UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT AND PERFORMANCE EVALUATION OF POLYPROPYLENE COMPOSITE REINFORCED WITH COAL BOTTOM ASH MODIFIED VIA ESTERIFICATION AND HYDROTHERMAL PROCESSES

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ABSTRACT

Coal bottom ash (CBA) is one of the by-products of coal combustion from the power plant to generate electricity. However, due to its hygroscopic and porous structure, it has not been the interest of many researchers. Therefore, it is left unattended at the landfill and hence has now become the main dumping issue and environmental concern as it contains potential toxic elements such as As, Cd, Co, Cu, Cr, Mo, Ni, Pb, and Zn. Therefore, this study has modified this CBA to tackle the hygroscopic and porosity characteristics of CBA via esterification, $mCBA_E$, and hydrothermal, mCBAH processes, respectively. The hygroscopic and porous structures of CBA have been minimized by both esterification and hydrothermal processes, respectively. These modified CBAs, $mCBA_E$ and $mCBA_H$, were then used as fillers to develop green polypropylene (PP) and a PP composite. PP composites are materials made by combining a polymer matrix with fillers or reinforcements to enhance their mechanical, thermal, or other properties. In this case, the strength of the PP composite depends on the process conditions. It was found that the highest strength of the PP composite was obtained when CBA was modified via the esterification process at 40°C for 4hr using 75 g of palmitic acid as a surface modifier, $PP/mCBA_ET_{40}P_{75}t_4$. Unfortunately, CBA modified via the hydrothermal process (mCBAH) was unable to form a smoother composite surface due to the decomposition of less thermally and mechanically stable minerals formed during the hydrothermal process when CBA reacts with a strong base. $PP/mCBA_ET_{40}P_{75}t_4$ was further modified using maleic anhydride (MA) as a binder to enhance its strength. It was found that the addition of 1% MA binder was able to enhance the impact energy of $PP/mCBA_ET_{40}P_{75}t_4$ from 3.75 J to 4.11 J, which is about a 10% increment. In addition, this 4 mm $PP/mCBA_ET_{40}P_{75}t_4$ containing 1% MA was able to improve the impact energy of 6 mm neat PP (2.9 J) up to 40. Overall, the properties of this $PP/mCBA_ET_{40}P_{75}t_4$ containing 1% MA were almost similar to the physical, chemical, mechanical, and electrical properties of pure PP, but with better strength. Therefore, for future work, it is recommended that this $PP/mCBA_ET_{40}P_{75}t_4$ containing 1% MA be used to replace PP-based products across various applications, such as cable protection slabs, cable clips, and dashboards etc., to support sustainable, cost-efficient material development.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

In Peninsular Malaysia, coal has become the primary source of electricity generation to sustainably feed the rapidly growing energy demand (Rashidi et al., 2022). The demand is projected to reach 7,571 kWh/person in 2030 (APEC, 2006). The burning process of coal produces by-products that include ~ 80% coal fly ash (CFA) and ~ 20% coal bottom ash (CBA) (Benavidez et al., 2003) (Figure 1.1).

Figure 1.1 Coal Combustion Waste (Rahim et al., 2023)

Fly ash is suspended particles in the exhaust gases collected by electrostatic precipitators or bag house filters. On the other hand, the portion of the non-combustible residues from combustion in the boiler furnace of a power plant that falls by itself into the bottom hopper is referred to as bottom ash.

Current practices, CFA, which is finer in size of below 75 microns, has high commercial value and has been sold to cement manufacturing industries since the 1930s to reduce the need for clinker in the cement industry (Global Cement and Concrete Association, United Kingdom, (Global Cement and Concrete Association, 2020). CBA, on the other hand, is being dumped at the landfill or ash ponds due to its bigger size than CFA, coarser, angular, porous surface, and amorphous, which is not suitable for making cement.

This situation has caused the CBA to be dumped in the ash pond, which is not