

Research article

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

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Abstract

Coal tar was extracted from GarinMaiganga(GMG)and Shankodi(SHK)coals by pyrolysis.The chemical analysis showed that the coal tar contained over 48 chemical compounds for GarinMaiganga and over 50 compounds for Shankodi including the presence of phenolic, benzo and naphthalenecompounds 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). **Copyright © IJMMT, all rights reserved.**

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 (Jianget *al.*, 2006). Coal tar has been utilized as raw materials for various industries such as synthetic fiber, medicines, coatings and national defence (Jiang *et al.*, 2006). It is a type of raw materials from which phenols, naphthalenes, anthracene can be extracted for the production of washing oil, cementitious 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 (Sutare *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 (Sarathet *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 seborrhea. Coal tar shampoo also works by slowing down bacterial growth and loosening / 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 GarinMaiganga 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 GarinMaiganga and Shangkodi 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°C. The furnace temperature was gradually raised at a rate of 10°C per minute up to 600°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°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 hydroxyethylcellulose (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 2.0g/mL.

2.3 Quality assessment of GarinMaiganga 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 (25°C), 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 (NIS 676:2009). 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 25°C and the specific gravity was calculated as follows;

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

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 (NIS 676:2009) 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;

$$\% \text{ Solid content} = \frac{\text{weight of shampoo} - \text{weight of ash}}{\text{weight of shampoo taken}} \times 100$$

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 GarinMaiganga and Shankodi coal tar samples are shown in Figures 1 and 2 respectively. The major compounds present in GarinMaiganga sample are summarized in Table 1 while Shankodi in Table 2.

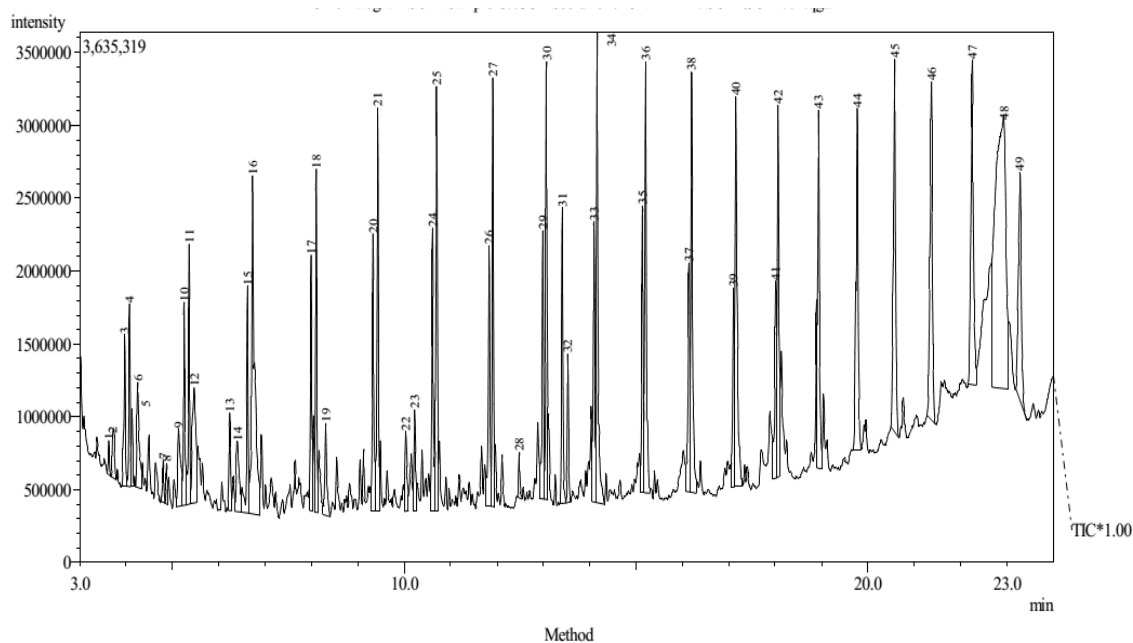


Figure 1: GC-MS Spectra of GarinMaiganga coal tar

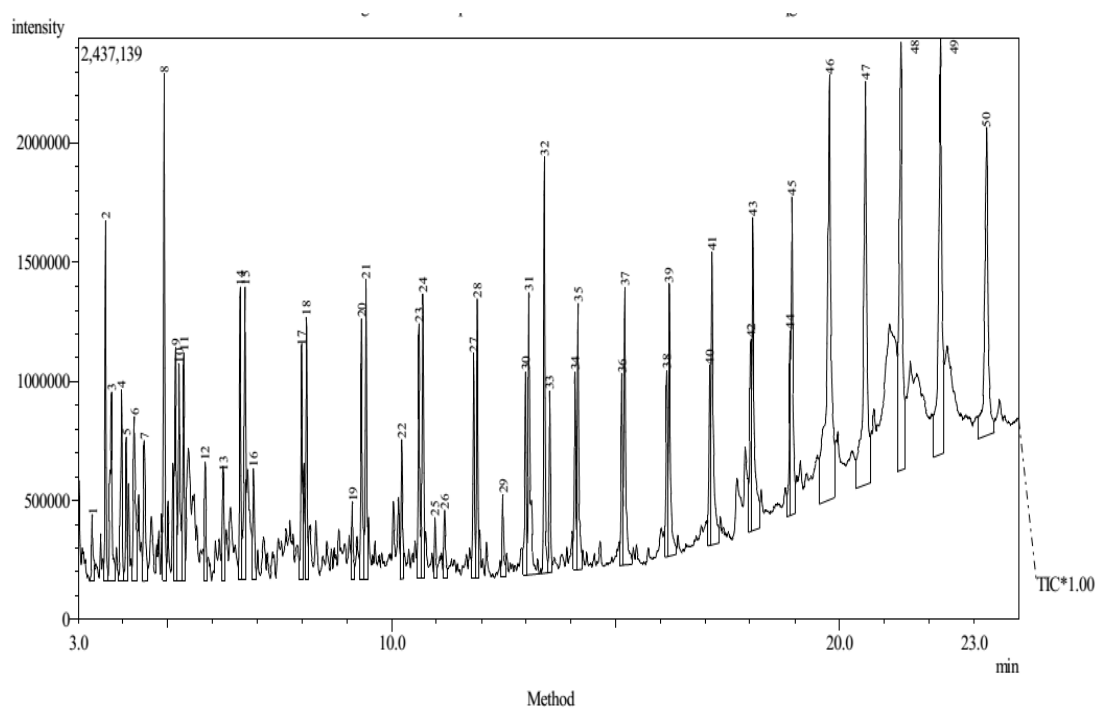


Figure 2: GC-MS Spectra of Shankodi coal tar

GarinMaiganga 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-methylphenyl) with abundance of 15.14%. O cresol, trimethylbenzene, phenylester (1-Nitroethyl) benzene, 2-methylnaphthalene and 2, 6-dimethylnaphthalene 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 GarinMaiganga coal tar is acidic.

Table 1: Major Chemical Composition of GarinMaiganga 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-Nitroethyl)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-dimethylnaphthalene with 21.45% while ethylmethylbenzene and methylnaphthalazine were 20.62% and 14.33% respectively. Naphthalene compounds has abundance in Shankodi coal tar of over 20% and was greater than GarinMaiganga 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	Ethylmethylbenzene	20.62
7	Methnaphthalazine	14.33
9	1,4-methylnaphthalene	21.45
13	Arachidic alcohol	11.49
25	1,H3a,7 methanoazulene,octahydro-3,6,8,8-tetramethyl	4.74

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

Table 3: Quality Assessment of Shampoo

Sample/Properties	GarinMaiganga	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 GarinMaiganga 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.

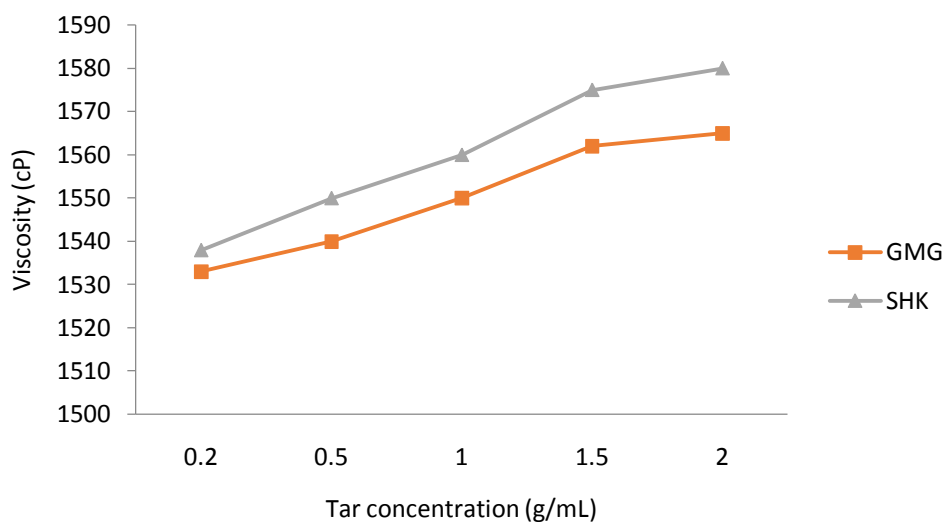


Figure 3: Effect of tar concentration on the viscosity

3.2.2 Effect of concentration on the pH of shampoo

From Table 3, the pH of GarinMaiganga 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 (Sutaret *et al.*, 2013).

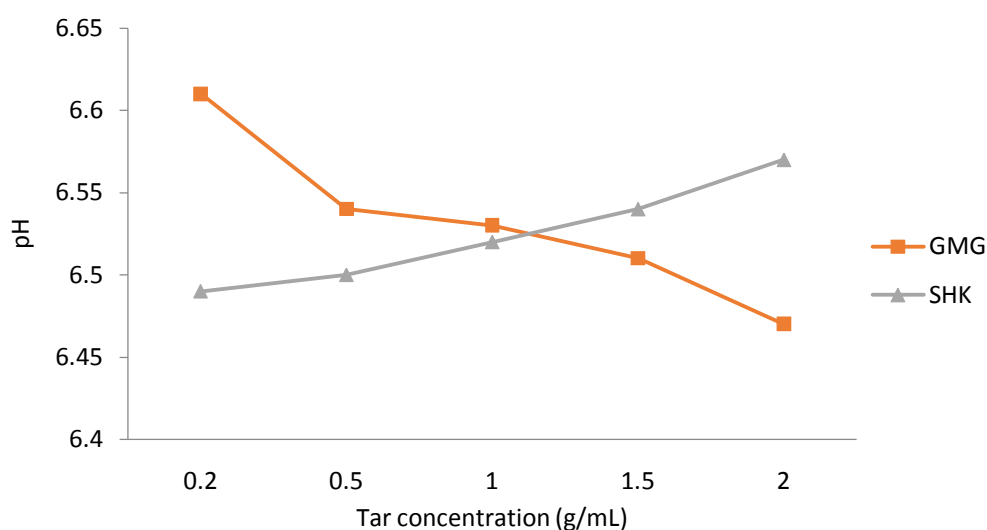


Figure 4: Effect of tar concentration on the pH of the shampoo

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.

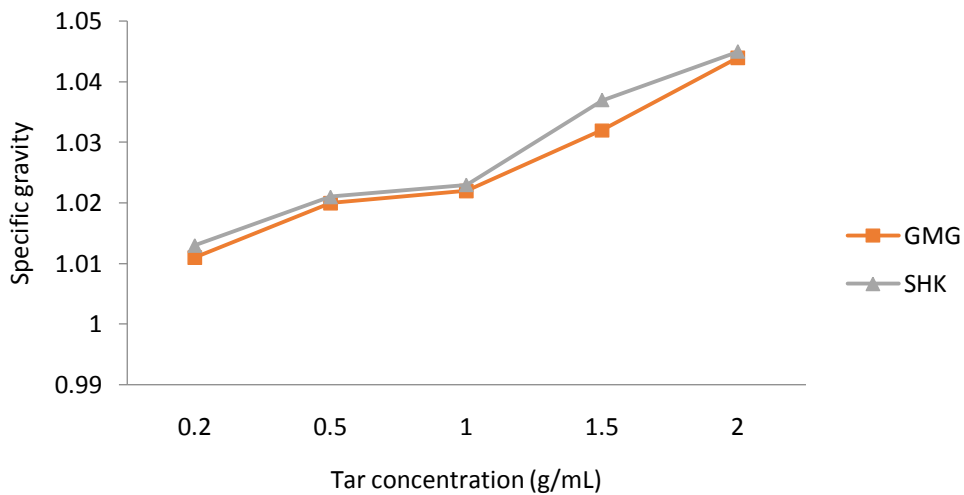


Figure 5: Effect of tar concentration on shampoo specific gravity

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 GarinMaigangaand Shankodi tar. The increase in solid content may be due to the presence of higher molecular weight compounds.

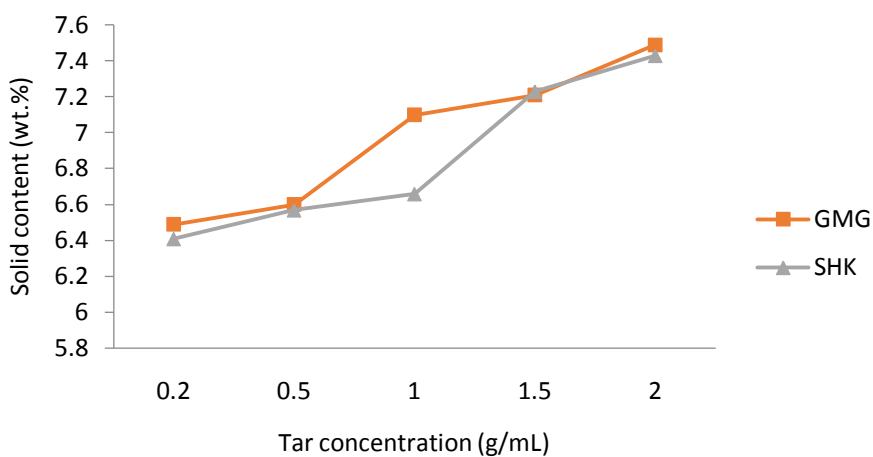


Figure 6: Effect of tar concentration on solid content of shampoo

4.0 Conclusions

Coal tar was extracted from GarinMaiganga 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.

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