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Thermal and catalytic decomposition behavior of PVC mixed plastic waste with petroleum residue

Mohammad Farhat Ali, Mohammad Nahid Siddiqui *

Department of Chemistry, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia

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Abstract

The pyrolysis and hydropyrolysis of PVC mixed plastic waste alone and with petroleum residue was carried out at 150 and 350 °C under N_2 gas and at 430 °C under 6.5 MPa H_2 gas pressure. The behavior of plastic waste during thermal and catalytic decomposition has also been studied in single- and two-stage reaction processes. In the individual pyrolysis process, both the petroleum residue and polystyrene (PS) undergo more than 90% conversion to liquid and gaseous products, whereas low-density polyethylene (LDPE) and high-density polyethylene (HDPE) yielded lower conversions products, and polypropylene (PP) and polyvinyl chloride (PVC) afforded somewhere a moderate to high conversion products.

In a single-stage pyrolysis reaction, PVC was processed with petroleum residue at 150 and 430 °C, under N_2 gas for 1 h at each temperature in a glass reactor. The model PVC and waste PVC showed slight variations in the products distribution obtained from the glass reactor. In two-stage process, model PVC, vacuum gas oil (VGO) and a number of different catalysts were used in a stainless steel autoclave micro tubular reactor at 350 °C under the stream of N_2 gas for 1 h and at 430 °C under 950 psi (6.5 MPa) H_2 pressure for the duration of 2 h. Significantly, different products distributions were obtained. Among the catalysts used, fluid catalytic cracking (FCC) and hydrocracking catalysts (HC-1) were most effective in producing liquid fuel (hexane soluble) materials. The study shows that the catalytic coprocessing of PVC with VGO is a feasible process by which PVC and VGO materials can be converted into transportation fuels.

Keywords: PVC; Thermal and catalytic degradation; Fuel oils; Coprocessing; Residue upgrading

1. Introduction

The disposal of waste plastics has become a major environmental problem all over the world. USA, Europe and Japan generate about 50 million tons of post consumer plastic waste material. Saudi Arabia is one of the major producers of plastic in the world with total production capacity of around six million metric tons per year. The amount of plastic wastes in Saudi Arabia is about 15 wt% in the composition of domestic municipality waste [1]. The number of landfill sites is decreasing. Also land filling could result in plastic additives such as phthalates and various dyes polluting ground water. Incineration is an alternative to landfill disposal of plastic wastes, but this practice could result in the formation of unacceptable emissions of gases such as nitrous oxide, sulfur oxides, dusts, dioxins and other toxins. The option of secondary recycling or mechanical recycling, which is the reprocessing of plastic waste into new plastic products with a lower quality level, is not showing any signs of growth in the recycling industry. Tertiary recycling, which returns plastics to their constituent monomers or to their higher value hydrocarbon feed stock and fuel oil, is gaining momentum as an alternative method. Tertiary recycling includes all those processing which attempt to convert the plastic wastes to basic chemicals by the use of chemical reactions such as hydrolysis, methanolysis and ammonoloysis for condensation polymers and to fuels with conventional refinery processes such as pyrolysis, gasification, hydrocracking, catalytic cracking, coking and visbreaking for addition polymers excluding PVC. Pyrolysis of waste plastic affords high rates of conversion into liquid fuels that can be used as feedstock in refinery. There has been a lot of research work on the pyrolysis of individual

* Corresponding author. Tel.: +966 3860 2529; fax: +966 3860 4277.
E-mail address: mnahid@kfupm.edu.sa (M.N. Siddiqui).

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