PREFACE

Given the global challenges presented by petroleum-based polymers, as well as the need to combat climate change and dwindling fossil fuel resources, there has been a noticeable push on sustainable technologies and research. These challenges have highlighted a crucial effort to shift away from the conventional dependence on polymers derived from petroleum to sustainable and affordable alternatives that are both eco-friendly and renewable. Development of renewable polymers with scalable processes for commercial utilization is another focus point towards developments in sustainable polymers. In line with the research progress in renewable polymers, there exists sustainable development goals (SDGs) such as clean water and sanitation (SDG6), industry, innovation and infrasturucture (SDG 9), life below water (SDG 14), life on land (SDG 15), climate action (SDG 13), responsible consumption and production (SDG 12), sustainable cities and communities (SDG 11), and affordable and green energy (SDG 8) by United Nations. There has been a strong push to find alternative methods for producing polymers to address environmental concerns. As a result, there has been an intensive attempt to investigate biopolymers as potential solutions. In this field, agricultural biomass and waste offer exciting opportunities to create valuable products while reducing environmental harm. Cellulose is an extremely promising option for biopolymer production due to its remarkable properties such as mechanical strength, crystallinity, hydrophilicity, biodegradable, sustainable, environmentally friendly, non-toxic, affordable, and widely accessible. This thesis focuses on utilising different agro-wastes to extract cellulose, their *in-situ* modification, and phosphorylation *via* green routes for development of value-added products. The present thesis consists of 8 chapters in which chapter 4 to chapter 7 discuss the methodologies performed. The cellulose extraction and phosphorylation have been performed using an industrially viable, scalable, and green approach. The phosphorylated cellulose processed with the sustainable routes were 3D-printing, moulding, solution casting, freeze drying, and spinning to fabricate complex structure, cups and plates, films, aerogels, and threads. This thesis explores various sustainable solutions derived from abundantly available agricultural biomass to value-added products, specifically emphasizing sugarcane bagasse (SB), rice husk (RH), viscose cloth, and rice straw for addressing urgent environmental challenges and provide practical advancements in different sectors. In chapter 4, the process of delignification of SB and RH is revealed, resulting in the extraction of cellulose that can be used as an effective adsorbent for methylene blue (MB) and malachite green (MG) dyes, respectively. In addition, using molybdenum salt and thiourea treatments, the resulting cellulose is converted into highly effective adsorbents and photocatalysts for removing dyes. These absorbents also demonstrate antibacterial properties against *Escherichia coli* and *Staphylococcus aureus* for scalable and continuous wastewater dye and bacterial decontamination with potential practical applicability. The chapter introduces a unique strategy for the up-conversion of agricultural biomass into value-added bio-adsorbents, which can effectively and economically address the remediation of dyes with simultaneous microbial decontamination from polluted wastewater streams. Chapter 5 demonstrates an important development in sustainable material innovation using viscose cloth for gel production through phosphorylation. The phosphorylated gels exhibit improved properties, including higher water absorption, swelling capacity, and rheological attributes. Additionally, they show significant enhancements in their ability to remediate MB. The addition of MoS_2 salts to PC also showed excellent shear-thinning properties. It facilitated the *in-situ* growth of MoS_2 to introduce photocatalytic and antibacterial properties, enhancing the rate of MB degradation and pathogens removal from wastewater. This chapter provides a green, facile and energy-efficient strategy for fabricating PCs with easy processability through additive manufacturing techniques for producing value-added products, opening up new avenues for high-performance applications including continuous photodegradation and antibacterial properties. Chapter 6 of the thesis explores the process of transforming rice straw waste into useful materials like food packaging films, aerogels, and thermal boxes. The films and aerogel boxes demonstrate remarkable mechanical strength, thermal stability, and flame-retardant properties using phosphorylation, solution casting and freeze-drying techniques. Furthermore, the development of biodegradable cups and aerogel boxes showcases the versatility and environmental friendliness of materials made from rice straw. The rice straws have been processed to form films (heat sealing), cups (anti-fizzing and solvothermal stability) and aerogels properties (thermal insulation, low thermal conductivity) and can acts as potential replacement of non-biodegradable and highly flammable polyethylene and polyurethane, and polystyrene. In Chapter 7, we explore the potential of sugarcane bagasse and demonstrate the production of phosphorylated films, aerogels, and fruit foams that offer a wide range of functionalities. These materials possess transparency, mechanical strength, flame retardancy, thermal stability, and biodegradability, making them highly suitable for a wide range of packaging applications. The foams prepared with sugarcane bagasse biomass can become a suitable mechanically stable alternative for damage protection in perishable fruit products, as a potential replacement for non-biodegradable polystyrene foams used currently. It is worth mentioning that the use of these materials for packaging paneer and apples highlights their ability to prolong shelf life and provide environmentally friendly alternatives to traditional packaging materials. Together, this thesis highlights the importance of utilising agricultural biomass and waste to create sustainable materials that can be used in a wide range of applications. This not only helps address pressing environmental issues and UN SDGs, but also promotes innovation and progress in different industries. This thesis aims to make a valuable contribution towards a scalable, facile, low-cost, utilization of abundantly available waste biomass for making high value products with lower carbon footprints which can be utilized in the direction of the global efforts in achieving a sustainable and resilient future.