
The Effect of Compositions (PIONA) on the Octane Numbers of Environmental Gasolines of Reformate, Isomerate and Hydrocracked Naphtha Blends by Using GC

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Abstract: This paper will discuss the effect of compositions (PIONA) on the octane numbers of environmental gasolines of reformate, isomerate, and hydrocracked naphtha blends by using gas chromatography analyses. Six blends have been studied to produce environmental gasolines according to the European standard specifications of Euro 3, 4, 5, and 6. Moreover, the observation and evaluation of blends depend on how to reduce the aromatic content which causes many harms to the environment and thus other components must be taken into study. In addition, all blends have shown that iso-paraffins are with composition of more than 36 vol.% and these contribute to the production of high quality environmental gasolines. The results represent that blends 1 and 2 have 39.051 vol.% and 37.503 vol.% of aromatics respectively which allow the samples to lie within the specifications of Euro 3. Furthermore, blends 3 and 4 have 37.717 vol.% and 33.947 vol.% of aromatics respectively which allow the samples to lie within the specifications of Euro 4. In addition, the environmental gasoline blends 5 and 6 have 31.450 vol.% and 28.746 vol.% respectively of aromatics which match within the specifications of Euro 5 and 6 that represent the present specifications until 2020. Finally, all these blends are ready to be used in our country instead of the regular gasoline with Euro 2 specifications.

Keywords: Gas Chromatography Analyses, Environmental Gasolines, European Standard Specifications

1. Introduction

Gasoline is one of the petroleum products derived of a fractionation tower which separates crude oil into useful products [1]. It has a transparent color and mainly is composed of organic compounds where additives are added to enhance its properties and performance. Gasoline has many uses but its main use is as fuel for vehicles and some other machines. The main role of production of gasoline is to delay the early ignitions that could occur in the motor causing a knocking sound that is defined by the octane rating or octane number. The measuring of octane number is based on the standard mixture of both n-Heptane and iso-Octane with given ratios to provide the best performance at a high

quality of gasoline compositions. There are several categories of gasoline octane numbers each with slightly different performance levels which are: regular, midgrade, and premium. Many additives were added to the Gasoline in the past such as tetraethyl lead which is no longer used anymore due to their negative impact on the environment. Nowadays, some environmentally friendly compounds are discovered to meet the air pollution standard requirements such as ethanol which has also been proven to be more economic. Gasoline widely impacts the environment as the combustion products are harmful to the atmosphere locally and globally, sometimes leakage occurs during production, transportation,

and storage which also harm the environment.

Environmental gasoline is gasoline that could precede complete combustion to produce Carbon dioxide, water, and heat energy within a given range that satisfies the air pollution standards and requirements [2-6]. Reformate is the main group in a Gasoline blend as it is able to produce a high quality gasoline with high octane number ratings, yet, it causes many environmental issues as it has a high aromatics content of about 72%. In order to reduce aromatics content in gasoline and get a high performance of gasoline as well, some additives are added like isomerate, hydrocracker naphtha, coker naphtha, alkylate, and some oxygenated compounds with given compositions to produce environmental gasoline with slightly moderate aromatic content and give a premium performance. Gasoline throughout history has been proven to have negative impact on the environment causing air pollution and harming the human and other organisms' health.

PIONA (Paraffins, Isomerate, Olefins, Naphthenes, and Aromatics) analysis is a method to analyze petroleum naphtha and gasoline to determine their compositions and ratios [7, 8]. It has been proven that gasoline consists of 94 subgroups in addition the oxygenated compounds present within its structure such as: methanol, ethanol, t-butanol, and other compounds. The device operates for components with boiling points ranging between -161°C to 216°C . For gasoline, PIONA analysis tends to supply the market with an environmental product that also has a high performance, in order to do so, some additives that enhance the octane rating are added such as iso-octane and oxygenated compounds that tend to elevate the octane number. The addition of such compounds does enhance the octane number but could produce harmful compounds to the environment such as benzene and toluene, to avoid the production of such harmful compounds or to reduce its effect; the additives are added with specific ratios that allow gasoline to ignite with safe impact on the environment. The method that allows all these previous steps to take place is the PIONA analysis that takes place by using the Gas Chromatography device (GC). The device is made of analyzing tubes for analysis of inserted gasoline, and a computer screen is showing the results. By showing the results, one could control the components to reach an optimum result.

Air pollution usually results from major sources such as burning fuels like natural gas, oil, and coal that originate from the fossil fuel family [9]. In addition, from decomposition of materials, pollutants in air and vehicle emissions, all results in polluting air are leading to excessive emissions in air that react with air components causing the deviation in natural conditions of environmental behavior.

Gasoline as discussed above is a highly flammable and volatile liquid that contains many toxics within its structure [10]. When burned, gasoline releases out many toxic materials that could harm the environment and human health. So, when combusted, many aspects should be taken into considerations as to achieve a premium performance with minimum harm to the environment. Many air pollution researches have revealed that gasoline engines alongside

other vehicle engines release exhaust gases that react with the components of atmosphere; leading to the formation of extremely harmful compounds that impact both the environment and the human health.

When gasoline is combusted in an engine, some gases are emitted out of the engine; those gases are called "Exhaust Gases" including carbon monoxide, carbon dioxide, nitrogen oxides, unburned hydrocarbons, and some other gases [11]. The ratio of nitrogen, water vapor, and carbon dioxide are not considered to be noxious, although carbon dioxide could be harmful as it causes global warming since it is a greenhouse gas. When gasoline is burnt, some other exhaust is also emitted out of the engine like carbon monoxide that results from uncompleted oxidation of hydrocarbons, unburned hydrocarbons, and nitrogen oxides that result from the excessive raise of temperature.

Ethanol is known to be a chemical alcohol compound that helps in cleaning the engine in use as it does not leave any gummy deposits into the engine and acts as a detergent or cleaner to the engine as well [12]. By the middle of 1980s around 1985 or 1986 gasoline was sold in the market to include detergents within their structures as to clean the engine and not to cause any plugging to the engine. Nowadays, all gasoline sent to the market should include any sort of detergents as to avoid any problems within the engine.

There are many ethers used as additives to gasoline such as MTBE (Methyl Tert-Butyl Ether), ETBE (Ethyl Tert-Butyl Ether) and TAME (Tert-Amyl Methyl Ether), but MTBE and ETBE has been shown to be the most common used ethers throughout the ether family of gasoline additives[13, 14]. Ethers have shown some great advantages when used as gasoline additives as they have low Reid vapor pressures (RVP), a low value of water solubility, and most importantly a low value of latent heat of vaporization. MTBE is manufactured from methanol which usually comes from synthesized gas, while ETBE is manufactured from ethanol which comes from biomass and considered to be renewable which makes ETBE a more efficient additive as it reduces the consumption of methanol (natural gas) also decreasing the greenhouse effect. ETBE has also shown a better octane number than that of MTBE as it has low volatility and solubility values due to the lower content of oxygenated compounds, also showing a lower value of RVP.

This paper will discuss the gasoline with its applications and composition according to PIONA analyses and GC analyses as to adjust the GC components and compounds to produce an environmental gasoline with high octane numbers according to the GC analyses of samples introduced through this paper. The experimental work should then take place by the preparation of nine samples as follows: Six samples of different gasoline sources to study their GC analyses, and three base samples of Isomerate, Reformate, and Hydrocracker naphtha, then perform: GC analyses, PIONA analyses, RON (Research Octane Number) of samples, and MON (Motor Octane Number) of samples. Another objective is to adjust those analyses to obtain an environmental gasoline that abides to Euro 3, 4, 5 and 6 environmental

standards for the six samples with selecting the optimum samples without the addition of any additives to gasoline.

2. Methodology

The “Gas Chromatography Device (GC)” where the compositions and the required data basically depend on the source of crude oil itself [7]. The Gas chromatographer device is a device with a sample inlet opening where the samples are injected inside the device for analysis, it contains a carrier gas that is usually Helium due to its very light molecular weight also as it is inert, so it would not react with any of the components where it propagates with a speed of about 30 cm/s, capillary tubes inside the device with dimensions of 30 m × 0.25 mm × 1m thickness called “Supelco”. When the samples are injected into the device, they are exposed to a temperature of 275°C where they are separated into components each with a different mass spectrum and apexes showing peaks on the graph shown on the computer monitor screen. Those curves and peaks are compared to other peaks and spectra present within the library of the device program and computer for identification purposes to match each with its similar peak. The main variable that identifies many characteristics of each component is the retention time as well, which is the maximum time period taken by each compound to remain within the sample before being separated. The following Figure illustrates the GC device (Figure 1).



Figure 1. The Gas Chromatography Device.

3. Experimental Work

There have been nine samples undergone the study (Three base samples of reformate, Isomerate, and Hydrocracker Naphtha, and six samples of gasoline blends), and the samples are prepared for a Gas Chromatography analysis (GC) to show their compositions. All samples contain 10 ppm of sulfur as the samples are taken for experimentation after they have been taken for treatment (desulfurization), those samples are usually exported to meet with the universal specifications, while the samples used in our country are of 500 ppm sulfur which are too harmful for the environment. The samples will undergo PIONA analysis, GC analysis, and RON and MON measurements (Figures 1 & 2) [15-17].



Figure 2. Octane Number Device.

4. Experimental Results and Discussions

The following tables are the PIONA analyses of the samples.

4.1. PIONA Analysis of Reformate

Table 1. PIONA Analysis of Reformate.

Type	Volume%
Aromatics	74.515
Iso-Paraffins	17.347
Naphthenes	0.704
Olefins	0.629
Paraffins	6.805
Total	100.00

Table 1 illustrates the percentages of hydrocarbon groups (PIONA) of reformate and aromatics have a high percentage of 74.515% with research octane number of 101.8 and motor octane number of 92 for reformate sample.

4.2. PIONA Analysis of Isomerate

Table 2. PIONA Analysis of Isomerate.

Type	Volume%
Aromatics	0.035
Iso-Paraffins	74.660
Naphthenes	11.488
Olefins	0.003
Paraffins	13.815
Total	100.00

Table 2 shows the percentages of hydrocarbon groups (PIONA) of isomerate and aromatics have a low percentage of 0.035% with research octane number of 85.8 and motor

octane number of 83 for isomerate sample.

4.3. PIONA Analysis of Hydrocracked Naphtha

Table 3. PIONA Analysis of Hydrocracked Naphtha.

Type	Volume%
Aromatics	10.649
Iso-Paraffins	36.729
Naphthenes	27.899
Olefins	0.030
Paraffins	24.694
Total	100.00

Table 3 indicates the percentages of hydrocarbon groups (PIONA) of hydrocracked naphtha and aromatics have a percentage of 10.649% with research octane number of 72 and motor octane number of 68 for hydrocracked naphtha sample.

The tables above illustrate the PIONA analyses of the three base samples introduced through this paper which are the reformat, isomerate, and hydrocracked naphtha in order to produce environmental gasoline samples by blending those three samples along with the prepared samples of gasoline. The experimental work includes six samples of gasoline where they are blended with the three base samples with given compositions as to experiment the effect of environmental gasoline on the performance. In this paper, blends 5 and 6 only will be reviewed and discussed as they both are the only two samples that fulfilled the aim of the paper which is producing environmental gasolines that approaches the specifications of Euro-6 that are valid until 2020.

4.4. PIONA Analysis of Blend Sample 5

Table 4. PIONA Analysis of Blend Sample 5.

Type	Volume%
Aromatics	31.450
Iso-Paraffins	39.024
Naphthenes	15.551
Olefins	0.334
Paraffins	13.641
Total	100.00

Table 4 illustrates the percentages of hydrocarbon groups (PIONA) of Blend Sample 5 and aromatics have a percentage of 31.450% with research octane number of 85.7 and motor octane number of 79.4 for the sample 5.

4.5. PIONA Analysis of Blend Sample 6

Table 5. PIONA Analysis of Blend Sample 6.

Type	Volume%
Aromatics	28.746
Iso-Paraffins	38.948
Naphthenes	15.884
Olefins	0.189
Paraffins	16.234
Total	100.00

Table 5 illustrates the percentages of hydrocarbon groups (PIONA) of Blend Sample 6 and aromatics have a high

percentage of 28.746% with research octane number of 84.8 and motor octane number of 78.7 for sample 6.

The following tables show the GC analyses of Samples. The Complete GC Analysis could include more than 300 components which is difficult to facilitate and include within this paper and thus the selection of the major components take place where the analysis of their octane numbers is provided as well to determine their effect on the entire sample behavior. The highlighted components in the tables are components with octane numbers higher than 80.

4.6. GC Analysis of Reformat

Table 6. Major Components of GC Analysis of Reformat.

Major Components	Volume%	RON	MON
Paraffins			
Normal Butane	0.405	95	92
Normal Pentane	1.773	62	62
Normal Hexane	0.672	25	26
Normal Heptane	2.949	0	0
Normal Octane	0.561	-20	-20
Iso-Paraffins			
Iso-Pentane	2.991	92	---
2-Methyl Pentane	0.866	73	74
3-Methyl Pentane	0.652	74.5	74
2, 2-Dimethyl Pentane	0.533	92.8	96
2, 4-Dimethyl Pentane	0.567	83.1	83.8
3, 3-Dimethyl Pentane	0.508	80.8	86.6
2-Methyl Hexane	3.185	42.4	46.4
2, 3-Dimethyl Pentane	1.202	91.1	88.5
2, 2-Dimethyl Butane	0.207	91.8	93.4
2, 3-Dimethyl Butane	0.182	103.5	94.3
3-Ethylpentane	0.397	65	69.3
2, 2-Dimethylhexane	0.131	72.5	77.4
2, 4-Dimethylhexane	0.231	65.2	69.9
3, 3-Dimethylhexane	0.101	75.5	83.4
2-Methyl-3-Ethyl-pentane	0.151	87.3	88.1
4-Methylheptane	0.469	26.7	39
3, 4-Dimethylhexane	0.223	76.3	81.7
3-Methylhexane	3.925	52	55
3-Ethylhexane	0.554	33.5	52.4
Aromatics			
Benzene	1.853	100	114.8
Toluene	23.115	120	103.5
Ethylbenzene	4.797	107.4	97.9
Para-Xylene	17.818	116.4	109.6
Ortho-Xylene	7.711	120	100
Normal-Propylbenzene	0.964	111	98.7
1-Methyl-3-Ethylbenzene	3.350	112.1	100
1-Methyl-4-Ethyl benzene	1.521	100	97
1, 3, 5-Trimethylbenzene	1.219	>120	120
1-Methyl-2-Ethylbenzene	1.557	102.5	92.1
1, 2, 4-Trimethylbenzene	5.980	109	105
1-Methyl-3-Isopropylbenzene	1.617	108	96.9
Isopropylbenzene	0.328	113.1	99.3
1, 4-Diethylbenzene	0.210	106	96.4
1-Methyl-4-normal-propylbenzene	0.121	107.8	96.3
1, 2-Diethylbenzene	0.226	109.4	97.1
1, 4-Dimethyl-2-ethylbenzene	0.210	106	96
1, 3-Dimethyl-4-ethylbenzene	0.191	109	95.9
1, 2-Dimethyl-4-ethylbenzene	0.371	104	91
1, 2, 4, 5- Tert-methylbenzene	0.239	105	100

Table 6 demonstrates that the major components that contribute to the Research Octane Number of components in

reformate are mostly iso-paraffins and aromatics showing values of octane numbers higher than 80 which allow the ignition to become more efficient. However, the percentage of aromatics should not exceed 32 vol.%, the PIONA analysis shows that the percentage of aromatics exceed 45 vol.% and thus, reformate must be used as a blend sample to other refinery products to upgrade the gasoline octane number environmentally.

4.7. GC Analysis of Isomerate

Table 7. Major Components of GC Analysis of Isomerate.

Major Components	Volume%	RON	MON
Paraffins			
Normal butane	1.443	95	92
Normal Pentane	10.259	61.7	61.9
Normal Hexane	1.910	25	26
Iso-Paraffins			
Isopentane	30.573	92	---
2, 2-Dimethylbutane	22.719	91.8	93.4
2, 3-Dimethylbutane	5.412	103.5	94.3
2-Methylpentane	11.924	73.4	73.5
3-Methylpentane	3.168	74.5	74.3
2, 2-Dimethylpentane	1.101	92.8	95.6
2-Methylhexane	0.126	42.4	46.4
3-Methylhexane	0.111	52	55
3-Ethylhexane	0.313	65	69.3
Naphthenes			
Cyclopentane	1.164	100	---
Methylcyclopentane	2.630	91.3	80
Cyclohexane	6.964	83	77.2
1, 1, 3-Tri-methylcyclopentane	0.446	87.7	83.5

Table 7 illustrates that the iso-paraffins and naphthenes are the most dominant components with the highest octane numbers that contribute to the final octane number of Isomerate, making Isomerate a desirable compound where its percentage in samples should be increased more than the reformate as it shows a high performance of ignition due to high RON and also a high contribution to gasoline to be able to perform as environmental gasoline to exert the least exhaust. The PIONA analysis of Isomerate shows that the aromatics composition is around 0.035 vol.% which is a negligible percentage compared with iso-paraffins which show a percentage of 74.66 vol.% and naphthenes that indicate a value of 11.488 vol.% that represent high octane numbers.

4.8. GC Analysis of Hydrocracked Naphtha

Table 8. The Major Components of GC Analysis of Hydrocracked Naphtha.

Major Components	Volume%	RON	MON
Paraffins			
Normal Butane	3.410	95	92
Normal Pentane	7.225	61.7	61.9
Normal Hexane	5.207	25	26
Normal Heptane	3.548	0	0
Normal Octane	3.716	-20	-20

Major Components	Volume%	RON	MON
Normal Nonane	0.389	<0	<0
Iso-Paraffins			
Isopentane	9.346	92	---
2, 3-Dimethylbutane	0.721	103.5	94.3
2-Methylpentane	4.947	73.4	73.5
3-Methylpentane	3.269	74.5	74.3
2, 2-Dimethylbutane	0.102	91.8	93.4
2, 4-Dimethylpentane	0.401	83.1	83.8
3-Ethylpentane	0.231	65	69.3
2, 4-Dimethylhexane	0.439	65.2	69.9
2-Methylhexane	3.012	42.4	46.4
2, 3-Dimethylpentane	0.714	91.1	88.5
3-Methylhexane	3.076	52	55
2, 2-Dimethylhexane	0.582	72.5	77.4
2, 2, 3-Trimethylpentane	0.526	108.7	99.9
2, 3-Dimethylhexane	0.544	71.3	78.9
2-Methylheptane	2.140	26.8	35
3-Methylheptane	2.098	26.7	39
3-Ethylhexane	1.750	33.5	52.4
Naphthenes			
Cyclopentane	0.594	100	85
Methylcyclopentane	5.274	91.3	80
Cyclohexane	1.498	83	77.2
Methylcyclohexane	4.783	74.8	71.1
Ethylcyclopentane	1.947	67.2	61.2
Cis-1, 3-Dimethylcyclopentane	1.797	80.6	72.6
Trans-1, 3-Dimethylcyclopentane	1.508	79.2	73.1
Trans-1, 4-Dimethylcyclohexane	0.596	71	66
Cis-1, 3-Ethylmethylcyclopentane	0.877	59.8	57.6
Trans-1, 2-Ethylmethylcyclopentane	0.671	59.8	57.6
1, 1-Dimethylcyclopentane	0.252	92.3	89.3
1, 1-Dimethylcyclohexane	0.125	87.3	85.9
Trans-1, 2-Dimethylcyclohexane	0.491	77	75
Aromatics			
Benzene	1.890	99	114.8
Toluene	4.801	120	103.5
Ethylbenzene	1.246	107.4	97.9
Meta-Xylene	1.197	117.5	115
Para-Xylene	0.567	116.4	109.6
Ortho-Xylene	0.597	120	100
1-Methyl-3-Ethylbenzene	0.103	112.1	100

Table 8 represents that the main components affecting the octane number of the entire sample of hydrocracked naphtha are the aromatics showing very high octane numbers followed by naphthenes and iso-paraffins. The PIONA analysis of hydrocracked naphtha shows that the percentage of aromatics is 10.649 vol.%, iso-paraffins is 36.729 vol.%, and naphthenes is about 27.899 vol.%, making this sample very environmental as it does not exert toxic exhaust to the atmosphere. The octane numbers of components are also very high showing a high ignition performance where several components in iso-paraffins and naphthenes groups show higher octane numbers than 80, and the aromatics family shows extremely high octane numbers over 100.

4.9. GC Analysis of Blend Sample 5

Table 9. Major Components of GC Analysis of Blend Sample 5.

Major Components	Volume%	RON	MON
Paraffins			
Normal butane	1.786	95	92
Normal Pentane	6.130	61.7	61.9
Normal hexane	3.014	25	26
Normal Octane	1.909	-20	-20
Normal Nonane	0.206	<0	<0
Iso-Paraffins			
Isopentane	11.665	92	---
2, 2-Dimethylbutane	5.148	91.8	93.4
2, 3-Dimethylbutane	1.585	103.5	94.3
2-Methylpentane	5.193	73.4	73.5
3-Methylpentane	2.412	74.5	74.3
2, 2-Dimethylpentane	0.242	92.8	95.6
2, 4-Dimethylpentane	0.397	83.1	83.8
3, 3-Dimethylpentane	0.212	80.8	86.6
2-Methylhexane	2.550	42.4	46.4
2, 3-Dimethylpentane	0.768	91.1	88.5
3-Methylhexane	2.846	52	55
3-Ethylpentane	0.253	65	69.3
2, 2-Dimethylhexane	0.312	72.5	77.4
2, 5-Dimethylhexane	0.251	55.2	55.7
2, 2, 3-Trimethylpentane	0.325	108.7	99.9
2, 3-Dimethylhexane	0.309	71.3	78.9
2-Methylheptane	1.144	21.7	23.8
3-Methylheptane	1.142	26.8	35
3-Ethylhexane	0.176	33.5	52.4
Olefins			
1-Pentene	0.120	90.9	77.1
Naphthenes			
Cyclopentane	0.530	100	---
Cyclohexane	2.251	83	77.2
1,1-Dimethylcyclopentane	0.129	92.3	89.3
Methylcyclopentane	2.996	91.3	80
Cis-1, 3-Dimethylcyclopentane	0.833	80.6	72.6
Trans-1, 3-Dimethylcyclopentane	0.703	79.2	73.1
Methylcyclohexane	2.255	74.8	71.1
Ethylcyclopentane	0.889	91.3	80
Trans-1, 3-Dimethylcyclohexane	0.480	71.7	71.1
Cis-1, 3-Dimethylcyclohexane	0.401	66.9	64.2
Aromatics			
Benzene	1.525	99	114.8
Toluene	10.606	120	103.5
Ethylbenzene	2.335	107.4	97.9
Meta-Xylene	4.995	117.5	115
Para-Xylene	2.268	116.4	109.6
Ortho-Xylene	3.070	120	100
Isopropylbenzene	0.124	113.1	99.3
Normal Propylbenzene	0.404	111	98.7
1-Methyl-3-Ethylbenzene	1.267	112.1	100
1-Methyl-4-Ethylbenzene	0.576	---	97
1, 3, 5-Trimethylbenzene	0.460	120	120
1, 2, 4-Trimethylbenzene	2.209	105	100
1-Methyl-3-Isopropylbenzene	0.590	108.3	96.9
1, 2-Dimethyl-4-Ethylbenzene	0.136	104.4	91.9
1, 2, 3, 5-Tertmethylbenzene	0.137	107.5	102.5

Table 9 illustrates that the sample 5 has many components that contribute to the octane number of the entire sample. The most dominant components are from the iso-paraffins, naphthenes, and aromatics groups showing elevated octane numbers (above 80). According to the PIONA analysis, the percentages of each group to the entire sample are: iso-

paraffins 39.024 vol.%, naphthenes: 15.551 vol.%, and aromatics: 31.450 vol.%. According to the shown composition, the sample approaches to the specifications of Euro-6 (2020) which is the target of this study as to produce an environmental gasoline.

4.10. GC Analysis of Blend Sample 6

Table 10. Major Components of GC Analysis of Blend Sample 6.

Major Components	Volume%	RON	MON
Paraffins			
Normal butane	1.772	95	92
Normal Pentane	6.051	61.7	61.9
Normal hexane	3.054	25	26
Normal Heptane	2.647	0	0
Normal Octane	1.955	-20	-20
Normal Nonane	0.205	<0	<0
Iso-Paraffins			
Isopentane	11.364	92	---
2, 2-Dimethylbutane	4.949	91.8	93.4
2, 3-Dimethylbutane	1.543	103.5	94.3
2-Methylpentane	5.128	73.4	73.5
3-Methylpentane	2.407	74.5	74.3
2, 2-Dimethylpentane	0.222	92.8	95.6
2, 4-Dimethylpentane	0.380	83.1	83.8
3, 3-Dimethylpentane	0.191	80.8	86.6
2-Methylhexane	2.473	42.4	46.4
2, 3-Dimethylpentane	0.731	91.1	88.5
3-Methylhexane	2.741	52	55
3-Ethylpentane	0.241	65	69.3
2, 2-Dimethylhexane	0.317	72.5	77.4
2, 5-Dimethylhexane	0.252	55.2	55.7
2, 2, 3-Trimethylpentane	0.323	108.7	99.9
2, 3-Dimethylhexane	0.311	71.3	78.9
2-Methylheptane	1.165	21.7	23.8
3-Methylheptane	1.159	26.7	35
3-Ethylhexane	0.958	33.5	52.4
Naphthenes			
Cyclopentane	0.529	100	---
Cyclohexane	2.220	83	77.2
1, 1-Dimethylcyclopentane	0.131	92.3	89.3
Cis-1, 3-Dimethylcyclopentane	0.861	80.6	72.6
Trans-1, 3-Dimethylcyclopentane	0.727	79.2	73.1
Methylcyclohexane	2.340	74.8	71.1
Methylcyclopentane	3.054	91.3	80
Ethylcyclopentane	0.922	67.2	61.2
Trans-1, 4-Dimethylcyclohexane	0.315	63	64
Trans-1, 3-Ethylmethylcyclohexane	0.498	59.8	57.6
Cis-1, 3-Ethylmethylcyclohexane	0.418	59.8	57.6
Trans-1, 2-Dimethylcyclohexane	0.258	77	75
1, 1, 4-Trimethylcyclohexane	0.254	87.7	83.5
Aromatics			
Benzene	1.478	99	114.8
Toluene	9.765	120	103.5
Ethylbenzene	2.172	107.4	97.9
Meta-Xylene	4.530	117.5	115
Para-Xylene	2.060	116.4	109.6
Ortho-Xylene	2.784	120	100
Isopropylbenzene	0.111	113.1	99.3
Normal Propylbenzene	0.369	111	98.7
1-Methyl-3-Ethylbenzene	1.138	112.1	100
1-Methyl-4-Ethylbenzene	0.519	---	97
1, 3, 5-Trimethylbenzene	0.412	120	120
1, 2, 4-Trimethylbenzene	1.969	105	100
1, 2-Dimethyl-4-Ethylbenzene	0.122	108.3	96.9
1, 2, 3, 5-Tertmethylbenzene	0.123	104.4	91.9

Table 10 indicates that the sample 6 has many components that contribute to increase the octane number of the entire sample. The most dominant components are iso-paraffins, naphthenes, and aromatics groups showing elevated octane numbers (above 80). According to the PIONA analysis, the percentages of each group to the entire sample are: iso-paraffins 39.024 vol.%, naphthenes: 15.551 vol.% and

aromatics: 28.746 vol.%. According to the shown composition, the sample approaches to the specifications of Euro-6 (2020) which is the target of this research as to produce environmental gasoline. The following table illustrates the entire classifications of gasoline blended samples with their octane numbers and contents (Table 11).

Table 11. Classifications of Gasoline Blended Samples.

Gasoline Blends	1	2	3	4	5	6
Reformate, vol.%	47	44	41	38	35	32
Isomerate, vol.%	20	20	20	20	20	20
Hydrocracked Naphtha, vol.%	33	36	39	42	45	48
RON	89.4	88.5	87.5	86.6	85.7	84.8
MON	82.3	81.6	80.8	80.1	79.4	78.7
Difference between RON & MON	7.1	6.9	6.7	6.5	6.3	6.1
PON	85.85	85.05	84.15	83.35	82.55	81.75
Euro Standards	Euro 3	Euro 3	Euro 4	Euro 4	Euro 5 and 6	Euro 5 and 6
Aromatics Content, vol.%	39.051	37.503	35.717	33.947	31.450	28.746
Iso-Paraffins Content, vol.%	36.233	36.665	37.167	37.725	39.024	38.948

Table 11 illustrates that as the difference in RON and MON decreases and the PON also decreases; the sample approaches a more advanced Euro level of environmental specifications as being compared with the aromatic content which also decreases which obeys the rules of Euro Standards. On the other hand, a slight increase occurs in the iso-paraffin content, which is desirable as they have high octane numbers. Finally, the direction from blend 1 through blend 6 represents the increasing in the quality of environmental gasoline to meet the Euro 6 specifications. Finally two blend samples (blend 5 and 6) are categorized within the specifications of Euro 6 (until year 2020). All blends have been observed to be better than the actual gasoline used in our country as it follows the regulations of Euro 2 and thus these samples illustrate the upgrade to produce environmental gasolines that meet with the current Euro regulations and environmental standards.

5. Conclusions

- I. PIONA analysis has been observed to be the key to select the high quality samples of gasolines and the deep in refining processes contribute to produce more useful refinery products (Reformate, Isomerate, and Hydrocracked Naphtha) that aid in upgrading the gasoline samples by blending the obtained refinery products along with gasoline to enhance their octane numbers.
- II. The European Standard Specifications contribute to the selection of environmental gasoline to reduce the exhaust that causes air pollution.
- III. After experimentation and discussions of results, it is concluded that the only two blends (blends 5 and 6) approached the specifications of Euro 5 & 6 (2020) standards which contribute in solving the problem of air pollution in our country because the regular gasoline generally approaches the specifications of Euro 2 which is not preferable with respect to the environmental and industrial standards.

References

- [1] Gary, J. H., & Handwerk, G. E. (2001). Petroleum Refining Technology and Economics. Marcel Dekker Inc. New York.
- [2] Albahri, T. A., Riazi, M. R., & Alqattan, A. A. (2002). Octane Number and Aniline Point of Petroleum Fuels. In 224th ACS National Meeting (pp. 710-711).
- [3] El-Bassiouny, A. A., Aboul-Fotouh, T. M., & Abdellatif, T. M. (2015). Upgrading the Commercial Gasoline A80 by Using Ethanol and Refinery Products. International Journal of Scientific & Engineering Research, 6 (8), 405-417.
- [4] Aboul-Fotouh, T. M., Mazen, O. A. & Ashour, I. (2017). Experimental Study on the Influence of Ethanol and Automotive Gasoline Blends. Journal of Petroleum & Environmental Biotechnology, 8 (1), DOI: 10.4172/2157-7463.1000318, USA.
- [5] El-Bassiouny, A. A., Aboul-Fotouh, T. M., & Abdellatif, T. M. (2015). Maximize the Production of Environmental, Clean and High Octane Number Gasoline-Ethanol Blends by using Refinery Products. International Journal of Scientific & Engineering Research, 6 (7), 1792-1803.
- [6] Aboul-Fotouh, T. M. & Hussein, M. S. (2016). Experimental Determination of Physicochemical Characteristics of New Environmental Gasoline, Ethanol and Isopropanol Blends. The 2016 Spring Meeting and 12th Global Congress on Process Safety of AIChE, Houston, TX, USA, № 443187.
- [7] Pasadakis, N., & Xekoukoulotakis, N. (2012). Gas Chromatographic Analysis of Crude Oils With Thermal Extraction Sampling. Petroleum Science and Technology, 25 (9), 1135-1142; London: Taylor & Francis.
- [8] Pavlova, A., & Ivanova, R. (2003). GC Methods for Quantitative Determination of Benzene in Gasoline. Acta Chromatographica, 215-225.
- [9] Faiz, A., Weaver, C. S., & Walsh, M. P. (1996). Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions. World Bank Publications.

- [10] Confer, K. (2011). Gasoline Ultra Fuel Efficient Vehicle. Wayne: Wayne State University. U. S. Department of Energy.
- [11] Sellnau, M., Moore, W., Sinnamon, J., Hoyer, K., Foster, M., & Husted, H. (2015). GDCI Multi-Cylinder Engine for High Fuel Efficiency and Low Emissions. S. A. E.: Delphi Powertrain. DOI: 10.4271/2015-01-0834.
- [12] Majid, A. H. (2010). Optical Study of Ethanol Gasoline Blends With or Without Heating. Malaysia: Faculty of Mechanical Engineering UNIVERSITI MALAYSIA PAHANG.
- [13] Carlos, A. (2012). The Blend Ethanol / Gasoline and Emission of Gases. Brazil: Santos Empresa de Pesquisa Energética, 33-55.
- [14] Menezes, E. W. (2006). Addition of an Azeotropic ETBE/Ethanol Mixture in Eurosuper-type gasolines. Elsevier, 2567–2577.
- [15] American Society for Testing and Materials (2016). Standard test method for research octane number of spark-ignition engine fuel. D2699-16.
- [16] American Society for Testing and Materials (2016). Standard test method for motor octane number of spark-ignition engine fuel. D2700-16.
- [17] American Society for Testing and Materials (2016). Standard Test Method for Gas Chromatography of Petroleum Products D6839-16.