

Article

Characterization and Development of Ceramics with Inorganic Additives

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Abstract: Date palm tree (DPT) and pine tree (PT) needles in forests form a combustible mat, posing fire risks during summer in Pakistan that damage vegetation, wildlife habitats, and biodiversity and impact local livelihoods. In this article, sintered ceramic specimens were prepared at different weight concentrations (DPT5, DPT10, DPT20, and DPT 30 and PT5, PT10, PT20, and PT30) of date palm tree leaf ash and pine tree needle ash as secondary additives in ceramic manufacturing along with primary material kaolinite (China clay). Raw materials composition was analyzed using X-ray diffraction (XRD), taking loss on ignition, water absorption, bulk density, saturated surface dry density (SSD), weight per unit area, and thermal cycling as measurement indexes. The result indicates that loss on ignition increases while increasing the quantity of secondary additives and the maximum increase for DPT30 was 19.6% and for PT30, it was 22.1%. As the secondary additives increase, the water absorption rate also increases and the maximum increase for DPT30 and PT30 is 4.5%. Meanwhile, with the increase in secondary additives, the density decreased; for DPT 30, it was 1457.7 kg/m³ and for PT30, it was 1829.8 kg/m³. Thermal performance was investigated by heating and cooling cycles. It was observed that thermal performances increase with the increase in secondary additives. The results reveal this novel approach has the potential to form a ceramic and good properties can be achieved. The prepared specimens have the potential to be used in the fields of electronics, aerospace, construction, and building engineering, alleviating environmental strain, curbing the exhaustion of China clay reserves, and most importantly, lowering the risk of forest fires in Pakistan.

Keywords: inorganic waste; ceramic properties; date palm tree ash; pine tree needle ash; microscopic characteristics



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1. Introduction

Gone are the days when ceramics were used only for household items and kitchenware. Now, ceramics are being used for steam jet engines, vehicle engines, electricity conductors, electric insulators, refractories, ceramics tiles, and many other advanced applications. In the context of material science, ceramics are defined as any solid made of clay and several additives. In Pakistan, the forest fire peak season typically begins in mid-December and lasts around 27 weeks. There were 1922 fire alerts reported between the 16 October 2023 and the 14 October 2024, only considering high-confidence alerts. From 2001 to 2023, Pakistan lost 5.52 kha of tree cover from fires [1]. These dry waste leaves are one of the major factors for forest fires, particularly in the summer season. This approach not only reduces fire in forests but also as these agricultural wastes are produced in significant quantities, converting them into ash, which is known as inorganic matter in biomass for manufacturing ceramic tiles, is an attractive waste disposal method. The resulting clay mixture is fired at a high temperature to increase the hardness and durability

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