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Investigation of Thermo-Gravimetric Analysis (TGA) on Waste Tires and Chemical Analysis Including Light Hydrocarbons, Substituted Aromatics, and Polycyclic Aromatic Hydrocarbon (PAH)

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ABSTRACT

This investigation has been initiated to characterize the thermal decomposition of waste tires with Thermo-Gravimetric Analysis (TGA) in various atmospheres ranging in oxygen content; 100% N_2, 7%, 21% (air) and 30% O_2. Chemical analysis focusing on light hydrocarbons, substituted aromatics, and polycyclic aromatic hydrocarbon has been done qualitatively and quantitatively to understand the mechanism of thermal degradation of scrap tires and hazardous air pollutants such as PAH. The release of chemicals from scrap tires has been determined experimentally using Gas Chromatography/Mass Spectroscopy (GC/MS) coupled to TGA unit. The identities and absolute concentrations of over 50 major and minor species have been established. Significant volatile organic carbons (VOC) including substituted aromatics and PAH were observed between 300°C and 500°C. In addition, significant black carbon residual was observed in most environments except air and oxygen enhanced atmospheres and suggested not only the potential recovery of black carbon out of feedstock, but also the possibility of combined thermal treatment between combustion and gasification. These measurements supply information on the identities and levels of hazardous air pollutants, and provide useful new data for the development and validation of detailed reaction mechanisms describing their origin and fate. Finally, while high contents of VOC show significant potential to be utilized as an unconventional solid fuel, they also tend to generate hazardous pollutants.

Keyword: Polycyclic Aromatic Hydrocarbon (PAH), Thermo-Gravimetric Analysis (TGA), Combustion, Gasification, GC/MS, Hazardous Air Pollutant, Reaction Mechanism, Scanning Electron Microscope/Energy dispersive X-ray spectroscopy (SEM/EDX)

INTRODUCTION

Based on and Environmental Protection Agency (EPA) report at the end of 2003, the U.S. yielded roughly 290 million waste tires. The estimate number of waste tires in stockpiles in U.S. was 700 to 800 million. Since that time, millions of tires have been removed from stockpiles primary due to aggressive cleanup through state scrap tire management programs. For example, Minnesota, Wisconsin, and Maryland are three states, which report having cleaned up all scrap tire stockpiles, however a significant amount remains. In view of the push to find alternative energy sources to reduce dependence on fossil fuels, waste tires serve as a source of high quality fuel, having a high calorific value that is roughly similar to that of coal, yet their heterogeneity posses issues with regard to complete burnout and emissions[1].

Tires contain reinforcing filler, fiber, and extenders with various rubbers, such as natural rubber (Poly-Isoprene: IR), Butyl Rubber, and Styrene-Butadiene Rubber (SBR)[2, 3] to improve the physicochemical properties leading to long operational life, high performance and safety. However, it is this same mix of constituents which impede the direct reuse in other applications and lead to complex conditions during thermal conversion. Moreover, the different content in mineral matter and sulfur which tire shows is lower than that of coal, making this fuel more desirable from a direct emission of SOx standpoint. In addition, their low moisture and fuel-bound nitrogen content positions waste tires well for recovering energy as an end use[4-9].

Previous work related to utilizing waste tires to recover energy has been focused on pyrolysis/gasification, and limited research on tire combustion has been carried out due to its heterogeneity which gives rise to a poor understanding of the decomposition mechanisms and the ultimate production and rate of emissions during the combustion.

A considerable amount of work has been done to understand the degradation process of waste tires both fundamentally and at an overall process level [10]. Several investigations have been done using isothermal and non-isothermal methods to obtain the necessary kinetic parameters that are needed for combustor development [11-17]. Most of