

It was observed at the end of the penetration tests that as the percentage by mass of sulphur added to the bitumen was increased, the grade of the bitumen increased as the bitumen containing 5% percentage by mass sulphur was tested to have the lowest penetration value which compared favorably to the tested penetration value of the European produced bitumen indicating a successful upgrade.

Therefore, the remaining tests were carried out on the bitumen containing 5% percentage by mass sulphur.

II. **Flash point test:** The flash point test was carried out and the first flash of flame was observed and measured to have come up at a temperature of 300°C. Therefore, the flash-point was measured as 300°C

III. **Solubility test:** Solubility test carried out on the by dissolving 2g of the upgraded Nigerian bitumen sample using 5% sulphur into 100ml carbon disulfide yielded the following result:
Residue weight after filtration = 0.025g
Solubility = 98.75%

IV. **Viscosity test:** The viscosity test was carried out using the vacuum capillary viscometer at 135°C and a viscosity value of 3017centipoise was obtained.

EXPERIMENT D

500g of bitumen crump rubber and two types of polymers, ethylene vinyl acetate (EVA) and styrene butadiene styrene (SBS) with varying percentage of 2%, 5% and 8% were used in this experiment to upgrade the Nigerian Produced Bitumen.

I. Penetration test using EVA polymer, SBS polymer, and crump rubber.

Using EVA polymer

For 2% EVA (10g), the following results were obtained:

TABLE 8: SHOWING THE PENTRATION TEST VALUES FOR 2% EVA (10g)

PENETRATION TEST @ 25°C	PENETRATION VALUE (DMM)
TEST 1	45
TEST 2	45
TEST 3	45

Average penetration value is equal to 45

For 5% EVA (25g), the following results were obtained:

TABLE 9: SHOWING THE PENTRATION TEST VALUES FOR 5% EVA (25g)

PENETRATION TEST @ 25°C	PENETRATION VALUE (DMM)
TEST 1	39
TEST 2	40
TEST 3	41

Average penetration value is equal to 40

For 8% EVA (40g), the following results were obtained:

TABLE 10: SHOWING THE PENTRATION TEST VALUES FOR 8% EVA (40g)

PENETRATION TEST @ 25°C	PENETRATION VALUE (DMM)
TEST 1	30
TEST 2	34
TEST 3	35

Average penetration value is equal to 33

For 11% EVA (55g), the following results were obtained:

TABLE 11: SHOWING THE PENTRATION TEST VALUES FOR 11% EVA (55g)

PENETRATION TEST @ 25°C	PENETRATION VALUE (DMM)
TEST 1	27
TEST 2	26
TEST 3	26

Average penetration value is equal to 26.3

For 14% EVA (70g), the following results were obtained:

TABLE 12: SHOWING THE PENTRATION TEST VALUES FOR 14% EVA (70g)

PENETRATION TEST @ 25°C	PENETRATION VALUE (DMM)
TEST 1	18
TEST 2	19
TEST 3	19

Average penetration value is equal to 18.67

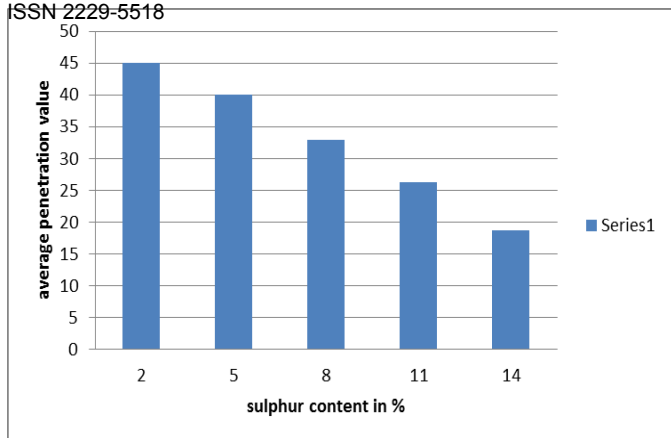


Figure: 3: Showing a plot of varying amounts of Ethylene Vinyl Acetate against the corresponding penetration values

I. The Ethylene vinyl Acetate gave the best upgrade results when 14% of EVA was used therefore, the remaining tests were carried out on the upgraded bitumen at 14% EVA polymer mixed.

II. Flash point test: The flash point test was

carried out and the first flash of flame was observed and measured to have come up at a temperature of 303⁰C. Therefore, the flashpoint was measured as 303⁰C

III. Solubility test: Solubility test carried out on the by dissolving 2g of the upgraded Nigerian bitumen sample using 14% EVA polymer into 100ml carbon disulfide yielded the following result:

Residue weight after filtration = 0.021g
Solubility = = 98.95%

IV. Viscosity test: The viscosity test was carried out using the vacuum capillary viscometer at 135⁰C and a viscosity value of 3014 centipoise was obtained.

TABLE 13: SHOWING THE TEST RESULTS FOR THE TESTS CARRIED OUT ON THE MODIFIED AND UNMODIFIED SAMPLES

TEST	UNMODIFIED NIGERIAN BITUMEN	UPGRADED WITH EVA	UPGRADED WITH SUL- PHUR	EUROPEAN PRODUCED BITUMEN
PENETRATION (DMM)	67.67	18.67	18.33	17.83
FLASH POINT ⁰ C	280	303	300	306
SOLUBILITY %	83.7	98.95	98.75	99

The table 13 above shows a comparison between the results obtained after carrying out the various experiments on the unmodified Nigerian bitumen, the upgraded Nigerian bitumen using EVA and Sulphur, and the European produced bitumen. It was observed that the upgraded Nigerian sample with sulphur compared most favorably with the European produced bitumen which was used as the standard.

CONCLUSIONS

After a comparative analysis carried out on the unmodified Nigerian bitumen, the EVA modified bitumen, the Sulphur modified bitumen, and the European produced bitumen, the upgrade can be said to be successful. This is because the measured properties of the upgraded Nigerian bitumen with Sulphur and EVA respectively, compared favorably with the measured properties of the European produced bitumen, which is of international standards. The use of Sulphur, Crump rubber, Ethylene Vinyl Acetate (EVA), and Stryene Butadiene Stryene (SBS) shows that the process is not so expensive in terms of the raw materials required.

5.1.2 RECOMMENDATION

Upgrading our locally produced bitumen should be encouraged rather than importing from other countries to help conserve our foreign reserves. Also in the nearest future, our locally produced bitumen could be exported to countries whose bitumen does not meet up with the international standards

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