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Thermal Degradation of Plastic Wastes (PP, LDPE) Using Metal Particles, Metal Oxides and Metal Nano Particles as a Catalyst

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Abstract. Two different vacuum thermal degradation processes of plastic wastes materials: Poly Propylene (PP) and Low Density Poly Ethylene (LDPE) were conducted with homemade thermal degradation setup. The two processes were used 1-bulk metal particles,2- metal oxides (Fe,Ni,Fe_2O_3,NiO) and 3-metal nano particles (Fe and Ni) as a catalysts supported on feldspar clay respectively. The experimental results for both processes shows the presence of different products like liquid, wax, gas, and carbon. Our characterization was focused on the liquid product. The produced liquid was characterized by Fourier transform infra-red (FTIR) and Gas chromatography (GC) The octane number, cetane number, flash point, fire point, aniline point and some physical properties were also measured. The results indicated that the process with metal nanoparticles catalyst produces liquid much better properties compared to the other materials results used metal particles catalyst.

Introduction.

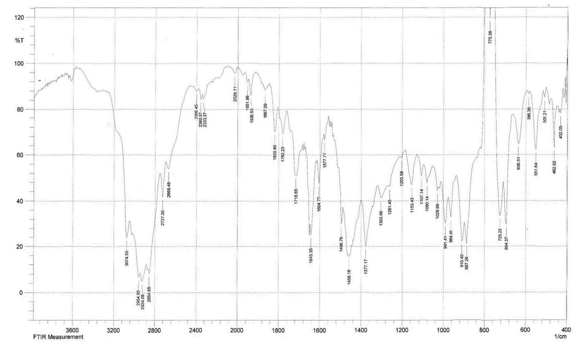
The big amount of plastic waste and global demand are increase in polymer production, gives evidence to serious environmental risk, due to plastic does not full decay and remains in the municipal landfill for decade [1-2]. Also rates and quantities of municipal solid waste in some Arab countries are Egypt 81.300 million ton/Year, UAE 16.400 million ton/Year, Saudi Arabia 12.100 million ton/Year, Iraq 9.150 million ton/Year and Sudan 7.950 million ton/Year [3]. So a huge amount of energy could be obtained from this waste as hydrocarbons compounds. Therefore Many researchers improvement the possible transforming of waste to fuel and having prospective for industrial [4-5]. The expected benefit of using catalyst is to reduce degradation temperature, to promote degradation speed, and improve the final products Outputs. Catalytic decomposition of plastic wastes is produced by mixing melted plastic wastes with catalyst in fixed bed reactors [7]. Mixtures of polymer and catalyst grains have been heated in a reaction container [8,9,10].The goal from research is aiming to reduce the environmental pollution and to improve the quality of liquid fuel production.

Experimental.

The nanomaterial were purchase from (MTI-corporation/USA) with size (Ni=50nm, Fe=80nm), the bulk material were purchase from (BDH company) with size (<53 μm) and the feldspar was purchase from (Itali,STIEL company,S.I.D.A.C) . The experimental setup for degradation of plastic waste consist of a batch reactor made of stainless steel ,height 11cm and diameter of 5.5cm in which the reaction takes place heated by oven supplied with a temperature controller. This reactor is contacted to three neck flask heated by heating mantle for waxes collection. The latter is contacted to Condenser and then to another three neck flask for final liquid product collection. The vacuum was created in the reactor to ensure the absence of oxygen during the reaction in the system. Polymer was charged into the reactor at the beginning and then the reactor was heated up to the required temperature. At the first 5 min; a linear temperature increase was observed and then increased with slow rate for remaining 10 minutes inter heating oven and 25 minutes inter reactor. The waste plastic from plastic shopping bags type low density polyethylene (LDPE), vegetable boxes type polypropylene (PP) were used. The process uses thermal degradation to heat the waste plastic at a temperatures ranging from 370°C to 420° C with catalyst supported on the clay to form liquid slurry in the absence of atmospheric oxygen. In a laboratory scale, the weight of 50 grams for one type of input plastic as a single batch for the fuel production process was used. The waste plastics are collected, optionally sorted, cleaned of contamination and grinded into small pieces prior to the thermal liquefaction process. The final products of liquid were collected through the condenser in a collecting vessel are kept in a cooled container and the produced gases will be captured in kept plastic tire and the solid residue (waxes, coal) are kept in containers.

Results and discussion.

FTIR Analysis. Various experimental products of plastic wastes (PP, LDPE) are characterized by Fourier transform infrared (FTIR- model: Bruker-Aleha: Germany). Fig. 1-7, are shown the functional groups of the output liquid from plastic waste degradation alone and with catalyst supported on feldspar. The functional groups of,=C-H stretch for alkene , C-H stretch so for alkene , alkane ,C=C stretch and C-H scissor for alkene ,C-H methyl rock and =C-H bend for alkene are observed respectively .



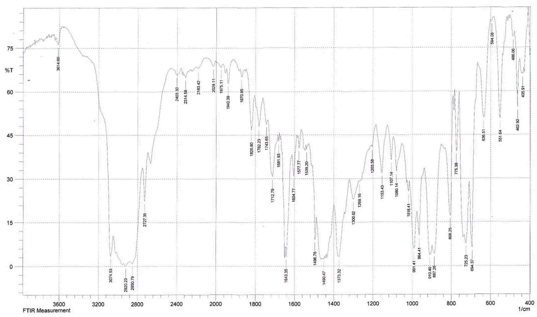
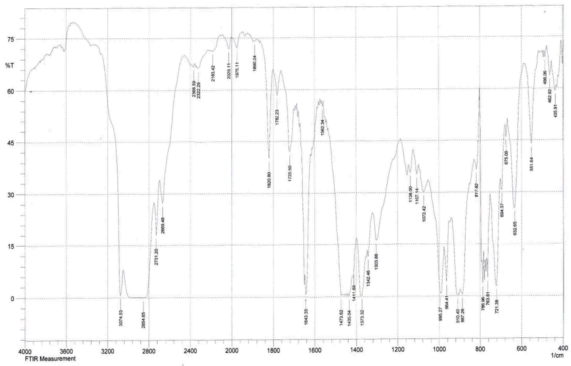


Fig. 1: FTIR for output liquid (feldspar only). Fig. 2: FTIR for output liquid (feldspar+ Fe_2O_3).



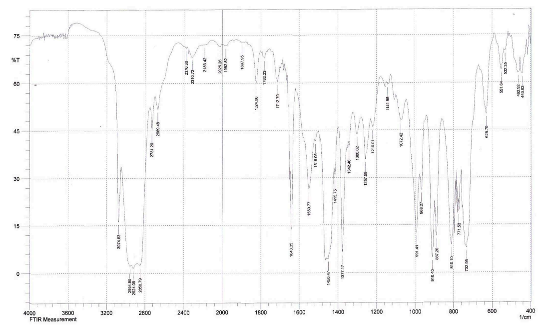
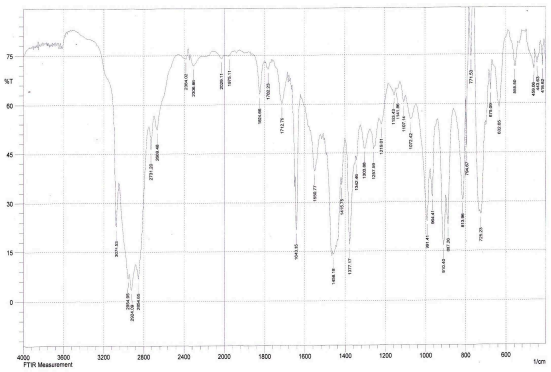


Fig. 3: FTIR for output liquid(feldspar+Fe metal). Fig. 4: FTIR for output liquid(feldspar+Fe nano).



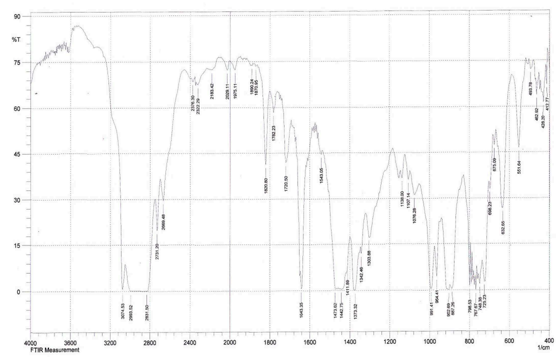


Fig. 5: FTIR for output liquid (feldspar +NiO). Fig. 6: FTIR for output liquid (feldspar + Ni metal).

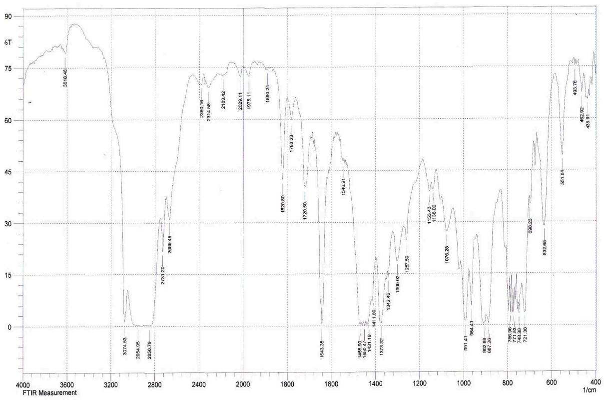


Fig. 7: FTIR for output liquid (feldspar +Ni nano).

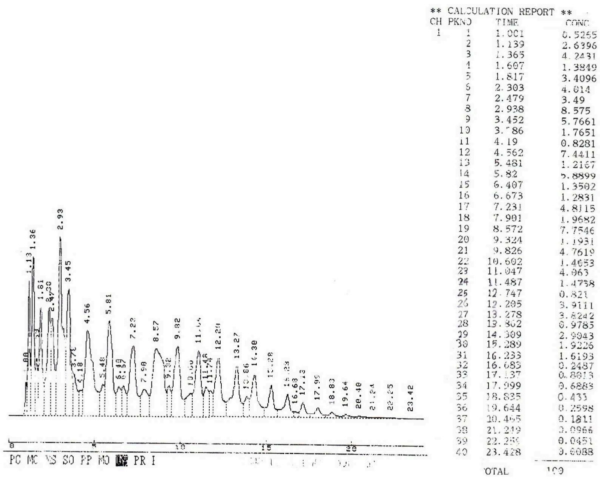


Fig. 8: GC for output liquid (feldspar only).

Gas chromatography (GC) Analysis . Gas chromatography (GC ,PACKARD model :43817) is used for the liquid products analysis .From studying Fig. 8-14, having many change in liquid mixture materials concentration and seeing that when plastic wastes degradation with feldspar compare by supported catalyst on feldspar ,having increasing in output liquids concentration specially with catalyst nano .that emphases by physical properties.

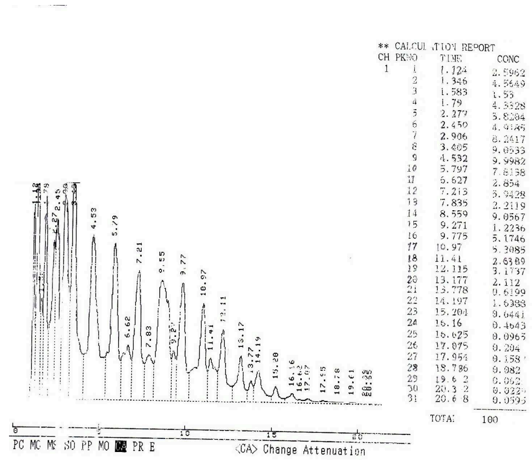


Fig. 9: GC for output liquid (feldspar+Fe_2O_3).

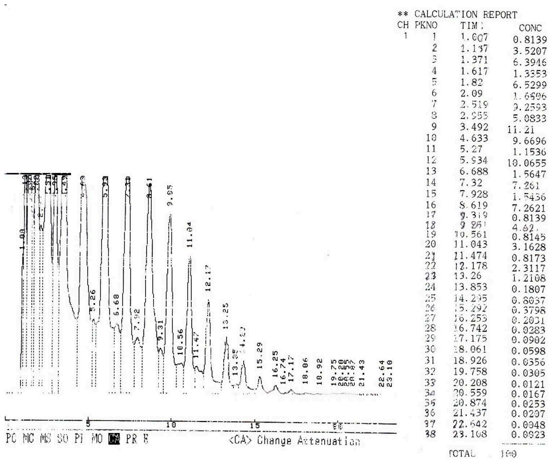


Fig. 10: GC for output liquid (feldspar+Fe metal).

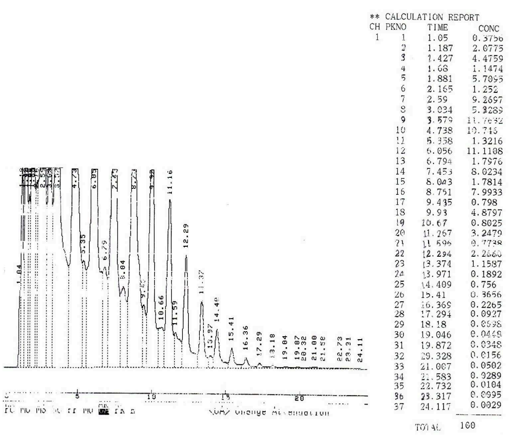


Fig. 11: GC for output liquid (feldspar + Fe nano).

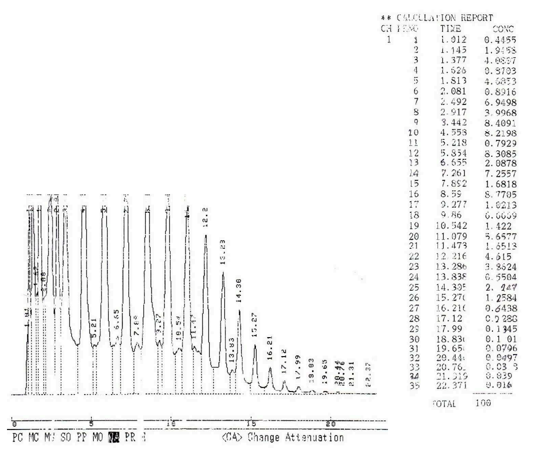


Fig. 12: GC for output liquid (feldspar+NiO).

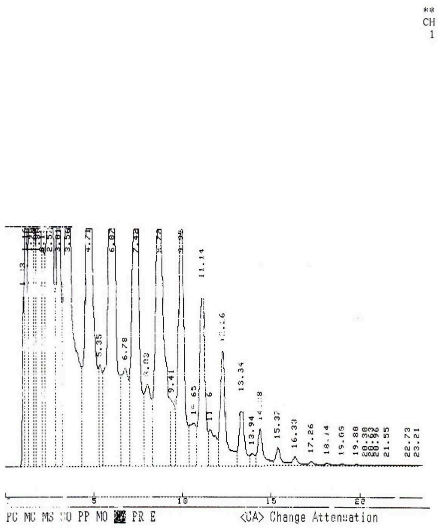


Fig. 13: GC for output liquid (feldspar+Ni metal).

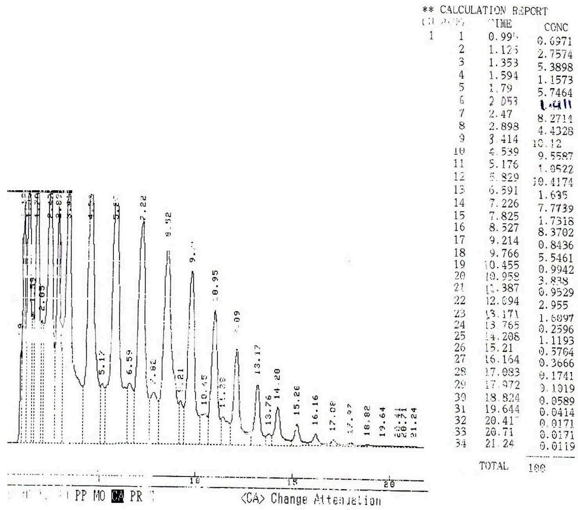


Fig. 14: GC for output liquid (feldspar +Ni nano).

Physical characters. Table 1, shows many variables in quantities by using supported catalyst on feldspar, seeing reduce in residue material (carbon), gas production and experimental time, also increasing in output wax. In other side, output liquids are frequency between reduce and increasing but physical characterizes were best with using nano catalysts.

Table 2, is summarizing the physical characterization of the produced liquid. The reduced values of the distillation point, flash point, fire point, relative viscosity and aniline point is quite clear. While the octan number and cetane index is increased gradually. These experimental data improvements are due to the effect of catalyst nanomaterials through the reaction process.

Table 1: Quantities outputs of plastic wastes degradation.

Time Minute.	Gas g	Carbon g	Wax g	Liquid g	WASTE PLASTIC	Feldspar : catalyst
150	0.6	66.1	19.95	29.12	50g	Feldspar25g
90	0.89	34.47	46.12	35.02	50g	Feldspar20g+Fe_2O_3 5g
105	0.59	27.35	57.28	28.98	50g	Feldspar20g+Fe metal 5g
95	0.39	23.15	67.34	24.86	50g	Feldspar20g+Fe nano 1g
100	4.33	22.82	57.87	24.07	50g	Feldspar20g+NiO 5g
100	0.57	27.41	60.11	27.59	50g	Feldspar20g+Ni metal 5g
100	0.52	27.41	60.21	27.59	50g	Feldspar20g+Ni nano 1g

Table 2: Physical Characters of outputs liquids.

Cetane Index	Octan NO.			Aniline point	viscosity	Density	Fire point C°	Flash point C°	distillation point C°	Feldspar : catalyst
	Average	Motor	Research							
39.1	87.1	82.7	91.5	179	0.985	0.736	31.5	5	40-110	Feldspar25g
56.9	92.4	87.4	97.4	173	0.863	0.732	19.5	2	30-113	Feldspar20g+Fe_2O_3 5g
45.6	90.0	85.4	94.6	158	0.830	0.713	2	4.5 -	32-106	Feldspar20g+Fe m.5g
43.7	89.1	84.9	93.2	178	0.728	0.732	3.5 -	7 -	33-100	Feldspar20g+Fe nano1g
49.6	91.2	86.4	95.9	165	0.967	0.724	22	4.5	38-115	Feldspar20g+NiO5g
40.6	88.0	83.8	92.2	170	0.817	0.727	1	5.5 -	33-99	Feldspar20g+Ni m.5g
46.7	90.4	85.7	95.2	167	0.768	0.710	7.5	6 -	35-105	Feldspar20g+Ni nano1g

Conclusions.

In the present work, it was successfully produced liquid with novel specifications by using vacuum thermal degradation with nanocatalyst supported on feldspar in a comparison with metal and metal oxide catalysts. The results are clearly depends on the physical properties improvement that makes liquid product as good as an alternative fuel.

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