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Investigation of Co and So_2 from Acid Clay Treatment of used Lubricating Oil

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Abstract: Recycling and treatment processes is one of the acceptable means to reduce the effect of pollution from used oil. These recycling methods save some amount of time and money and also helps to conserve our natural resources. However, various methods have been used for used oil treatment which has resulted in toxic air emissions. This work monitored the emissions of Carbon Monoxide (CO) and Sulphur Dioxide (SO_2) from used lubricating oil using a combustion analyzer. CO emission was found to be the highest emitted pollutant with MEC of 167.07 mg/m^3 due to incomplete combustion. Also, CO concentration at dehydration exceeded the set limits which could cause adeverse effect to receptor locations while SO_2 was within the limit. Hence, quantifying the emissions at each stage of this process is needed to control emissions in the sector. The predicted results in this study can help decision makers to formulate policy for controlling the impact of air emissions from used lube oil treatment plants using acid-clay treatment method.
Keywords: Acid-Clay, Emissions, Used lubricating oil, combustion analyzer

1. Introduction

One of the major problems that developing countries in Africa face is pollution. Improper disposal of Used Lubricating Oil (ULO) is one of the contributing factors involved in environmental pollution. Toxic and carcinogenic materials found in the used lubricating oils corroborates the point on how improperly disposed lubricating oil can cause debilitating effects to man and the environment at large [1]. Such materials include poly-aromatic hydrocarbons, Polychlorinated Biphenyl (PCB), poly-cyclic benzenes, lead, zinc, arsenic [2]. As a result, recycling the used lube oil became one of the best methods of effective disposal. Recycling of used lube oil can help reduce the environmental threats that improper disposal poses as well as helping to preserve crude oil reserves [3].

Acid-clay method is one of the famous existing treatment methods of ULO. Several works have been done on used oil treatment using acid clay method. These include [4] , [5], [6], [7]. [8] states that regardless of the disadvantages in acid-clay, it also has several distinguishing features from other technologies which include low capital investment, non-sophisticated and simple process, requires no skilled operators, low operating cost. This treatment process generate air pollutant which include Carbon Monoxide (CO), Sulphur Dioxides (SO2). CO is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide (CO2), it is also formed from incomplete combustion of various other fuels [9]. CO is a deadly poison which binds to hemoglobin molecules in blood, reducing the amount of oxygen carried to body tissues and organs [10]. Fossil fuel combustion accounts for almost all anthropogenic (human-caused) sulphur emissions. [11] reports that exposure to sulphur dioxide in the ambient air has been associated with reduced lung function, increased incidence of respiratory sympt oms

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and diseases, irritation of the eyes, nose, and throat, and premature mortality. CO and SO2 can be emitted from the dehydration stage of used oil treatment.
Detailed information concerning the air pollution emissions for used oil treatment is very important for used oil treatment evaluation of air emissions sources and pollutants quantification. In order to achieve this aim, this study investigate CO and SO2 emission from the treatment of ULO using acid-clay method.

2. Materials and Method

2.1. Materials

The used lubrication oil was collected from a mechanic workshop. Equipment used include Sieve, Weighing balance (RADWAG,WLC 0,6/B1), Filtering flask, Measuring cylinders (500 ml, 100ml), Pyrex Beakers (250 ml, 100ml), Pyrex Conical Flask (100ml, 500ml, 250 ml), Pyrex Round bottom Flask (500 ml), Thermometer (Uniscope), Stir Hot Plate (Maple Scientific Limited), Seperating Funnels (200 ml, 500 ml- BS 2021 Borosilicate 24/29), Retort stands, Gallenkamp Centrifuge, Buchner Funnel and Combustion analyzer (E-instrument E8500). The chemical, Acetic acid (98%) was from Sigma Aldrich.

2.2. Methods

The used lubricating oil sample was allowed to settle for 24 hrs before it was filtered to remove solid impurities such as metal chips, sand and dust. The filtered oil was measured in a beaker covered with a a metal which has a sampling port where the combustion analyzer was connected and heated on hot plate at 250˚C for about 1 hour for dehydration (plate 1). Impurities in form of antifreeze, water and other solvent present in the oil were significantly removed. Emission concentration for the pollutant present in the process were displayed on the analyzer screen. The dehydrated oil was then treated with acetic acid (10:1 oil-acid ratio), heated at 50o C and left for a day in a seperating funnel. Two layers were formed- filterate and residue. The filterate was treated with Kaolin clay to remove the odour and dark colour and the mixture was heated at 240oC. Emission concentration for all the process was obtained using the analyzer. CO and SO2 emission concentration were recorded at different range of oil temperatures (Toil). The concentration was measured in mg/m3.

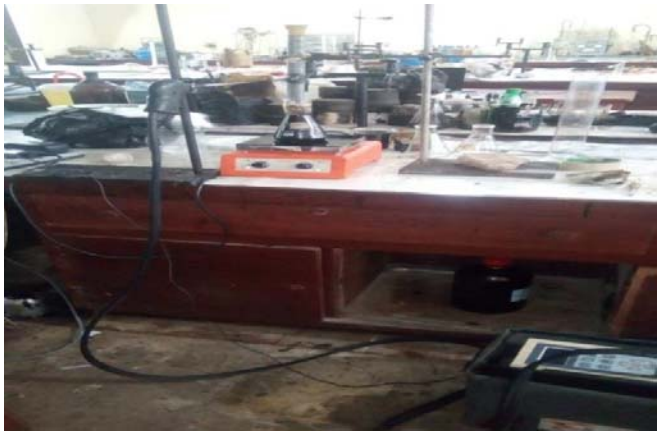

Plate 1: Emission Measurements Set-up at Dehydration stage

3 Result and Discussion

3.1 Emissions at Dehydration stage

The temperature of used oil was monitored at temperature range of 110 oC to 250oC. The combustion analyzer was connected to the dehydration apparatus setup as shown in plate 1 and the readings of pollutant

identified was displayed on the analyzer screen as presented in Table 1. The pressure was constant at 760 mmHg while Carbon monoxide (CO) and Sulphur dioxide (SO2) were the emission concentration measured in mg/m3. The mean concentration of emissions of each pollutant and averaging time was also calculated. A sample calculation of dehydration process is presented below.

Table 1: Dehydration Stage of Acid-clay treatment

S/N	Ta (°C)	T.oil (°C)	Time (mins)	CO (mg/m3)	SO2 (mg/m3)
1	28	110	2	5.443	0.000
2	28	120	2	9.154	6.340
3	28	130	2	9.550	6.550
4	28	140	3	12.324	7.530
5	28	150	3	19.675	7.530
6	29	160	3	26.854	9.555
7	29	170	4	70.143	9.578
8	30	180	4	95.546	9.578
9	30	190	4	99.879	11.255
10	30	200	5	105.564	13.543
11	30	210	5	115.789	14.677
12	30	220	5	459.223	17.540
13	31	230	6	495.675	17.955
14	31	240	6	535.775	20.934
15	31	250	6	445.458	21.967

Note: 0 means no pollutant was identified for that activity
Where T.oil = Temperature of oil in oC Ta = ambient temperature in oC measuring temperature of the room

Mean emission concentration for CO = $\frac{\text{total emission rate of CO}}{no\ of\ emissions} = \frac{\in fx}{\in f} = \frac{2506.052}{15}$ = 167.07 mg/m3

Mean emission concentration for SO2 = $\frac{\text{total emission rate of NO2}}{no\ of\ emissions} = \frac{\in fx}{\in f} = \frac{174.532}{14}$ = 12.467 mg/m3

Averaging time = 1 hour

3.2 Emissions at Acid Treatment stage

Acid treatment is the stage of reaction of dehydrated oil with acid (acetic acid). The temperature was monitored at 50oC to ensure adequate mixture of the sample. The combustion analyzer was connected to the acid treatment apparatus setup and readings of pollutant identified was displayed on the analyzer screen as presented in Table 2. At constant pressure, 760 mmHg only CO was identified as the pollutant while no readings was displayed for SO2 .

Table 2: Acid Treatment Stage of Acid-clay treatment

S/N	Ta (°C)	T.oil (°C)	Time (mins)	CO (mg/m3)
1	28	30	6	23.457

2	28	35	8	20.389
3	29	40	10	22.788
4	29	45	16	23.734
5	29	50	20	24.134

Mean emission concentration for CO = $\frac{114.502}{5}$ = 22.9 mg/m3

Average time = 1 hour

3.3 Emissions at Clay Treatment stage

This stage removes dark colour and odour in the used oil. The temperature was monitored from 90 – 240oC. The combustion analyzer was connected to the clay treatment apparatus setup and readings of pollutant identified was displayed on the analyzer screen as presented in table 3. The pressure was constant at 760 mmHg. Also CO was identified has pollutant and SO2 was not emitted

Table 3: Clay treatment Stage of Acid-clay treatment

S/N	Ta (°C)	T.oil (°C)	Time (mins)	CO (mg/m3)
1	27	90	1	2.899
2	27	100	1	0.000
3	28	110	1	2.156
4	28	120	1	2.156
5	28	130	1	3.233
6	28	140	1	3.233
7	29	150	1	4.067
8	29	160	1	5.154
9	29	170	2	4.123
10	29	180	2	4.225
11	29	190	2	1.987
12	30	200	2	2.013
13	30	210	2	2.114
14	31	220	4	7.897
15	31	230	4	10.556
16	31	240	4	16.768

Note: 0 means no pollutant was identified for that activity

Mean emission concentration for CO = $\frac{72.581}{15}$ = 4.83 mg/m3

Average time = 30 mins

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 Acid-clay treatment method of used lubricating oil

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

Air Pollutants	Emission Limits	Averaging time
CO		
	9ppm (10.31 mg/m3)	8-hour
	35ppm (40.08 mg/m3)	1-hour
SO2	75 mg/m3	1-hour

[12]; [13]

Table 5: Mean Emission Concentration (MEC) of CO and SO2 compared with NAQS

S/N	Treatment stages	Air Pollutants	MEC (mg/m3)	NAQS (mg/m3)
1	Dehydration	CO	167.07	40.08
		SO2	12.467	75
2	Acid Treatment	CO	22.9	40.08
3	Clay Treatment	CO	4.83	40.08

Comparing the MEC of CO and SO2 with NAQS from Table 5, it was observed in dehydration stage that SO2 was within the set standard limit which means no health risk is present in the receptor locations while CO exceeded the set standard limits and it means there is health risk in the receptor locations. Also in acid and clay treatment, CO is within the set limit.

4. Conclusion

In this study, the emissions of pollutant in the treatment of used oil using acid-clay was investigated at varying oil temperature CO emission was found to be the highest emitted pollutant with MEC of 167.07 mg/m3 due to incomplete combustion. When compared with NAQS standards, CO concentration at dehydration exceeded the set limits which could cause adeverse effect to receptor locations while SO2 was within the limit. The findings indicated that there is a need to quantify the effects of the emissions from used lube oil treatment plants. However, the predicted results of this study will help decision makers to formulate policy for controlling the impact of emission from used lube oil treatment plants using acid-clay method.

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