COMPARISON OF THE RATE OF EXTRACTION OF SYNTHETIC CRUDE FROM NIGERIAN OILSANDS USING VARIOUS SOLVENTS

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Abstract- **This research compares the extractive strength of four different organic solvents for the production of synthetic crude from Nigerian oilsands. Benzene, Toluene, Xylene and Carbon tetrachloride were used in a Soxhlet extractor. The most popular surface mining method uses hot water and caustic soda for the extraction of the crude from the oilsands but this research considered the use of hydrocarbon solvents. The change in the colouration of the black oilsand to dirty-white in the course of this research is an indication of high extraction efficiency. The results also showed that Carbon Tetrachloride gave the highest rate of extraction followed by Benzene while Xylene gave the minimum rate of extraction. It was discovered that the rate of reaction is inversely proportional to the boiling point of the solvents used. Considering the flammability and health hazards, Carbon Tetrachloride is recommended as the best solvent extractor among the four since it has low flammability and health risks. Alternative to the carbon Tetrachloride is Xylene because of its very low health risk and flammability when compared to the remaining two solvents, which tends to have higher rate of extraction than the Xylene.**

Index Terms- Nigerian Oilsands; Solvent Extraction; Extraction Rate; Extractive Strength

I. INTRODUCTION

Oilsands are naturally occurring mixtures of sand or clay, water and a heavy and viscous form of crude oil called bitumen. They are found in large amounts in many countries throughout the world, but are found in extremely large quantities in Canada and Venezuela. In African content, some substantial amounts have been found to exist in the Democratic Republic of Congo and Nigeria. The beauty about the Nigerian oilsands is that it flows naturally, during hot season, to the surface in form of an outcrop in lots of places in the Nigerian oilsand belt most especially at Ondo and Ogun states. Efforts are now been geared towards the production of synthetic crude from the sands especially now that oil price is high and the oilsand exploitation very profitable. This research tends to proffer solution in form of best extraction solvent for the Nigerian oilsands.

On a commercial scale, oil sands can be extracted through the following processes:

- Surface Mining involving excavation from shallow deposit followed by hot water and caustic soda, NaOH, treatment of the sand. The resulting slurry is piped to the extraction plant where it is agitated and the oil skimmed from the top. It gives a recovery factor of about 7% of original oilsand content.
- Cold Flow, also known as Cold Heavy Oil Production with Sand (CHOPS) involving the pumping of oil out of the sands using progressive cavity pumps. For this to be practicable the oil must be of low viscosity. The advantage of this method is better production rates and recovery (around 10%)
- Cyclic Steam Stimulation (Huff and Puff method). In this method, the well is put through cycles of steam injection, allowed to soak and then oil production. First, steam is injected into a well at a temperature of about 300^{o}C for a period of some weeks; then the well is allowed to soak for some few weeks to allow quality heat transfer. The injection well is then used to produce the oil.
- Steam Assisted Gravity Drainage (SAGD). A pair of horizontal wells is drilled in the oil sands such that one is at the bottom of the formation and another about 5m above it. These wells are typically drilled in groups and can extend for miles in all directions. In each well pair, steam is injected into the upper well; the heat melts the bitumen, which allows it to flow into the lower well, where it is pumped to the surface.
- Vapour Extraction Process. It is similar to the SAGD method but instead of steam, hydrocarbon solvents are injected into the upper well to dilute the bitumen and allow it to flow into the lower well giving better production efficiency.

- Toe to Heel Air Injection (THAI). The process involves ignition of oil in the reservoir and creates a vertical wall of fire moving from the "toe" of the horizontal well toward the "heel", which burns the heavier oil components and upgrades some of the heavy bitumen into lighter oil right in the formation for easy flow.
- Combustion Overhead Gravity Drainage (COGD). The new process involves the injection of air into a vertical well, igniting the upper bitumen and mobilizing, through heating, the lower bitumen to flow into the production well. It is expected that this process will result in water savings of 80% compared to SAGD.

Nigerian oilsands has many outcrops [5], [6] and the most applicable process as highlighted above is the first process of surface mining. Unfortunately, considering the degradation to Nigerian ecological system as a result of oil production, the use of the process may complicate the environmental problem presently existing in the oil belt zone of the country. Hence, the need to consider solvent extraction is strong. Moreover, it is believe that extraction with hydrocarbon solvent will give better result than extraction with caustic soda.

A trichloromethane was used as a solvent in the extraction of oil from oilsands of approximately 18% bitumen by weight. The aim was the development of high yield solvent extraction with minimize solvent loss and low energy consumption. The experiment was carried out over temperature range of 21^{o}C - 427^{o}C and pressure range of 14.7psia - 214.7psia. Little amount of surfactant and polyelectrolytes were added in form of catalyst [8]. A patent number 4046669 of September 6, 1977 was issued on this research.

This research employed the Vapour Extraction Process and Soxhlet extraction method to determine the effectiveness of using different solvents for extraction of synthetic crude oil from Nigerian oilsands.

Ibisi [1] used benzene as solvent in the extraction of oilsands obtained from four locations in Ondo State, Nigeria at three different temperatures of 100, 150 and 200^{o}C and discovered that extraction improves with increase in temperature. Ademodi [2] carried out preliminary studies on recovery of bitumen from Nigeria oilsands using toluene as extraction solvent. Saleh [3] also used soxhlet extraction process in determination of Polycyclic Aromatic Hydrocarbons in Soil. Hence, use of Soxhlet is employed in this research.

The solvents used in this research certainly exhibit their own peculiar properties which are clearly presented below:

TABLE 1-Physical and Chemical Properties of Solvents Used

	Boiling Point (°C)	Melting Point (°C)	Density (g/cm^3)	Specific gravity at 25 °C	API gravity	Viscosity (cp) at 20 °C	Solubility in water (g/L)
Benzene (C_6H_6)	80.10	5.50	0.8765	0.884	28.57	0.652	0.80
Toluene ($C_6H_5CH_3$)	110.60	-93.0	0.8669	0.865	32.08	0.590	0.47
Xylene ($C_6H_4(CH_3)_2$)	138.50	-47.4	0.8640	1.010	8.60	0.812	-
Carbon Tetrachloride (CCl_4)	76.72	-22.9	1.5940	1.589	-42.45	0.972	0.79

II. METHODOLOGY.

A simple procedure was employed in the course of this research. The average weight of oilsand used in all the four solvent extractions was 40g. The procedure is as follows for each of the solvents used:

1. Weigh 40g oilsand sample and place the sample in the main chamber (extraction tube) of the extractor and set up the unit.
2. Pour the solvent from the top of the condenser until there is a reflux giving an average volume of 250ml of solvent.
3. Raise the temperature to a level above the boiling point of the solvents. About 100^{o}C for Benzene and Carbon Tetrachloride, 120^{o}C for Toluene and that of Xylene to about 140^{o}C.
4. Measure the weight of oilsand sample remaining at various times during the extraction.

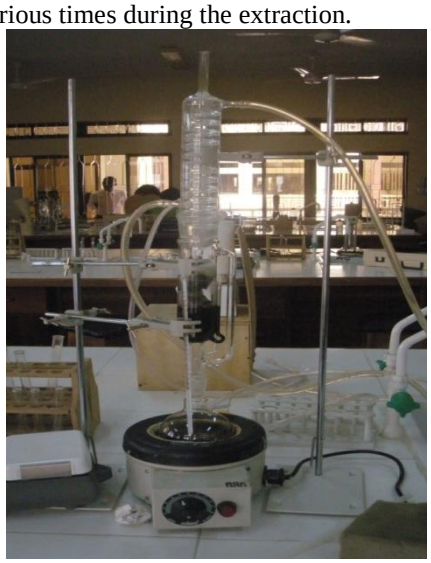

FIG. 1: Experimental Setup of Extraction Apparatus

III. RESULTS AND DISCUSSION

The table 2 below gives the average weight of the oilsand remaining with time of extraction.

TABLE 2-Mass of Extract versus Time For Different Solvents

	Mass of Extract (g)			
Time	**Benzene**	**Toluene**	**Xylene**	**CCl_4**
0	0	0	0	0
2	1.6	1.8	1	2
4	3.3	3.8	2.5	5
6	5	5.6	4.2	8.1
8	6.6	7.3	6.1	10.1
10	8.2	8.7	7.5	11.8
14	10.6	11	9.4	12.9
24	12.8	12.9	11	13.2
48	13.2	13.2	13.2	13.2

The mass of bitumen extracted by different solvents with time of extraction is shown in Fig.2 below. The result shows that Carbon Tetrachloride gives the highest rate of extraction while Xylene gives the lowest extraction rate. Toluene gave the second best extraction rate. Batch processing method was employed.

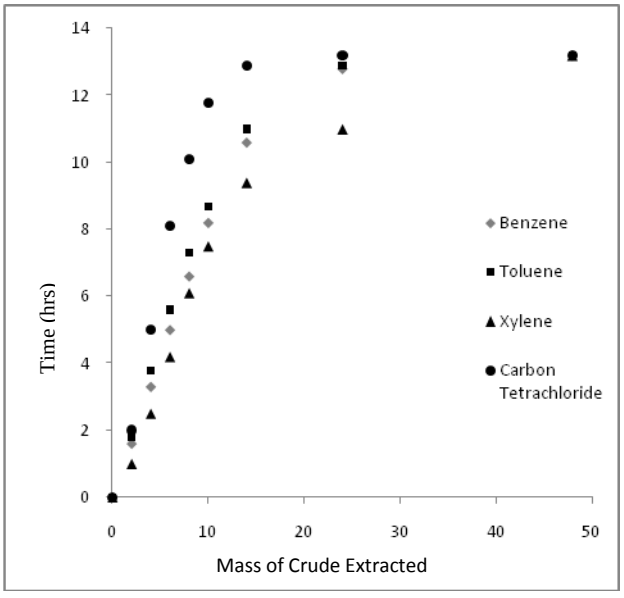

Fig. 2: The Graph of Time of Extraction and Mass of Crude Extracted.

From the graph, it can be deduced that if batch reaction is employed, the choice of solvent may be independent of rate of reaction as time exceeds 48hours. But practically this may not be possible considering the volume of oilsand to be processed. Hence, a continuous or semi-batched process is ideal and in this case, the rate of reaction is of paramount importance. Hence, Carbon Tetrachloride is recommended as extracting solvent.

IV. CONCLUSION

The results obtained showed that Carbon Tetrachloride gave the highest rate of extraction followed by Benzene and Toluene while Xylene gave the minimum rate of extraction. Based on Table.1, it can be deduced that these rates are inversely related to the boiling points of the solvents. The solvent with the lowest boiling point gave the highest rate of extraction while the solvent with the highest boiling point gave the lowest rate of extraction.

V. REFERENCES.

1. Ibisi N.E, D.E. Okwu and M.M. Ekwenchi, 2006, Evaluation of the Chemical Composition of Tar Sands of Southwestern, *Nigeria Journal of Engineering and Applied Sciences*, Volume: 1, Issue: 2, pp. 138-142.

2. Bayonile Ademodi, Toks oshinowo, Sikiru A. Sanni and Olukayode F. Dawodu, 1987, Preliminary Studies on The recovery of Bitumen From Nigerian Tarsands: Benefication and Solvent Extraction, *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, volume 9, issue 3, pp.173-188.

3. Noorashikin M. Saleh, M. Marsin Sanagi, 2009, Comparison of Pressurized Liquid Extraction with Soxhlet Extraction in the Determination of Polycyclic Aromatic Hydrocarbons in Soil, *The Malaysian Journal of Analytical Sciences*, Vol. 13 No 1 (2009): 141 – 145.

4. L. Govindarajan, Nitin Raut and Ahmed Alsaeed, 2009, Novel Solvent Extraction for Extraction of Oil from Algae Biomass grown in Desalination Reject Stream, *Journal of Algal Biomass Utilization*, 1(1), pp.18-28.

5. R. K. Odunaike, J. A. Laoye, O. O. Fasunwon, G. C. Ijeoma, and L. P. Akinyemi, 2010, Geophysical mapping of the occurrence of shallow oil sands in Idiopopo at Okitipupa area, South-western Nigeria, *African Journal of Environmental Science & Technology* Vol. 4 (1), pp. 034-044.

6. R.K. Odunaike, G.C. Ijeoma, R.O. Edigbe, A.H Babatope, Oil Sands Exploration in Ijebu-Mushin using Magnetic and Electrical Resistivity Methods, *11th SAGA Biennial Technical Meeting and Exhibition Swaziland*, 16-18 September 2009, pp.247-252.

7. www.atsdr.cdc.gov/csemtoluene/physiologic_effects.html

8. Blaine, Neal Franklin (inventor) www.patentstorm.us/patents/4046669/description.html

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