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Emissions of CO and SO$_2$ from solvent extraction treatment of used lubricant

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Abstract: Emissions fromused lubricant could have adverse effect on man and its environment due to the presence of degraded additives and contaminants. Different treatment methodshas been developed with few check on its pollution aspect. This study investigated the emissions of two major criteria pollutants - carbon monoxide (CO) and sulphur dioxide (SO$_2$) from the solvent extraction treatment of used lubricant. CO was found to be the highest emitting pollutant with mean emission concentration of 85.85 mg/m^3 which has exceeded the set NAQS standard while SO$_2$ falls within the standard limit. Therefore,there is a great need to give attention to the control of CO emissions around the treatment plant. However, CO emission can be controlled by employing a CO converter to convert the poisonous gas to a less poisonous gas or substituting the existing process in solvent extraction with a more environmentally friendly one.

Keywords: Lubricant, solvent extraction, treatment, emission

1. Introduction

Pollution is as a result of release of harmful substances to the environment, among several other sources of pollution,emissions from used lubricant (UL) is of higher percentage[1].It was reported in 2004 that about 150 million litres of used lube oil were generated yearly [2] and due to urbanization there is increase in number of automobiles hence increase in UL generated yearly.The largest source of used lubricant is from automotive source which usually result from impurities such as sulphur, water and metals from engine wears. Effects from these source of UL can be environmentally damaging than crude oil pollution if not controlled [3]. Impacts of UL to humans and environment include emissions of toxic pollutants, carcinogenogenic in nature which affect lungs, careless disposal of UL can also form films on water bodies which can suffocate aquatic lives.

Degradation of lubricant occur due to oxidation and thermal decomposition of lubricating oil when subjected to high temperature [4] this inturn affectthe properties of the oil and render it unsuitable for use.Lube oil degradation also depends on physical environment, operating conditions and temperature which can degrade its base oil and additives.To reduce the effect of degradation of lubricant, several treatment methods has been employed such as acid-clay, solvent/clay extraction, solvent extraction/adsorption, hydrogenation, [5.6.7.8]amongst others.

Solvent extraction/vacuum distillation and adsorption has been a competitive process for treatment of used oil due to high yield of base oil as well has less pollution compared to other methods [9]. Vaccum distillation operates at higher pressurewhich could result in emission of harmful gases such as carbon monoxide (CO). Also, residue obtained due tothe solvent and adsorbent used could result in release of harmful substances such as sulphur dioxide (SO_2), hydrocarbon (HC), and other pollutants to the environment.Udonne and Bakare (2013) reported that the sulphur content of lubricating oil increases with usage due to wear and tear efffect on moving parts, therefore oxidation of sulphur compounds in the used lube oil result in engine corrosion.

Treatment of used lubricant is important as it requires less energy and cost when compared with crude oil refining but it is also necessary to put control gadgets in place as to reduce the emission in this sector to zero level therefore, this study focused on the investigation of CO and SO_2 emission in the used lubricant oil treatment processes.

## 2. Experimental Stage

2.1 Materials and Instrumentation

The materials used in this work include used lubricant and 2-Propanol (Aldrich),equipments used also include weighing balance, buchner flask,hot plate (MSL), different sizes of conical flasks and measuring cylinders (pyrex) while Instrumentation used include Liebig condenser(NS19/26), E8500 Combustion analyzer (E-instrument) and vacuum pump (CE GQ056400).

2.2 Treatment of used Lubriant

Used Lubricant of 100 ml was put in a 250 ml conical flask and heated at regulated temperature of $180^{o}C$ for atmospheric distillation, water and light components were removed as condensate.The residue in the flask was further sand heated (to avoid direct heating which could crack the flask) for vacuum distillation at 250 ^{o}C, 10mm Hg pressure in order to remove impurities of heavier components from the used oil. The filterate was collected in the buchner flask and treated with propanol in ratio 4:1, the mixture was stirred for 30 mins at 50 ^{o}C and allowed to settle for 1 day in a seperating funnel. Two layers was formed, the filtrate which contains mixture of solvent and lubricant and residue which contain sludge. The filterate was heated at 90 ^{o}C, a temperature higher than the solvent to recover the lubricant. The block diagram showing the treatment process of the used lubricant can be seen in figure 1.

2.3 Measurement of CO and SO_2 Emissions from the Used lubricant Treatment

The sources of emissions was majorly from the atmospheric distillation and vacuum distillation stage. The conical flask was covered with a metal cork which has a sampling port where the combustion analyzer probe was connected to measure CO and SO_2 emissions at atmospheric distillation. Also, the combustion analyzer was connected to the vacuum pump to measure CO and SO_2emissions.
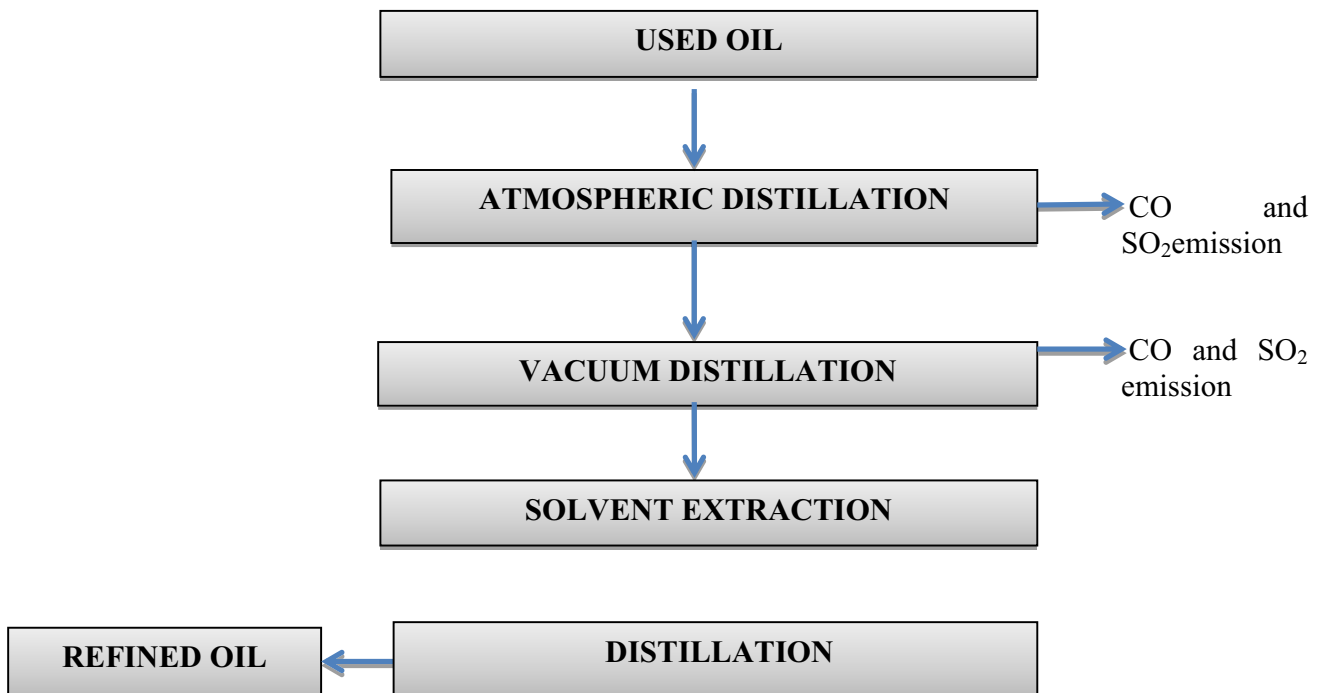
Figure 1: Block Diagram of Solvent Extraction Process

3 Result and Discussion
3.1 Emissions at Atmospheric distillation stage

CO emission was identified at atmospheric stage and measured in mg/m^3 for different oil temperature ranging from 80°C - 180°C. The readings of the pollutant concentration were recorded from the screen of the combustion analyzer and presented in Table 1. The mean emission concentration and average time were calculated and presented below.

Table 1: Emissions atAtmospheric Distillation Process

S/N	T_{oil} (°C)	Ta (°C)	Time (min)	CO (mg/m^3)
1	80	29	53	0.000
2	85	30	62	0.000
3	90	30	71	0.000
4	95	30	80	0.000
5	100	30	88	0.000
6	105	30	96	0.000

7	110	30	103	0.000
8	115	30	110	0.000
9	120	30	117	0.000
10	125	31	123	0.000
11	130	31	130	0.000
12	135	31	136	2.330
13	140	31	142	2.330
14	145	31	148	2.330
15	150	31	153	2.330
16	155	31	158	2.330
17	160	31	163	2.330
18	165	33	167	2.330
19	170	33	171	2.330
20	175	33	176	2.330
21	180	33	182	0.000

Note: 0 means there was no pollutant emitted for that activity

Where T_{oil} meansTemperature of lubricant in ^oC

Ta means ambient temperature in ^oC

At Atmospheric Distillation stage, the mean emission concentration (MEC) was estimated below;MEC for CO $= \frac{total\ \ EC\ \ of\ CO}{no\ of\ \ emissions} = \frac{\in fx}{\in f} = \frac{20.97}{9} = 2.33$ mg/m^3

Average time = 182 mins = 3 hours

This implies that at 3 hours of atmospheric treatment process of used lubricant, 2.33 mg/m^3 of CO was emitted. Also, CO emission was emitted at temperature range between 135 ^oC - 175 ^oC due to incomplete combustion.

3.2   Emissions at vacuum distillation stage

CO and SO$_2$ emissions at vacuum stage were identified and measured in mg/m^3 for different oil temperature ranging from 60^oC - 250^oC. The readings of the pollutant concentration were presented in Table 2. The mean emission concentration and average time were presented below.

Table 2: Emissions at vacuumDistillation Process

S/N	T_{oil} (°C)	Ta (°C)	Time (min)	CO (mg/m^3)	SO$_2$ (mg/m^3)
1	60	29	14	0.000	0.000
2	65	29	28	0.000	0.000
3	70	29	42	2.330	0.000
4	75	29	55	2.330	0.000
5	80	30	68	0.000	0.000
6	85	30	81	0.000	0.000
7	90	30	93	0.000	0.000
8	95	30	105	0.000	0.000
9	100	30	117	0.000	0.000
10	105	30	129	0.000	0.000
11	110	30	140	0.000	0.000
12	115	31	151	0.000	0.000
13	120	31	162	0.000	5.325
14	125	31	173	0.000	5.325
15	130	31	184	0.000	5.325
16	135	31	194	0.000	5.325
17	140	31	204	0.000	5.325
18	145	31	214	0.000	5.325
19	150	31	223	0.000	5.325
20	155	31	231	0.000	7.987
21	160	33	239	0.000	7.987
22	165	33	247	0.000	7.987
23	170	33	256	0.000	7.987
24	175	33	265	0.000	10.649
25	180	33	274	0.000	10.649
26	185	33	283	0.000	10.649
27	190	33	291	0.000	10.649

28	195	33	299	0.000	10.649
29	200	33	315	0.000	10.649
30	205	33	322	0.000	10.649
31	210	34	329	93.178	13.311
32	215	34	336	96.809	13.311
33	220	34	343	99.002	13.311
34	225	34	351	100.117	13.311
35	230	35	359	103.661	13.311
36	235	35	367	105.657	13.311
37	240	35	373	108.319	13.311
38	245	35	386	112.978	13.311
39	250	35	392	119.967	13.311

At vacuum Distillation stage, the mean emission concentration (MEC) were estimated below;

$$\text{MEC for CO} = \frac{\text{total EC of CO}}{\text{no of emissions}} = \frac{\in fx}{\in f} = \frac{944{,}348}{11} = 85.85 \text{ mg/m}^3$$

$$\text{MEC for SO}_2 = \frac{\text{total EC of SO}2}{\text{no of emissions}} = \frac{\in fx}{\in f} = \frac{308}{27} = 9.76 \text{ mg/m}^3$$

Average time = 6.53 hours

This implies that at 6 hours of vacuum treatment process of used lubricant, 85.85 mg/m^3 of CO and 9.76 mg/m^3 of SO$_2$ was emitted.

3.3 Emissions at Recovery stage

CO emission was identified at recovery stage and measured in mg/m^3 for different oil temperature ranging from 40°C - 90°C. The readings of the pollutant concentration were presented in Table 3. The mean emission concentration and average time was calculated and presented below.

Table 3: Emissions at Recovery Process

S/N	T$_{oil}$ (°C)	Ta (°C)	Time (min)	CO (mg/m^3)
1	40	26	53	0.000
2	45	26	63	0.000

3	50	26	73	0.000
4	55	26	82	3.494
5	60	26	91	9.318
6	65	27	99	8.153
7	70	27	107	6.988
8	75	27	110	6.785
9	80	27	115	5.824
10	85	27	142	8.153
11	90	27	167	8.457

At recovery stage, the mean emission concentration (MEC) was estimated below;

$$\text{MEC for CO} = \frac{\text{total EC of CO}}{\text{no of emissions}} = \frac{\in fx}{\in f} = \frac{57.172}{8} = 7.15 \text{ mg/m}^3$$

Average time = 167 mins = 2.78 hours = 3 hours
This implies that at 3 hours of recovery process of used lubricant, 7.15 mg/m^3 of CO was emitted.

3.4 Air quality standards

The mean Emission concentration of the pollutant at each stage was compared with National Air Quality Standards (NAQS) in Nigeria (Table 4) to measure the level of compliance of solvent extraction method of used lubricant treatment.

Table 4: National Air Quality Standards (NAQS) in Nigeria

Air Pollutants	Emission Limits	Average time
CO	10.31 mg/m^3 40.08 mg/m^3	8-hour 1-hour
SO$_2$	75 mg/m^3	1-hour

Reference: 10;11;12

Table 5: Mean Emission Concentration (MEC) of CO and SO$_2$ compared with NAQS

Treatment Processes	Air Pollutants	MEC (mg/m^3)	NAQS (mg/m^3)
Atmospheric distillation	CO	2.33	10.31
Vacuum distillation	CO	85.85	10.31
	SO$_2$	9.76	75
Recovery	CO	7.15	10.31

When the mean emission concentration of the pollutants were compared with NAQS standards for all treatment stages of solvent extraction, it was observed that emission concentration of SO$_2$ pollutant from the treatment processes falls within the set limit while CO pollutant from the

vacuum distillation stageexceed the NAQS standard. The source of CO emission in vacuum distllation process of used lubricant treatment is from the vacuum pump, hence there is a need for the pump to be substituted with a more environmentally friendly one which can drastically reduce the emissions.

4. Conclusion

Several treatment methods of used lubricant has been in existence today with few check on its pollution aspect, this study shows that there is a need to investigate air pollution around used lubricant treatment plants. Emissions from solvent extraction treatment of the used lubricating oil was studied in this research, Carbon monoxide pollutant in the vacuum distillation stage was found to exceed the NAQS set standard with mean emission concentration of 85.85 mg/m^3, this could pose a high health risk to habitats around the plant, if control measures are not put in place. Hence, CO converter can be employed to convert CO poisonous gas to a less poisonous gas However,emissions from other treatment methods of used lubricants should also be checked for proper mitigation.

Acknowledgement

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