CHAPTER

9

TOXICITY ASSESSMENT OF POLYSTYRENE IN CONE CALORIMETER

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9.1 INTRODUCTION

Fire is widely recognised as the most prevalent threat to both human life and property. As societies advance, populations grow, and lifestyles evolve, various aspects of building design and construction materials are also changing. These changes include alterations in insulation materials, compartmentalisation, ceiling height, and ventilation techniques (Alarifi et al., 2016). Unfortunately, the increased utilisation of synthetic polymers has significantly amplified the risk of fire incidents (Stec & Hull, 2010). Furthermore, other factors such as heat, oxygen depletion, flame, and smoke further contribute to the hazards faced by life and property. Consequently, the complexity of a fire is influenced by the overall fire scenario rather than solely being determined by the burning materials. Even a single material burning under different conditions can produce distinctively toxic gas emissions (Nelson, 1990; Yang & Nelson, 2012). However, when it comes to comparing the relative toxicity of materials, a

single fire test can suffice, provided it faithfully replicates a real-world fire scenario. The cone calorimeter meets this criterion effectively.

The primary focus of this project was to examine a specific fire condition that involved an openly ventilated environment with a heat release rate (HRR) of 35 kW/m^2. By employing this approach, a fair comparison of the toxic emissions from various polymeric materials under the same fire condition could be made. In real-world scenarios, fires typically commence within enclosed spaces with unrestricted airflow, and the degree of confinement only becomes a significant factor once the room's available oxygen is depleted. Therefore, fire progression is primarily influenced by the extent of air ventilation at that stage. In this study, although the tests were conducted in an openly ventilated environment, they still resulted in under-ventilated fires at the cone calorimeter outlet, where peak toxicity was observed. While toxic yield results obtained under controlled ventilation environments that simulate room compartments would more accurately represent realistic scenarios, a substantial amount of existing research data on fire toxicity has been acquired in openly ventilated environments.

The objective of this project was to underscore and investigate the potential toxicity hazards associated with commercially available polymers used in building materials, utilising a modified cone calorimeter, fourier transform infrared (FTIR) spectroscopy, and an oxygen analyser. A total of ten distinct polymers, including polystyrene (PS), acrylic polymethyl methacrylate (PMMA), and polyurethane (PU), were subjected to combustion testing. Through this comprehensive experimental approach, the project sought to provide valuable insights into the potential toxicity hazards posed by commercially available polymers commonly used in building materials. The findings would contribute to a deeper understanding of the fire safety risks associated with these materials and aid in the development of strategies to mitigate their potential adverse effects on human health and safety.

9.1.1 Fire Statistics

The inhalation of toxic gases during a fire is widely acknowledged as a significant factor that leads to fatalities and injuries. Fire statistics from the Department for Communities and Local Government [DCLG], 2015 in the United Kingdom (UK) reveal that more than 75% of deaths caused by fires occur within buildings. Specifically, the recorded data for the year 2013/2014 indicates that 41% of the total fatalities were due to smoke inhalation, while an additional 20% of fatalities resulted from burns caused by exposure to smoke. As a result, the toxic components present in smoke account for over 60% of deaths in building fires.

These statistics highlight the critical impact of toxic smoke on the outcome of fire incidents. Inhalation of smoke can have severe consequences on human health, often leading to fatalities. The presence of toxic substances in smoke exposes individuals to a range of hazardous chemicals, which can cause respiratory distress, damage vital organs, and impair cognitive function. The devastating effects of smoke inhalation emphasise the urgent need to understand and mitigate the toxicity dangers associated with building fires. By comprehensively investigating the toxic emissions of materials used in building construction, we can develop strategies to minimise the harmful effects of smoke and protect human lives during fire incidents.

9.2 STRATEGIES TO MINIMISE THE HARMFUL EFFECTS

Preparation of test materials prior to the toxicity assessments in the Cone Calorimeter was properly done following the procedures. Every sample was tested through ultimate and proximate analysis in determination of its chemical and physical properties. Gas sampling point in the Cone Calorimeter was attached to a measuring equipment also known as fourier transform infrared (FTIR) to allow the measurement of toxic gases that were produced for further assessment on toxicant concentrations.