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**Research Article**

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# Distillation – Gas chromatograph Analytical Study of Hydrocarbon Fuel-Motor Gasoline

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**ABSTRACT**

*Motor gasoline is a Hydrocarbon fuel used in internal combustion engine. Fuel used should be quality and benefit of traveling long distance. Motor gasoline is obtained from the atmospheric distillation of crude oil. And it is fraction of crude oil. Motor gasoline consists of carbon C5 to C12, which contains a mixture of various component namely, low aromatic naphtha (LAN), high aromatic naphtha (HAN) and some part of superior kerosene (SK). These LAN, HAN and SK are available in commercial market at low cost, which persuade to quality problem in excess. So quality preservation of fuel is very significant and vital which could be study using distillation and gas chromatograph technique.*

**Keywords**: Distillations; Gaschromatograph; Motorgasoline; DHA; Aromatics; Paraffin's group

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## INTRODUCTION

Hydrocarbon fuel motor gasoline fuel a volatile liquid. It is obtained from crude oil or petroleum. Crude oil is mixture of hydrocarbon material starting from C1 to C70 Carbon. Crude oil is obtained from atmospheric distillation. Crude oil [1], is taken from offshore or underground using bore well or digging machine. Then it is sent to processing for removing impurities like sand, water, trace metals, nitrogen and sulphur. Then moved to atmospheric distillation tower for volatile and nonvolatile fraction separations based on boiling point. The separated fraction are namely LPG, naphtha motor gasoline, superior kerosene, aviation turbine fuel, lubricating oil, fuel oil and residuum. The motor gasoline is mixture of hydrocarbon consists of carbon C1 to C12, which include components of isomer of pentane, hexane, heptane, octane, nonane, decane, undecane and undecane. The fuel is coordinated with the specification of motor gasoline in the refinery [2], and sent to the fuel filling station for community usage in day to day lifetime. The fuel available in the fuel filling station should meet quality and specification. But during fuel transportation some time fuels are contaminated by the transport (ASTM D2699) authority folks. So motor gasoline sample are collected from various places [3], and analyzed for quality limitation using distillation [4], and gas chromatograph test Distillation [5] give a signs of contamination but using gas chromatograph give a clear signals of contaminates. Few motor gasoline sampled, using tail pipe and stored in aluminum container, kept at refrigeration, then distillation and gas chromatograph [6,7], investigated. The data obtained from the analysis are correlated for the contamination. Distillation [8], is volatility test and gas chromatograph is separation technique. These test are useful for contamination as well as adulteration purpose.

## EXPERIMENTAL SECTION

Six motor gasoline samples were collected from fuel filling stations from different parts of Chennai, Tamil Nadu, India. The motor gasoline samples are reserved from region of north, south, east, west and central part of Chennai. The collected samples are stored in refrigeration and during analysis it is taken form the refrigeration. The motor gasoline are analyzed for density [9], distillation and gas chromatograph [10,11], by volume percentage. The analysis are carried out as per BIS (IS 1448) method for density, distillation and ASTM methods for gas

chromatograph. Density test were carried out at 150C. Distillation parameter are examined at initial boiling point (IBP), 5%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% 95% and final boiling point (FBP). Simultaneously the volume recovered are also examined at different phase –REC @ 700C, REC @ 1000C, REC @ 1500C and REC @ 1800C.

## GAS CHROMATOGRAPH OPERATIONAL CONDITION

Column Details:

- Petrocol DH 100 meters,
- 100% Dimethyl polysiloxane (Non-Polar) 0.25 mm id,
- Sample size-0.5 µl,

Fuel gas:

- Hydrogen @ 30mL/min,
- Oxidant- Air @ 300mL/min,

Make up gas-
Helium @ 20mL/min,
Injection temperature 260ºC,
Injection mode- Split Mode-200 ml / Min- Split ratio1:98 Inject pressure-44 Psi,
Detector- Flame Ionisation Detector,
Detector Temperature: 265°C,
Oven Temperature i-35ºC,
Oven Time: i-15 Minutes,
Oven Rate: i-1ºC/Min,
Oven Temperature: ii-60ºC,
Oven Time : ii-20 Minutes,
Oven Rate : ii-2ºC/Min,
Oven Temperature : iii-210ºC,
Oven Time : iii-10 Minutes,
Total Time: 145 Minutes,
Oven Max: 265ºC.

## RESULT

### Density

The density of MG1 found to 0.724 while MG2, MG3, MG4 found to be 0.732, MG5, MG6 found to be 0.741 respectively, The density limits between 0.72 to 0.74, as shown in Figure 1 and Table 1.

**Table 1: The density of MG1 found to 0.724 while MG2, MG3, MG4 found to be 0.732, MG5, MG6 found to be 0.741 respectively, The density limits between 0.72 to 0.74**

| S No | Parameters | Requirements (MG) | | Methods of Test [P:] of IS 1448 |
|---|---|---|---|---|
| | | Unleaded Regular | Unleaded Premium | |
| 1 | Colour | Orange | Red | Visual |
| 2 | Density@150C.Kg/$m^3$ | 720-775 | 720-775 | [P:16] |
| 3 | Distillation | | | |
| a) | Recovered upto $70^0$C(E70) percent by volume | Oct-45 | Oct-45 | [P:18] |
| b) | Recovered upto $100^0$C(E100) percent by volume | 40-70 | 40-70 | |

| | | | | |
|---|---|---|---|---|
| c) | Recovered upto 150°C(E150) percent by volume, Min | 75 | 75 | |
| d) | Final Boiling Point(FBP),Max | 210°C | 210°C | |
| 4 | Research Octane Number(RON)Min | 91 | 91 | [P:27] |
| 5 | Motor Octane Number(MON)Min | 81 | 91 | [P:26] |
| 6 | Reidvapour pressure(RVP), kPa | 60 | 60 | [P:39] |
| 7 | Aromatics content, percent by volume, Max | 42 | 42 | ASTM D 1319 |
| 8 | Olefin content, percent by volume, Max | 21 | 18 | ASTM D 1319 |

**Distillation**

The IBP, 5%, 10%, 20%, 30%, 40% 60%, 80% 90, are similar in increasing order but in circumstance at 50%, 70% the deviation are very large this indicates the contamination, which is difficult to prove since the test satisfies the specifications, which are broad spectrum. Yet again this test is only confirmatory as shown in Figures 2 and 3 and Table 2.

**Table 2: Distillation of sample of Motor gasoline**

| Sample ID | MG1 | MG2 | MG3 | MG4 | MG5 | MG6 |
|---|---|---|---|---|---|---|
| **Density @ 15ºC (g/ml)** | 0.724 | 0.732 | 0.732 | 0.732 | 0.741 | 0.7349 |
| **Distillation:IBP ºC** | 38 | 42 | 38 | 37 | 39 | 38 |
| **5% Vol.Recovery @ ºC** | 52 | 52 | 48 | 48 | 52 | 51 |
| **10%Vol.Recovery @ ºC** | 55 | 58 | 53 | 53 | 55 | 56 |
| **20%Vol.Recovery @ ºC** | 63 | 63 | 61 | 58 | 62 | 64 |
| **30% Vol.Recovery @ ºC** | 70 | 70 | 66 | 66 | 68 | 72 |
| **40% Vol.Recovery @ ºC** | 80 | 79 | 75 | 76 | 75 | 84 |
| **50% Vol.Recovery @ ºC** | 92 | 92 | 88 | 90 | 90 | 96 |
| **60%Vol.Recovery @ ºC** | 103 | 105 | 103 | 105 | 103 | 109 |
| **70% Vol.Recovery @ ºC** | 115 | 120 | 123 | 120 | 118 | 122 |
| **80%Vol.Recovery @ ºC** | 130 | 136 | 140 | 138 | 133 | 138 |
| **90%Vol.Recovery @ ºC** | 170 | 155 | 162 | 161 | 150 | 161 |
| **95%Vol.Recovery @ ºC** | 184 | 169 | 172 | 176 | 164 | 178 |
| **FBP @ºC** | 200 | 192 | 205 | 203 | 194 | 200 |
| **Recovery@70$^{O}$C** | 30% | 30% | 33% | 35% | 32% | 28% |
| **Recovery@100$^{O}$C** | 58% | 58% | 59% | 57% | 58% | 53% |
| **Recovery@150$^{O}$C** | 85% | 87% | 86% | 86% | 90% | 85% |
| **Recovery@180$^{O}$C** | 96% | 96% | 95% | 95% | 98% | 96% |

**Gas chromatograph analysis**

**Average Molecular weight**

The AVG of (MG1, MG3 & MG4) were 90. (MG2, MG5& MG6) were 91 as shown in Figure 4 and Table 3.

**Table 3: Calculated Physical Properties of sample of Motor gasoline**

| MG Sample Identity | MG1 | MG2 | MG3 | MG4 | MG5 | MG6 |
|---|---|---|---|---|---|---|
| **Avg MW** | 90.647 | 91.242 | 90.119 | 89.916 | 91.223 | 91.488 |
| **Avg SG** | 0.72 | 0.745 | 0.739 | 0.735 | 0.746 | 0.737 |
| **Avg API @ 60.0F** | 66.743 | 61.659 | 64.595 | 64.648 | 61.814 | 63.952 |
| **RVP** | 6.869 | 7.333 | 7.397 | 8.197 | 7.407 | 7.43 |
| **Total H** | 14.111 | 13.38 | 13.659 | 13.668 | 13.409 | 13.596 |
| **C/H** | 6.05 | 6.454 | 6.305 | 6.304 | 6.447 | 6.345 |
| **E200** | 67.834 | 56.957 | 61.141 | 61.19 | 56.823 | 54.571 |
| **E300** | 91.439 | 90.505 | 88.973 | 89.031 | 90.02 | 89.795 |

**Average specific gravity**

The ASG of (MG2 MG3, MG4, MG5 and MG6) were between 0.735 to 0.745.But MG1 found to different 0.72 as shown in Figure 5 and Table 3.

**Average API @ 60.0F**

The Ave API of (MG, MG4 and MG6) found to be 64.o to 64.6 while (MG2 and MG5) found to be 61.5 to 61.8 but MG1 is different from other samples 66.7 it shows a high volatile component is present in excess as shown in Figure 6 and Table 3.

**Ried Vapor Pressure**

RVP of (MG2, MG3) found to be 7.3 and (MG5 & MG6) found to be 7.4 while MG1 and MG4 found to be 6.8 and 8.1 correspondingly. This show a low and high volatile contaminant are found in MG1 and MG 4 respectively as shown in Figure 7 and Table 3.

**Total Hydrogen**

RVP of (MG2, MG5) found to be 13.4 and (MG3 & MG4) found to be 13.7 while MG 1 is 14.1 MG6 is 13.5 correspondingly. This also confirms contaminants as shown in Figure 8 and Table 3.

Carbon / Hydrogen Ratios

C/H ratio of (MG3, MG4 & MG6) found to be 6.3 and (MG2 & MG5) found to be 6.4 while MG1 is 6.0. This also confirms contaminants as shown in Figure 9 and Table 3.

**Aromatics**

Aromatics of (MG1, MG2 & MG3) found to be 23 and (MG4 & MG6) found to be 26 while MG5 is 28.2. There is no large deviation except MG5 which is common as shown in Figure 10 and Table 4.

**Table 4: Summary By Group of sample of Motor gasoline**

| Summary By Group-Volume Percentage | | | | | | |
|---|---|---|---|---|---|---|
| Sample ID | **MG1** | **MG2** | **MG3** | **MG4** | **MG5** | **MG6** |
| Aromatics | 23.165 | 23.573 | 24.217 | 26.353 | 28.227 | 26.615 |
| I-Paraffins | 39.089 | 40.776 | 39.353 | 43.001 | 44.025 | 41.169 |
| Napthenes | 10.389 | 10.227 | 9.999 | 6.31 | 4.288 | 7.01 |
| Olefins | 17.825 | 15.585 | 16.623 | 12.212 | 10.336 | 13.495 |
| Paraffins | 9.394 | 9.839 | 9.808 | 12.125 | 13.124 | 11.711 |
| RON | 84.89 | 87.64 | 88.72 | 86.77 | 86.32 | 87.27 |
| MON | 77.99 | 79.93 | 80.01 | 80.12 | 80.37 | 79.97 |

**Iso paraffins**

Iso paraffins of (MG1 & MG3) found to be 39 and (MG2 & MG6) found to be 41 while MG4 and MG5 is 43, 44.respectivily as shown in Figure 11 and Table 4.

**Napthenes**

Naphthenes of (MG1, MG2 & MG3) found to be 10 and (MG5, MG4 & MG6) found to be 4, 6 and 7 correspondingly as shown in Figure 12 and Table 4.

**Olefins**

Olefins of (MG1, MG2 & MG3) found to be 16 -18 and (MG5, MG4 & MG6) found to be 10, 12 and 14 correspondingly as shown in Figure 13 and Table 4.

**Paraffins**

Paraffins of MG1 is found to be 9.3 (MG2 & MG3) found to be 9.8 and (MG4 & MG6) found to be 12 and MG5 is 13, which indicates some contaminants are from paraffin's groups as shown in Figure 14 and Table 4.

**Research Octane Number and Motor Octane Number**

RON of MG1, MG5 are different from others MG2, MG3, MG4, MG6 samples. MON of MG1, MG5 are different from others MG2, MG3, MG4, MG6 samples both these test show the explosion characters of the fuel which implies the sample of contaminants as shown in Figures 15 to 16 and Table 4.

**Carbon number C4**

Carbon number C4 for MG5 implies very low 1.5 while MG1 is 1.3, considering the other MG2 to MG6 samples this also doubts contaminants as shown in Figure 17 and Table 5.

**Table 5: Summary By Group of sample of Motor gasoline**

| Summary By CARBON-Volume Percentage | | | | | | |
|---|---|---|---|---|---|---|
| **Sample ID** | **MG1** | **MG2** | **MG3** | **MG4** | **MG5** | **MG6** |
| **C4** | 1.346 | 1.759 | 1.852 | 1.726 | 1.541 | 1.535 |
| **C5** | 24.498 | 23.897 | 25.289 | 26.352 | 27.247 | 26.666 |
| | | | | | | |
| **C6** | 19.313 | 21.082 | 20.77 | 18.438 | 17.109 | 18.874 |
| **C7** | 23.764 | 20.904 | 22.003 | 21.329 | 21.261 | 21.949 |
| **C8** | 17.252 | 19.835 | 19.346 | 19.127 | 18.735 | 18.538 |
| **C9** | 9.651 | 7.005 | 6.506 | 7.748 | 8.266 | 7.547 |
| **C10** | 3.54 | 4.397 | 3.704 | 4.319 | 4.708 | 4.235 |
| **C11** | 0.451 | 0.9 | 0.529 | 0.675 | 0.878 | 0.588 |
| **C12** | 0.043 | 0.222 | 0.235 | 0.285 | 0.254 | 0.069 |

**Carbon number C5**

Carbon number C5 for MG5 implies very high 27.2 while MG1 is 25, considering the other MG2 to MG6 samples this also doubts contaminants as shown in Figure 18 and Table 5.

**Comparison of carbon number C9 &C10**

Carbon number C9 &C10 for MG5 implies very high 8.2 & 4.7 while MG1 is 9.6 & 3.5, considering the other MG2 to MG6 samples this also doubts contaminants as shown in Figures 19 and 20, and Table 5.

**Benzene C6**

Carbon Benzene C6 for MG5 implies very high 1.27 while MG1 is 0.63, considering the other MG2 to MG6 samples this also doubts contaminants as shown in Figure 21 and Table 6.

**Table 6: List of Some Components of sample of Motor gasoline**

| List by Component -Volume Percentage | | | | | | |
|---|---|---|---|---|---|---|
| **Sample ID** | **MG1** | **MG2** | **MG3** | **MG4** | **MG5** | **MG6** |
| **Benzene** | 0.623 | 0.73 | 0.753 | 1.003 | 1.278 | 0.955 |
| **Toluene** | 8.141 | 7.537 | 8.005 | 6.842 | 6.354 | 7.006 |
| **O-Xylene** | 2.366 | 1.868 | 2.148 | 2.052 | 2.203 | 2.281 |
| **M-Xylene** | 3.323 | 3.343 | 3.99 | 3.534 | 3.658 | 3.953 |
| **P-Xylene** | 4.342 | 1.282 | 1.614 | 1.541 | 1.605 | 1.689 |
| **Ethly benzene** | 1.555 | 1.222 | 1.387 | 1.349 | 1.42 | 1.442 |
| **Isopentane** | 11.626 | 11.325 | 12.164 | 13.073 | 13.759 | 13.253 |
| **224Trimethylpentane** | 0.642 | 3.399 | 2.263 | 3.759 | 3.925 | 2.629 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Cyclopentane** | 0.141 | 0.418 | 0.348 | 0.315 | 0.257 | 0.272 |
| **Methyl Cyclopentane** | 2.022 | 2.83 | 2.626 | 1.637 | 1.062 | 1.691 |
| **Pentane** | 3.526 | 3.726 | 3.919 | 5.023 | 5.204 | 5.828 |
| **Hexane** | 1.923 | 2.582 | 2.362 | 3.033 | 3.21 | 2.861 |
| **Heptane** | 1.588 | 1.244 | 1.257 | 2.057 | 2.407 | 1.912 |
| **Nonane** | 0.25 | 0.23 | 0.2 | 0.167 | 0.1156 | 0.188 |
| **Octane** | 1.047 | 0.765 | 0.776 | 0.605 | 0.521 | 0.656 |
| **Decane** | 0.112 | 0.161 | 0.107 | 0.076 | 0.065 | 0.089 |

**Iso Pentane C5**

Carbon iso pentane C5 for MG5 implies very high 13.8 while MG1 is 11.6, considering the other MG2 to MG6 samples this also doubts contaminants as shown in Figures 22-25 and Table 6.

**Hexane C6 and Heptane C7**

Carbon Hexane C6 and Heptane C7 for MG5 implies very high 3.2 and 2.4 while MG1 is 1.9 and 1.6 , considering the other MG2 to MG6 samples this also doubts contaminants as shown in Figure 26 and Table 6.

## CONCLUSION

The motor gasoline sample of MG1 to MG6 were analyzed by distillation method and gas chromatograph method. Distillation method shows only the confirmatory but gas chromatograph method implies what type of carbon are the contaminants. The carbon group, the carbon type, the carbon number and the individual component that are contaminated are clearly indicated by gas chromatograph. According to specification all the parameters are within the limits but the motor gasoline sample MG1 and MG5 are containments with volatile components iso-pentane, hexane and heptane carbon.

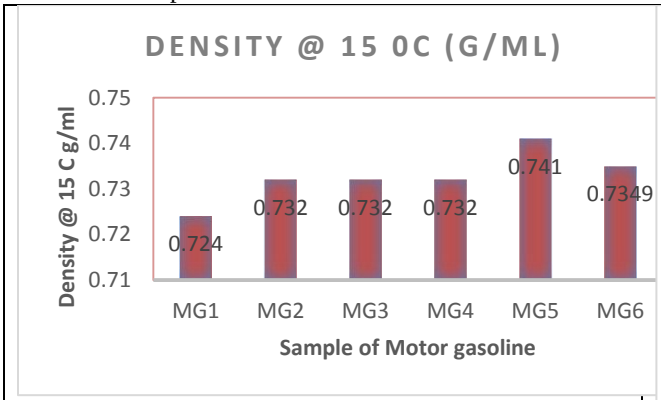


**Figure 1: Density @ 15 0C (g/Ml)**

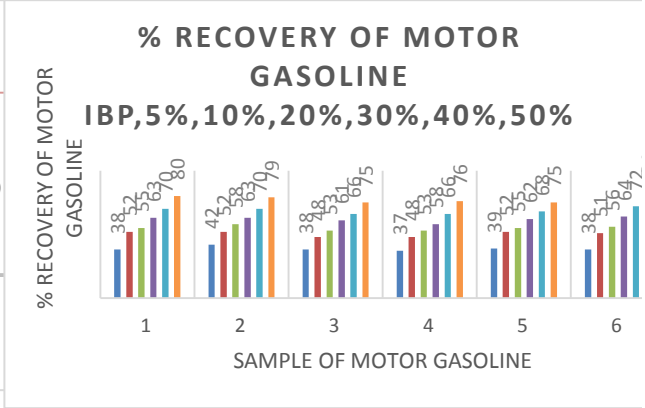


**Figure 2: % Recovery of motor gasoline IBP,5%,10%,20%,30%,40%,50%**

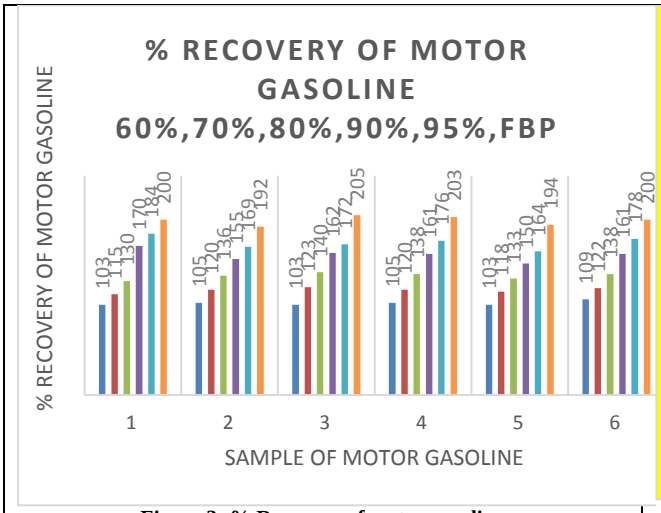


**Figure 3: % Recovery of motor gasoline 60%,70%,80%,90%,95%,FBP**

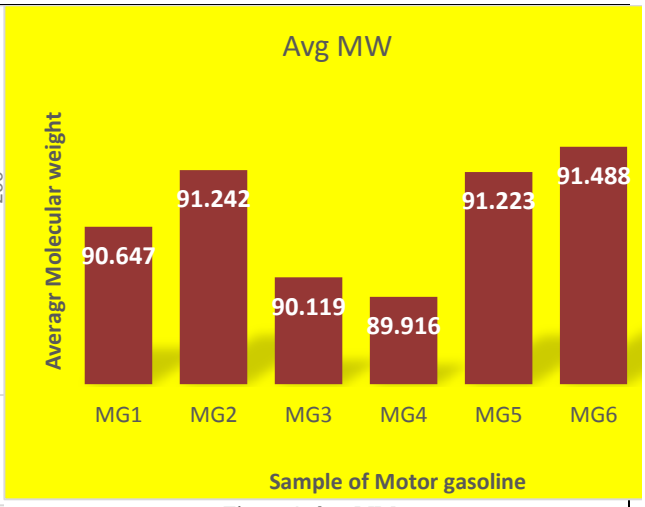


**Figure 4: Avg MW**

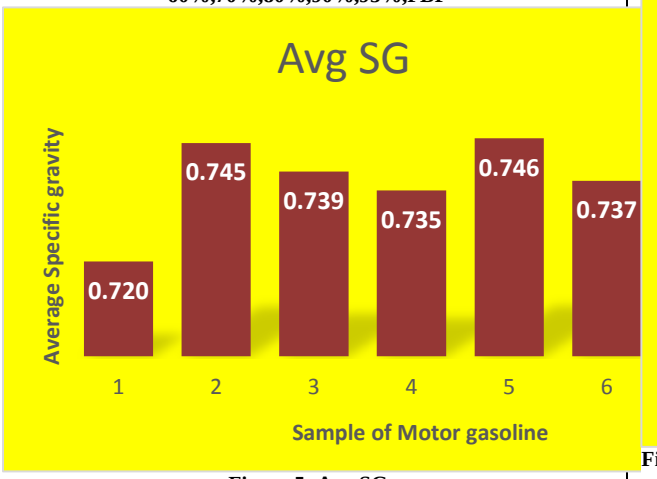


**Figure 5: Avg SG**

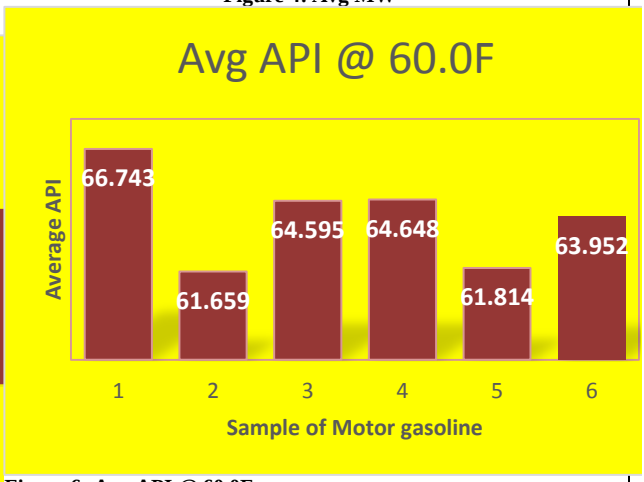


**Figure 6: Avg API @ 60.0F**

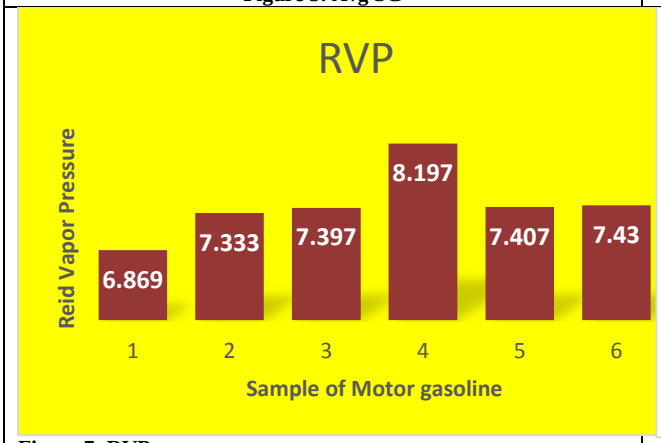


**Figure 7: RVP**

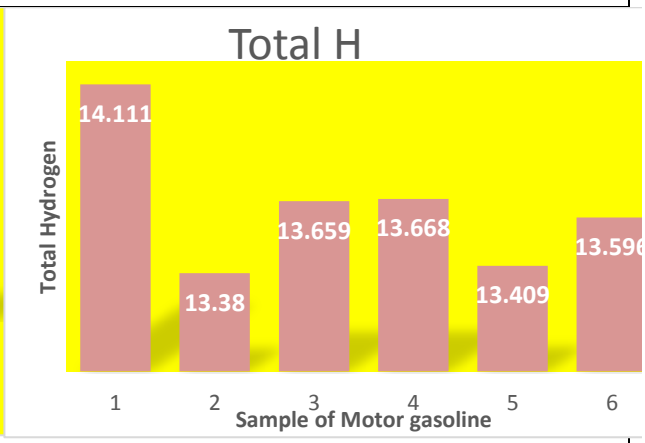


**Figure 8: Total H**

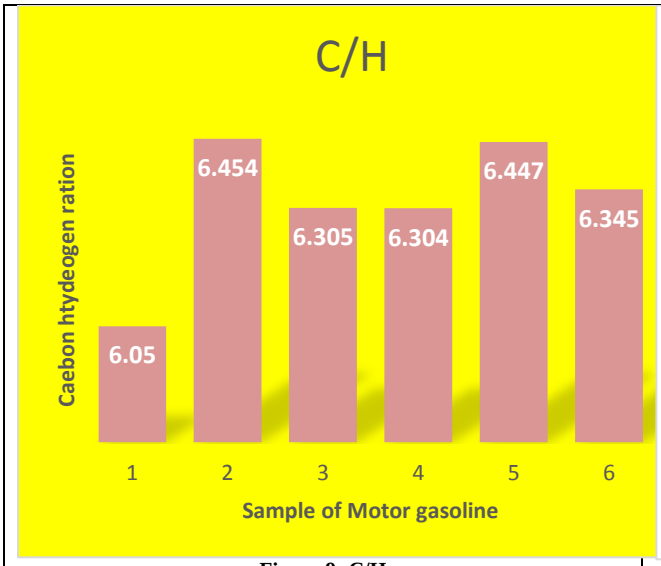


**Figure 9: C/H**

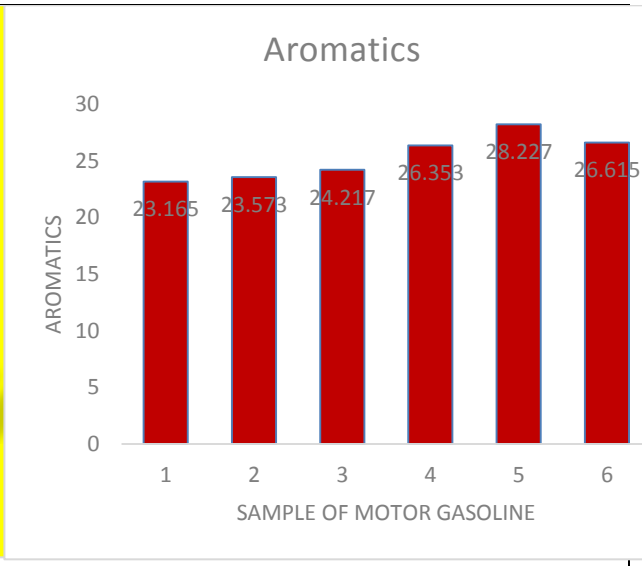


**Figure 10: Aromatics**

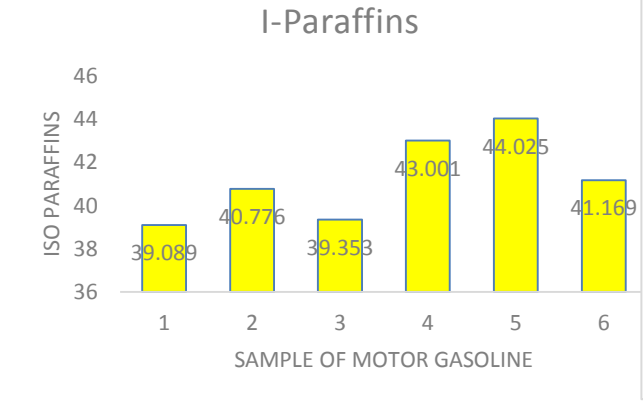


**Figure 11: I-Paraffins**

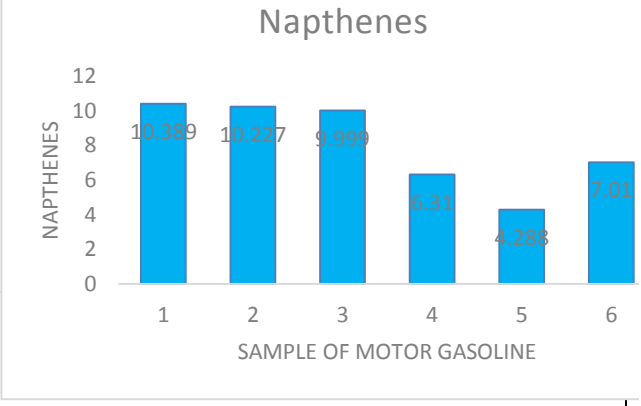


**Figure 12: Napthenes**

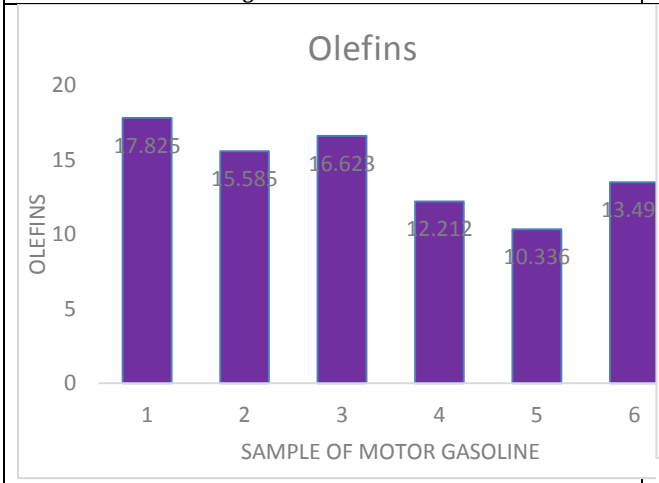


**Figure 13: Olefins**

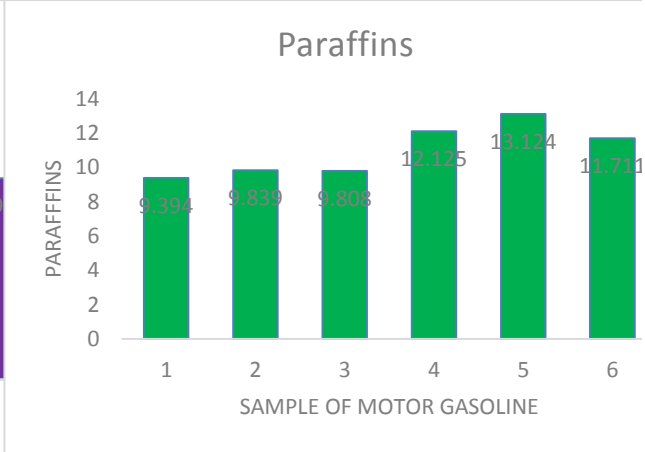


**Figure 14: Paraffins**

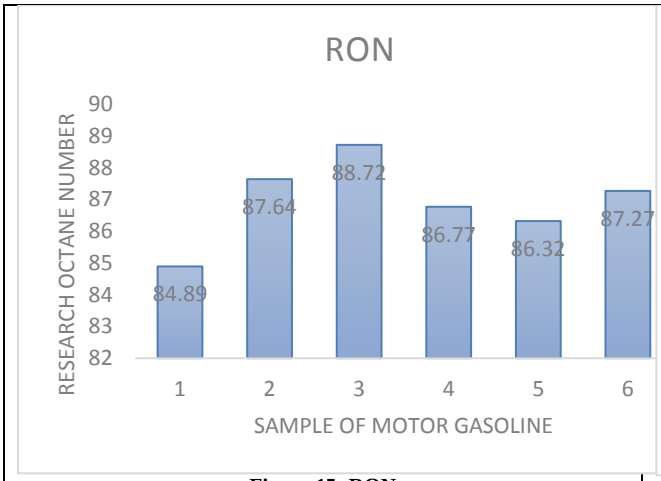


**Figure 15: RON**

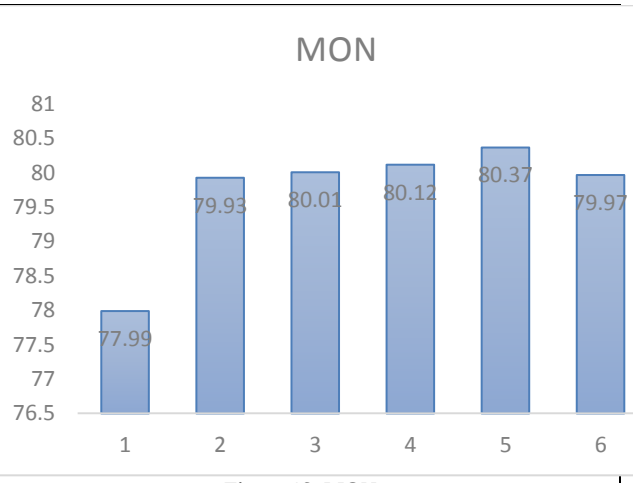


**Figure 16: MON**

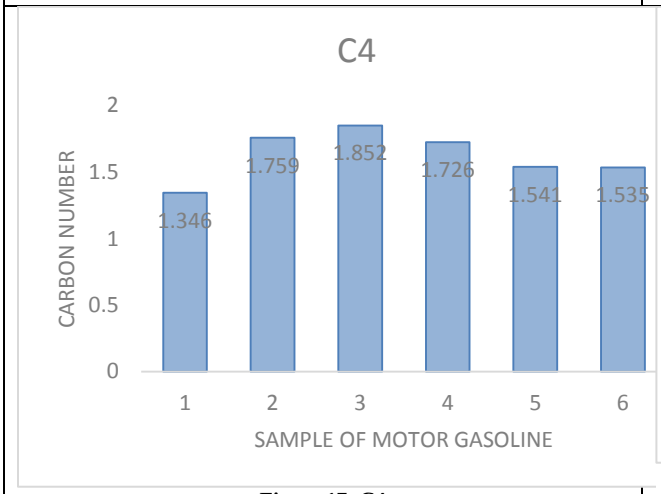


**Figure 17: C4**

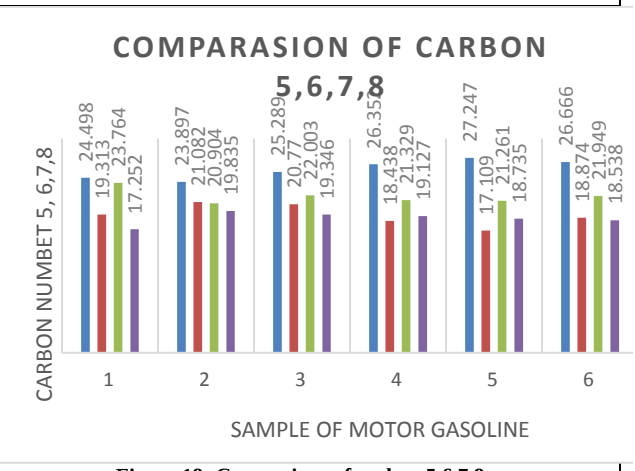


**Figure 18: Comparison of carbon 5,6,7,8**

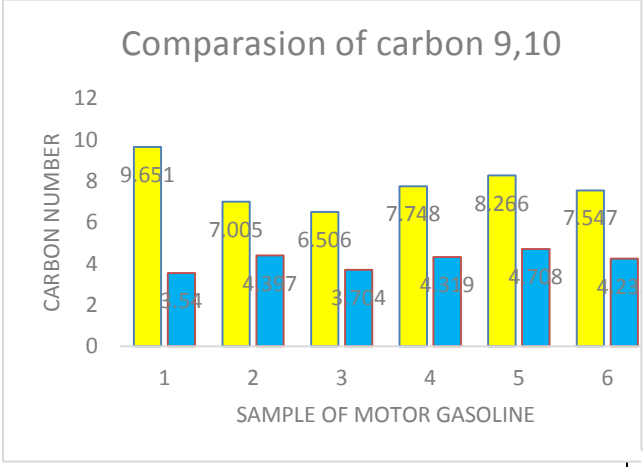


**Figure 19: Comparison of carbon 9,10**

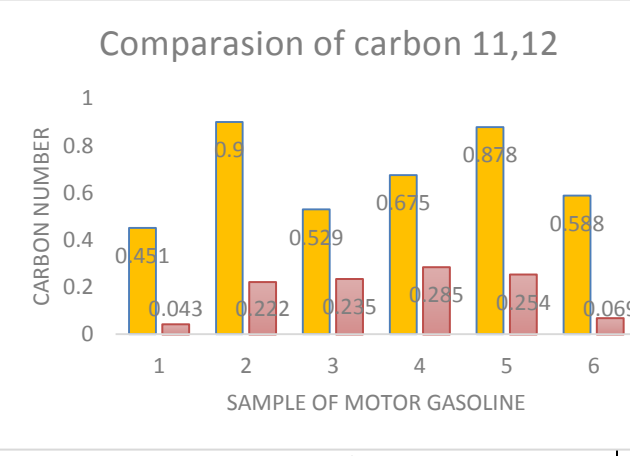


**Figure 20: Comparison of carbon 11,12**

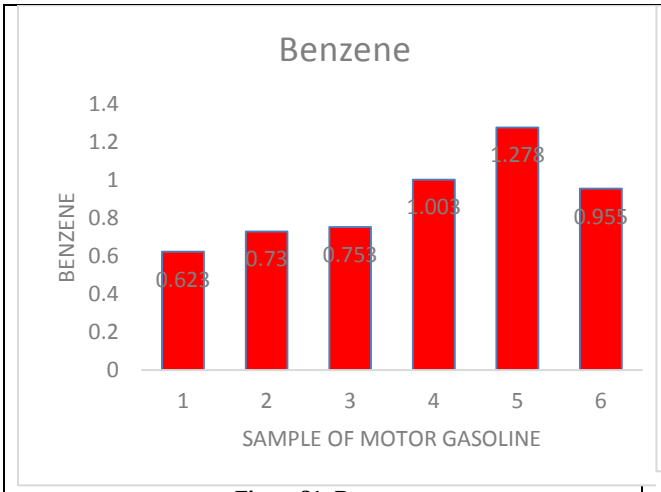


**Figure 21: Benzene**

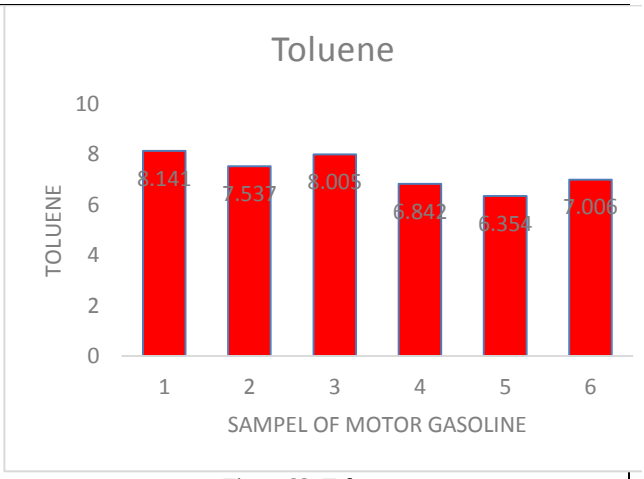


**Figure 22: Toluene**

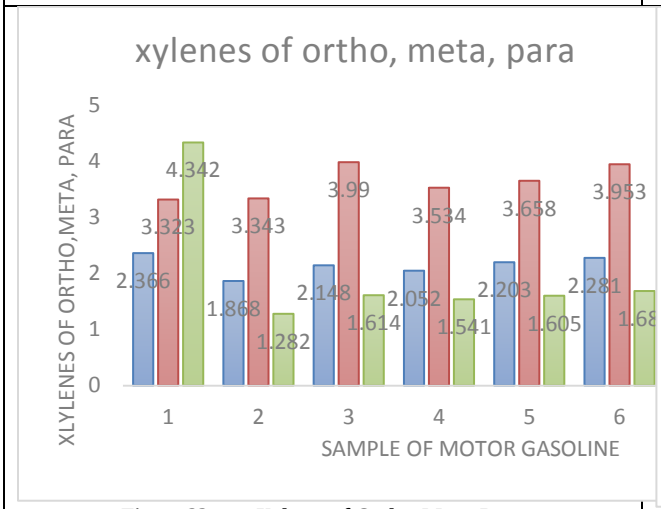


**Figure 23: Xylenes of Ortho, Meta, Para**

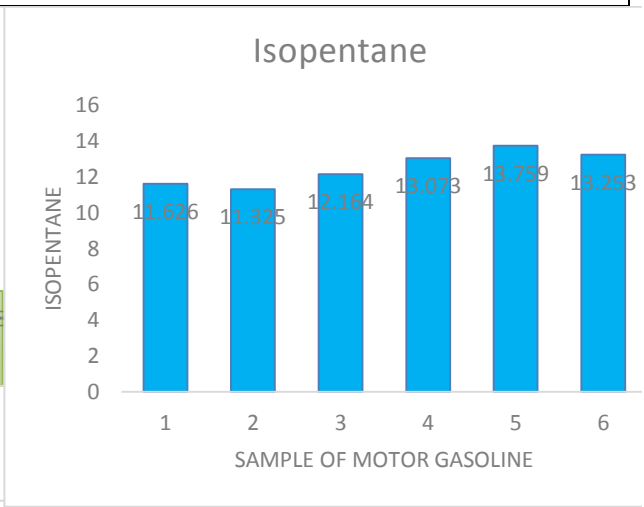


**Figure 24: Isopentane**

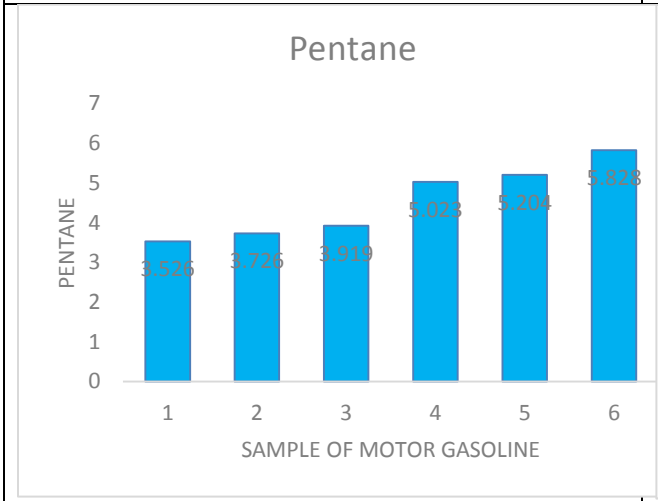


**Figure 25: Pentane**

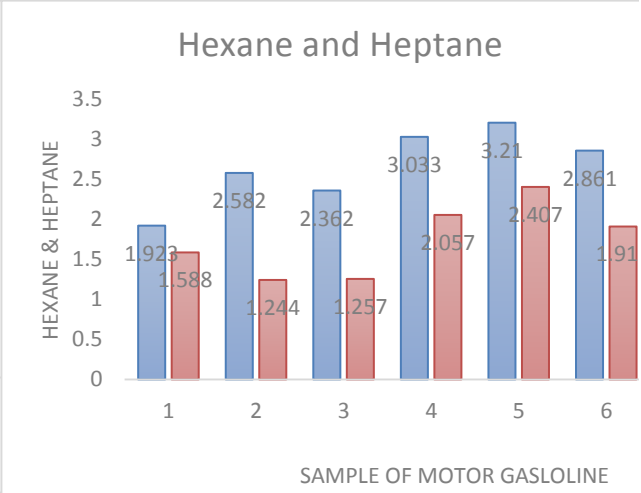


**Figure 26: Hexane and Heptane**

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## REFERENCES

[1] Lappas AA, Iatridis DK, Asalos IAV. *J Cat Today*. **1999,** 50, 73-85
[2] Chebre M, Creff Y, Petit N. *J Pro Control.* **2010,** 20, 441.
[3] Myers MB, Stollsteimer J, Wims AM. *J Ana Chem*. **1975,** 47, 2301.
[4] Balakrishnan J, Balasubramanian V. *J Petro Sci Tech*. **2011,** 30(3), 237-246.
[5] Spieksma W. *J Chromato Sci*. **1998,** 36.
[6] Balakrishnan J, Balasubramanian V. *J Oil Asia.* **2009,** 29, 6, 47-56.
[7] Balakrishnan J, Balasubramanian V. *J App Chem Res*. **2010,** l13, 30-40.
[8] Balakrishnan J, Balasubramanian V. *J Hydro Carbon Asia*. **2010,** 25-61.
[9] Balakrishnan J, Balasubramanian V. *J App Chem Res*. **2011,** 75-82.
[10] Balakrishnan J, Balasubramanian V. *J App Chem Res.* **2011,** 8, 69-78.
[11] Balakrishnan J, Balasubramanian V. *J App Chem Res*. **2011,** 19, 4, 40-48.