EXTRACTION AND PHYSICOCHEMICAL CHARACTERIZATION OF CASHEW NUT SHELL LIQUID (CNSL) - A POTENTIAL DEFOAMER IN PAINT FORMULATION

*Alabi F. M.¹, Lajide L.¹, Ayodele O.² and Idoko O.³

¹. Department of Chemistry, Federal University of Technology, P. M. B. 704 Akure, Ondo State, Nigeria
². Department of Industrial Chemistry, Ekiti State University, P. M. B. 5363, Ado-Ekiti, Nigeria
³. Chemistry Advance Centre, Sheda Science and Technology Complex, P. M. B. 186 Garki, Abuja, Nigeria

*Corresponding author: alabifortune72@gmail.com

ABSTRACT

There is a growing need for local sourcing of alternative raw materials from agricultural sources to replace synthetic ones obtained from the petrochemical industry because of environmental concerns coupled with the high cost of importation of these raw materials. In this study, the physicochemical properties of extracted Cashew Nut Shell Liquid (CNSL) as a defoamer was studied in comparison with polydimethylsiloxane (PDMS), a synthetic defoamer and Linseed oil, a non-synthetic one. The cashew nut shell were extracted by soxhlet apparatus using hexane as the extracting solvent, and analyzed using standard methods. The results show relatively comparative properties in the extracted CNSL and PDMS and Linseed oil. The refractive index was 1.53 compared to 1.4 and 1.47 of PDMS and Linseed oil; viscosity of 38.5 mPa.s which falls within the acceptable range of PDMS for industrial application; specific gravity of 0.99 g/cm³ to 1.04 g/cm³ and 0.93 g/cm³ of PDMS and Linseed oil, respectively. The saponification and iodine values for linseed oil were 188 mgKOH/g and 170 Wijs while 105.85 MgKOH/g and 121 Wijs were reported for the extracted CNSL. The GC-MS analysis identified six (6) different compounds in the mass spectrum consisting of mono-unsaturated, di-unsaturated, saturated cardanol and saturated cardol. These compounds could be responsible for its comparative properties with PDMS and Linseed oil as alternative defoamer.

Keywords: Cashew nut shell liquid, defoamer, polydimethylsiloxane, paint formulation

INTRODUCTION

The concern with the paint industry in Nigeria is the local sourcing of raw materials for production as over 70 % of the raw materials need of the industry is imported [1]. This is as a result of the non-completion
of the second phase of the petrochemical plants which is expected to supply most of the chemical raw materials. Therefore the search for alternative raw materials from available local sources and the development of less polluting raw material are some measures necessary to address the challenge of raw materials for the paint industry in the Country.

The cashew tree is indigenous to Brazil but is now widely cultivated as an economic crop in terms of food source, income, industrial raw materials and foreign exchange, across the tropics especially in Africa and Asia [2]. Major cashew producing countries in these regions are India, Sri Lanka, Thailand, Malaysia, Indonesia, Tanzania, Kenya, Madagascar, Senegal, Malawi, Angola and Nigeria [3]. In Nigeria cashew production is mainly concentrated in 27 States with increased production from 30,000 MT in 1990 to 836,500 MT in 2012 [4]. Cashew nut shell liquid (CNSL) is a by-product of the cashew processing industry. The cashew nut liquid is extracted from the cashew nut’s shell and represents approximately 25 % of the cashews weight and 30-35 % of the nut shells weight [2]. It is a cheap and renewable raw material with many industrial applications in polymer-based industries, synthesis of chemicals and intermediates including bactericides, insecticides and surface active agents [5]. CNSL industrial versatility is as a result of the phenolic constituents such as anacardic acid, cardanol and cardol that easily react forming various derivatives including polymers and resins [6]. In industry, CNSL polymers and resins are widely employed as friction materials, surface coating, adhesives, laminates, rubber compounding, flame retardants, and anticorrosive paints [7]. They are also recently studied as rubber plasticizers [8] and antioxidant [9], in polyurethanes synthesis [10], in the cure of epoxy resin [11], and in well-known phenol formaldehyde resin [12].

Its common use in the coating industry is in the form of alkyd and epoxy resins in oil based paint formulation as binder and a curing agent to give a wide range of properties.

In the production and application of paint system, foam formation is an undesired side effect that arise. The resultant effect is an increase in production time, difficulty in filling paint vessels with the correct quantity of paint and surface defects such as craters and weak points in dried film [13]. For this reason, defoaming agents such as mineral and silicone oils, are added to prevent these problems. The most commonly used defoaming agent in the paint industry is Polydimethyl Siloxane, a mineral-organic polymer of the siloxane family. This study therefore reports the evaluation of cashew nut shell liquid (CNSL) as a potential natural defoamer in the formulation of paints.

MATERIALS AND METHOD

Materials
Cashew (Anacardium occidentale Linn) nuts (procured from local cashew traders along
the Abuja-Keffi Road, Nigeria), laboratory mortar and pestle, Soxhlet extractor, Abbe Refractometer, NDJ 5S type of viscometer, Finnigan GC 8000 series interfaced with a Voyager Electron Impact-Mass Selective Detector on RTX-5MS column, pH meter (Hanna Instruments Model 211 Microprocessor), reflux condenser, water bath. All reagents used for this analysis are of analytical grade.

Methods

Extraction of Cashew Nut Shell Liquid (CNSL)
The cashew nut was sundried for 14 days, washed and bi-sectioned with manual cashew cracker to separate the nut shell from the kernel. The cashew nut shells were ground using a laboratory mortar and pestle. The extraction was conducted using Soxhlet apparatus and n-hexane as the extracting solvent. The extraction was done for 8 h and the extracted CNSL was stored in a laboratory sample bottle prior to analysis.

Determination of Refractive index
Measurement of the refractive index of the sample was done by means of Abbe Refractometer at 30.6 °C using the method of AOAC (2000).

Determination of Viscosity
The viscosity measurement was carried out at 30 °C by means of NDJ 5S type of viscometer. Rotor 1 was used at the speed of 60 rpm for the determination of viscosity of the CNSL samples.

Determination of pH
Measurement of pH was done using pH meter (Hanna Instruments Model 211 Microprocessor). The pH meter was calibrated using buffer 7 and readings were obtained by inserting the probe of the pH meter into CNSL.

Gas Chromatography - Mass Spectrometer
Gas Chromatography - Mass Spectrometer (GC - MS) analysis was carried out using a Finnigan GC 8000 series, interfaced with a Voyager Electron Impact-Mass Selective Detector, on RTX-5MS column. Sample (1 mg) was dissolved in 10 mL of dichloromethane and 1 μL of this solution was injected into the GC - MS. The temperature was programmed from 50 to 250°C at 10°C/ min and maintained at 250°C for 30 min.

Determination of Specific Gravity
The specific gravity was determined according to AOAC (2000) using pyncometer bottle.

Determination of Acid Value, Saponification value, Iodine value and Free Fatty Acid
The Acid, Saponification, Iodine and Free Fatty Acid values were obtained the method of IPAN (2003).

RESULTS AND DISCUSSION
The results of the physicochemical properties of the extracted CNSL are presented in Table I. The appearance of the final extract was dark brown and can be termed industrial grade similar to reports in literature [3, 14, 7, 15]. The percentage
The yield of the sample was 64.07%, the sample was viscous in nature and the refractive index was 1.53 which indicated that the oil is a little bit thicker when compared with most non-drying oils [16, 17]. The value of the refractive index also compared favourably with polydimethylsiloxane (1.4), a commonly used inorganic defoamer [18] and linseed oil (1.47) which is being used as an organic defoaming agent in paint formulation [19].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CNSL</th>
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<tbody>
<tr>
<td>% Yield</td>
<td>64.07</td>
</tr>
<tr>
<td>Appearance</td>
<td>Dark brown liquid</td>
</tr>
<tr>
<td>Nature</td>
<td>Viscous</td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.53</td>
</tr>
<tr>
<td>Viscosity at 27 °C (mPa.s)</td>
<td>38.5</td>
</tr>
<tr>
<td>Specific gravity (g/cm³)</td>
<td>0.99</td>
</tr>
<tr>
<td>pH</td>
<td>4.29</td>
</tr>
<tr>
<td>Saponification value (MgKOH/g)</td>
<td>105.85</td>
</tr>
<tr>
<td>Iodine value (Wijs)</td>
<td>121.93</td>
</tr>
<tr>
<td>Acid value (MgKOH/g)</td>
<td>124.85</td>
</tr>
<tr>
<td>Free fatty Acid (MgKOH/g)</td>
<td>60.92</td>
</tr>
</tbody>
</table>

The viscosity of polydimethylsiloxane (PDMS) ranged from 15-50,000 Centistoke depending on its end use, and the viscosity of the extracted CNSL (38.5 mPa.s) falls within the range of PDMS industrial applications [20]. The specific gravity (0.99 g/cm³) compared favourably with linseed oil (0.93 g/cm³), an organic defoamer; and polydimethylsiloxane (1.04 g/cm³), an inorganic defoamer used in paint formulation [21]. The saponification and iodine values for linseed oil were reported to be 188 mgKOH/g and 170 Wijs while 105.85 MgKOH/g and 121 Wijs were reported for the extracted CNSL [19, 3, 15]. The pH (4.29) reported in this work confirms the presence of anacardic acid in CNSL which gives the liquid its antimicrobial properties [22].

Fig. 1 shows the main lines (1-15) as observed from the GC-MS analysis of the CNSL. Six different compounds (Hit 1-6) were detected in the mass spectrum of each of the lines as presented in Figs 2-16.
Fig. 1: GC-MS chromatograph of cashew nut shell liquid

From the mass spectra, the main constituents identified were cardanols (monounsaturated cardanol peak of 302; di-unsaturated cardanol peak of 300 at lines 8, 9 and 10; and saturated cardanol peak of 304 at line 6 in Hits 1, 2, and 5). Other relative abundant constituents identified were cardols: saturated cardol at 316 in Line 12.
Fig. 2: Line 1 mass spectra of cashew nut shell liquid
Fig. 3: Line 2 mass spectra of cashew nut shell liquid
Fig. 4: Line 3 mass spectra of cashew nut shell liquid
Fig. 5: Line 3 mass spectra of cashew nut shell liquid
Fig. 6: Line 5 mass spectra of cashew nut shell liquid
Fig. 7: Line 6 mass spectra of cashew nut shell liquid
Fig. 8: Line 7 mass spectra of cashew nut shell liquid
Fig. 9: Line 8 mass spectra of cashew nut shell liquid
Fig. 10: Line 9 mass spectra of cashew nut shell liquid
Fig. 11: Line 10 mass spectra of cashew nut shell liquid
Fig. 12: Line 11 mass spectra of cashew nut shell liquid
Fig. 13: Line 12 mass spectra of cashew nut shell liquid
Fig. 14: Line 13 mass spectra of cashew nut shell liquid
Fig. 15: Line 14 mass spectra of cashew nut shell liquid
Fig. 16: Line 15 mass spectra of cashew nut shell liquid
CONCLUSION
The results of this study indicate that CNSL could be used as a defoamer for the prevention of foam during production and application of paint systems as its properties are in consonance with conventional defoamers like polydimethylsiloxane and Linseed oil used in paint formulations.

REFERENCES


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