EUROPEAN JOURNAL OF MATERIALS SCIENCE AND ENGINEERING
Volume 4, Issue 4, 2019: 161-165 | www.ejmse.tuiasi.ro | ISSN: 2537-4338

EJMSE

DOI: 10.36868/ejmse.2019.04.04.161

CHEMICAL CHARACTERIZATION OF HEAVY FUEL OIL WHICH IS USED FOR BURNING IN POWERPLANT "KOSOVO-B" BY FTIR-SPECTROSCOPY

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Abstract

Last decade in Kosovo fuel oil it was used as a primary combustion heating material in most of public institutions, schools, powerplants etc. Our research focus is to characterize chemical composition of fuel oil before combustion by FTIR –Spectroscopy and other conventional physico-chemical parameters. Investigated results confirms high level of pollutants such as aromatic compounds, sulphur compounds and other oxygenated compounds based on their chemical analysis by different methods. This investigations suggest removing fuel oil from direct application as a combustion material and initiate investigation for separation of their components for different kind of application.

Keywords*: FTIR-Spectroscopy, fuel oil, powerplants, pollution.*

Introduction

Heavy fuel oil contain complex hydrocarbon compounds with highly viscosity index includes aromatic, olefins, paraffins, naphthenes and different heteroatom unknown compounds, as a residues of the crude oil refining process [1, 2]. Perera reports about environmental and health impact in young children and community where this fuel it is used as a heating material and she suggests possibility to use other alternative option which in general today exist.

Major compounds present in heavy fuel oil are aliphatic saturated hydrocarbons (straight chained, branched and cyclic hydrocarbons), aromatic hydrocarbons, sulphur compounds, and very large aromatic asphaltene compounds [4].

Heavy fuel oil as one useful burning complex material but with high unknown contaminants which are directly in relation to its composition and really their characterization by instrumental methods is crucial research challenge [5-7].

Fuel oil has widely application as a combustion material in schools, public institutions and powerplant "Kosova B". Otherwise Air pollutions in Prishtina city has high concentration of PM10 and PM2.5 based from Institute of air monitoration official daily reports and other researchers study mechanism of PM formation which starts from benzene and toluene as precursor [8].

Study about identifying source of aromatic compounds is the challenge of this research to monitor fuel oil which is widely used in powerplant "Kosova B" by FTIR Spectroscopy, Elemental analysis and other physico-chemical parameters.

Experimental Methods

Three different heavy fuel oil sample were used in current research were collected from thermal power plants in Prishtina, Kosovo. Physico-Chemical Properties was done by standard

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applied methods reported below in Table one. Elemental chemical analysis of four crucial elements (C, H, N, S and O) was carried by CHNS Perkin Elmer analyzer, model 2400.

Fuel oil from the only one supplier operating in all territory of Kosovo were collect and analyzed by FTIR-Spectroscopy. An Irrafinity^{-1} Shimadzu FT-IR spectrophotometer equipped with a deuterated L-alanine doped triglycene sulphate (DLATGS) detector was used to acquire FT-IR spectra. Fuel oil sample were deposited between two CaF2 transparent windows for region 4000-1000 cm^{-1} and for region lower than 1000 cm^{-1} we applied transparent polyethylene film. All spectra were processed using IR-Solution Software for Windows (Shimadzu). After each operation, the CaF_2 window was thoroughly cleaned up by acetone and then dried.

The assignment of bands was done by comparison with literature spectral data and with reference compounds spectra included in the software spectral library. Height and area of each band were measured and calculated by the essential FTIR software.

Table 1. Selected FTIR spectra peak frequencies in fuel oil [9]

Functional Group	Region (cm^{-1})	Intensity*	Comments
Ar–H	3010~3080	M	stretch.
–CH_3	2950~2975	m-s	asym.str.
	2865~2885	m	sym.str.
–CH_2	2915~2940	m-s	asym.str.
	2840~2870	m	sym.str.
–CH	2880~2890	w	stretch.
–CH_3	1440~1465	m	asym def
	1370~1390	m-s	sym def.
–CH_2	1440~1480	m	scissors vib.
C=C (in ring)	1605-1585	l	stretch
S=O (sulfoxide)	1070-1030	‘s	stretch
C-H (di and trisubstituated)	900-750	s	bending

Result and Discussion

Correlation between physic chemical parameters and composition of fuel oil has been reported before [10, 11]. All results of physico chemical parameters are presented in (Table 2) and results from elemental analysis it is presented in (Table 3).

Table 2. Physico chemical parameters of fuel oil

Property	Units	Result	Method
Density at 15° C	g/ml	0.987	EN ISO 3675
Flash point	°C	95.5	EN ISO 2719
Pour point	°C	-3	ISO-3016
Viscosity at 50°C	mm^2/s	253.95	EN ISO 3104
Viscosity at 100°C	mm^2/s	25	EN ISO 3104
Carbon Residue	% m/m	11.1	EN ISO 10370
Ash	% m/m	0.035	EN ISO 6245
Water and sediments	% v/v	0.2	ASTM D 1796
Net heat of combustion	MJ/kg	40.7	ASTM D 4868
Gross heat of combustion	MJ/kg	43	ASTM D 4868

Table 2. Elemental analysis of fuel oil

Element	Composition %
C	84
H	11.7
N	0.15
O	1.5
S	0.96

From elemental analysis it can be seen that carbon and hydrogen are normal constituent but three other elements are evidently that heavy fuel oil contain and oxygenated or sulphur compounds for which is important to know level and type of compounds.

Characteristic band under 3000 cm^{-1} exactly 2952, 2922 and 2852 cm^{-1} corresponds with methyl and methylene stretching symmetric and asymmetric vibrations which are usually present vibrations in all aliphatic hydrocarbon molecules. Peaks higher than 3000 cm^{-1} usually are characteristic for unsaturated double bond =C-H which is usually from 3000-3010 cm^{-1} and in our case is mistake and based on this olefin compounds do not contain analyzed fuel oil but in case when has absorbance higher than 3000 cm^{-1} usually (3010-3080) that is characteristic for aromatic double bond =C-H (aromatic) which is significant for presence of aromatic compounds in fuel oil. Vibrations from aromatic ring confirms and band around 1602 cm^{-1} which origin is from C-C aromatic ring stretching vibrations. Band observed around 1458 and 1375 cm^{-1} are from CH_3 group symmetric and asymmetric deformation vibrations.

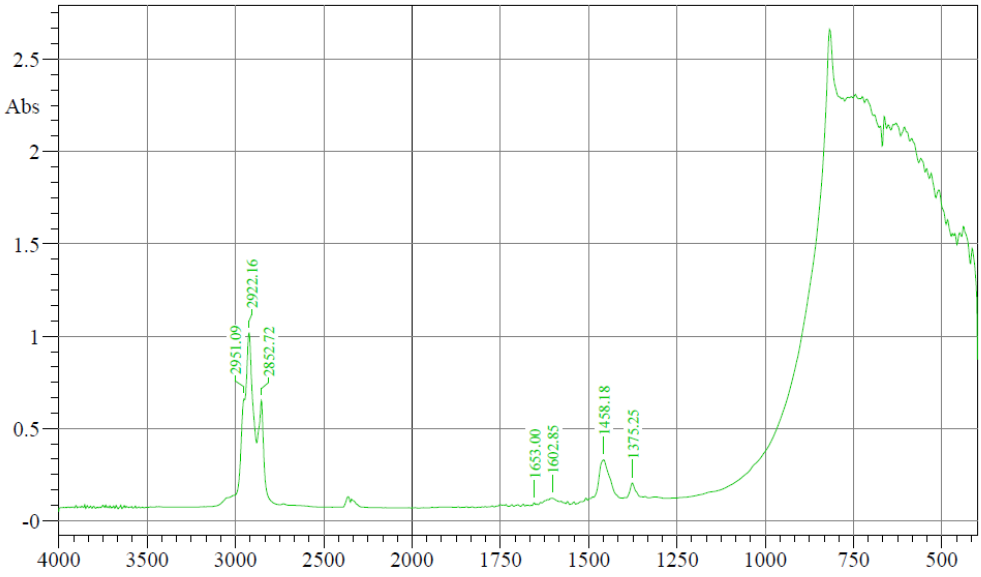

Fig. 1. FTIR spectra of fuel oil scanning from 400-4000 cm^{-1}

Other observed band such as 1307 cm^{-1} or 1166 cm^{-1} are from oxygenated aromatic and non-aromatic compounds. Band around 1033 cm^{-1} probably is from sulfoxine stretching vibrations because sulfoxine functional group is mostly present from all sulphur compounds present in fuel oil with high level of total sulphur. Band 875 cm^{-1}, 810 cm-1, and 785 cm^{-1} (Figure 2) are C-H vibrations from disubstituated or trisubstituated organic molecules.

From this we can confirm that the peaks observed for aromatics and oxygenated compounds have detectable intensities but some of them can be in low concentrations. It may be concluded from the results that the fuel oil used around Kosovo contain major constituents paraffins and as a minor constituent are aromatic, oxygenated compounds, sulphoxine compounds, di and trisubstituatet organic molecules.

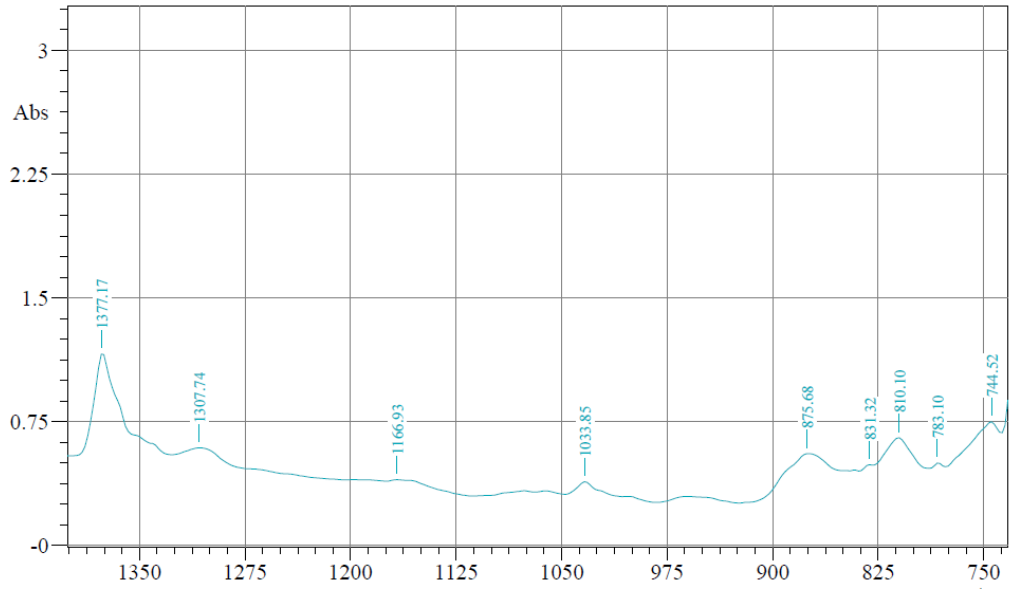

Fig. 2. FTIR spectra of fuel oil scanning from 700-1400 cm^{-1}

Conclusions

Fuel oil which is widely useful in Kosovo has different type of organic contaminant such as paraffinic, olefinic, sulphur, and aromatic functional group which most of them has high environmental impact. Also applied FTIR Spectroscopy in this study confirms possibility for rapid monitoring of fuel oil as a complex sample without using any sample preparation and green and cheaper method for analysis.

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Received: July 20, 2019
Accepted: August 28, 2019