Preface

This book covers thermal and catalytic pyrolysis processes that produce liquid fuels (or other useful chemicals) from waste plastics. The book provides a comprehensive overview of the main commercial plastics pyrolysis processes, the types of plastics that can be processed, the properties of the respective fuels produced and the key variables influencing the pyrolysis of plastics such as temperature, residence time, pressure and catalyst types.

Only some 15–20% of all waste plastics can be effectively recycled by conventional mechanical recycling technologies (i.e. sort/grind/wash/extrusion). Beyond this level the plastics become increasingly commingled and contaminated with extraneous materials such as soil, dirt, aluminium foils, paper labels and food remnants.

Pyrolysis is a tertiary or feedstock recycling technique capable of converting plastic waste into fuels, monomers, or other valuable materials by thermal and catalytic cracking processes. This method can be applied to transform both thermoplastics and thermosets in high-quality fuels and chemicals. Moreover it allows the treatment of mixed, unwashed plastic wastes.

In its simplest definition pyrolysis is the degradation of polymers at high temperatures under nonoxidative conditions to yield valuable products (e.g. fuels and oils). Pyrolysis is also referred to as polymer cracking and its main advantages are that it can deal with plastic waste which is otherwise difficult to recycle and it creates reusable products with unlimited market acceptance.

As feedstock recycling and pyrolysis is not incineration there are no toxic or environmentally harmful emissions. Pyrolysis recycling of mixed plastics thus has great potential for heterogenous plastic waste that cannot be economically separated.

This book provides an overview of the science and technology of pyrolysis of waste plastics. The book will describe the types of plastics that are suitable for pyrolysis recycling, the mechanism of pyrolytic degradation of various plastics, characterization of the pyrolysis products and details of commercially mature pyrolysis technologies.

The major advantage of the pyrolysis technology is its ability to handle unsorted, unwashed plastic. This means that heavily contaminated plastics such as mulch film (which sometimes contains as much as 20% adherent dirt/soil) can be processed without difficulty. Other normally hard to recycle plastics such as laminates of incompatible polymers, multilayer films or polymer mixtures can also be processed with ease,
unlike in conventional plastic recycling techniques. In fact, most plastics can be processed directly, even if contaminated with dirt, aluminium laminates, printing inks, oil residues, etc.

The production of gasoline, kerosene and diesel from waste plastics is an emerging technological solution to the vast amount of plastics that cannot be economically recovered by conventional mechanical recycling.

Pyrolysis recycling of mixed waste plastics into generator and transportation fuels is seen by many as the answer for recovering value from unwashed, commingled plastics and achieving their desired diversion from landfill. Pyrolytic recycling of plastic wastes has already been achieved on commercial scale albeit to a limited extent. Nevertheless, the development and improvement of the pyrolysis plastics recycling technologies in recent years has great commercial potential. The development of bench-scale experiments carried out in laboratories to full-scale pyrolysis processes have now resulted in a number of technically mature processes.

Through the use of low-temperature vacuum pyrolysis and cracking catalysts, liquid fuels yield of up to 80% are possible with the resultant product resembling diesel fuel, kerosene, gasoline or other useful hydrocarbon liquids. There are now emerging a number of processes which will take post-consumer plastics and catalytically convert them into gasoline and low-sulfur diesel fuel. The diesel fuel meets or exceeds both European and Federal EPA standards for emissions and is designed specifically for the solid waste disposal industry that has significant investment in diesel-powered equipment. The types of plastic targeted as feedstock for this project have no commercial value and would otherwise be sent to landfill.

High-temperature pyrolysis and cracking of waste thermoplastic polymers, such as polyethylene, polypropylene and polystyrene is an environmentally acceptable method of recycling. These type of processes embrace both thermal pyrolysis and cracking, catalytic cracking and hydrocracking in the presence of hydrogen. Mainly polyethylene, polypropylene and polystyrene are used as the feedstock for pyrolysis since they have no heteroatom content and the liquid products are theoretically free of sulfur.

The principal output products are gaseous and liquid hydrocarbon fractions that are remarkably similar to the refinery cracking products. Their chemical composition and properties strongly depend on the input feed composition, (i.e. proportion of polyethylene, polypropylene and polystyrene in the feedstock) and they can also be unstable due to their high reactive olefins content (especially from polyethylene and polystyrene cracking).

The book also explores the application of various acidic catalysts, such as silica–alumina, zeolites (HY, HZSM-5, mordenite) or alkaline compounds such as zinc oxide. However, the main problem with catalytic cracking is that in the course of the cracking process all catalysts deactivate very quickly. Expensive zeolite catalysts increase the cost of waste plastics cracking process to the point where it becomes economically unacceptable since the catalyst becomes contained in coke residue and therefore cannot be recovered and regenerated.

Effective engineering design of the cracking reactor for waste plastic processing is very important since the carbonaceous solid residue is one of the cracking products (levels up to 10% or more) and its continuous removal from the reactor is necessary to ensure profitable running. Stirred vessel reactors which have augers in the bases to facilitate continuous char removal are presented.
This book is truly international in scope with contributing authors from Spain, Saudi Arabia, Italy, New Zealand, Japan, Turkey, Hungary, Poland, Belgium, France, Germany, Korea, UK, USA, India, China and Australia.

John Scheirs
Walter Kaminsky
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