MedCrave
Step into the World of Research

MOJ Polymer Science

Short Communication

Open Access
CrossMark

Utilization of polymer containing wastes by the method of pyrolysis with the use of zeolites

Volume 2 Issue 2 - 2018

Isakov AA, Torosyan GH
National polytechnic university of Armenia, Armenia

Correspondence: Gagik Torosyan, Doctor of Chemical sciences, Professor, National polytechnic university of Armenia, Tel +374 93 998830,
Email gagiktorusyan@seua.am, gagiktorusoyan@polytecnic.am

Received: February 06, 2018 | **Published:** November 21, 2018

Short communication

It is known that polymer-containing wastes from industry and people's consumption, which are practically not exposed to natural decomposition and create global environmental problems for the whole world, and for each individual country. Along with this, recently there is an acute shortage of hydrocarbon raw materials and energy resources, which is associated with a reduction in the world's natural oil and gas reserves, which leads to higher prices for energy carriers and raw materials for organic synthesis. An integrated approach to the issues of the possibility of safe disposal of industrial and domestic waste and its reuse as a secondary raw material will ensure the rational use of a part of natural resources and at the same time sharply reduce the level of environmental pollution and help in solving environmental and economic problems.[1]

As a result of the analysis of existing methods of utilization, in our opinion one of the optimal solutions to the problem of waste disposal can be the organization of their decomposition by pyrolysis. Pyrolysis products of polymer-containing wastes are mainly ecologically safe and can be used as fuel or for processing into other valuable products.[2,3] The output and selectivity of the products are affected by the thermal mode of the process, as well as the availability and selection of a catalytic system by which the composition of the final mixture can be controlled. The actual task remains to use efficient catalysts, which ensure a high yield of the product in combination with the environmental friendliness of the process and simplified technology.

Currently, there are pyrolysis technologies that allow to obtain a liquid phase used as synthetic fuel, as well as gases suitable for use as a source of thermal energy. To produce pyrolysis resin, the most valuable source of liquid products, low-temperature pyrolysis is carried out. Thus, recycling the dregs of the polymer for the purpose of recycling, it is possible not only to reduce the volume of their burial, which will solve many environmental problems, but also to get a significant economic effect.

In this paper it had presents the results of our research in the field of thermal catalytic decomposition of polymer-containing waste products at low temperatures and pressures, for obtaining secondary energy resources.[4,5]

Experimental part

Previously prepared mixture of waste and the catalyst is loaded into the retort lid which is equipped with the discharge tube. The branch pipe is connected to the condensers. The retort with the loaded raw material is placed in a pyrolysis furnace. The inner chamber of the furnace is heated at a rate of 5-10 degrees per minute. In the waste material layers, in the oxygen-free conditions, thermal decomposition of the material takes place. Initially, the plant operates on external coolants, and after stabilization of the process it switches to the pyrolysis gas released as a result of decomposition.

Gases on branch tube fall into the condensers where the change their physical state, turning into a liquid phase. As a result of pyrolysis, the polymeric compounds are converted into simpler paraffinic, olefinic, cyclic, aromatic and heterocyclic classes, which are codified in a collection, from where they are sent to fractional distillation. Pyrolysis gases, as well as the gas-vapor mixture formed during fractionation, are collected and fed for post-combustion to pyrolysis furnace to maintain the process temperature, thereby excluding their release into the atmosphere.

Result and discussion

The main areas of polymer consumption are: packaging-40%, construction-21%, motor industry-8%, electronics-5%, other industries-26%. As a result, typical waste of polymeric materials contain ~63% of high and low density polyethylene, 11% of polypropylene and polystyrene, 7% of polyethylene terephthalate, 5% of polyvinyl chloride and about 2% of other plastics.[6] Such wastes are generally aliphatic and have a high H/C ratio, which is favorable for the production of liquid hydrocarbons.

These agents have a wide range of physical - chemical properties, for which reason their content in a mixture of different influences on the regime and the composition of the end products of the process. Therefore, the temperature of pyrolysis of polymer waste was maintained at 350-450°C, at which most of the polymers undergo degradation, and only when a significant amount of the polystyrene component was present, was the temperature raised to 600°C.

The yield of the liquid phase in this case also depended on the component composition of the mixture and reached an average of 55% (wt.).

The introduction of aluminosilicates accelerated the pyrolysis process, and also significantly improved the yield of the final product. Presumably this is due to the fact that aluminosilicates, being catalysts used in petrochemical synthesis, participate in the reforming process, which leads to "ennobling" of the final products.[7–9] We used as modified aluminosilicate additive the modified natural clinoptilolite of composition $(Na_2, K_2, Ca)\ O*Al_2O_3*10SiO_2*8H_2O$ from Noyemberyan deposit of RA in the amount of 10-15% of the waste mass, with the yield of liquid products in some cases reaching 72- 75%.

a. Catalytic pyrolysis of an individual low density polyethylene (LDPE) on a batch unit was investigated. The experiments were performed with different temperatures in the range 350-450°C and with a constant holding time of 60 min. periodic action. In experiments, the zeolite was fed by mixing with the recycled plastic in an amount of 10%. Under these conditions, the resulting liquid contained up to 70% of the C_5-C_{12} gasoline fraction, moreover, C_7-C_8 hydrocarbons predominate.

b. The pyrolysis of a mixture of a zeolite additive and packaging materials containing mainly polyethylene and polystyrene has been investigated. The experiments were carried out in a closed reactor, without air access, at temperatures from 300 to 500°C. During the joint pyrolysis of a mixture of polyethylene and polystyrene, a liquid fraction was obtained at 350-400°C. The oily pyrolysis product contained mainly (more than 90%) aromatic compounds, in particular derivatives of toluene and benzene.

c. The study of pyrolysis of packaging waste and ABS plastics showed that at a temperature of 400-450°C the yield of liquid products is more than 80%, in which mainly styrene, xylenes, toluene and benzene are contained.

d. When pyrolysis is carried out under similar conditions of mixtures with a high content of rubber, 70-75% of the products consist of cyclic olefins and olefins with a terminal double bond (Table 1).

Table 1 Investigation of the effect of temperature on products obtained by pyrolysis

S. No	Input			Output		
	Wastes	Zeolite %	Temperature, °C	Product	Boil temperature, °C	Yield %
1	Low density polyethylene (LDPE)	10	350-450	liquid contained up to 70% of the gasoline fraction	60-115	70
2	LDPE+ polystyrene		350-400	derivatives of toluene and benzene	85-130	60
3	LDPE+ABS+ polystyrene		400-450	derivatives of styrene, xylenes, toluene and benzene	100-180	82
4	Plastics+ worn tire		400-450	olefins and cyclic olefins	100-240	45

Investigation of the effect of temperature on products obtained by pyrolysis of solid polymeric household waste has shown that the temperature has a strong effect on the characteristics of the pyrolysis liquid. At low temperatures up to 400°C, liquids with a large content of long hydrocarbon chains were obtained. When the temperature rises, the liquid is characterized by a high percentage of aromatics. It was found that 380-430°C optimum temperature for the pyrolysis of such mixtures in terms of both conversion and quality of the products obtained.

In all cases, the use of zeolite additives facilitated the production of liquid fractions with a boiling point in the range characteristic for motor fuels, which increases the promise of the method.

Conclusion

This pyrolysis method is based on mixing polymers with a zeolite catalyst. The reaction caused by the catalyst leads to a weakening of molecular bonds in polymer structures, which leads to waste degradation and conversion to useful substances. This technology makes it possible to obtain liquid fractions used to produce synthetic diesel fuel. In addition, when pyrolysis of plastic is destroyed 100% of harmful substances, and the resulting ash can be used for stove heating, in construction or as a sorbent.

Acknowledgments

None.

Conflicts of interest

The authors declare there is no conflict of interest.

References

1. Khoroshavin LB, Belyakov VA, Svalov EA. *The main technologies for processing industrial and solid municipal waste*. Ministry of Education and Science of the Russian Federation, Ural Federal University. Ekaterinburg: Ural University; 2016:220.
2. Gonin K, Manos G. Polymer degradation to fuels over microporous catalysts as a novel tertiary plastic recycling method. *Polym Deg Stab*. 2004;83(2):267–279.
3. Satsuma A, Ebigase T, Inaki Y, et al. 24-P-25-Catalytic sites of mesoporous silica in degradation of polyethylene. *Stud Surf Sci Catal*. 2001;135:277.
4. Torosyan GH, Isakov AA, Davtyan VA, et al. Catalytic cracking of car tire products. *Bulletin NPUA: Collected articles*. 2:674–677.
5. Torosyan GO, Hakobyan Zh S, Aleskanyan HO, et al. Pyrolysis of worn automobile tires is the way to solve an important problem of environmental protection. *Ecological Bulletin of the North Caucasus*. 2015;11(2):25–30.
6. https://mplast.by/novosti/2015-08-11-statistika-mirovogo-proizvodstva-i-potrebleniya-polimerov-po-dannyim-eek
7. Cardona SC, Corma A. Tertiary recycling of polypropylene by catalytic cracking in a semibatch stirred reactor. Use of spent equilibrium FCC commercial catalyst. *Appl Catal B Env*. 2000;25(2-3):151.
8. Hesse N, White RL. Polyethylene catalytic hydrocracking by PtHZSM-5, PtHY and PtHMCM-41. *J Appl Polym Sci*. 2004;92:1293–1301.
9. Seddeggi SZ, Budrthumal U, Al-Arfaj AA, et al. Catalytic cracking of polyethylene over all-silica MCM-41 molecular sieve. *Applied Catalysis A*. 2002;225:157–176.

Citation: Isakov AA, Torosyan GH. Utilization of polymer containing wastes by the method of pyrolysis with the use of zeolites. *MOJ Poly Sci.* 2018;2(2):68–69. DOI: 10.15406/mojps.2018.02.00050