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Influence of storage time on the compositions of fuel fractions of microwave-irradiated heavy crude oil

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ABSTRACT

The current work shed more light on the influence of storage time on the equilibrium of products distribution during conventional distillation process of microwave-irradiated stored heavy crude. As a result of irradiation, followed by storage at various durations from 0-6 days, a noticeable decrease in fuel fraction was recorded. On the contrary, the heavy gasoil fraction was on the increase. During the analysis for the detonation quality of the obtained naphtha, it was observed that the research method for the octane number increased in favor of longer duration of storage which signifies the activity of hydrocarbon restructuring in the process.

Keywords: Asphaltens, fractions, irradiation, microwave, polycylic arenes,

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INTRODUCTION

Heavy crude oil is known to be a class of hydrocarbon rich in polycyclic arenes beside the heteroatom group compositions. The trends of quick depletion of paraffinic types of crude oil popularly known as "bonny'' light is at fast rate due to various factor like heavy demands for the type since it has high potential composition of light-ends fractions such as gasoline, kerosene and diesel couple with its relative economy in refining(low sulfur, and organometalic complex such as vanadium and nickel- porphyrins); next is it relative few area of deposit in the world compare to its high demand[1] of which Nigeria is among the leading producer of the "bonny light". Consequently the lesser paraffinic stocks called the heavy crude oils are among the broad deposit of the fusil fuel after coal and bitumen. The production and processing of the later class of crude oil poses some economic and environmental consequences.

Various options of upgrading and refining of heavy crudes processes have been considered contemporarily[2–11] and vigorous works in the mentioned object are still going on. The crude oil nature of heavy oil till date has not been fully explored but several advancement have been made by various scholars of various ages[12–16].

Several works revealed that physical perturbation on the structure and properties of crude oil can lead to its easier refining and transportation[17]. The novel techniques in crude oil component restructuring also goes along in reducing the sulfur compounds in diesel fraction to meet the FPA standard[18].

Microware interaction with complex mixtures such as heavy crude is an object of continuous investigation[22–25] but from the work of[26] and[27] it was pointed out that among the oil components, the aromatic derivatives shows a high resistance to high energy irradiation. By nature of crude oil components, the dispersed system consisting of complex structural unit (CSU), and a core enveloped by a solvated shell and by existence the cores are the high-molecular alkanes, poly-arenes, and resinous-asphaltene. The solvated shell on the other hand consists of compounds that are less susceptible to intermolecular interactions[11].

All physical action on these complex objects is to transform the CSU size either by defragmenting the solvated shell subjecting the inner shell to further attack during photolytic irradiation.

MATERIALS AND METHODS

A 893.83g of Ural crude oil was weighed and heated in a tri-neck round bottom distillation flask fitted with thermometers, bubble arrester, a distillation column and condenser. A separate sample was prepared and heated initially in a domestic microwave model WM224R for 9 - 6 minutes duration at a power rating of 560 watts. Part of the irradiated sample was stored for some days while the other is further subjected to fractionation and their respective rheological properties are taken. The stored irradiated sample was also fractionated after respective duration of storage (between 1 – 6 days). Particle size analysis of residues was obtained and that of samples before distillation was performed using analogue model 7525 UV/VIS spectrophotometer. An FTIR spectroscopic analysis of the quality of Naphtha, kerosene and light gas oil obtained where carried out. Total sulfur content for the obtained distillates and residue was carried out using ASTM N-4294 model. Likewise the research Octane number of the obtained naphtha distillates was analyzed.

RESULTS AND DISCUSSION

The influence of the storage time on the activated heavy crude oil (Urals Novo) is presented in table1 and figure1. From the analysis of the obtained result it is clear that the Naphtha fractions decreases with increase in the storage duration. The same effect is recorded for the yield of kerosene fractions. However the trend is reversed for light gas oil fraction.

The initial high yield of lighter distillates can be attributed to localize superheating during the microwave activation of the crude oil sample prior to distillation. This phenomenon is also explained in the work of[26], that application of radiation on hydrocarbons leads to cracking of paraffinic components of the feed-stocks to form hydrocarbon radicals. On storing, recombination of the hydrocarbon radicals leading to polymerization process

The same effect was also observed for the heavy gas oil, which shows a peak increment at the fifth day of storage time. The yield of residue increases as the storage period increases which may be attributed to recombination of fragmented resins during activation.

Changes in physiochemical properties of oil

From the qualitative differential analysis of stored activated heavy crude oil in table 1, for the period of six days, the specific gravity before activation of the crude oil was fixed at 0.8765, but during the process of storage of activated heavy crude oil, gradual increment in the specific gravity was recorded till the sixth day of storage. This signifies the recombination of activated fragmented hydrocarbons during the irradiation process.

Likewise such change in trend follows for viscosity, in this case, the viscosity of the heavy Urals crude oil doubled at the sixth day of storage after activation. This shows a strong evidence of higher recombination effect of paraffinic hydrocarbons. However during the irradiation period the product obtained in the process (at the zero day) shows higher pour point value. This signifies dis-engagement of paraffinic hydrocarbons component in the heavy crude oil. Particle size analysis which is a means of explaining the intermolecular interaction between dispersed phase and dispersing medium of oil dispersed system, as apparent in the table, longer duration of storage influences the formation of highly developed solvated shell in oil dispersed system

Cetane index (C.I)

The results of the calculated cetane index of the light gas oil in table 1 shows that they all met the required C.I range of 40- 60, with that of 0 day activation prior to distillation having the highest of 50.686 while that before activation having the lowest of 48.147.

Table 1: Quality differential assay for crude oil before activation after activation and storage

SAMPLES	NON ACTIVATED SAMPLE	ACTIVATED AND STORED CRUDE OIL						
		0 DAY	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
CRUDE OIL								
Density @ 15.56 ^{0}C (g/cm^3)	0.8761	0.8332	0.8585	0.8719	0.8868	0.8887	0.8908	0.8952
Specific gravity @ 15.56 ^{0}C	0.8765	0.8336	0.8589	0.8723	0.8872	0.8891	0.8912	0.8986
API gravity	29.94	38.25	33.25	30.72	27.99	27.65	27.28	25.97
Viscosity (Cst) @ 100 ^{0}C	42.25	31.2	38.91	43.11	46.15	48.61	51.85	66.18
Pour point in ^{0}C	-9.0	-20.0	-16.5	-14.0	-12.0	-10.0	-7.0	-2.0
Particle size (m10^{-10})	21.8055	7.2899	7.4814	11.4814	12.5411	13.8423	16.9300	25.2222
NAPHTHA (IBP -175 ^{0}C)								
Research Octane number	74.6	85.5	85.6	86.2	86.5	86.5	86.6	86.6
KEROSENE (175-245^{0}C)								
Flash points in ^{0}C	50.30	42.30	51.70	53	53.9	55	55	56
Sulphur (w %)	0.10231	0.0516	0.05734	0.06387	0.07034	0.08615	0.09198	0.10912
L` GAS OIL (245-345^{0}C)								
cloud point in ^{0}C	7.5	-17.5	-15	-14.5	-12.5	-11.5	-9.5	-8.5
calculate cetane index	48.147	50.686	48.815	48.625	49.232	48.873	48.701	48.677
Sulphur (w %)	0.48103	0.36156	0.39015	0.39162	0.40167	0.41023	0.49156	0.51095
H` GAS OIL(345-360^{0}C)								
Cloud point in ^{0}C	9.0	-15.5	-14.5	-13.5	-11.5	-10.5	-7.0	-5.5
Conradson carbon residue(w%)	0.054	0.025	0.036	0.049	0.052	0.062	0.067	0.071
RESIDUE > 360 ^{0}C								
SPECIFIC GRAVITY @ 15.56 ^{0}C	0.94184	0.93662	0.95113	0.95261	0.96250	0.96312	0.96620	0.96719
Pour point in ^{0}C	16.0	-13.50	-11.0	-5.0	2	8	15	20
Viscosity (Cst) @ 82.2 ^{0}C	51.36	38.27	47.81	48.72	53.85	54.23	64.86	66.18

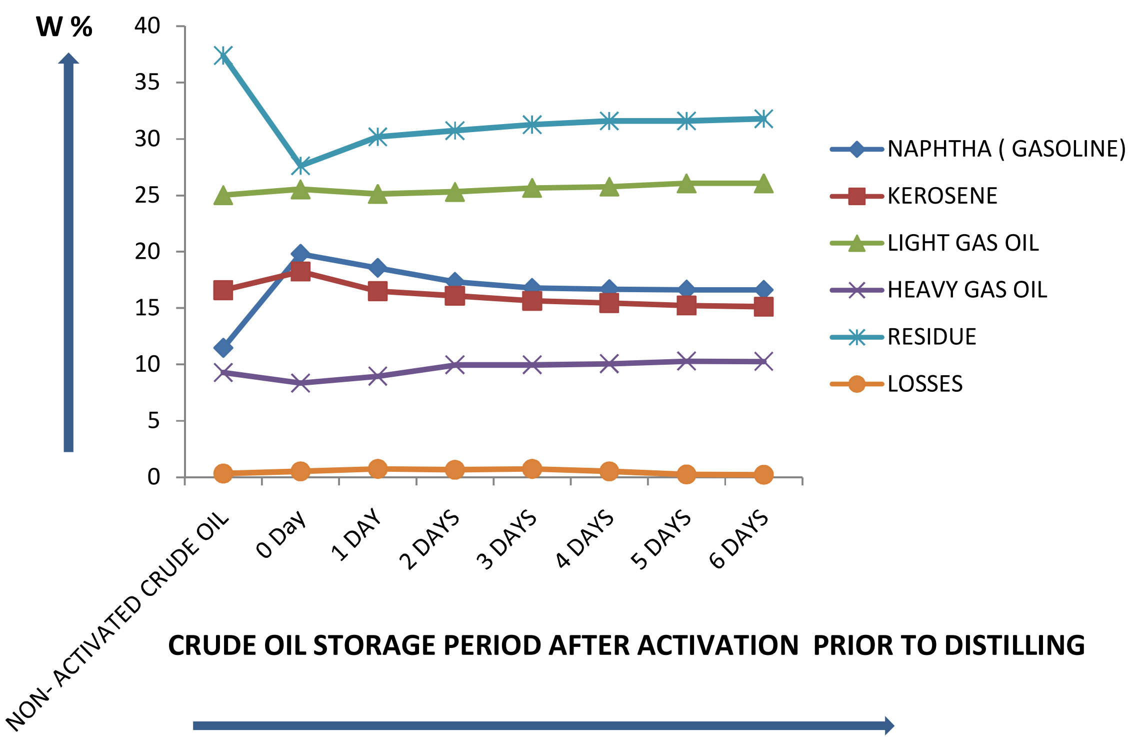

Fig1. Relationship of Distillates yield on the storage durations

Heavy gas oil conradson carbon residue

The deteriorating value of the conradson carbon residue of heavy gas oil in table 1, as storage duration increases, shows evidence of higher ash forming tendencies of the heavy gas oil

Naphtha detonation value

The 10 points increase in research octane number (RON) of naphtha when compared to non- activated sample, shows that during activation that most of the aromatic hydrocarbons remained while on storage most of the fragmented paraffinic components reacted to produce more higher molecular weights product with an increase in branched aliphatic and cyclo-aliphatic hydrocarbons and thus resulting in an increase in higher octane number in naphtha fractions. An FT-IR analysis of the naphtha also show evidence of this while the refractive index (RI) analysis of the naphtha fractions shows evidence of higher carbon to hydrogen ratios as the day increases.

Quality of kerosene

The flash points of kerosene listed in tables 1, shows trends of higher molecular hydrocarbons transformation, as an evidence that after the first day of activation till sixth day, the said parameter increases gradually

The results of the irradiation shows that the sulphur content in the kerosene fraction reduces by half when compared with that of non- activated crude oil, this may be attributed to strong evidence of hydrogen sulphide removal from the crude oil. However during the course of storage, the sulphur bearing hydrocarbon components increases till the sixth day. The value of the sixth day almost equals that of non-activated crude oil.

CONCLUSION

1. Storage of activated crude oil for 0-6 days results in the condensation of simple hydrocarbon fragments produced during microwave irradiation.
2. That there is a substantial improvement in the burning characteristics of the naphtha component of the distillate obtained during storage of activated crude oil.
3. Sulfur content analysis shows great increment and in proportion to the duration storage duration.
4. Yield of kerosene fractions is neither affected by storage of the activated nor by irradiation action on the sample.

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