

into naphtha, which can be easily processed into fuel. The amount of fuel that can be obtained by recycling plastic will cover the need for gasoline by about 5%. Currently, it is considered as a method that develops the most the spectrum of environmental protection. Plastic waste can be processed into valuable gaseous and liquid fuels using chemical processing methods such as hydrogenation, chemical depolymerization, gasification, thermal cracking and catalytic transformations [10–12].

In addition, in order to ensure high conversion and selectivity for the target product, the catalysis is a great opportunity for converting polymer waste, since the catalysis provides low temperature and pressure, as well as high conversion and selectivity for the target product. Catalysts for energy recovery processes such as chemical processing and cracking, hydrocracking, and gasification have been studied. It is shown the effectiveness of zeolite for processing polymer waste by cracking and hydrocracking. In addition, zeolites are materials whose properties meet the requirements of the reaction, since in the liquid phase, the most important aspects are the restrictions taken into account by weight and thermal conductivity in the macromolecule of polymers of high viscosity and large size during the process of catalytic processing of the polymer in the liquid phase. Recently, the method of hydrogenation of polymer waste is used for processing various polymers, such as polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET) and its compounds. The reaction is carried out mainly under hydrogen at a pressure of 150 atmospheric, in some cases in a descript autoclave at a temperature of 400–450 °C in the presence of solvents. Scientists have described the process of diluting PE, PP, PET and their waste in the presence of hydrogen at a temperature of 420–450 °C (54 atmospheres of cold hydrogen) with the addition of oil and tetralin used as a solvent. The results of heat treatment are compared with the results of the latter process in the presence of ZSM-5 zeolite and a highly dispersed Fe catalyst (ferrihydrite, treated citric acid). One of the directions of using production wastes and polymers as secondary raw materials is thermal and thermocatalytic modification of hydrocarbon fractions used as high-quality motor fuels. In the process of thermocatalytic hydrogenation of polymer waste, hydrocarbon fractions similar to motor fuels will be obtained. In general, this will allow us to process secondary raw materials, add additional fuel materials to the market, and have a positive impact on the environment. New catalysts based on natural zeolite from the Taizhuzgen deposit modi-

fied with Mo (VI) salt were studied in order to jointly study the processes of thermocatalytic hydrogenation of plastic waste and optimize the process [13].

The purpose of the work was to develop resource-saving technologies for the preparation and joint processing of industrial and household waste based on carbon-containing raw materials and solid fuels into fuel materials; and to establish the mechanism and regularities of chemical transformations of hydrocarbons on composite catalysts made of natural zeolites modified with active metals, as well as to develop and pilot test the technology of joint thermocatalytic hydrogenation processing of coal, shale, rubber and plastic waste in motor fuels on the developed catalysts. Improving the technology of the process and the use of appropriate catalysts can minimize losses and produce high-quality fuel distillates from spent carbon and hydrogen-containing raw materials.

Materials and methods

The experimental work in this paper differs from previous studies [13] in that the process was first studied in a continuous catalytic reactor operating under pressure in a cyclo-mixing mode with catalysis and hydrogenation of raw materials by direct distillation of liquid distillate and removal of gases. The process was carried out without the stage of draining the liquid product and its further distillation. Liquid products of thermocatalytic hydrogenation processing of polymer waste in the presence of a new composite catalyst were divided into fractions with boiling points: up to 180 °C, 180–250 °C and 250–320 °C. At the end of the process, the product is divided into fractions at a boiling point of 0–180 °C, 180–250 °C and 250–320 °C as described in the article [13].

The raw material used was a mixture of polymer waste-fuel oil with particle sizes of 2.0–6.0 mm and catalysts based on natural zeolites from the Taizhuzgen field (Kazakhstan). Natural zeolite of the Taizhuzgen deposit was activated with a solution of NH_4Cl without 1 M acid and with 1.0% Mo and 1.0 % W by the method of absorption with activated zeolite. The catalyst obtained during application is 2.0% of the total mass. The process was carried out in a continuous mixing mode at a pressure of 0.5–0.6 MPa at a temperature of 450 °C. The duration of the experience is 15 minutes [13]. To determine the crystal nature of the materials, a powder X-ray diffraction analysis was performed using a RigakuUltima IV diffractometer equipped with a Cu $K\alpha$ radiation source ($\lambda=0.15406$ Nm). XPS analysis was made on the technical characteristics of the 300 device. The