International Journal of Materials, Methods and Technologies
Vol. 5, No. 1, May 2017, pp. 1-11, ISSN: 2327 - 0322 (Online)
Available online at http://ijmmt.com

Research article

PRODUCTION AND CHARACTERIZATION OF MEDICATED SHAMPOO FROM COAL TAR IN GARIN MAIGANGA AND SHANKODI COAL DEPOSITS

Sori Ronald Makan[1], Jock Asanja Alexander[2*], Nkafamiya Iliya Ibrahim[3], Ayodele Akinterinwa[3] and Gushit Stephen John[2]

[1]National Metallurgical Development Center, Jos-Nigeria.
[2]University of Jos-Nigeria.
[3]Modibbo Adama University of Technology, Yola-Nigeria.

*Corresponding author: alsanja@gmail.com

Abstract

Coal tar was extracted from Garin Maiganga (GMG) and Shankodi (SHK) coals by pyrolysis. The chemical analysis showed that the coal tar contained over 48 chemical compounds for Garin Maiganga and over 50 compounds for Shankodi including the presence of phenolic, benzo and naphthalene compounds as active ingredient in shampoo formulation. The produced shampoo evaluated for quality assessment tests revealed that the pH (6.5), viscosity (1550 - 15560 cP), specific gravity (1.02) and solid content (6.66 – 7.10 wt.%) are within the requirement for standard medicated shampoo prescribed by Standard Organisation of Nigeria (SON).

Key words: Coal tar, Pyrolysis, Formulation and Shampoo

1.0 Introduction

Coal is playing a fundamental role in global development. It can be used not only as a source of energy, but as a high-value added raw material for chemicals and carbon based materials. Coal pyrolysis is one of the significant approaches for the comprehensive utilization of coal and one important product of the process is coal tar (Jiang *et al.,* 2006). Coal tar has been utilized as raw materials for various industries such as synthetic fibre, medicines, coatings and national defence (Jiang *et al.*, 2006). It is a type of raw materials from which phenols, naphthalene, anthracene can be extracted for the production of washing oil, cementious agents, antiseptic agents and catalyst for catalytic hydrogenation to produce gasoline, diesel oil etc. (Jiang *et al.*, 2006). Coal tar is used as raw materials or intermediate materials in various chemical industries (as antioxidants, antiseptics, resin, softeners, ingredients in plastic industry, paint, perfume, medicine etc., (Hayashi, 1995). Coal tar can also be used for the production of soap, ointment and medicated shampoo which is used in the treatment for dandruff and psoriasis, as well as being used to kill and repel head lice (Van Metre *et al.*, 2010).

Shampoo treatments are the most commonly used of managing hair and scalp conditions (Ralph, 2007). Shampoo is a hair care product used for the removal of dirt, oils, skin particles, dandruff, environmental pollutants and other contaminant particles that gradually build up in hair (Sara *et al*., 2013). There are various types of shampoo and these includes; powder shampoo, clear liquid shampoo, liquid shampoo, lotion shampoo, aerosol shampoo, liquid herbal shampoo, cream shampoo, solid gel shampoo, specialized shampoo which may include medicated shampoo like plain shampoo, antiseptic shampoo, anti-dandruff shampoo, baby shampoo, conditioning shampoo, two layer shampoo, nutritional shampoo containing vitamins and amino acids (Sutar *et al*., 2013).

Shampoo is primarily used for cleaning of the hair accumulated with sebum, scalp debris and residues of hair glooming preparations and dandruff, a clinical condition caused by malassezia (pityrosporum) species (Sarath *et al*., 2013). Shampoo produced from coal tar falls under the category of medicated shampoo and is used for relieving itching, scaling, dryness and flaking of skin due to dandruff, psoriasis and seborrhoea. Coal tar shampoo also works by slowing down bacterial growth and loosing,/ softening sealers and crust (Berenblum, 1948). Anti-dandruff shampoos are designed to alleviate dandruff or scalp disorder which manifest itself as scaly flakes of scalp skin.

This research work therefore was geared on production of shampoo from coal tar samples obtained from coal collected along the Benue trough of Garin Maiganga and Shankodi deposits. The product was analyzed and compared with commercial medicated shampoo as prescribed by Standard Organization of Nigeria (SON). This research may however, create awareness on the potential and other application of coal tar considering the abundance of coal deposit in Nigeria.

2.0 Methods

2.1 Pyrolysis of coal samples

The coal samples collected from Garin Maiganga and Shankodi deposits were pyrolysis using fixed bed reactor. The coal samples weighing 100 g were placed inside a pyrolysis reactor (500 mL, round bottom flask) each at a time. The reactor containing the coal sample was transferred into the furnace at a set temperature of 350^{o}C. The furnace temperature was gradually raised at a rate of 10^{o}C per minute up to 600^{o}C which was maintained for 30 minutes. The tar alongside with water was collected via a Liebig condenser into 250 mL beaker (collector). The tar and the water were separated by filtration, using filter paper number 42. The tar on the filter paper was scooped into a 100 mL beaker and heated on a hotplate to drive out the remaining water in the tar. The tar was then stored in a sample bottle, wrapped with foil paper and kept in refrigerator for chemical analysis and subsequent use in the production of shampoo.

2.2 Production of shampoo

The method of shampoo production used was the one adopted by Mottram (2000) and Goodfield, *et al*., (2004). 75 mL hot water at 70^{o}C was measured into mixing vessel (a plastic bowl), 11.5 g of surfactant (alkyl benzene sulphonate) was transferred into the vessel and mixed. 1 g of coal tar (active ingredient) was added and stirred. 1.5 g of Aloe Vera was added and was stirred again. 5 mL hydroxyethyl cellulose (Natrosol), 2 mL perfume, 1 mL colouring agent and 2 mL of formaldehyde were also added. Finally, the pH of the mixture was adjusted to 6.5, using citric acid, with greater stirring until a homogenous paste was obtained.

The process was repeated with different tar concentrations of 0.2, 0.5, 1.0, 1.5 and 2.0 g/mL.

2.3 Quality assessment of Garin Maiganga and Shankodi coal tar shampoo

The prepared shampoo samples were evaluated via quality control tests including visual assessment and physicochemical analysis such as pH, solid contents, specific gravity and viscosity, were performed.

2.3.1 Shampoo pH

The pH of 10% shampoo solution in distilled water was determined at room temperature 25°C using a pH meter (Sharma, 1998).

2.3.2 Viscosity of shampoo

The viscosity of the shampoo sample was determined using the Brookfield dial viscometer (Model DV-1, LVT USA). The sample was placed in a small sample adapter, and then transferred into the sample cup of the viscometer. The viscometer was set at different spindle speed from 0.3 to 100 rpm. The viscosity of the tar was measured using spindle T95. The temperature was kept constants (25ºC), the viscosity of the sample was then measured and recorded directly in cP (Sharma, 1998). This process was done for the different tar concentrations.

2.3.3 Specific gravity of shampoo

The specific gravity was determined using specific gravity bottle and according to the procedure prescribed by Standard Organization of Nigeria (SON, 2009). Empty specific gravity bottle was washed, rinsed with water then with ethanol. The bottle was dried and weighted. The empty bottle was filled with distilled water, closed with a stopper, thoroughly wiped with a clean towel and weighed. After this, the water was decanted, the bottle dried in a hot air oven and was cooled in a desiccator. The shampoo sample was introduced into the bottle filled to the neck and tightly closed with the stopper and weighed. The test was carried out at 25ºC and the specific gravity was calculated as follows;

$$Specific\ gravity = \frac{weight\ of\ sample}{weight\ of\ water} = \frac{Z - Y}{X - Y}$$

Where, x = weight of bottle filled water

y = weight of empty bottle

z = weight of bottle filled with shampoo

x – y = weight of water only

z – y = weight of shampoo only.

This was also repeated for the different coal tar concentration.

2.3.4 Solid contents of Shampoo

The solid content test determination was also performed using the method adopted from Standard Organization of Nigeria (SON, 2009) A clean dry evaporating dish was weighed and 4 g of shampoo was added to it. The dish and shampoo was placed on the hot plate until the liquid portion was evaporated. The weight of the shampoo only (solids) after drying was calculated as follows;

% Solid content = $\frac{weightofshampo - weightofash}{weightofshampotaken} X\ 100$

International Journal of Materials, Methods and Technologies
Vol. 5, No. 1, May 2017, pp. 1-11, ISSN: 2327 - 0322 (Online)
Available online at http://ijmmt.com

This was repeated for the different tar concentration.

3.0 Results and Discussions

3.1 Chemical composition of coal tar.

The GC-MS spectra of Garin Maiganga and Shankodi coal tar samples are shown in Figures 1 and 2 respectively.

The major compounds present in Garin Maiganga sample are summarized in Table 1 while Shankodi in Table 2.

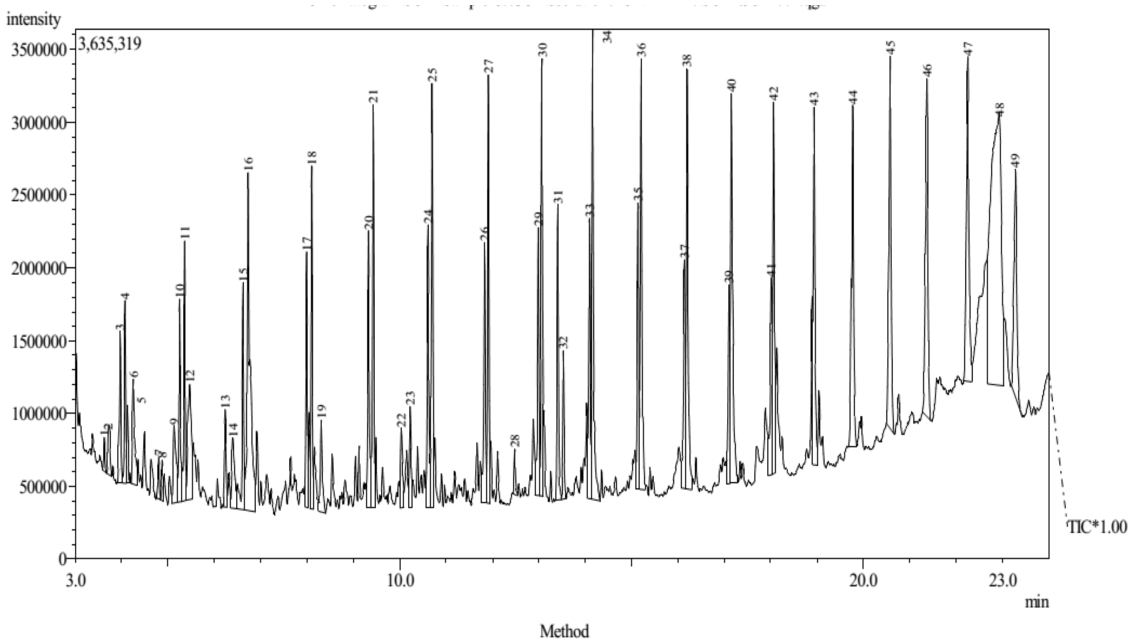

Figure 1: GC-MS Spectra of Garin Maiganga coal tar

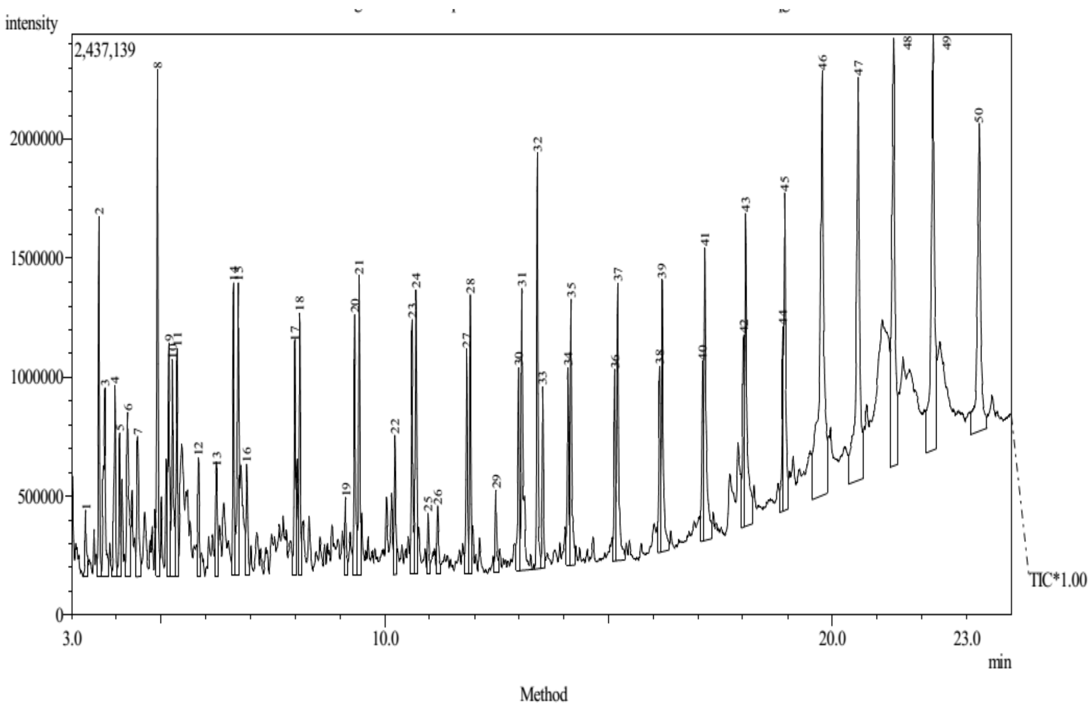

Figure 2: GC-MS Spectra of Shankodi coal tar

Garin Maiganga coal tar contains over 48 chemical compounds and from Table 1, benzene ethanol is found in major abundance (27.25%) followed by phenol-3-methyl-1-(2-methylpheyl) with abundance of 15.14%. O cresol, trimethyl benzene, phenylester (1-Nitrethyl) benzene, 2-methyl naphthalene and 2, 6-dimethyl naphthalene have abundance of 8.82%, 3.6%, 8.91%, 7.06%, 6.64% and 6.14% respectively. The chromatogram also identify the presence of organic acids with abundance of 16.4% indicating that Garin Maiganga coal tar is acidic.

Table 1: Major Chemical Composition of Garin Maiganga Coal Tar

Peak Number	Compounds	Percentage abundance (%)
2	Trimethyl benzene	3.6
6	Phenyl ester	8.91
3,6,12	Acids	16.4
9	O cresol	8.82
12	Phenol-3-methyl-1-(2-methylphenyl)	15.14
14	(1-Nitrethyl)benzene	7.06
19	2,methylnaphthalene	6.64
22	2,6-dimethylnaphthalene	6.14
38	Benzene ethanol	27.25

Shankodi coal tar contains about 50 chemical compounds as shown in Figure 2. From Table 2, the major compound in Shankodi coal tar was methylene with abundance of 21.56% and followed by 1, 4-dimethylnapthalene with 21.45% while ethylmethyl benzene and methyl naphthalazine were 20.62% and 14.33% respectively. Naphthalene compounds has abundance in Shankodi coal tar of over 20% and was greater than Garin Maiganga coal tar with less than 20%. The increase of the chemical compounds down the Benue trough may be due to the geological formation of the coal deposits (Obaje, 1997).

Table 2: Major Chemical Composition of Shankodi Coal Tar

Peak Number	Composition	Percentage abundance (%)
1	Benzene ethanol	5.81
2	Methylene	21.56
3	Ethyl methyl benzene	20.62
7	Methly naphthalazine	14.33
9	1,4-methyl naphthalene	21.45
13	Arachidic alcohol	11.49
25	1,H3a,7 methanoazulene, octahydro-3,6,8,8-tetramethyl	4.74

International Journal of Materials, Methods and Technologies
Vol. 5, No. 1, May 2017, pp. 1-11, ISSN: 2327 - 0322 (Online)
Available online at http://ijmmt.com

3.2 Quality assessment of coal tar shampoo

3.2.1 Effect of concentration on the viscosity of shampoo

Table 3 showed the quality assessment of Garin Maiganga and Shankodi shampoo compared with the standard shampoo. Shankodi has viscosity of 1560 cP slightly greater than Garin Maiganga (1550 cP) shampoo and these values are higher than the standard (1150 cP). The relative low viscosity of Garin Maiganga may be due to the variation in coal composition along the Benue trough. However, this indicates that Garin Maiganga shampoo will flow more easily than Shankodi.

Table 3: Quality Assessment of Shampoo

Sample/Properties	Garin Maiganga	Shankodi	*Standard
pH	6.5	6.5	5.0-7.0
Viscosity (cP)	1550	1560	1150
Specific gravity	1.022	1.023	0.9-1.10
Solid content (wt.%)	7.10	6.66	2.5
Foam height (mL)	95	80	-

*SON (2009)

The effect of concentration on the viscosity of Garin Maiganga and Shankodi shampoo is shown in Figure 3. It was observed that the viscosity of the shampoo increased with increasing tar concentration. The increase in viscosity with increasing concentration indicates that the thickness of the shampoo increased with increased in tar content.

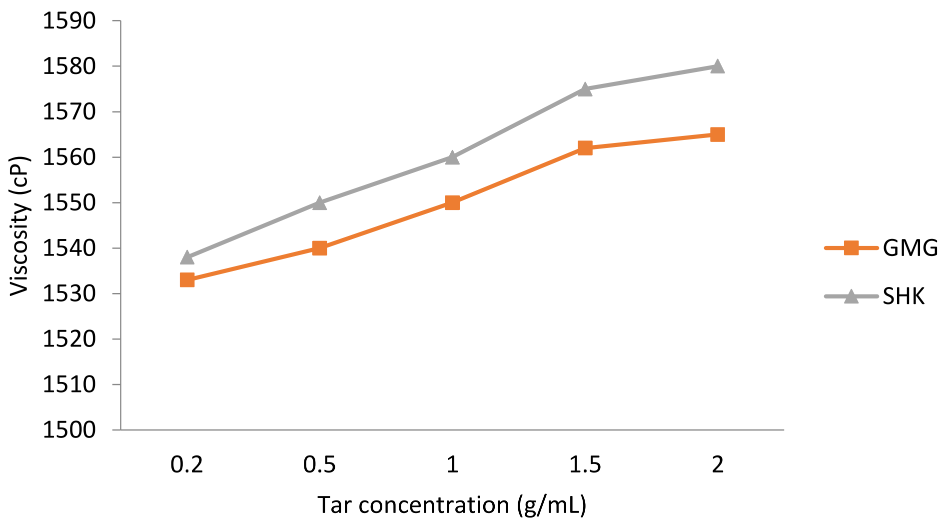

Figure 3: Effect of tar concentration on the viscosity

3.2.2 Effect of concentration on the pH of shampoo

From Table 3, the pH of Garin Maiganga and shankodi are the (6.5) and within the accepted limit of standard medicated shampoo (5.0-7.0). The pH values of GMG and SHK showed that these shampoo are slightly acidic and may be due to the present of chemical compounds summarized in Tables 1 and 2 respectively. The pH of these shampoos are acid balanced which is just the pH of skin (pH 6.5) and balanced pH is one of the ways to minimize damage to the hair. Mild acidity prevents swelling and promotes tightening of the scales, thereby inducing shine (Sutar *et al.*, 2013).

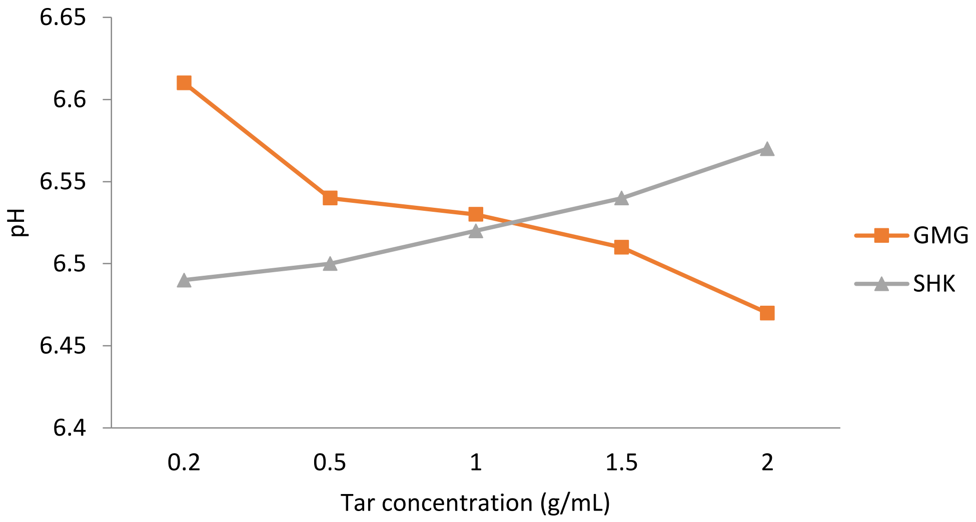

Figure 4: Effect of tar concentration on the pH of the shampoo

Figure 4 showed the effect of tar concentration on the pH of GMG and SHK tar shampoo. The pH of GMG slightly decreased with increasing tar concentration while SHK increases with increasing tar concentration. The decreased in pH showed increased in acidity while increased in pH indicates decreased in acidity. However, both shampoo samples are acidic and within the required range for shampoo (SON, 2009).

3.2.3 Effect of concentration on the specific gravity of shampoo

Table 3 showed that GMG and SHK shampoos have similar value of specific gravity (approximately 1.02) which is within the limit (0.9-1.10) of the standard. The result of specific gravity is relatively lower compared to the work conducted by Ashok and Rakesh (2010). Figure 5 showed that the specific gravity of GMG and SHK increases with increasing tar concentration. This could be due to increase in quantity of the tar as concentration increases.

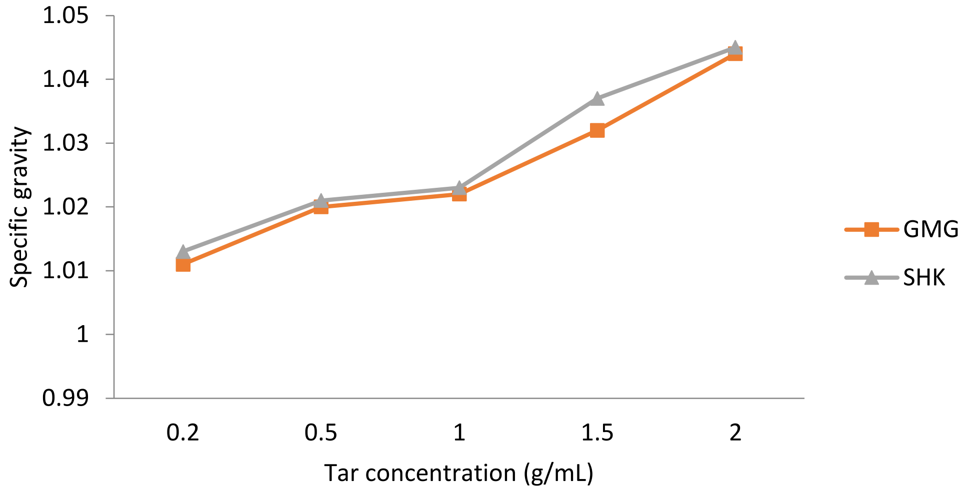

Figure 5: Effect of tar concentration on shampoo specific gravity

3.2.4 Effect of concentration on the solid content shampoo

The solid content of GMG and SHK shown in Table 3 are 7.10 and 6.66wt.% respectively. These values are higher than for standard shampoo (2.5 %wt.) and this showed that the solid components present GMG are higher than SHK coal tar. It was reported that if shampoo has too many solids, it will be too hard to work into the hair or too hard to wash out (Ashok and Rakesh, 2010). Figure 6 showed that the solid content increased with increased tar concentration for both Garin Maiganga and Shankodi tar. The increase in solid content may be due to the presence of higher molecular weight compounds.

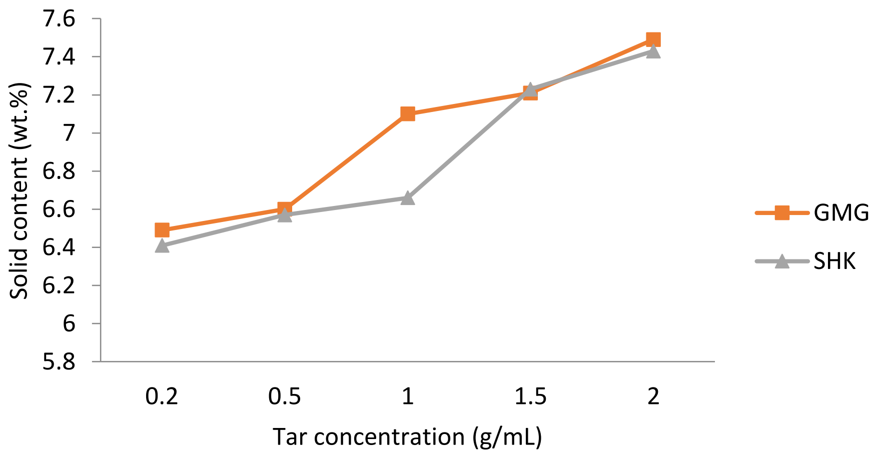

Figure 6: Effect of tar concentration on solid content of shampoo

4.0 Conclusions

Coal tar was extracted from Garin Maiganga and Shankodi coals using pyrolysis process. The chemical analysis showed that the coal tar samples contain many chemical compounds with the presence of phenolic, benzo and naphthalene compounds as active ingredient in medicated shampoo formulation. The quality assessment tests carried out on the formulated shampoos revealed that most results are within the standard range for commercial medicated shampoo. This shows that the shampoo produced from GMG and SHK coal tar may be considered as medicated and could be fit for human use.

5.0 References

Ashok, K. and Rakesh, R. M. (2010). Evaluation of prepared shampoo formulations and to compare formulated shampoo with market shampoo. International Journal of Pharmaceutical sciences. (3), 120-125.

Berenblum I. (1948). Liquor piciscarbonis. British medical Journal. 2, 1 (577): 601.

Goodfield, M.K. and Berth, J. J. (2004). Comparing a 1 % Exorex coal tar preparation with a 5 % Asphalt coal tar preparation in chronic plaque psoriasis J dermatology treatment. International Leaque of Dermatology Societies. 15 (1). 14 – 22.

Hayeshi, J., Amamoto, S., Kusakabe, K. and Morook, S. (1995). Evaluation of vapor phase Reactivity of primary tar produced by flash pyrolysis of coal. Energy and fuels. 9. 290 – 294.

Jiang, J., Qiyu, W., Yingyu, W., Weicheng, T and Bo, X. (2006). GC/MS analysis of coal tar composition produced from coal pyrolysis. Environmental monitoring of China. 321-333

Mottram, F. J and Lees C. C. (2000). Hair shampoos, pourchers perfumes. Journal of cosmetic and soaps. 289 – 306.

Obaje N.G. (1997). Petrographic evaluation of the coking potential of Cretaceous Lafia -Obi Coal Deposit in the Benue trough of Nigeria Mining and Geol. 43, 103 – 176

Sara, C., Vipin, K. V., Ann, R. A., Lindumol, K. V., Arun. (2013). Development and evaluation of antidandruff shampoo based on natural sources.

Sharma P.P., (1998). Cosmetic Formulation, Manufacturing, and Quality Control. Third edition, Vandana publications; 644 – 647.

Standard Organization of Nigeria (2009). Nigerian Industrial Standard for hair shampoo, NIS 676:6-21

Sutar, M., Deshmukh, S., Chavan, M. and Singh S. (2013). Preparation and Evaluation of Polyherbal Shampoo Powder. International Journal of Pharmacy and biological Science 3, 154 – 159.

Van Metre P.C. and Mahler B.J. (2010). Contributions of PAHs from coal tar pavement sealcoat and other sources to 40 US lakes. 23-42