) of INTROPica. This issue focuses on "Biopolymer and derivatives industry during till after the COVID-19 pandemic".

The COVID-19 pandemic has reemphasized the indispensable role of plastic in our daily life. Due to the fact, COVID-19 pandemic has led to an increased demand for single-use plastics that intensifies pressure on an already out-of-control global plastic waste problem. Most of the plastic waste is contributed by single-use plastic-based medical waste such as disposable face masks, gloves, and gowns. Impact of takeaway services and e-commerce shopping also generates to an increase in the build-up of plastic waste during the pandemic. The dependency on e-commerce shopping and takeaway services for home delivery of essential items has resulted in the increased demand for carry bags and other types of plastic for packaging purposes. With these plastics intended for single-use, it is hardly to imagine the direct impact on the landfill if the pandemic is still occurring.

Environmental impacts are pervasive worldwide with landfill and incineration as the main implemented waste treatment and final disposal systems. In the view of the accumulated of plastic waste in the landfill and incineration as the elimination method, it has led to a major public health concern since toxic gasses and pollutants are released. This non-biodegradable product will develop microplastics, which will eventually end up in the sea, disrupting and affecting the environment and biodiversity of ocean life. Hence, it will be more important than ever for researchers to use their subject matter expertise to address these challenges by developing greener and sustainable products that will help mitigate the impact of COVID-19. In recent years, bioplastics or biopolymers have emerged as a substitute to conventional fossil-based polymers. Biopolymers are produced from polysaccharides such as cellulose, starch, and polylactic acid, and degrades easily to be composted alongside organic waste. A number of research indicate that biopolymers save fossil energy resources and reduce greenhouse gas emissions. Many researcher view biopolymers as inherently biodegradable, low toxicity and carbon-neutral to be attractive alternatives for the conventional polymers because they are easily extracted from abundant and inexhaustible natural sources.

Biopolymers can be used in different applications to replace synthetic polymers such as biomedical, food coatings, agricultural and packaging industries. Biodegradable packaging is gaining interest from the food industry. However, it still has many hidden advantages that are very challenging to find and apply to bio-based packaging. One of the complications is that natural polymers do not have the same desirable level of physical and mechanical properties as synthetic polymers. Therefore, researchers have fabricated blends with biopolymers to produce composite materials with biodegradable properties in addition to being compatible to the characteristics of conventional polymer. In this respect, substantial research is still being conducted in terms to minimize the quantity of synthetic polymers used in manufacturing.

COVID-19 pandemic took a toll on all of us, forcing us to rethink our ways of living, working and interacting with one another. We, at INTROP, believe that this was nonetheless an opportunity to learn, grow, and find new ways to improve and contribute to making the world a better place. Whilst the fight against COVID-19 is not over yet, we will continue to stand united to overcome these difficulties.

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THE IMPACT OF COVID-19 ON RESEARCH AND UNIVERSITY PROGRAMMES

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University or higher education closures due to COVID-19 have brought significant disruptions to education and research across the world. Emerging evidence from some of the region's developing countries such as Malaysia indicates that the pandemic is giving rise to learning losses and increases in inequality, especially those urban and village students' access to the internet. At the peak of the pandemic, nearly all the countries in the epidemic centre, especially Europe and Central Asia region, ceased the school operation, affecting millions of students. Given the abruptness of the situation, academic staff and administrations were unprepared for this sudden shift and were forced to build emergency online learning systems almost immediately without any experience. However, one of the limitations of emergency online learning is the lack of personal interaction between academic staff and students. The students need to develop psychomotor skills through interaction with academic staff during the active learning process. For example, a substantial amount of practice (up to 40% contact hour) is required throughout an engineering programme to develop the psychomotor skill for a practice-oriented industry and fulfil the hands-on component of the accreditation requirements. The role of higher education is to create a holistic education for the students by integrating all learning domains, such as cognitive, psychomotor, and affective into the programmes. Integration of these domains from Bloom's Taxonomy will be able to produce graduates with positive attributes such as having excellent practical skills, able to communicate well, and working in a team. Lack of psychomotor might create students with poor ability in hands-on and practical skills as well as communication and teamwork.

The COVID-19 pandemic is not only wreaking havoc on university programmes and students' psychomotor learning, the knowledge network which includes science, technology, and engineering has been severely disrupted due to the pandemic as well. International knowledge networks are essential for research and research is a core function of universities. Many research activities in universities were largely suspended from early 2020 until the recent day, except those COVID-19-related and other essential research. This is mainly due to universities scrambling to put in place necessary protections to allow laboratories and other research groups to safely resume their activities. The closure of labs and labbased scientific research activities not only impacted research progress and projects but also added some pressures around indirect costs. Universities still had to pay for many of the expenses covered by these indirect costs, such as research support services, utilities, and additional medical expenses for staff. These losses may have been relatively minor in many cases and only temporary regardless, but they still contributed to budget shortfalls at many institutions.

Further from that, many research universities heavily rely on research funds from government and government agencies to make their research possible. At the current stage, most of the government budget was channeled into fighting for COVID-19, which includes vaccine purchases, monetary loans to small and medium enterprises, increased hospital facilities and equipment, etc. Fewer research funds were provided to the universities to carry out knowledge discovery during the pandemic of COVID-19. As mentioned early, this reliance on funds has been affected by the global pandemic, and we are seeing more money being poured into COVID-19 research, but less information provided about what is happening to non-COVID-19 related research.

The COVID-19 pandemic which is caused by a single virion of SARS-CoV2 is only approximately 50-200 nanometers in diameter but the effect is gigantic to the university research and programmes. The virus disrupts the conduct of research and forces scientists and graduate students to adapt their work to continue its progress. Graduate students are the major workforce for the research activities in the universities. Without them, the research work cannot be delivered, and no research paper will be published. However, there are numerous challenges faced by this group, major challenges for graduate students were reported to be international travel, due to both financial and travel restrictions. Students with faculty responsibilities were challenged, as well. And most institutions reported fewer job placements for graduates than usual. Besides, universities have limited in-person activities, thus research and training have been disrupted. Many graduate students have faced time limits in carrying out research as new barriers. In other aspects, achieving graduate program milestones on time has been a priority for students and graduate programs long before the emergence of COVID-19. But the COVID-19 pandemic has introduced a longer graduation period that graduate students must navigate, resulting in increased stress especially financial stress. These challenges are not unique to students. Faculty face difficulties in navigating new barriers introduced by COVID-19. Some faculty have focused on writing up existing data and submitting those manuscripts. But even the peer review process has been affected. The disruptive effects of the COVID-19 outbreak have impacted almost all sectors of our society. Higher education is no exception. COVID-19 is greatly affecting academic research and programmes.

Pandemic restrictions influence not only the way the researchers work but also create new barriers for interacting with peers, for ensuring continuity in the funding of research work, setting up and pursuing international research collaborations, and for disseminating research results, like conferences, meetings, and workshops are cancelled. The COVID-19 pandemic and response have impacted research

activities and outputs of the world's research and development (R&D) sector in many ways. During the early phase of the pandemic, scientists reported a sharp decline in time spent on research. The number of new publications or submissions in post-pandemic will be lower than pre-pandemic. To this end, there will be a decrease in co-authorships in the new articles and publications. However, more new projects will be initiated during the pandemic era, as researchers are looking the solution to the pandemic, the effect of the pandemic on the social status of different groups of people, new drugs discoveries for treating the covid-19 patients, specific products for the hospital utensils, hygiene paper for quarantine centers and many more. Nonetheless, the pandemic and associated social distancing measures halted many in-person interactions that might otherwise have facilitated the flow of new research ideas and collaborations.

NATURAL RUBBER BASED COMPOSITE REINFORCED WITH LIGNOCELLULOSIC FIBRES

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▶ INTRODUCTION

Natural rubber is a unique biopolymer with great economic significance due to its large molecular weight and several minor components found in latex. Due to the vast amount of high molecular weight latex produced, the rubber tree remains the primary source.

▶ CONVENTIONAL FILLERS FOR NATURAL RUBBER NANOCOMPOSITE

Traditionally, natural rubber has been mixed with carbon black and silica during the vulcanization process to create a rubber composite with improved characteristics. The effects of carbon black type, concentration, and treatment on the curing characteristics and mechanical properties of rubber hybrid composites were explored by the majority of researchers. The use of carbon black filler generally lengthens the time it takes for a rubber composite to cure, as evidenced by the lower cure rate index (CRI). The tensile strength of natural rubber composites peaked at 40 phr carbon black content and thereafter declined as carbon black content increased. The modulus, on the other hand, increased in direct proportion to the filler content (Salaeh and Nakason 2012; Choi et al. 2003). As for silica, the effects of silica type, loadings, and treatment on the curing characteristics and mechanical properties of rubber hybrid composites were explored by the majority of researchers. According to several studies, the higher the silica content, the longer the cure time. Other studies, on the other hand, discovered the exact opposite. The mechanical properties of silica-reinforced rubber composites are more consistent across investigations and follow a similar pattern to those of carbon black reinforced rubber composites. The addition of silica to a rubber composite improves its mechanical qualities when compared to a rubber composite without reinforcement. The strength of the material, on the other hand, is not proportional to the amount of silica supplied. The strength of the material peaks at a given silica percentage before dwindling when more silica is added.

▶ LIGNOCELLULOSIC FIBRE AS A REINFORCING AGENT FOR NATURAL RUBBER

However, carbon black and silica, despite their capabilities as rubber composite reinforcements, are not of natural latex. Guayule *(Parthenium argentatum Gray)* and Russain dandelion *(Taraxacum koksaghyz)* are the most promising alternatives to rubber tree (Van Beilen and Poirier 2007). Natural rubber has remained unrivalled by any other synthetic material due to its durability, flexibility, abrasion and impact resistance, and effective heat dissipation. biodegradable and require a large amount of energy to manufacture. Carbon black is likewise non-renewable because it is made from petrochemicals. As a result of its natural qualities, lignocellulosic fibre has received attention and traction in the rubber composite sector as a renewable and environmentally beneficeal filler. The basic issue with the lignocellulosic fibre reinforced rubber composite is the poor compatibility of the hydrophilic wood flour or other natural fibres with the hydrophobic rubber matrix, which results in inferior mechanical properties. Several lignocellulosic fibres have been used as a natural filler in fabricating natural rubber composite such as cereal straw, hemp fibre, oil palm wood flour, etc. (Table 1).

▶ CONCLUSION

As the automobile industry's demand grows over time, natural rubber's application and supply become increasingly important. Environmental and health problems caused by the rubber sector, on the other hand, have become more prominent in recent years. Environmental restrictions have become increasingly strict in order to prevent the rubber sector from producing certain types of rubber. As a result, the development of green-based natural rubber products is becoming increasingly crucial for environmental protection. The need for environmentally friendly rubber is growing over the world. The advantages of lignocellulosic fibres obtained from renewable resources as a natural rubber reinforcing filler has become obvious at this time.

▶ ACKNOWLEDGEMENTS

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Table 1: Type of lignocellulosic fibres as fillers for rubber composite

Lignocellulosic Fiber/ Filler	Treatments	Variables	References
Torrefied almond shells (TAS) and torrefied rice hulls (TRH)	Torrefaction	Carbon black to torrefied filler loadings ratio (40:20, 30:30, 20:40)	Torres et al. (2021)
Horsetail (*Equisetum Arvense*)		Horsetail filler loading (10, 20, 30, 40 50 phr)	Masłowski et al. (2020)
Cereal straw	Silane treatment	Silanes coupling agents (PTES, VTES, TESPTS), filler loading (10, 20, 30 phr)	Miedzianowska et al. (2020)
Hemp fiber	Silane (Si69) and permanganate ($KMnO_4$) treatment	Filler loading (5, 10, 15 phr)	Moonart and Utara (2019)
Coconut shell powder	Alkali treatment	Filler loading (10, 20, 30, 40 phr)	Sareena et al. (2012)
Rice husk	Electron beam irradiation	Irradiation dosage	Chong et al. (2010)
Wood flour	Corona treatment in air and in ammonia	Filler loading (10, 20, 30, 40, 50, 60, 70 phr)	Vladkove et al. (2006)
Oil palm wood flour		Filler loading	Ismail et al. (1998)

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RISING DEMAND OF FOOD PACKAGING PAPER DUE TO PANDEMIC COVID-19

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The world was hit by COVID-19 pandemic that began at the end of 2019 in China which the first case of pneumonia was reported to the World Health Organization on 31 December 2019 in Wuhan, China (Anonymous 2020). The spread of this virus is so rapid because it is transmitted through the air. Looking at the mobility of people nowadays had permitted the virus to easily transferred and hence, the infection to spread so quickly. The world has taken drastic action by closing the borders of their respective countries and strictly controlling the countries' entry-exit unless for crucial activities by certain groups such as front-liners like medical, security, and identified teams. Several more than 90 countries involving 3.9 billion people around the world had to implement lockdowns comprised of quarantines, curfews, stay-at-home, and societal restrictions which such restrictions are practiced reducing the spreading of coronavirus and later flattening the curve of infections (Nicola 2021). Such movement control order focally to break the chain of the virus that people staying and working at home, children studying from home and most routine activities need to be carried out at residences. At the same time, the majority of factories had to temporarily shut down (Dankochik 2021) or slow down or even close permanently (Bennet 2021) their mill production that also included the pulp and paper production sector around the world (Feber et al. 2021).

A virtue besides challenging scenario for pulp and paper mills occurred when the pandemic created a positive demand for food packaging products especially those made of paper. This includes paper boxes, paper straws, paper bags, and paper food wrappers followed by personal hygiene products, corrugated packaging materials, and medical specialty paper (Figure 1). It is expected that the packaging industry of pulp and paper keep on soaring begin 2021 onwards (Beroe 2021). The biggest growth in the packaging industry would be coming from the pulp and paper segment. Asia will lead the world pulp market production with a Compound Annual Growth Rate (CAGR) of 4.0 to 4.5% until 2025. In the meantime, The Association of Southeast Asian Nations (ASEAN) market is expected to experience 2.0-3.0% growth specifically in the carton board category until 2025 as well. And the containerboard market is forecasted to continue expanding with an estimated 3.0-4.0%. As reported by Beroe Incorporation (2021), the biggest growth in the packaging industry would be coming from the pulp and paper segment which Asia will lead the experience 2.0-3.0% growth specifically in the carton board category until 2025 as well. And the same goes for the containerboard market which is forecasted to continue growing with an expected 3.0-4.0%.

Pandemic coronavirus significantly impacted people's lifestyles and behaviors worldwide in daily life. People started to be more cautious on cleanliness that made more people prefer home cooking but surprisingly home orders tremendously increasing that any foods can be just reached home by our fingertips. In other words, food orders either home or office orders becoming very popular which was previously famous among those who are very familiar with digital technology only. But now, almost everyone uses online food ordering services as long as they have their handphones or computers and for sure internet services with them. Impact on the food packaging sector offered opportunities and positive concern in their business sales profit. South Korean distributors found out early of the pandemic that they successfully gained 34% of avenue rise (Cho Mu-Hyun 2020). Looking at the shocking online purchases, all these packing materials caused piles of waste at the dumping areas. A study carried out by Brazilian researchers, found a 152-459% increase in paper or paper board that have been collected from April to June 2020 (Zambrano-Monserrate et al. 2020). Hence, systematic or upgraded disposal and recycling need to be taken seriously by environmental experts to control the matters. Looking at the trend of life, such food packaging waste will keep on higher from time to time.

Food packaging products from paper are more preferred as reported by ODDY Uniwraps (2021) situated in India. Their sales increased up to 240% due to customers that are particularly interested in packaging products from paper because it is more user and environmentally friendly. Not only particular on environmental aspects, but people are also more demanding on advanced packaging that is equipped with protection and safety criteria details. Such packaging is called active, smart, and intelligent packaging that can provide superb protection to the food (Packaging Today 2020), not only ease very much to the customers but the retailers and the producers too. This is because such packaging can detect or even measure any attribution to the content that is affected by the inner or outer atmosphere along the way from the factory, consignment, and storage period before it reached the final users.

The coronavirus pandemic changed the worldwide practice routine in general and the food packaging paper industries as well. Fast adapt to the situation by all respective person along the chain of food packaging paper usage by grabbing any opportunities and delivering the best to the society can help to achieve a better world after a challenging 2-year experience of the coronavirus traumatic attack that still not yet subsided.

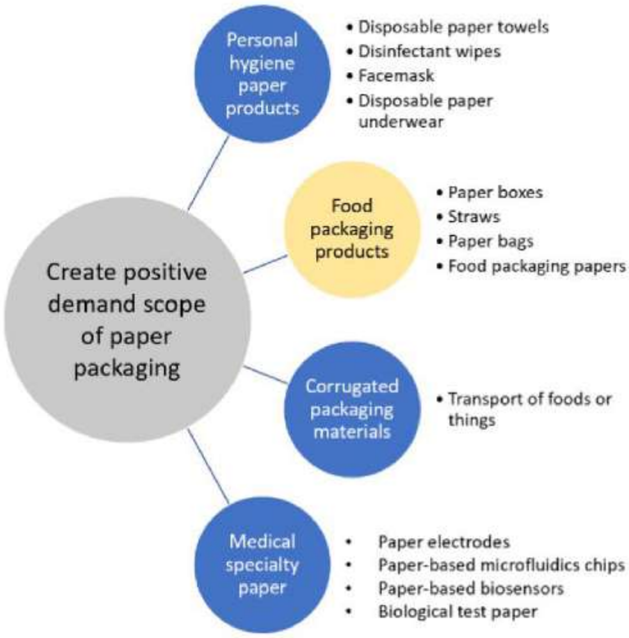

Figure 1 Outbreak of coronavirus pandemic created positive demand scope of paper packaging especially for food packaging products.

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3D PRINTING DURING COVID-19: OPPORTUNITIES AND CHALLENGES FOR PLANT-DERIVED BIOPOLYMERS

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▶ INTRODUCTION

Global ambiguity caused by the COVID-19 pandemic has staggered the world into a still-unfolding crisis. Logistical challenges due to interruptions in manufacturing and transportation, together with pushbacks against globalization and free trade, have constrained supply chains, subsequent to critical deficiencies of crucial products especially during the early year of 2020 when the COVID-19 pandemic first hit. Emergency response efforts were coordinated to alleviate shortages of much-needed medical supplies and essential products. There is a need for manufactures to build on-demand or manufacturing on-demand certain materials and devices for a range of essential services. In this situation, a resilient advanced manufacturing network enabled by a distribution of 3D printing factories has great potential. Indeed, these 'art-to-part' factories can be co-located at hospitals and transportation hubs to quickly serve the needs of the medical profession. 3D printing has redeployed its capabilities in the crucible of COVID-19 responses, demonstrating its competitive advantage in this emergency situation.

In general, 3D printing is forming objects by loading layers of constituents to shape the desired part. Depending on the 3D printing method, subtractive fabrication processes generally waste 80-90% of the raw material compared to 3D printing which offers less material wastage (Jasveer and Jianbin 2018). 3D printing is creating substantial changes in various industries, including packaging, architecture, and construction, medical, energy, aviation, food, and others (Shahrubudin et al. 2019). These industries adopt 3D printing to decrease operational costs and improve manufacturing efficacy (Rezaei et al. 2021). The 3D printer is an example of rapid prototyping and allows manageable manufacturing to everyone at a reasonably low setup and printing cost, especially for globally critical situations, similar to this pandemic, when time and human interaction are under restrictions (Scheithauer et al. 2015; Yuk et al. 2020). Over the past decades, 3D printing technologies have significantly assisted engineers to rapidly meet their customer's requests by reducing material wastage and production time (Attaran 2017; Manero et al. 2020; Razavi Bazaz et al. 2020). In the packaging industry, 3D printing makes it possible to produce personalized packaging for customers by producing different prototypes at high speed according to their requests. In this way, wastage of raw materials can be reduced, more environmentally friendly, and production efficiency improved during manufacturing. During the pandemic, 3D printing has significantly helped in the rapid manufacturing of PPE. 3D printing can be mainly categorised into the following groups: two-photon polymerization, stereolithography, fused deposition modelling, digital light processing, selective laser sintering, and MultiJet printing. Generally, stereolithography has the highest resolution, fused deposition modelling is the most common inexpensive method, and MultiJet printing is well-known for its biocompatibility, biodegradability, and mechanical properties (Ngo et al. 2018; Shrestha et al. 2019; Tack et al. 2016).

▶ PLANT-DERIVED BIOPOLYMERS USED IN 3D PRINTING

Materials applied in 3D printing are mostly derived from synthetic thermoplastic polymers like polyethyleneglycol, Nylon 6 (polyamide), poly(vinyl alcohol), poly(styrene-co-acrylonitrile), and others. The increasing concern on environmental and social issues has led to the search for a bio-based alternative that can potentially replace fossil-based polymers. These biopolymers have received tremendous attention in materials development as they are widely available, low-/non-toxic, biodegradable, biocompatible, chemically versatile, and inherently functional (Sharma et al. 2021). The selection of biopolymers to the formulation of paste/ink preparations is crucial for 3D-printing as it influences the application properties. For example, in 3D printing for tissues and organs, cells need to adhere tothe surface of implanted biopolymer to maintain theirviability and proliferation for promoting tissue regeneration (Serra et al. 2013).

Currently, the application of plant-derived biopolymers in 3D printing has been greatly highlighted (Kariz et al. 2016; Ma et al. 2018; Xu et al. 2018). Due to the valuable benefits, various industries tend to use plantderived biopolymers for 3D printing (Håkansson et al. 2016; Li and Zhou 2015; Ma et al. 2018). In the plant cell wall, cellulose is the primary component available readily. It is a renewable material and has an important role in preventing greenhouse emissions and climate change (Pakkanen et al. 2017). Renewable products are in continuous demand due to their lower cost and energy efficiency. Moreover, utilizing such materials in 3D printing leads to the effective recycling of 3D printed wastes (Pakkanen et al. 2017). Plant-derived biopolymers have interesting, complex structures and properties and are available abundantly. The annual growth of plant-based biomass has been estimated to be 1.5 trillion tons (Khan et al. 2016). This remarkable growth of plant-based materials provides other higher opportunities to use these materials in 3D printing. It is not far from expectations that the renewable 3D printing sector to be one of the fastest-growing sectors in developed countries soon. With the attention given to the abundant availability of plant-based materials to derive biopolymers, 3D printing is estimated to grow in various industries. 3D printing using materials from plant-derived biopolymers can offer innovative and superior designing and manufacturing methods.

Plant-derived biopolymers are available as bleached pulp as well as lignocellulose. Cellulose is one of the most abundant biopolymers available from nature, and it has been investigated recently by the researchers to be used in 3D printing. The intrinsic structure of cellulose poses a high crystallinity degree and rigid intra/intermolecular hydrogen bond networks, thereby restricting its application in 3D printing. However, the abundant hydroxyl groups on the cellulose surface provide an active site for chemical modification/functionalization achieved through esterification, etherification, selective oxidation, graft copolymerization, or intermolecular crosslinking reaction. Research on cellulose nanofibrils (CNF), nanocellulose/ micro cellulose (MCC), bacterial cellulose (BC), cellulose nanocrystalline (CNC) have been conducted over the years (Carreño et al. 2017; Osong et al. 2016). Cellulose, along with its derivatives, offers better design composite constituents. As it is investigated in multiple academic researches, wood and cellulose-based products have exhibited efficiency as printing materials in additive manufacturing, improving the outcomes for 3D printing (Carreño et al. 2017; Håkansson et al. 2016; Kariz et al. 2016). Homogeneous printing without nozzle blocking is vital in 3D printing based on biomaterials. Nozzle clogging can occur due to improper particle sizes. In most cases, wood particles are segregated to obtain homogenous printed results with better properties. However, this solution alone is not enough to solve these problems. Syntheses of literature also disclose that wood and cellulose materials that have not been subjected to chemical modifications are infeasible to be used as 3D printing material because they are thermally unstable and subject to decomposition before they can be melted (Dai et al. 2019; Feng et al. 2018). When heat is applied, they become flowable. Table 1 summarises some of the research on the potential of plant-derived biopolymers as a desirable 3D material for ink/paste formulation, biomedical utilizations, fabric, food, automobile, aerospace and electronic applications.

▶ CURRENT CHALLENGES AND FUTURE DIRECTIONS

Although plant-derived biopolymers show to be advantageous in terms of sustainability and ecofriendliness, these biopolymers cannot be utilized in their native forms, and efforts are being made to modify them into valuable 3D printing materials. The main challenges for the usage of plant-derived biopolymers on 3D printing technologies are inadequate material characteristics which needs to be overcome such as poor printability and low mechanical properties. Another current challenge that infuriates the 3D printing process is the poor characteristic of physicochemical properties of some plant-derived biopolymers such as infusibility and insolubility in common solvents

In 3D food printing, the main challenges of using plantderived biopolymers include: (i) Strict food safety safeguards of the biopolymers from different sources; (ii) Appropriate rheological properties of biopolymers for processing and printing; (iii) Acceptable printing precision and accuracy; (iv) Manipulation of multiple biopolymers for personalized nutrition or flavors (Pradhan et al. 2021). Moreover, the limited availability of printable biopolymers that are compatible with food ingredients and conventional manufacturing processes result in the high processing cost and unpopularity in the 3D printing of food. While, in the biomedical industry, there is still tremendous works needed to achieve functional tissue as current state-of-the-art technologies are producing printed structures that are mostly avascular (lack blood vessels), aneural (no neurons and nerves), and alymphatic (no lymphatic system) (Liu et al. 2019). To 3D printers capable of precise printing of multiple biopolymers and cell types with high resolution, processing speed, and more precise robotic systems. Furthermore, 3D printing of apparel and textile products using plant-derived biopolymers has advantages of quick product development and personalized design in a sustainable and renewable way; however, it poses challenges for designing, largescale production, postprocessing, and most importantly safety concerns.

Knowledge gaps have to be investigated to address the structural changes of the printing materials and their impact on the physical properties during different processing steps. Extensive application potential of plant-derived biopolymers in 3D printing technologies can be realized by entail adaptation or modification on commercial printers, forming tailor-made prototypes from biopolymers, improving rheological performances by developing a novel solvent system, as well as improvement in different postprocessing technologies to hold and preserve the desired shape of the product such as surface coating and plasma radiation. In conjunction with chemical modification of plant-derived biopolymers, a physical blending of plant-derived biopolymers with other ingredients can be another approach to formulate printing materials with favourable processability, printability, mechanics, and bioactivities.

Table 1. Researches on the potential of plant-derived biopolymers as a desirable 3D material.

Plant-derived compounds	3D printing technique and paste formulation	Printed structure and properties	Potential applications	References
Nanocellulose (cellulose nanofibrils)	3D based Dual-extrusion printer 8.35% (w/v) of cellulose nanofibrils diluted in 200 mL water, further mixed with aqueous aqueous single-walled carbon nanotubes dispersion (1%, w/v); The resulting mixture had cellulose nanofibrils: carbon nanotubes dry weight ratio of 80:20.	• Electrical conductivity • Enhanced cell development	Neural tissue engineering	Kuzmenko et al. 2018
Nanocellulose (cellulose nanofibrils)	3D based extrusion printer Sample 1: 3 wt% cellulose nanofibrils mixed with 3 wt% alginate in water; Sample 2: 4 wt% cellulose nanofibrils in water	• Cell viability • Proliferation • Growth of cells	Human tissue constructs	Göhl et al. 2018
Cellulose ethers (Hydroxypropyl methylcellulose)	3D based extrusion printer Polylactic acid (75%): Hydroxypropyl methylcellulose (20%)	• Controlled release of active pharmaceutical ingredients (Nitrofurantoin)	Drug delivery vehicle	Boetker et al. 2016
Cellulose ethers (Ethyl cellulose)	3D based extrusion printer Acetaminophen (60%): Hydroxypropyl methylcellulose (20%): Ethyl cellulose (10%): Polyvinylpyrrolidone (9.5%): Colloidal silicon dioxide (0.5%)	• Controlled release of active pharmaceutical ingredients (Acetaminophen) • Hardness • Friability	Drug delivery vehicle	Yu et al. 2009
Microcrystalline cellulose	3D based extrusion printer 1 g hydroxypropyl methylcellulose mixed with 30 ml hot water (90 ◦C) until a good dispersion was formed and then 70 ml of ice water was added and stirred for half an hour to increase polymer solubility.	• Fast release of drug (Guaifenesin and hydrochloric acid)	Drug delivery vehicle	Khaled et al. 2014
Cellulose esters (Cellulose acetate)	3D based extrusion printer Cellulose acetate in acetic acid (concentration 30 w %). Acetoxypropyl cellulose (concentration 80 w%).	• Adhesion on fabric • Viscosity	3D printed textile	Tenhunen et al. 2018
Lignin	Stereolithography printing Lignin-coated cellulose nanocrystal The L-CNC at a content of 0, 0.1, 0.5, and 1 wt.% was directly mixed with MA under stirring 112 for 10 min, followed by an ultrasonication treatment at a power of 300 W for 6 min	• Thermal and mechanical properties	Electronic component, tissue engineering	Feng et al. 2018
Starch	3D based extrusion printer 50 wt.% cornstarch, 30 wt.% dextran and 20 wt.% gelatin.	• Stiffness • Compressive strength	Scaffolds	Lam et al. 2002
Starch	Fused deposition modelling Potato starch and pea protein (0%, 1%, 2%, 4%, and 8% of total) were mixed up, and added water (water: potato starch = 1 mL: 1 g) for gelatinization at 67°C. Then melted butter (butter: potato starch = 1 g: 5 g) was added into the gelatinized mixture.	• Cohesiveness • Adhesiveness • Filament-forming ability	3D food printing	Chuanxing et al. 2018
Starch	3D based extrusion printer Lemon juice mixed with potato starch (content: 10, 12.5, 15, 17.5, and 20 g/100 g), followed by steam-cooking for 20 min	• Storage modulus	3D food printing	Yang et al. 2016
Starch	3D based extrusion printer Starch, milk powder, rye bran, oat, faba bean protein concentrates, and cellulose nanofibers	• Shape retention	3D food printing	Lille et al. 2018
Polylactic acid	3D based extrusion printer Polylactic acid and 15 wt% hydroxyapatite powder blended in a screw extruder for 15 min at 30 rev/min at a temperature of 180˚C.	• Mechanical strength • Degradability	Scaffolds for bone replacement	Senatov et al. 2016
Polylactic acid	3D based extrusion printer Polylactic acid (95 w/w %) and polyethylene glycol (5 w/w%) dissolved in chloroform (2.5% w/v) and later combined with glass particles (50 w/w %) to obtain a homogeneous polymer blend solution	• Porosity • Biocompatibility	Scaffolds	Serra et al. 2013
Polylactic acid	Fused deposition modelling Carbon fiber-reinforced PLA composites	• Strength • High modulus	Automobile and aerospace	Tian et al. 2016

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ANTIMICROBIAL COATING ON FOOD PAPER PACKAGING AND ITS APPLICATIONS

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▶ INTRODUCTION

Paper packaging material is the primary option for packaging material as worldwide market standards for environmental protection of packaging material grow. Paper has ecological benefits in terms of being decomposable and sustainable. Still, the long-term viability offers far more sustainable growth in its "healthy" design and functionality than alternatives like plastics (Poole, 2018). Paper package benefits include a diverse range of raw materials, low prices, and various species that are easy to mass manufacture. Second, it has excellent printing capabilities, making it a perfect choice for composite processing. Third, there are hygienic and safety concerns. Fourth, trash may be recycled, which is beneficial for the environment (Advantages, 2018). Paper packaging's drawbacks include its porous structure and the hydrophilic nature of cellulose fibers, as well as the fact that paper/paperboard has fundamentally weak barrier characteristics. (i.e., Low water and grease resistance, high gas, and water vapor permeability) (Nechita & Iana-Roman, 2020).

Customers and merchants want longer shelf life and better protection against a variety of risks; thus, the food sector's difficulties in preserving products have grown increasingly complicated (Rodríguez et al., 2007). Furthermore, biodegradable paper-based food packaging has emerged as a viable option for ensuring sustainability, although it is restricted by its vulnerability to ambient dampness, which can lead to an increase in microbial activity. As a result, adding functional elements like antimicrobials and antioxidants to the coating materials might increase their value (Zulfiana et al., 2020).

▶ ANTIMICROBIAL PACKAGING

Antimicrobial packaging is described as a packaging system that interacts with the food product or the surrounding headspace to kill or inhibit the growth of microorganisms in the food product (Surwade & Chand, 2017). It can provide slow, continuous migration of the antimicrobial agent from the packaging material to the food or the package headspace, ensuring that a sufficient antimicrobial agent concentration maintains the product's shelf life (Quintavalla & Vicini, 2002).

Table 1. Antimicrobial agents coating on papers and their application in paper food packaging

Antimicrobial agent	Polymer/ composite	Target microbial	Application	Type of paper	References
Monovalent, divalent, and trivalent cations crosslink anionic nanocellulose	-	*Escherichia coli, Salmonella typhi, Staphylococcus aureus,* *Bacillus subtilis*	Antimicrobial food packaging material.	Paper from cylindrical pulp	Zulfiana et al., 2020
ZnO nanoparticles	PLA pellets (Polylactic Acid)	*E. coli* and *S. aureus.*	Antimicrobial packaging	White kraft paper (106 g / m2)	Rihayat et al., 2019
Silver nanoparticles (AgNPs)	Starch/chitosan	*S.enteritidis* *E.coli*	Enhance the water and air barrier characteristics of coated sheets, as well as their grease resistance. For oily solid foods	Kraft pulps	Nechita, 2017
Epsilon-poly-L-lysine (ε-PL)	Cellulose paper-chitosan / epsilon-poly-L-lysine (ε-PL)	*Listeria monocytogenes*	In vitro and in chicken breast meat, antimicrobial efficacy against Listeria monocytogenes was studied.	Cellulosic paper	Razavi et al., 2020
Sr1 – xAgxTiO3	-	*S. aureus,* *P. aeruginosa ,* *C. albicans* and *A. niger.*	Tensile strength, roughness, short span, and water absorption have been improved	Kraft paper sheets	Ibrahim, Abbas, et al., 2019)
Chitosan	Chitosan and O,O'-dipalmitoylchitosan (DPCT)	*Salmonella Typhimurium* and *Listeria monocytogenes*	Antimicrobial surface-hydrophobic papers for potential food packaging applications	Papers (40 gm-2, 48μm thick)	Bordenave et al., 2010

The target ofantimicrobial food packaging is to ensure food safety, shelf life extension, and quality preservation while also preventing spoilage. Besides, the addition of an antimicrobial agent to paper makes it suitable for use as a food packaging material, as the presence of these bacteria in food can cause significant illnesses, particularly in children. Different microorganisms, such as molds, yeasts, bacteria, and others, degrade and deteriorate foodstuffs, lowering their quality and shelf life. Antimicrobial agents can be used to suppress the majority of these microorganisms. These antimicrobials can be used alone or in conjunction with one another (Mertin, 2009). Chemical agents and natural agents are the two types of antimicrobial agents.

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COVID-19'S IMPACT ON NATURAL GAS AND THE FACTORS INFLUENCING THE ADOPTION OF BIOGAS TECHNOLOGY

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▶ INTRODUCTION

In the past few decades, our government achieve multiple economic and social goals in the pursuit of a resilient future that leaves no one behind by accelerating renewables and making the energy transition an integral part of the overall recovery. The energy transition, as part of short-term stimulus and recovery plans, provides a critical link to medium- and long-term global climate and sustainability goals. Among all the renewable industries, biogas seems to have the potential to play a significant role in the developing renewable energy market, with global biogas usage expected to more than double in the coming years, rising from 14.5 GW in 2012 to 29.5 GW in 2022 (Yong et al., 2021). Increased adoption of the biogas renewables and energy-transition industry appeared as one of the long-term investments amid the COVID-19 pandemic crisis. However, is renewable energy capable of supporting a resilient and equitable COVID-19 recovery?

The aftermath of COVID-19 has a significant impact on Malaysian electricity consumption trends, as movement restrictions have resulted in a sudden shift in socio-economic habits. At the height of the pandemic, only essential industries were permitted to operate, some at half capacity, while the rest were either shut down or adapted to remote working practices. It had resulted in a sharp drop in energy demand, particularly in commercial and industrial applications. Despite an increase in household electricity consumption, it was insufficient to compensate for a drop in commercial and industrial usage, as the economy was only operating at 45% of its capacity during the movement control order (MCO) period (Anonymous, 2020a). Electricity consumption fall around 6% in year 2020, owing primarily to a slowing in commercial activity (Dave and George, 2020).

The lockdowns and restrictions imposed in response to COVID-19 had a significant impact on natural gas consumption worldwide. For example, France's natural gas consumption decreased by 23% in year 2020 (Dorothée Allain-Dupré and Michalun, 2020). Faced with this unprecedented shock, natural gas markets are going through a strong supply and trade adjustment, resulting in historically low spot prices and high volatility. Natural gas demand is expected to progressively recover in 2021, however, the COVID-19 crisis will have longer-lasting impacts on natural gas markets as the main medium-term drivers are subject to high uncertainty (Gas 2020, 2020). Apart from that, the global biogas plant market has also been impacted by disruptions in the international supply chain and a reduction in investment for upcoming projects. Furthermore, approximately 8% of the 40 million direct jobs provided by the energy sector are in jeopardy or have already been lost (Anonymous, 2020b). COVID-19 was predicted to delay or impede the construction of 5000 compressed biogas plants in India (Kumar, 2021).

▶ FACTORS INFLUENCING BIOGAS TECHNOLOGY ADOPTION

The adoption of biogas is a complex process in which many factors interact at the same time, including technical factors, economic forces, market influences, organizational constraints, social-cultural factors, and environmental exposures (Nevzorova and Kutcherov, 2019). Among these, economic considerations play a major role in the choice of energy source. The installation of biogas plants is an expensive endeavour. This includes the cost of constructing a biogas plant, purchasing machinery, employing engineering and team, introducing new technology, and so on. Although the feedstock is free in the case of a biogas digester, the transportation costs of the feedstock, particularly over long distances, have a negative impact on the economics of a biogas power plant. The pervasiveness of coronavirus has had a significant impact on global shipping markets. World economies are in danger of falling as a result of nationwide lockdowns that could last months, if not years. Numerous industries included the energy industry have come to a halt, and the shipping industry is venturing into uncharted territory. Moreover, this industry has a large number of fixed assets, resulting in high fixed costs in day-to-day operations (Fu and Shen, 2020). Thus, the high operating leverage introduces significant risks to the adoption of biogas technology.

As the year 2021 began, the world was still reeling from the pandemic. The conflicting messages from vaccine development and a new virus strain cement 2021 as another year of uncertainty. However, cautious optimism persists, particularly in the renewables sector. The natural gas sector has been showing signs of improvement in 2021. Encouraging news became more prevalent, as the biogas and methane-rich biogas (biomethane) industries defined the resiliency of the renewables sector in 2021. Renewable discourses and policy actions were also discovered as an integral part of pandemic response and recovery. The year 2021 is shaping up to be another year of uncertainty, but cautious optimism about the energy transition could stem from a combination of renewables promotion and green recovery. According to the International Energy Agency (IEA), renewables were the only source of demand growth, owing to increased installed capacity and priority dispatch ("Global Energy Review 2020," 2020).

The new government policies are being framed to encourage sustainable biogas power generation in response to growing concerns about climate change and rising levels of greenhouse gases in the atmosphere caused by the burning of fossil fuels such as coal and oil. The growing public concern about the emissions from fossil fuel-based power generation, as well as a growing emphasis on diversifying the energy portfolio has accelerated biogas industry statistics. According to BCC Research Report, the global biogas market is anticipated to grow at a CAGR of 10.6% by 2022 (Sawale et al., 2020). Such a positive trend is primarily due to the companies reorganizing their operations and recovering from the COVID-19 impact. The biogas sector had previously resulted in restrictive containment measures such as social distancing, remote working, and the closure of commercial activities, which created operational challenges. Furthermore, the growth of the biomass electric power generation market is fuelled by increasing government support through various government subsidies and policies. For example, the introduction of biogas energy sources in China and India has significantly improved the livelihoods of rural communities by reducing their reliance on energy consumption from fossil and wood sources (Berhe et al., 2017). The Indian government has even offered subsidies for the construction of family-type biogas plants, primarily for rural and semi-urban households (Aggarwal et al., 2021).

▶ CONCLUSION

COVID-19 and climate change crises are global issues that necessitate bold government action, international cooperation, and long-term, inclusive solutions. Biogas technology offers the potential to reduce climate change and eutrophication, and it is the ideal alternative source of energy (Winquist et al., 2019). Beyond the renewable, investments in the biogas energy sector, in the wake of the COVID-19 pandemic can pave the way for equitable, inclusive, and resilient economies. Moreover, the growth of a national biogas sector helps to boost rural income and create new jobs (Korbag et al., 2020). Biomethane could also be used in place of natural gas as a feedstock for the production of chemicals (Lin et al., 2021). The noise levels produced by methanepowered engines are significantly lower than those produced by diesel engines, which is advantageous in congested urban environments (Korbag et al., 2020). Broadly speaking, biogas technology played a key role not just in waste management and renewable energy, but also in the water and food security sectors. Henceforth, biogas is regarded as the renewable and sustainable energy of the future (Berhe et al., 2017).

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IMPACTS OF COVID-19 ON THE ENERGY DEMAND AND GROWTH PROSPECT OF SOLAR ENERGY IN MALAYSIA

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The Covid-19 disease is still evolving and affecting millions of lives in many ways. Until October 2021, the worldwide cases reached 251.26 million with 5.07 million deaths as reported by the WHO (WHO, 2021). In the same month, the recorded cases in Malaysia were 2.52 million with 29.48 thousand fatalities as reported by the Minister of Health, Malaysia (MOH, 2021). Various ways have been enforced to halt the spreading of the virus including travel restriction, isolation, bans of public events, and economic shutdown in the infected area. The WHO recommended to performed protective measures by wearing a face mask, regularly washing hands, selfisolation for people with symptoms, and staying at home (Dawi et al., 2021). In Malaysia, the government imposed a Movement Control Order (MCO) to control the quick spreading of covid-19. The MCO greatly influenced many sectors like tourism, education, agriculture, health care, finance, sports, and manufacturing industries. Malaysia has been through several phases of MCO Since March 2020, resulting in a severe economic downturn. Apart from that, the Covid-19 pandemic has also impacted the energy industry. Tenaga Nasional Berhad (TNB) reported that electricity usage in the industrial and commercial sectors dropped between 25% and 50% at the peak of the pandemic in 2020. At this time, only essential industries were allowed to operate, while the others reduced the capacity to 50% or fully shut down. However, as people stayed indoors and employees worked from home, there was an increased pattern of household electricity consumption. TNB recorded asurge of electricity usage for households between 20% and 50% within the period of MCO in 2020 (TheStar, 2020). Globally, a similar pattern of declining energy demand was observed (Jiang et al., 2020).

Currently, the main sources of power generation in Malaysia are based on coal and natural gas (Syakirah et al., 2019). Because both of these resources are not sustainable, the government is actively promoting and developing renewable energy as an alternative for power generation. In general, renewable energy is the energy obtained from natural resources on Earth that are neither finite nor exhaustible. Various types of renewable energy can be found nowadays including biomass, hydropower, geothermal, wind, tidal and solar. In Malaysia, the major sources come from biomass, solar and hydro. Solar energy is regarded as one of the most promising renewable energy sources among other options of renewable energy available nowadays. Solar energy is the cleanest, the most abundant, and considered an inexhaustible energy resource. It does not emit carbon dioxide during an operation and it can be harnessed almost in all areas of the world as long as there is the sun. Solar energy can be used in diverse applications such as electricity generation, photochemical, solar desalination, room temperature control, etc. Various technologies have been developed to utilize solar energy efficiently, including solar lighting, solar thermal, solar hydrogen production, solar cell, and so on (Zhang et al., 2018). The solar cell, or often called a photovoltaic cell, is a device that converts sunlight energy directly into electrical energy through photovoltaic effects. Solar cell technology is convenient as it does not produce any noise and it does not require any mechanical movement or movable parts to generate electricity. There are a few concerns about pollution related to the production, transportation, and installation of solar panels; however, it was far less compared to other alternative energy sources.

There are three generations of solar cells up to recent years. The first generation of solar cells is based on silicon wafers, which is also the oldest and the most popular technology used due to their high power efficiency. Despite that, the production cost is relatively expansive for mainstream consumer distribution. The second generation is based on thinfilm technology. This is done by layering various types of semiconducting materials on top of one another to create a series of thin films. In terms of cost, the second generation of solar cells is more economical than the first generation. However, they have lower efficiency, which makes them less ideal as a replacement to the previous generation. The third generation is the emerging solar cell technologies in which most of them are yet to be commercialized, but there is a lot of research going on in this area. The main aim is to produce solar cells with lower costs and improved performance (Kibria et al., 2014). One example of the emerging third generation of solar cell is the dye-sensitized solar cell (DSSC). DSSC is a kind of artificial photosynthesis by the way that it mimics nature's absorption of light energy. DSSCs are interesting with their remarkable advantages such as low-cost production, robustness, colorful appearance, and possible flexibility. Unlike other thinfilm solar cells, DSSCs are easy to fabricate and are made of low-cost materials. They are mechanically robust, which makes them easy to use and to be maintained. Besides, DSSCs have the ability to work at wider angles without suffering from the angular dependence of sunlight or artificial light (Lee et al., 2017). DSSC also can function under illumination in cloudy weather and low-light conditions without much effect on power efficiency. At present, DSSC research is still ongoing, with researchers attempting to attain efficiency similar to those of silicon-based solar cells. It will be interesting to follow this research development in order to find more economical, environmentally friendly, and high-efficiency solar cells.

Despite the many advantages of solar cells, they only contributed less than 1% of total power generation in 2018 (Zulkifli, 2021). The government has implemented several schemes to develop the growth of renewable energy in Malaysia especially for solar. This includes the introduction of Net Energy Marketing (NEM), Large Scale Solar (LSS) Self-Consumption (SELCO) programme, and tax incentives. Sustainable Energy Development Authority (SEDA) was set up to monitor the progression of these programmes, assessing and fostering more sustainable energy solutions. The NEM scheme was first introduced in 2016, executed by the Ministry of Energy and Natural resources, and regulated by the Energy Commission. To date, the phase NEM 3.0 is divided into three categories which are NEM Rakyat, NEM GoMEn, and NOVA programme. Meanwhile, the LSS scheme is a bidding programme to drive down the Levelized Cost of Energy for the large-scale development of the solar plant. The LSS is aiming to achieve a total of 250 megawatts in peninsular Malaysia and 50 megawatts in Sabah. Through the SELCO programme, electricity being generated for own usage and the excess cannot be exported to the grid. This is to encourage individual and industrial consumers to install solar PV to cut down the electricity cost (SEDA, 2020).

The spread of Covid-19 has indeed disrupted the solar energy sector. The global demand for solar was reduced by 16% in 2020. Malaysia, as one of the locations for manufacturing solar components, has been severely impacted by the pandemic, resulting in slow-down production. From this point on, clear and effective strategies are needed to ensure the growth of solar energy in Malaysia. More importantly, beyond this pandemic, a successful outcome will require collective efforts from the government, industries and every individual.

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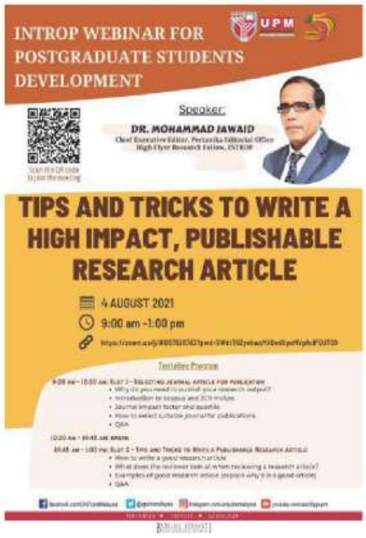
TIPS AND TRICKS TO WRITE A HIGH IMPACT, PUBLISHABLE RESEARCH ARTICLE (4 August 2021)

Organised by: INTROP Graduate Unit

The Graduate Committee, INTROP, organized a seminar entitled 'Tips and Tricks to Write a High Impact, Publishable Research Article' on 4 August 2021 which was held through the Zoom Meeting application. The program was also attended by the Head of Laboratory of Sustainable Bioresource Management of INTROP, Assoc. Prof. Dr. Zaiton Samdin who gave a welcome speech at the opening of the program.

The first session of the talk was entitled 'Selecting journal article for publication', where the speaker explained why it is necessary to publish research results, introduction of Scopus, Journal citation reports (JCR), impact factors and quartiles and how to select the appropriate type of journal for the field of research to publish articles correctly. While the second session is entitled 'Tips and Tricks to Write a High Impact, Publishable Research Article', which focuses more on how to write and important information of articles from introduction to conclusion, what reviewers want in research articles, examples of good articles and ended with a question-and-answer session.

The webinar was attended by a total of 76 participants consisting of graduate students and government agency staff. As a result of this webinar, students have knowledge of the purpose of article publication, how to select an appropriate journal and better understand the features that need to be assessed in publishing an article. The question-and-answer session was also well received as there were various questions answered and explained by the speaker to the participants. Therefore, this webinar provides an impact and opportunity for students to add knowledge in the publication of their research articles later.



LEAVE NO ONE BEHIND (10 September 2021)

Organised by: INTROP Graduate Unit

A course entitled "Leave No One Behind" which was held on 10 September 2021 was attended by more than 30 participants, namely students and staff of INTROP. This course was implemented by the INTROP Graduate Unit with the first slot aimed to provide support related to students' awareness and understanding related to the use of laboratories during pandemics. This slot has been delivered by Assoc. Prof. Dato Dr. H'ng Paik San as head of the laboratory at INTROP. Students were also given information related to the security of their presence at UPM by Prof. Dr. Mohd Rafee Bin Baharudin from UPM Occupational Safety and Health Division (OSHA). In the final slot, Registered Chancellor Dr. Azmawaty Mohamad Nor from Universiti Malaya discussed how to manage time, study and family during pandemic. Evaluation and suggestions for course improvement were also conducted.

BAMBOO TREE PLANTING PROGRAMME IN CONJUNCTION WITH WORLD BAMBOO DAY MALAYSIA CELEBRATION (18 September 2021)

The Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia (UPM), has participated in the Bamboo Tree Planting Programme held recently in conjunction with the World Bamboo Day Malaysia 2021 celebration organised by the Malaysian Timber Industry Board (MTIB). The programme was led by the Director of INTROP, Prof. Ts. Dr. Khalina Abdan, and conducted simultaneously across the country virtually. It was held to demonstrate the strong support for developing the country's bamboo industry and as a symbol of the 58th Malaysia Day celebration.

INTROP, UPM, as part of HICoE (Higher Institutions Centres of Excellence) in the field of tropical wood and fibre, and Universiti Teknologi MARA's (UiTM) Pahang branch were two local Public Institutions of Higher Learning (IPTA) participated in the programme. The bamboo planted by INTROP in the programme is known as the honey bamboo *(Gigantochloa albociliata)*, a commonly planted bamboo by villagers to harvest its delicious shoots.

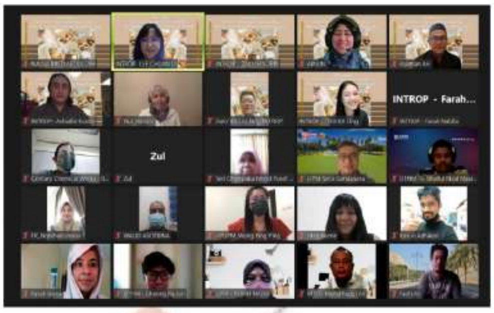
Participants of the programme planted their bamboo shoots simultaneously in their respective houses/residences/offices on the day according to the stipulated SOP of the National Rehabilitation Plan of each state. The programme had received a good response from the participants from all over the country, including Tanah Merah, Kelantan; Mount Lang, Perak; UiTM Pahang, Jengka, Pahang; Bandar Puteri Bangi, Selangor; Kampung Melayu Seri Kundang, Rawang, Selangor; Royal Bamboo Garden, Kampung Lada, Jerantut, Pahang; An-Nur Mosque, Taman Putera Jaya, Kota Kinabalu, Sabah; Kuala Kepok, Kelantan; Kuala Berang, Terengganu; Kampung Rantau Panjang, Klang, Selangor; Taman Sri Jelok, Kajang, Selangor; Kampung Bukit Bidang, Pasir Puteh, Kelantan; Goshen Village, Marudu City, Sabah; Kuala Nerus, Terengganu and Kampung Tarom, Johor Baharu, Johor.

WEBINAR ON COVID-19 AND FOOD PACKAGING: DRIVING TREND OF F&B PAPER BASED PACKAGING (22 September 2021)

Organised by: Biopolymer and Derivatives (BADs)

This webinar entitled 'COVID-19 and Food Packaging: Driving Trend of F&B Paper Based Packaging' was organized by Laboratory of Biopolymer and Derivatives (BADs), INTROP on 22 September 2021. Packaging is an important factor to reduce food waste and also provide protection from various damages during transport. Furthermore, an adequate package reduces the possibility of microbial contamination from the surrounding environment and extends food storage life while preserving its quality. Many consumers are really seeing the benefits of plastic packaging in this area. But there's still the end-of-life issue to consider. Hence, biodegradable packaging from pulp and paper is gaining interest from the food industry due to its significant impact on shelf-life extension and food-safety. However, it still has many hidden advantages that are very challenging to find and apply to paper-based food packaging. The COVID-19's impact on the packaging industry, current trend of paper-based food packaging, the next normal for paper packaging design and about food packaging myths and misconceptions were discussed in this live webinar.

These issues were discussed by 3 experienced speakers in their own expertise; (1) Dr. Ainun Zuriyati Mohamed @ Asa'ari from INTROP, UPM presented on the topic 'Rising Demand for Environmental-friendly Packaging to Mitigate Adverse Pandemic Impact'; (2) Assoc. Prof. Dr. Nur Hanani Zainal Abidin from Faculty of Food Science and Technology, UPM presented on the topic Current Trends of Paper-based Packaging for Food Applications; and (3) Prof. Dr. Rukman Awang Hamat from Faculty of Medicine and Health Science, UPM presented on the topic 'Food Poisoning Amid COVID-19 Pandemic: Public Favour or Fear?'. The webinar is moderated by the Head of BADs Laboratory, Assoc. Prof. Dato' Dr. H'ng Paik San. There were 196 registered participants from differentcountries; the United States, Brunei, Japan, South Korea and Malaysia as well. Participants represented by more than 56 institutions or agencies from different industries such as universities, private institutes, companies, pulp and paper industries, banks, research institutes/agencies, hospitals, polytechnics and communities. The audience responded positively andsuggested to have more similar webinars to be organized in the future.



TRAINING ON FLAMMABILITY ANALYSIS OF BIOCOMPOSITE MATERIALS (23 September 2021)

Organised by: Biocomposite Technology (BIOCOM)

A virtual training session on Flammability Analysis of Biocomposite Materials was organised by the Laboratory of Biocomposite Technology. This training covered the critical aspects of the characterization and flammability properties for biocomposite material. The speaker, Dr. Ridwan Yahaya provided participants with hands-on experience, along with information on the flammability properties of some natural fibres via the Cone Calorimeter and Smoke Box Analysis. The second section was led by the Laboratory of Biocomposite's Science Officer, Mr Mohd Shazwan. He demonstrated the standard testing method, technical parameters, and control system for the Limiting Oxygen Index (LOI) and Flammability Tester (UL-94).

2ND WORLD CONFERENCE ON BYPRODUCTS OF PALMS AND THEIR APPLICATIONS - BYPALMA 2021 (28-30 September 2021)

The 2nd World Conference on Byproducts of Palms and their Applications was held as an online event by the ByPalma Association and the Institute of Tropical Forestry and Forest Products (INTROP). ByPalma 2021 conference is covering a wide range of trends on palm byproducts in wood substitutes, composite reinforcements, biotechnology, fertilizers, food, paper, textiles and bioenergy. Experts from more than 20 countries have gathered to redefine palm byproducts as a springboard to the circular bioecomomy of the future. The programme covered a wide range of topics related to the use of palm byproducts in innovative applications. Three full days with three parallel sessions packed with innovation related to valorizing palm byproducts in added-value modern applications. This conference also provided an interdisciplinary platform for the leading academic community and reflected thatMalaysia has a bright future producing high-quality palm products for both domestic and export markets.

PGSM EDUCATION FAIR 2021
(6 October 2021)

STEM is a combination (Integration) of Science and Technology, Mathematics and engineering subjects to be applied in teaching and learning as it is among the important skills in the 21st century. INTROP has held a community service and knowledge transferprogram to secondary and primary schools in the state of Johor on 06 October 2021. The program is to educate the students on the importance of conserving our tropical forest and the environment.

Among the activities that were carried out during the program are; briefing and introductory session of Universiti Putra Malaysia (UPM) and the Institute of Tropical Forestry & Forest Products (INTROP) by En. Muhaizi Mat Daud, the Putra Rimba Rimbun Program by Dr. Syeed SaifulAzry Osman Al-Edrus, a talk on STEM in Tropical Forestry by YBhg. Prof. Ts. Dr. Khalina Abdan and Quizizz competition by Ms. Amirah Nur Amallina Osman.

For participants who successfully answered the quiz, they won a prize of a Touch 'n Go e-wallet voucher worth RM10 for first place, RM7 for second place, and RM5 for third place.A total of 83 participants were involved including primary and secondary school students. A total of 12 INTROP committee members while 55 primary school students and 28 secondary school students participated virtually in the program through Google Meet. STEM programs like this have received widespread response in several secondary schools, especially science stream schools. This collaboration is also meaningful at the university level because it can collaborate with the Johor State STEM Teachers Association and the Ministry of Education Malaysia.

COURTESY VISIT OF HICOE INTROP RESEARCH CENTER OF EXCELLENCE DIRECTOR GENERAL MALAYSIA TIMBER INDUSTRY BOARD (MTIB)
(20 October 2021)

A courtesy call was held by the management members of INTROP, UPM to the Office of the Director General of MTIB in Cheras. The visit was accompanied by 5 members of INTROP management led by the Director of INTROP, Prof. Ts Dr Khalina Abdan and on behalf of MTIB 5 officers joined the meeting led by the Director General of MTIB, Tn Hj Mahpar Atan. Discussions revolved around issues and obstacles faced by the industry as well as various potential collaborations that can help the development and progress of the Malaysian timber industry towards the Vision of Shared Prosperity 2030. Various plans for cooperation and collaboration were discussed especially to develop the bamboo industry, strengthen the use of oil palm trunk for value-added products as well as human capital development in various timber sub-sectors. It is hoped that this visit will help the Malaysian timber industry sector to continue to thrive and will be globally competitive.

COURTESY CALL FROM PAHANG FOUNDATION COLLEGE UNIVERSITY (UCYP) (30 September 2021)

A delegation from Universiti Kolej Yayasan Pahang (UCYP) paid a courtesy call to the Institute of Tropical Forestry and Forest Products (INTROP). The delegation was led by Pn. Hajjah Rugayah Bt Hussein as the Deputy Vice Chancellor (Assets and Infra Development) followed by Dr. Mohd Nozulaidi Bin Nordin, Head of Department, Faculty of Science, Engineering and Agrotechnology, En. Mohd Nor Firdaus Bin Mohd Nordi, the Assistant Vice Chancellor (Department of Business and Commercial Development) and En. Ezuan Hadi Bin Zulkefly as a Lecturer (Department of Research and Industrial Networking). The presence of this delegation was welcomed by members of INTROP management and staff. Both institutions discussed cooperation in the research of Paulownia trees which have great potential in the timber industry as well as to obtain more information on the methods or procedures for registration of tree breeds in Malaysia.

WOBIC 2021 Preconference Workshop VIRTUAL SCIENTIFIC WORKSHOP: PULP AND PAPER GRADING BASIS (17 November 2021)

Organised by: Biopolymer and Derivatives (BADs)

In conjunction with the 5th Wood and Biofibre International Conference (WOBIC2021), a pre-conference workshop, Virtual Scientific Workshop: Pulp and Paper Grading Basis was held virtually on the 17th November 2021. This interactive virtual workshop was an invaluable experience for technical and nontechnical based individuals who need a broad understanding of pulp & paper performance and grading basis to match the product usage.

A total of 27 delegates, including students from local universities, researchers and paper industry representatives were virtually gathered for the workshop. During the workshop, Mr. Roslan Shafil, the General Manager of Eco-Palm Paper Sdn Bhd, shared some practical processes in the industry for making papers, including fibre preparation, fibre screening, and fibre delignification.

Dr. Ainun Zuriyati, the Head of Pulp and Programme, BADs, INTROP and Dr. Sharmiza Adnan, the Managing Director of Product Certification Services, Forest Research Institute Malaysia discussed different testing techniques used on pulp and paper grading. From this workshop, participants were able to gain hands-on experience on how to handle testings on pulp and paper products using the scientific kits which were delivered to the participants prior to the day of the workshop.

CONFERENCE ON YOUTH COMMUNITY LEADERSHIP AND ENGAGEMENT (CYCLE) 2021
(17 November 2021)

Organised by: Biopolymer and Derivatives (BADs)

The Conference On Youth Community Leadership And Engagement (CYCLE) 2021 was held as an online event co-organised by Institute of Research and Community Services, Universitas Brawijaya, Malang, Indonesia and Institute of Tropical Forestry and Forest Products (INTROP). CYCLE 2021 conference aimed to assist young researchers in obtaining more ideas to move forward and expand their community programs. Researchers from Malaysia and Indonesia shared their experience and knowledge on conducting community programs from Malaysia and Indonesia researchers. INTROP was represented by Dr. Ainun Zuriyati as the keynote speaker of the conference. CYCLE 2021 was attended by 70 students and lecturers.

MONTHLY AGRO-BASED ENGINEERING SEMINAR (MABES)
(26 November 2021)

Organised by: Biopolymer and Derivatives (BADs)

Monthly Agro-Based Engineering Seminar (MABES) was organized by the Faculty of Agricultural Technology - Universitas Brawijaya. This monthly seminar was held in collaboration with Faculty of Agricultural Technology, Universitas Brawijaya, International Association of Agro-based Engineering and Technology (IAAET) and Institute of Tropical Forestry and Forest Products (INTROP). MABES aimed to assist researchers in obtaining more ideas to move forward and expand their community programs especially on agro-based engineering. Researchers from Malaysia and Indonesia shared their experience and knowledge on conducting community programs from Malaysia and Indonesia researchers. INTROP was represented by Assoc. Prof. Dr. Mohd Zulkhairi M.Y. as the speaker for the November edition. MABES was held monthly and attended by 60 students and lecturers.

5th Wood and Biofibre International Conference 2021 - WOBIC 2021 (23- 24 November 2021)

The 5th Wood and Biofibre International Conference 2021 (WOBIC 2021) was held as a hybrid event (combining virtual and physical). For the physical opening ceremony, it was held at the Bangi Resort Hotel, Selangor, Malaysia. The official opening of the conference was also held online, with invitees and participants interacting with the event. This conference featured presentations by bioresource experts from around the world. WOBIC 2021 provided a platform for the exchange of research findings and services related to natural fibres, timber, and forestry technology with high added value that is also safe for humans and the environment. WOBIC 2021 carried the theme Wood and Biofibere-transformation toward circular economy. The key concept of the circular economy is to waste and increase the reproducibility of products.

A total of 154 delegates, including students from local and international universities, researchers, national policymakers, and industry representatives, virtually gathered for the two-day conference. 14 domestic universities, 5 governmental and non-governmental organisations, and 4 international universities have sent representatives to WOBIC2021. Besides, a total of 88 presentation papers were presented in 11 technical sessions, as well as a forum session on the final day of the conference titled "From surviving to thriving: harnessing the circular economy for wood and biofibre in the post-pandemic era" to discuss the impact of the covid-19 pandemic on the economy and the timber industry.

During the opening ceremony, two Memorandums of Understanding (MoU) were signed between UPM and two industries to collaborate on research, human capital development, academic activities, community service, and knowledge transfer and sharing. The first MoU was signed between UPM and the Malaysian Timber Industry Board (MTIB) comprises research in the fields of timber, forestry biocomposite and lignocellulose biomass. The second MoU signing was between UPM and the RIMBA Foundation involves cooperation in community service and knowledge transfer programmes for school children and the community, especially in creating awareness in forest and environmental conservation. UPM Deputy Vice-Chancellor (Academic and International), Prof. Ts. Dr. M. Iqbal Saripan, was present on behalf of the Vice-Chancellor, Prof. Dr. Mohd Roslan Sulaiman. Also present were UPM INTROP Director, Prof. Ts. Dr. Khalina Abdan; MTIB Deputy Director General (Management and Operations); Kamaruzaman Othman; MTIB Director of Fibre and Biocomposite Centre (FIDEC), Banting, Nor Liza Mat Yasok; Chairman of Rimbun Foundation, Dato' Raveendra Kumar Nathan and a representative from Rimbun Foundation, Tamil Selvi Suppiah.

INTROP 2021 DIRECTION WORKSHOP
(30 November 2021)

The INTROP 2021 Direction Workshop was held on the 30 November 2021 with three objectives; (i) To plan the preparation and distribution of resources according to activities that have an impact and contribute to the achievement of UPM's Strategic Plan; (ii) To drive INTROP's visibility and advancement in tropical wood and fiber field research as required by HICoE; and (iii) To support and succeed UPM Strategic Plan 2021-2025. This workshop was attended by a total of 32 participants. Yg. B'bhg Deputy Vice Chancellor (Research & Innovation), Prof. Dr. Nazamid Saari was also present to convey UPM's aspirations and desires as well as strategy towards high-tech agriculture. Director of the Research Management Centre (RMC), Assoc. Dr. Mohd. Adzir Mahdi and Prof. Dr. Shamsilah Roslan also attended the workshop to share ideas and assist in detailing the formulation of INTROP's commercialization strategy. Participants include the INTROP Advisors; Dato' Dr. Jalaluddin Harun, Prof. Dr. Paridah Md Tahir, and Prof. Dr. Ahmad Ainuddin Nuruddin. Also participating were the Heads of Laboratories, Program Manager and Research Officer of INTROP. Participants were separated into four discussion groups; (i) Internationalization; (ii) Commercialization; (iii) Industry and communitynetworking; and (iv) Flagship Project. Each group had detailed the activities and timelines for the projects or programs identified under these groups.

MAJLIS JASAMU DIKENANG & MAJLIS GALA GEMILANG INTROP
(30 November 2021)

The Majlis Jasamu Dikenang and Majlis Gala Gemilang INTROP (MGGI) was held on the 30th November 2021 at the Bangi Resort Hotel. The MGGI was held to celebrate and appreciate the contribution of all INTROP staff who have worked hard for the success of INTROP in various fields. In addition, this event also helped to strengthen the relationships between staff and former staff who have moved and are retiring soon. This MGGI is an annual event that has been held in previous years. However, following the COVID-19 pandemic, the event could not be held in the year 2020. This year INTROP took the opportunity to hold this event again. This event gathered the appreciation for the contributions and services of all INTROP staff in the year 2020 and 2021. All the INTROP staff dressed up according to the theme of colour for the event which is black and gold.

INTROP LANDSCAPING PLANTING PROGRAMME (1-9 DECEMBER 2021)

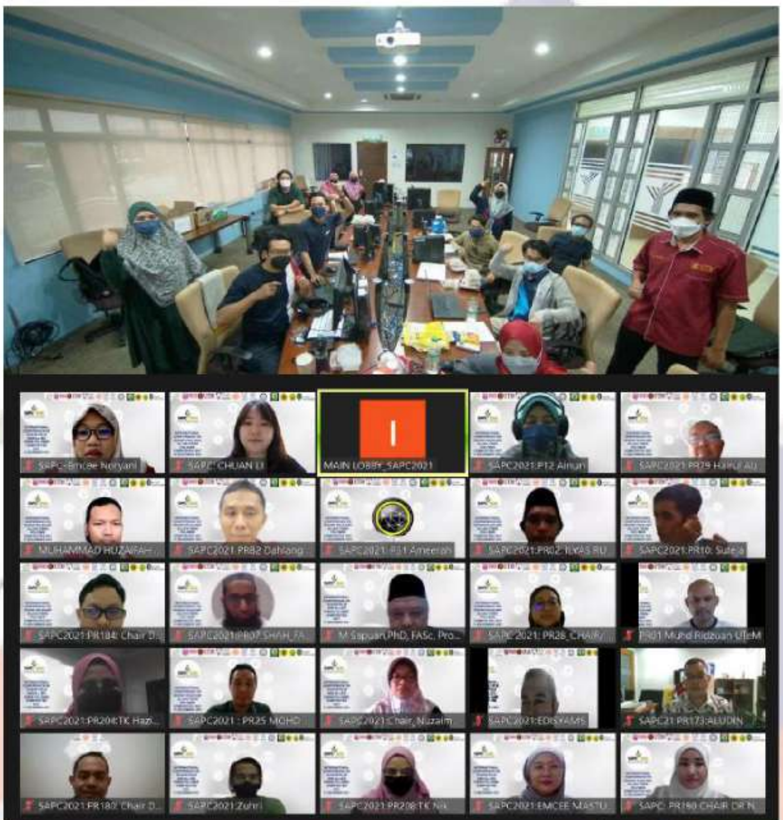
INTROP Landscaping Planting Programme was organised from the 1st to the 9th of December 2021. All INTROP staff had taken part in creating a positive workplace atmosphere by working together to create a beautiful plant landscape in the center of the INTROP compound. During the programme, *Heliconia densiflora* and *Excoecaria cochinchinensis* were planted. This program serves as a platform for all members to share knowledge and develop conservation techniques in order to preserve the beauty of INTROP. It will provide more opportunities for community improvement and aid in the dissemination of knowledge, particularly about the natural environment.

INTERNATIONAL CONFERENCE ON SUGAR PALM AND ALLIED FIBRE POLYMER COMPOSITES 2021 - SAPC 2021
(11 December 2021)

International Conference on Sugar Palm and Allied Fibre Polymer Composites (SAPC2021) is organised by the Persatuan Pembangunan Industri Enau Malaysia (PPIEM). This conference is also co-organized by Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia (UPM), Institute of Tropical Forestry and Forest Products (INTROP), UPM, Universiti Teknologi Malaysia, Technical University of Liberec, Czech Republic, Universitas Andalas, Indonesia, Universitas Jember, Indonesia, Universitas Mataram, Indonesia, National Textile University, Pakistan, King Mongkut's University of Technology North Bangkok, Thailand, University of Gambia, Gambia, Kalasalingam Academy of Research and Education, India and Universidade Estadual de Londrina, Brazil. This program also is sponsored by Proville Tech Sdn. Bhd. with the purpose to gather all leading experts, scientists, educators and researchers from many countries to disseminate their recent findings in all aspects of natural composite research (especially sugar palm), technology and innovation.

This international conference is a continuation of the 'National Enau Seminar 2019' which was held in Bahau, Negeri Sembilan,Malaysia with the support of the Institute of Tropical Forestry and Forest Products (INTROP) and the Advanced Engineering Materials and Composite Research Centre (AEMC), Universiti Putra Malaysia, together with Hafiz Adha Enterprise, one of the sugar palm industrial players in Malaysia. This year, the association moved a step further by organizing an international conference.

The selected theme reflects the current trends of innovation for sustainable advanced natural fibres. This conference is conducted using online platform on 11th December 2021 and gathered 7 renowned keynote speakers, 16 invited speakers, 64 presenters and 43 listeners from 33 organizations of 11 countries in the world like Indonesia, Thailand, India, Pakistan, Hungary, Gambia, Brazil, Czech Republic, Nigeria, Brazil and Malaysia that covers topics from upstream to downstream of sugar palm. The scopes of this conference are not limited to sugar palm, advanced manufacturing biocomposites, natural fibre composites, and bio-products. Six awards are awarded to the participants that have presented their excellence in presentation and manuscript preparation. And for the first time, 'Mohd Sapuan Award' were delivered to the successful participant that achieved the highest marks for both categories.



LVL PRODUCTION USING SMALL-DIAMETER LOGS FROM SHORT-ROTATION RUBBER FOREST PLANTATION SPECIES COULD "FORGE NEW LINKS BETWEEN LATEX AND TIMBER"

NAME: Khoo Pui San
PROGRAMME: Doctor of Philosophy (PhD)
FIELD OF STUDY: Biocomposite Technology and Design
SUPERVISOR: Assoc. Prof. Dato' Dr. H'ng Paik San

▶ INTRODUCTION

The demand for structural lumber in Malaysia has increased when the government introduced National Green Technology Policy (NGTP) in 2009 and the National Timber Policy (NATIP) 2010-2020 with the purpose to encourage the use of wood and wood products in green and energy-efficient buildings. In 2018, the construction sector in Malaysia was valued at RM 141.8 billion with the residential housing sector contributing approximately 43 % to this total (Bank Negara Malaysia, 2019). A lot of structural lumber is being used in the construction either as roof trusses or floor trusses in a high-end housing project (CIDB, 2018). At the same time, Malaysia also performed well in the global market as an exporter of structural lumber to many countries/regions. The export value of structural lumber reached nearly 250 million U.S. dollars in 2018 (MTIB, 2019). The most common structural lumber used within the construction sector is solid sawn lumber, followed by laminated veneer lumber (LVL), glued laminated timber (GLULAM), and cross-laminated timber (CLT) (Latib et al., 2019).

The increasing demand for structural lumber in Malaysia and by the world creates a huge demand for good quality logs from natural and plantation forests. Nonetheless, with the diminishing supply of large-sized logs from natural forests and planting forests, there would soon be a limited supply of good quality round logs for sufficient production of structural lumber for structural purposes. The total forested area in Malaysia is approximately 18.27 million ha (55.3 %), in which 14.55 million ha (79.6 %) is classified as permanent reserved forests (Malaysian Timber Council, 2017). Significant areas of forests are being managed principally for conservation purposes and controlled logging is implemented in line with the Sustainable Forest Management (SFM) principles. Hence, there is a shortage of these high-value tropical hardwoods from natural forests for commercial harvesting purposes. Simultaneously, as the environmental issues have drastically increased, forests are finding it harder and harder to meet the demand for both energy and wood material. Therefore, wood manufacturers accelerated the transition from using natural forest resources to forest plantation resources such as rubberwood, which is derived from rubber trees.

To meet the demand for the global market and domestic construction sector, the rubberwood supply must be sustainable. Concerning that, a higher planting density known as rubber forest plantation (RFP) was introduced (Shuib and Yusoff, 2015). A higher planting density with 625 trees/ha has been implemented in RFP to meet the growing demand for rubberwood compared to a lower planting density of 400 trees/ha (Saffian et al., 2014). Despite wood being one of the primary recoveries in RFP, latex production is still the priority (Shuib and Yusoff, 2015). The rubber trees were remained untapped for six years to allow better girth increment for higher stem volume, followed by tapping for 10 to 15 years, before felled for processing (Kamaruzaman and Yahy, 2008). With the continuous increase of rubber price, intensive tapping systems have been implemented to enhance harvesting yield (Sainoi and Sdoodee, 2012), i.e. 15 years as compared to conventional 25 to 30 years (Shuib and Yusoff, 2015), but may lead to shorter life-cycle of the RFP (Chantuma et al., 2011). High-frequency tapping allows two times tapping per day to obtain more latex yield (Balsiger et al., 2000) compared to conventional tapping systems (daily, two days out of three and three days out of four) (Chantuma et al., 2011). This high-frequency tapping temporarily increases latex yield but affects the growth in life cycles of rubber trees (Sainoi and Sdoodee, 2012) and damages the rubber plantation in the long term (Balsiger et al., 2000). Over-tapping in RFP often has negative effects on wood recovery (Balsiger et al., 2000). Under this RFP planting cycle and modern tapping system, rubber trees are harvested at a younger age and are much smaller in diameter compared to the conventional planting and tapping method applied years back.

Rubberwood has certain advantages over timbers from the natural forest. Nonetheless, due to its relatively low sawn timber recovery rate, which lies between 25 to 45 percent because of poor stem form and small diameter, the production cost per cubicmeter of rubberwood is much more expensive than those of the production cost for tropical hardwood species (Kamaruzaman and Yahy, 2008; FAO, 2001; Balsiger et al., 2000). Additionally, the rubberwood stem tends to be tapered (FAO, 2001).

Although rubberwood is not cost-effective for solid sawn wood, however, with the latest advanced technology in spindleless lathe for veneer processing, the recovery rate and utilizable wood volume per hectare of rubberwood can be increased through appropriate veneer processing technology (Leggate et al, 2017). The considerations for the use of wood veneer were to reduce production costs and to minimize inventory and quality consistency (Chin et al., 2019). The variation in wood density across the stem has prominent effects on the processing and utilization of wood, particularly in the production of rotary-peeled veneer. Thus, the density profile of these small diameter rubber trees has been disclosed at three distinct tree heights. The density ranged from 648 to 706 kg/m^3. Figure 1 shows the density distribution in a rubber tree trunk. Rubberwood found in this study has a slightly higher density than mature rubberwood. Rubberwood density can be maintained despite higher planting density and a shorter planting cycle; as a result, rubber trees from RFP can be harvested after 15 years of rotation, and industries do not need to wait for the rubber trees to mature after 25 to 30 years.

▶ VENEER RECOVERY FROM SMALL DIAMETER RUBBER LOGS

Rubberwood veneer recovery from these small diameter rubber logs ranged from 62.56 to 65.36 %. These small diameter rubber logs gave a high veneer recovery, yet they are classified as non-decorative structural grade veneer for structural purposes. The use of spindleless lathe for peeling small diameter plantation logs has been rapidly expanded. According to Arnold et al. (2013), the use of spindleless lathe drastically changed the veneer processing industry globally, as large diameter logs are no longer a prerequisite. Instead, small diameter logs (≤ 60 mm) from plantations as young as 4 to 5 years old can be processed economically to yield high-value veneer (Luo et al., 2013). The recoveries are approximately 2 to 6 times the recovery typically achieved with the traditional sawing method for processing similar resources, presenting an opportunity to process young, small diameter plantation logs with lower quality (McGavin and Leggate, 2019; McGavin et al., 2014).

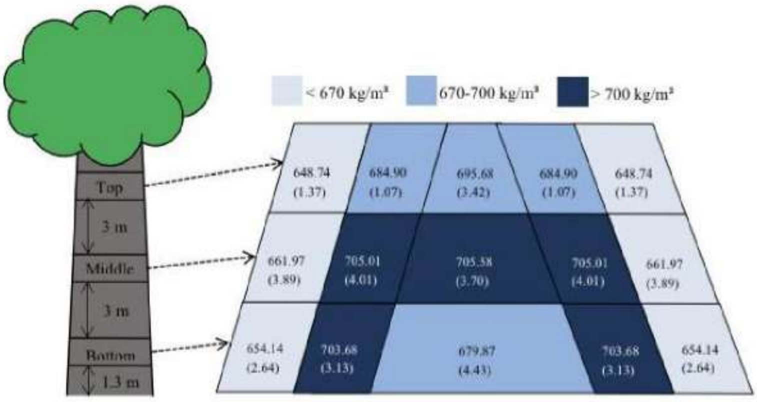


Figure 1: Density distribution in a rubber tree trunk

Rubberwood veneers produced from spindleless lathes can be converted into LVL through quality controls. LVL is a high-quality product that can be used to replace scarce high-quality solid wood in building construction as they retain the structural properties of solid wood (Basuki et al., 2021; Percin and Altunok, 2017; Wang et al., 2015). LVL is manufactured from veneers glued together with the grain parallel to adjacent ply using adhesives, under heat and pressure (Purba et al., 2019; Shi and Walker, 2006). LVL have various benefits over solid wood: 1) larger dimension can be produced compared to solid wood (LVL can be as long as 25 m, as thick as 300 mm, and as wide as 1200 mm) (Purba et al., 2019; Wang et al., 2015; Bal and Bektaş, 2012; Shi and Walker, 2006); 2) more uniform due to defects have been dispersed or removed during production (Pot et al., 2015; H'ng et al., 2012; Daoui et al.. 2011); 3) better dimensional stability (Xiong et al., 2020; Lustosa et al., 2015; Wang et al., 2015); 4) higher strength properties (Xiong et al., 2020; Lustosa et al., 2015; Pot et al., 2015); 5) various shapes can be produced (Xiong et al., 2020; Ozarska, 2014); and 6) cost advantage of efficient utilization of material during processing (Tenorio et al., 2011; Vlosky, 2007).

▶ CONCLUSION

The rubberwood LVL produced by veneers peeled from small diameter rubber plantation species using spindleless lathe was found to exhibit mechanical properties of; 91.05 MPa for MOR in flatwise direction, 11189.55 MPa for MOE in flatwise direction and 50.23 MPa for compressive strength parallel to the longitudinal axis. According to PRL- 501 (2000): performance standard for LVL, the mechanical properties of rubberwood LVL produced from this study have been fulfilled the minimum requirement for 2.1E-3100F stress class, except for MOE in the flatwise direction has met the 1.5E- 2250F stress class's minimum criteria. Based on the results of the study, it is recommended that further research should be done to investigate its other properties, such as biological resistance, thermal properties, fastener holding capacity, and a connection system for this product.

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STUDENTS GRADUATED IN YEAR 2020

Nama	:	Faris Syahiran bin Ismail
Matrix No.	:	GS48071
Degree Awarded	:	Master of Science
Field of Study	:	Biopolymer, Pulp and Paper Technology
Thesis Title	:	Characterization of Oil Palm Empty Fruit Bunch Fibres-Microcrystalline Cellulose for Potential High Mechanical Strength Paper
Supervisor	:	Dr. Mohammad Jawaid

Nama	:	Hunaidah binti Ramli
Matrix No.	:	GS36195
Degree Awarded	:	Master of Science
Field of Study	:	Biopolymer and Derivatives
Thesis Title	:	Rubber Wood Sawdust Fermentation by Indigenous Lignocellulolytic Fungi for Cellulase Production
Supervisor	:	Prof. Dr. Rosfarizan Mohamad

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Thesis Title	:	Ultrasonic Assisted Extraction of Thymol from *Plectranthus Amboinicus* (Lour.) Spreng Leaves
Supervisor	:	Prof. Dr. Luqman Chuah Abdullah

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Field of Study	:	Material Soience
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Supervisor	:	Prof. Dr. Luqman Chuah Abdullah

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Nama : Nadirah binti Rosli
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Supervisor : Assoc. Prof. Dr. Zaiton Samdin

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Degree Awarded : Master of Science
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Thesis Title : Cellulose Nanofiber as Nucleating Agent and Reinforcement Material in Improving Crystallization and Mechanical Properties of Polylactic Acid Nanocomposites
Supervisor : Prof. Ts. Dr. Hidayah Ariffin

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Thesis Title : Sap Flow Density and Hydraulic Conductivity of Three Mature Exotic Forest Species Under Similar Planting Condition
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Supervisor : Prof. Ts. Dr. Khalina Abdan

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Thesis Title	:	Peat Swamp Forest Stand Recovery After Ten Years of Logging in Pekan Forest Reserve, Pahang and Micropropagation of *Gonystylus Bancanus* (Miq.) Kurz
Supervisor	:	Prof. Dr. Nor Aini Ab Shukor

Nama	:	Marwah binti Rayung
Matrix No.	:	GS44509
Degree Awarded	:	Doctor of Philosophy
Field of Study	:	Biocomposite Technology and Design
Thesis Title	:	Preparation and Characterization of Jatropha Oil-Based Polyurethane Acrylate Gel Electrolyte for Dye-Sensitized Solar Cells
Supervisor	:	Dr. Min Min Aung @ Aishah Abdullah

Nama	:	Nik Syamsul Bahari bin Che Yusof
Matrix No.	:	GS45349
Degree Awarded	:	Doctor of Philosophy
Field of Study	:	Biocomposite Technology and Design
Thesis Title	:	Hybrid Technique for Material Composite Selection and Conceptual Design for Automotive Crash Box
Supervisor	:	Prof. Ir. Dr. Mohd Sapuan Salit @ Sinon

Nama	:	Nor Salwa binti Hamdan
Matrix No.	:	GS49838
Degree Awarded	:	Doctor of Philosophy
Field of Study	:	Biocomposite Technology and Design
Thesis Title	:	Conceptual Design and Life Cycle Assessment of Natural Fibre-Reinforced Biopolymer Composites Takeout Food Container Using Concurrent Engineering
Supervisor	:	Prof. Ir. Dr. Mohd Sapuan Salit @ Sinon

Nama	:	Rozilah binti Abdullah
Matrix No.	:	GS50792
Degree Awarded	:	Doctor of Philosophy
Field of Study	:	Biopolymer, Pulp and Paper Technology
Thesis Title	:	Characterization of Sugar Palm Starch/Sugar Palm Nanocrystalline Cullulose Composites Film Filled With Silver Nanoparticles on Mechanical and Antimicrobacterial Properties
Supervisor	:	Assoc. Prof. Dr. Che Nor Aiza Jaafar

AWARDS AND RECOGNITION

HIGH-IMPACT INDUSTRY AND COMMUNITY NETWORK AWARD 2019
BEST PTJ CATEGORY
Institute Of Tropical Forestry And Forest Products (INTROP)

DR. MOHAMMAD JAWAID

Name of Award: High-Impact Industry and Community Network Project Year 2020 – High-Impact Industry Project
Project Title: Safe Biodegradable Packaging (SafeBioPack)
Conferring Body: Universiti Putra Malaysia

TOP CITED ARTICLE 2019-2020

CONGRATULATIONS TO

S.M. Sapuan

whose paper has been recognized as a top cited paper in

Polymer Composites

WILEY

PROF. IR. DR. MOHD SAPUAN SALIT

Name of Award: Top Cited Article 2019-2020
Conferring Body: Polymer Composites Journal, WILEY

DR. MOHAMMAD JAWAID

Name of Award: Highly Cited Research Paper
Conferring Body: Journal of Bionic Engineering, SPRINGER

DR. MOHAMMAD JAWAID

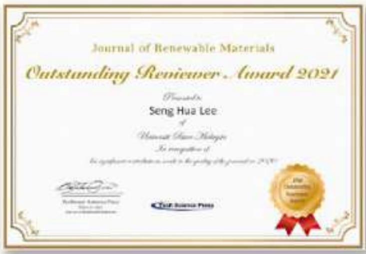
Name of Award: Silver Award - Manufacturing Process and Advanced Materials Category (Malaysia Technology Expo 2021)
Name of Project: Techno Economic Hard Body Armour
Conferring Body: Professional Trade Exhibition & Meeting Planner (PROTEMP)

PROF. IR. DR. MOHD SAPUAN SALIT

Name of Award: Perintis Publication Award 2021
Conferring Body: Persatuan Saintis Muslim Malaysia (PERINTIS), Malaysia

DR. LEE SENG HUA

Name of Award: Outstanding Reviewer Award 2021
Conferring Body: Journal of Renewable Materials, TECH SCIENCE PRESS



DR. AINUN ZURIYATI MOHAMED @ ASA'ARI

Name of Award: Bronze Award (Penang International Invention, Innovation, and Design (PIID 2021)
Name of Project: Preparation of Aroma Paper from Recycled Paper and Citrus Leaves
Conferring Body: Universiti Teknologi MARA (Penang branch)

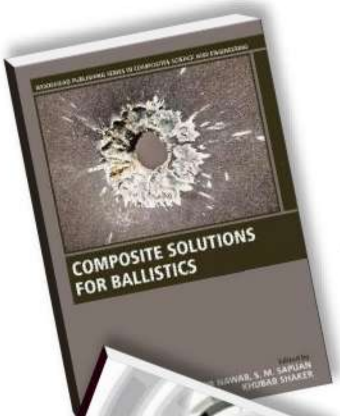
DR. SHERIZA MOHD RAZALI

Name of Award: Best Poster Award (Penang International Invention, Innovation, and Design)
Name of Project: High-Resolution Imagr and Field Observation for Assessment of Soil Water Content in Tropical Lowland Dipterocarp Forest
Conferring Body: Kuala Lumpur International Agriculture, Forestry & Plantation Conference (KLIAFP)

DR. CHIN KIT LING

Name of Award: Putra RO Award 2021 (Category Q43/44)
Conferring Body: Universiti Putra Malaysia

BOOK SHELF



Composite Solutions for Ballistics

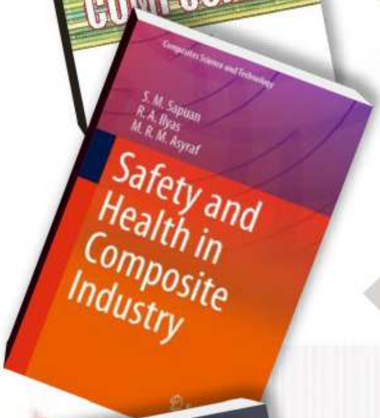
1st Edition
Editors : Yasir Nawab, S.M. Sapuan, Khubab Shaker
Year : 2021
eBook ISBN : 9780128219904
Paperback ISBN : 9780128219843

Roselle: Production, Processing, Products and Biocomposites

1st Edition
Editors : S.M. Sapuan, Nadlene Razali, A.M. Radzi, R.A. Ilyas
Year : 2021
eBook ISBN : 9780323852197
Paperback ISBN : 9780323852135

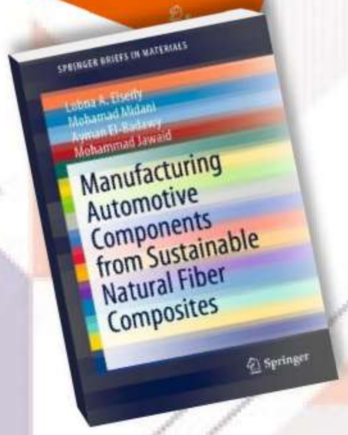
Natural Fibre Composites

Editors : Che Husna Azhari, Mohd Sapuan Salit, Rozli Zulkifli
Year : 2021
ISBN : 9789672513490



Safety and Health in Composite Industry

Editors : S.M. Sapuan, R.A. Ilyas, M.R.M. Asyraf
Year : 2021
eBook ISBN : 9789811661365
Paperback ISBN : 9789811661358



Manufacturing Automotive Components from Sustainable Natural Fiber Composites

Editors : Lobna A. Elseify, Mohamad Midani, Ayman El-Badawy and Mohammad Jawaid
Year : 2021
eBook ISBN : 9783030830250
Paperback ISBN : 9783030830243

The Road From R&D to Commercialisation

AquaPod was founded in 2021 to aid in the improvement of tap water quality in Malaysia. The company's strength comes from the expertise of the team members in designing green production processes from sustainable material, which provide dual economic and environmental benefits by integrating pollution prevention in the product development process from biomass materials. AquaPod has excellent adsorption properties, which removes contaminants from the water three times better than conventional carbon filter. It is compact, portable and generally fit all faucets. By using AquaPod when cooking, it can improve the overall taste of a dish, and also helps to slow the buildup of scale on cookware and kettles. The amazing characteristics of Aquapod heralds a new era in the water purification industry, which advanced the development of biomass-derived carbon.

OUR PRODUCT

PATENT NO : PI2019004543

Creating High Micropores Volume in Palm Kernel Shell for Activated Bioadsorbent

Without AquaPod | AquaPod

OUR TEAM

Assoc. Prof. Dato' Dr. H,ng Paik San
LEAD RESEARCHER

Dr. Chin Kit Ling
PROJECT ADVISOR

Dr. Lee Chuan LI
PROJECT MANAGER

Dr. Khoo Pui San
CHIEF EXECUTIVE OFFICER

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

6 CLEAN WATER AND SANITATION

CONTACT DETAILS

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