Study of Physiochemical and Properties of CNSL based Termiticides

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Abstract— *Cashew nut shell liquid based termiticides using neem seed oil, karanj seed oil and bhilawan shell liquid, were developed and the effect of formulations on acid value, Iodine value, saponification value and unsaponifiable matter of CNSL termiticides was studied. It was observed that CNSL based termiticides were oil based therefore the acid value, Iodine value, saponification value, unsaponifiable matter, flash point, fire point, refractive index, specific gravity, viscosity and colour properties of CNSL, Neem seed oil, Karanj seed oil and Bhilawan shell liquid were reflected in the termiticide formulations with respect to the temperature.*

Keywords— termiticide, CNSL, Cashew nut.

I. INTRODUCTION

Termites are now a day becoming nuisance to urban as well as rural areas causing loss of crores of rupee world over. Hazardous and costly chemicals are being used to control the termites which are leading to dreadful diseases. Therefore, Termiticides are applied to wood furniture and other articles made of wood by brush and by dipping in solutions. Termiticide solutions are absorbed in upper layer of wood articles but may be affected by temperature and humidity. The influence of atmospheric temperature on physicochemical properties of oils may affect the mixing of oils, forming uniform coat on the surface of wood samples and absorption of solution by wood samples when dipped in it. Chemical properties of these termiticides may be responsible for the retaining of termiticide inside the wood articles and become resistant to termites. the study on '**Development of Cashew Nut Shell Liquid based Termiticide'** was undertaken in the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. BSKKV, Dapoli with the objective to study the effect of temperature on some physicochemical properties of Cashew Nut Shell Liquid, Neem seed oil, Karanj oil and Bhilawan Shell Liquid.

II. MATERIALS AND METHODS

Cashew nut shell liquid based termiticides were made by using CNSL, Neem seed oil, Karanj seed oil and Bhilawan shell liquid in different combinations as shown in Table 1.Acid value, Iodine value, saponification value and unsaponifiable matter, flash point, fire point, refractive index, specific gravity, viscosity and colour properties of sixteen termiticides (TO_1 to TO_{16}) were determined by following standard procedure given in Table 2 and effect of formulation was studied in the field testing to know the efficacy of formulation as termiticide. The laboratory analysis was carried out in the NATP Laboratory in the College of Agricultural Engineering and Technology and Dept. of Agricultural Chemistry and Soil Science, Dr. BSKKV, Dapoli, Babasaheb Ambedkar Technical University, Lonare, Annasaheb Shinde College of Agricultural Engineering and Technology, MPKV, Rahuri and Insta, PolluTech Lab, Pune.

TABLE 1
TREATMENTS OF OIL FORMULATED CNSL BASED TERMITICIDE

No.	Treatment	Oils			
		CNSL (%)	NSO (%)	KSO (%)	BSL (%)
1	TO_1	100	0	0	0
2	TO_2	0	100	0	0
3	TO_3	0	0	100	0
4	TO_4	0	0	0	100
5	TO_5	80	10	10	0
6	TO_6	80	10	0	10
7	TO_7	80	0	10	10
8	TO_8	70	15	15	0
9	TO_9	70	15	0	15
10	TO_{10}	70	0	15	15
11	TO_{11}	60	20	20	0
12	TO_{12}	60	20	0	20
13	TO_{13}	60	0	20	20
14	TO_{14}	50	25	25	0
15	TO_{15}	50	25	0	25
16	TO_{16}	50	0	25	25

(TO- Treatment of oil formulation, CNSL- Cashew nut shell liquid, NSO- Neem seed oil, KSO- Karanj seed oil, BSL- Bhilawan shell liquid)

2.1 Acid Value

Acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat. It is a relative measure of rancidity as free fatty acids, normally formed during decomposition of oil glycerides, which has an adverse effect on the quality of many lipids. The value is also expressed as percent of free fatty acids calculated as oleic acid. Acid value of oil formulated termiticides was determined as per 'ISO 660: 1996'.

2.2 Iodine Value

The Iodine value of an oil/fat is the number of grams of iodine absorbed by 100g of oil/fat. The Iodine value of oil formulated termiticides was determined by using Wijs solution as per the 'AOAC 2000'.

2.3 Saponification Value

The saponification value is the quantity of potassium hydroxide (KOH) required saponifying 1g of oil. Saponification value of oil formulated termiticides was determined as per the 'AOAC, 2000'.

2.4 Unsaponifiable Matter

The unsaponifiable matter is defined as the substances soluble in oil which after saponification are insoluble in water but soluble in the solvent used for the determination. Unsaponifiable matter of oil formulated termiticides was determined as per the 'AOAC 2000'.

2.5 Flash point

Flash point is the temperature at which the sample will flash when a test flame is applied under the conditions specified for the open cup Cleveland test. It is taken as the lowest temperature at which the application of the test flame causes the vapour above the sample to ignite momentarily. Flash point of oil formulated termiticides was determined as per the 'I.S. 1448–1970' except that of BSL which was determined as per 'IS 1448 (P: 21) 1992'(Fig. 1)

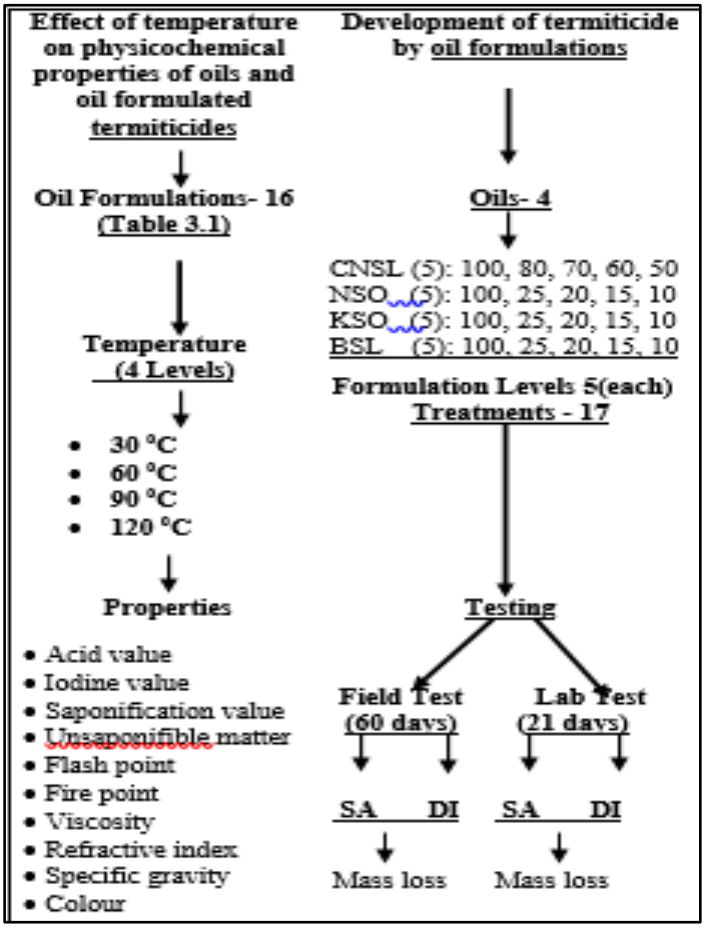

FIG. 1. Experimental design.

(FT – Field Test, LT – Laboratory Test, SA – Surface application, DI – Dipping method)

TABLE 2
METHODS FOR DETERMINATION OF PHYSICOCHEMICAL PROPERTIES OF OIL FORMULATED TERMITICIDES.

Sr. No.	Property	Method
1	Acid Value	ISO 660:1996
2	Iodine Value	AOAC, 2000
3	Saponification Value	AOAC, 2000
4	Unsaponifiable Matter	AOAC, 2000
5	Flash Point	IS 1448 – 1970, IS 1448 (P:21) 1992
6	Fire Point	IS1448 – 1970, IS 1448 (P:69) 1969
7	Viscosity	ISO 2555:1989
8	Refractive Index	AOAC, 2000
9	Specific Gravity	AOAC, 2000
10	Colour	I.S. 548(Part 1) - 1964

2.6 Fire point

The fire point is the lowest temperature at which the application of test flame causes the material to ignite and burn at least for 5 seconds under specified conditions of the test. After flash point, heating should be continued at such a rate that the increase in temperature recorded by the thermometer is neither less than 5 degrees Celsius nor more than 6 degrees Celsius per minute. The test flame was lighted and adjusted so that it is of the size of a bead 4 mm in diameter. Fire point of oil formulated termiticides was determined as per the 'I.S. 1448–1970' and fire point of BSL was determined as per 'IS 1448 (P:69) 1969'(Fig. 2b).

2.7 Viscosity

Viscosity is a measure of resistance to flow of a fluid. Although molecules of a fluid are in constant random motion, the velocity in a particular direction is zero unless some force is applied to cause fluid to flow. The magnitude of the force needed to induce flow at a certain velocity is related to the viscosity of a fluid. Viscosity of oil formulated termiticides was determined at different temperatures (30, 60, 90 and 120^{0}C) by using Brookfield Viscometer as per the 'ISO 2555:1989' (Fig. 3)

a. Flash Point **b. Fire Point**

FIG. 2: Flash point and fire point Testing (Open cup Cleveland Test).

FIG. 3: Brookfield Viscometer

2.8 Refractive index

The ratio of velocity of light in vacuum to the velocity of light in the oil or fat; more generally, it expresses the ratio between the sine of angle of incidence to the sine of angle of refraction, when a ray of light of known wave length (usually 589.3 nm, the mean of D lines of sodium) passes from air into the oil or fat. Refractive index of oil formulated termiticides was determined at different temperatures (30, 60, 90 and 120 ^{0}C) as per the 'AOAC 2000' by using ATAGO Refractometer (Fig. 4).

FIG. 4: Refractometer

2.9 Specific gravity

Specific gravity is the ratio of weight of oil at 30 ^{0}C to the weight of water at 30 ^{0}C. Specific gravity of oil formulated termiticides was determined by the formula given below

$$\text{Specific gravity of oil at } 30\ ^{0}\text{C} = \frac{A-B}{C-D} \quad (1)$$

Where,

A = weight in gm of specific gravity bottle with oil at 30 ^{0}C

B = weight in gm of specific gravity bottle at 30 ^{0}C

C = weight in gm of specific gravity bottle with water at 30 ^{0}C

Specific gravity of oils was determined at different temperatures (30, 60 and 90 ^{0}C) as per the 'AOAC, 2000.

2.10 Colour

The colour (L*, a* and b* values) of oil formulated termiticides was determined by using Colour Flex Meter. L* indicates the lightness and extends from 0 (black) to 100(white). The other two coordinates a* and b* indicate redness (+a) to greenness (-a) and yellowness (+b) to blueness (-b), respectively. The colour is expressed as the sum total of the yellow and red slides used to match the colour of the specimen oil sample. Colour of oils and oil formulated termiticides was determined by Colour Flex Meter as per the 'I.S. 548(part 1)-1964'. The colour values of oil formulated termiticides were determined at 30, 60, 90 and 120 ^{0}C temperatures.

III. RESULTS AND DISCUSSION

3.1 Acid Value

Table 3 shows that acid values of CNSL (TO_1), NSO (TO_2), KSO (TO_3) and BSL (TO_4) were found 98.20, 5.90, 21.90 and 20.80 mg of KOH/g of oil, respectively. The acid value of CNSL was found the highest and that of NSO the lowest among four pureoils. IS:840-(1986), Djibril *et al*. (2015), Bobade and Khyade (2012) and Chopra and Chopra (1956) have observed the similar results of acid value of CNSL. NSO, KSO and BSL, respectively. Acid value of oils was reflected in the formulations of termiticides (TO_5 to TO_{16}) and observed in the range of 50.70 to 80.76 mg of KOH/g of oil. The acid value of termiticide TO_7 was the highest i.e. 82.76 mg of KOH/g of oil and that of TO_{14} it was 51 mg of KOH/g of oil among all termiticides. It is a relative measure of rancidity as free fatty acids, are normally formed during decomposition of oil glycerides, which is observed as acid value in mg of KOH/g of oil.

TABLE 3
ACID AND IODINE VALUE OF OIL FORMULATED TERMITICIDES.

Sr. No.	Treatment	Formulation CNSL:NSO:KSO:BSL	Acid Value (mg of KOH/g of oil)	Iodine Value mg of Iodine/100 g of oil
1	TO_1	100:0:0:0	98.20	266.70
2	TO_2	0:100:0:0	5.90	81.28
3	TO_3	0:0:100:0	21.90	85.09
4	TO_4	0:0:0:100	20.80	121.92
5	TO_5	80:10:10:0	81.36	229.30
6	TO_6	80:10:0:10	81.16	232.80
7	TO_7	80:0:10:10	82.76	233.30
8	TO_8	70:15:15:0	72.67	210.70
9	TO_9	70:15:0:15	72.64	216.70
10	TO_{10}	70:0:15:15	74.74	216.70
11	TO_{11}	60:20:20:0	64.52	193.00
12	TO_{12}	60:20:0:20	64.32	200.00
13	TO_{13}	60:0:20:20	67.52	201.00
14	TO_{14}	50:25:25:0	51.00	175.50
15	TO_{15}	50:25:0:25	50.70	180.50
16	TO_{16}	50:0:25:25	54.70	182.50

(TO-Oil Formulation Treatment, CNSL- Cashew nut shell liquid, NSO- Neem seed oil, KSO- Karanj seed oil, BSL- Bhilawan shell liquid)

3.2 Iodine Value

Table 3 shows that Iodine value of CNSL (TO_1), NSO (TO_2), KSO (TO_3) and BSL (TO_4) were found 266.70, 81.28, 85.09 and 121.92 mg of Iodine/100 g of oil, respectively. The Iodine value of CNSL was found the highest and that of NSO the lowest among the four pure oils. Asogwa *et al*. (2007), Djibril *et al*. (2015), Bobade and Khyade (2012) and Chopra and Chopra (1956) have also observed the similar results of Iodine value of CNSL. NSO, KSO and BSL, respectively. Iodine value of oils was reflected in the formulations of termiticides (TO_5 to TO_{16}) and observed in the range of 175.50 to 233.30 mg of Iodine/100 g of oil. Iodine value of termiticideTO_7 was the highest 233.3 mg of Iodine/100 g of oil and that of TO_{14} the lowest i.e. 175.5 mg of Iodine/100 g of oil among all oil formulated termiticides.

3.3 Saponification Value

Table 4 shows that the saponification value of CNSL (TO_1), NSO (TO_2), KSO (TO_3) and BSL (TO_4) was 123.20, 156.80, 184.80 and 196.00 mg of KOH/g oil, respectively. It was found the highest in BSL and in CNSL the lowest among four pure oils. Mukhopadhyaya*et al*. (2010), Djibril et al. (2015), Bobade and Khyade (2012) and Chopra and Chopra (1956) have also observed the similar results of saponification value of CNSL. NSO, KSO and BSL, respectively. The saponification value of the oils was reflected in the formulations of termiticides(TO_5 to TO_{16}) and observed in the range of 133 to 196 mg of KOH/g oil. The saponification value of formulation TO_5 was observed the lowest i.e.133mg of KOH/g oil and that of TO_{15} the highest i.e.196 mg of KOH/g oil, among all oil formulated termiticides.

3.4 Unsaponifiable Matter

Table 4 shows that the unsaponifiable matter in the CNSL (TO_1), NSO (TO_2), KSO (TO_3) and BSL (TO_4) was 1.036, 1.285, 2.885 and 6.36 percent, respectively. It was found the highest in BSL (TO_4) i.e. 6.36 per cent and that of the CNSL (TO_1) the lowest among four oil formulations (TO_1 to TO_4) (pure oils). Prasad (2014), Puri (1999), Bobade and Khyade (2012), Chopra and Chopra (1956) have also observed the similar results of unsaponifiable matter in CNSL NSO, KSO and BSL, respectively. The unsaponifiable matter in oils was reflected in formulations of termiticides(TO_5 to TO_{16}) and observed in the range of 0.417 to 2.311 percent. The unsaponifiable matter in oil formulation TO_5 was the lowest i.e. 0.417 percent and that in TO_{16} it was the highest i.e. 2.311 percent among all formulations.

TABLE 4
SAPONIFICATION VALUE OF OIL FORMULATED TERMITICIDES.

Sr. No.	Treatment	Formulation CNSL:NSO:KSO:BSL	Saponification Value (mg of KOH/g of oil)	Unsaponifiable Matter (%)
1	TO_1	100:0:0:0	123	1.036
2	TO_2	0:100:0:0	157	1.285
3	TO_3	0:0:100:0	185	2.885
4	TO_4	0:0:0:100	196	6.36
5	TO_5	80:10:10:0	133	0.417
6	TO_6	80:10:0:10	134	0.765
7	TO_7	80:0:10:10	137	0.925
8	TO_8	70:15:15:0	137	0.625
9	TO_9	70:15:0:15	139	1.147
10	TO_{10}	70:0:15:15	143	1.387
11	TO_{11}	60:20:20:0	142	0.814
12	TO_{12}	60:20:0:20	144	1.529
13	TO_{13}	60:0:20:20	150	1.829
14	TO_{14}	50:25:25:0	147	1.042
15	TO_{15}	50:25:0:25	196	1.911
16	TO_{16}	50:0:25:25	157	2.311

(TO-Oil Formulation Treatment, CNSL- Cashew nut shell liquid, NSO- Neem seed oil, KSO- Karanj seed oil, BSL- Bhilawan shell liquid)

3.5 Flash point

Table 5 shows that flash point of CNSL (TO_1), NSO (TO_2), KSO (TO_3) and BSL (TO_4) were 216, 174, 224 and 269^{0}C, respectively. The flash point of BSL was the highest (269 ^{0}C) and that of NSO the lowest (174 ^{0}C) among four pure oils. Prasad (2014[c]), Djibril *et al*. (2015[e]), Bobade and Khyade (2012[g]), have reorted the similar results of flash point of CNSL, NSO and KSO, respectively. It was observed that BSL was not tried for its usefulness in fuel hence no reference was found for flash point. The flash point of oils was reflected in termiticides (TO_5 to TO_{16}) and observed in the range of 188 to 220 ^{0}C. Flash point of termiticide TO_8 was found the highest (220 ^{0}C) and that of T_{14} the lowest (188 ^{0}C) among all the termiticides. Flash point indicates the sensitivity of formulation at high temperature to ignite during handling and storage. Flash point of all the termiticides was in the range of 174 to 269 ^{0}C i.e. at quite safe level.

3.6 Fire point

Table 5 shows that fire point of CNSL (TO_1), NSO (TO_2), KSO (TO_3) and BSL (TO) be 221, 181, 229 and 280^{0}C, respectively. The fire point of BSL was the highest and that of NSO the lowest among four pure oils. Prasad (2014[d]), Djibril *et al*. (2015[f]), Bobade and Khyade (2012[h]), have reported similar results of fire point in CNSL, NSO and KSO, respectively. It was observed that BSL was not tried for its usefulness in fuel hence no reference was found for fire point. The fire point of oils was reflected in termiticides (TO_5 to TO_{16}) and observed in the range of 195 to 236^{0}C. Fire point of termiticide TO_{10} was found the highest (236^{0}C) and that of TO_{14} the lowest (195^{0}C) among all the oil formulated termiticides. Fire point indicates the sensitivity of formulation at high temperature to catch fire in the handling and storage. Flash point of all the formulations was in the range of 181 to 280^{0}C i.e. at quite safe level.

TABLE 5
FLASH POINT AND FIRE POINT OF OIL FORMULATED TERMITICIDES.

Sr. No.	Treatment	Formulation CNSL : NO : KO : BSL	Flash Point (^{0}C)	Fire Point (^{0}C)
1	TO_1	100:0:0:0	216	221
2	TO_2	0:100:0:0	174	181
3	TO_3	0:0:100:0	224	229
4	TO_4	0:0:0:100	269	280
5	TO_5	80:10:10:0	204	211
6	TO_6	80:10:0:10	198	204
7	TO_7	80:0:10:10	206	229
8	TO_8	70:15:15:0	220	226
9	TO_9	70:15:0:15	202	233
10	TO_{10}	70:0:15:15	195	236
11	TO_{11}	60:20:20:0	205	208
12	TO_{12}	60:20:0:20	203	220
13	TO_{13}	60:0:20:20	200	214
14	TO_{14}	50:25:25:0	188	195
15	TO_{15}	50:25:0:25	190	197
16	TO_{16}	50:0:25:25	197	200

(TO - Oil formulation treatment, CNSL- Cashew nut shell liquid, NSO - Neem seed oil, KSO - Karanj seed oil, BSL- Bhilawan shell liquid)

3.7 Viscosity

Table 6 shows that viscosity of CNSL (TO_1), NSO (TO_2), KSO (TO_3)and BSL (TO_4) was observed 562, 89, 32 and 1070 cP, at 30 ^{0}C, respectively and was found to be decreased to 395, 5, 4 and 422 with increase in temperature from 30 to 120 ^{0}C. The viscosity of BSL was found the highest and that of KSO the lowest among four pure oils. Viscosity of NSO was found to be decreased 94.38% with increase in the temperature from 30 to 120 ^{0}C. Asogwa *et al*. (2007[c]), Djibril *et al*. (2015[h]), Bobade and Khyade (2012[i]), and Lad *et al*. (2016[b]) have also observed the similar results of viscosity of CNSL. NSO, KSO and BSL, respectively. The viscosity of oils was reflected in termiticides (TO_5 to TO_{16}) and observed in the range of 296 to 1070 cP in the temperature range of 30 to 120 ^{0}C. The viscosity of termiticide TO_{15} was the highest i.e. 838, 782, 539 and 495 cP and that of the TO_{14} the lowest i.e. 311, 293, 267 and 234 cP at 30, 60, 90 and 120 ^{0}C, respectively among oil formulated termiticides. All the oils melt at higher temperatures therefore the viscosity of oil formulated termiticides was found decreased with increasing temperature from 30 to 120 ^{0}C.

TABLE 6
EFFECT OF TEMPERATURE ON VISCOSITY OF OIL FORMULATED TERMITICIDES.

Sr. No.	Treatment	Formulation CNSL:NSO:KSO:BSL	Viscosity (cP) Temperature (^{0}C)				Response to temperature (%)
			30	60	90	120	
1	TO_1	100:0:0:0	562	475	448	395	29.72
2	TO_2	0:100:0:0	89	20	10	5	94.38
3	TO_3	0:0:100:0	32	12	6	4	87.50
4	TO_4	0:0:0:100	1070	890	650	422	60.56
5	TO_5	80:10:10:0	462	449	343	321	30.52
6	TO_6	80:10:0:10	673	645	489	437	35.07
7	TO_7	80:0:10:10	667	621	467	405	39.28
8	TO_8	70:15:15:0	411	385	352	318	22.63
9	TO_9	70:15:0:15	727	679	438	410	43.60
10	TO_{10}	70:0:15:15	719	688	413	391	45.62
11	TO_{11}	60:20:20:0	361	344	310	296	18.01
12	TO_{12}	60:20:0:20	783	721	474	419	46.49
13	TO_{13}	60:0:20:20	771	705	458	401	47.99
14	TO_{14}	50:25:25:0	311	293	267	234	24.76
15	TO_{15}	50:25:0:25	838	782	539	495	40.93
16	TO_{16}	50:0:25:25	824	781	516	473	42.60

(TO - Oil formulation treatment, CNSL- Cashew nut shell liquid, NSO - Neem seed oil, KSO - Karanj seed oil, BSL- Bhilawan shell liquid)

3.8 Refractive index

Table 7 shows that refractive index of BSL (TO_4) was the highest i.e. 1.526, 1.510, 1.504 and 1.489 and that of KSO (TO_3) the lowest i.e.1.423, 1.411, 1.406 and 1.391 at the temperatures 30, 60, 90 and 120 ^{0}C, respectively among the four pure oils. Mukhopadyaya *et al*. (2010[b]), Djibril *et al*. (2015[j]), Bhalerao and Sharma (2014), and Lad *et al*. (2016) have also observed the similar results of refractive index of CNSL. NSO, KSO and BSL, respectively. Refractive index value of pure oils was found reflected in all the oil formulated termiticides. Among termiticides the highest refractive index was recorded in TO_6, i.e. 1.510, 1.504, 1.499 and 1.469 and the lowest in the termiticide TO_{14} i.e. 1.479, 1.472, 1.465 and 1.434, at 30, 60, 90 and 120 ^{0}C temperatures, respectively. The refractive index values of all the oil formulated termiticides were found the highest at 30 ^{0}C and then decreased with increase in the temperature from 30 to 120 ^{0}C.

3.9 Specific gravity

Table 8 shows that the specific gravity values 0.9867, 0.9848 and 0.9828 of BSL(TO_4) were the highest and that of KSO (TO_3) the lowest i.e. 0.9325, 0.9324 and 0.9322, at the temperatures 30, 60 and 90 ^{0}C, respectively among the four oils. Asogwa *et al*. (2007[d]), Djibril *et al*. (2015[k]), Bobade and Khyade (2012[k]), and Chopra and Chopra (1956[f]) have also observed the similar results of viscosity of CNSL. NSO, KSO and BSL, respectively. Among oil formulated termiticides from TO_5 to TO_{16}, the specific gravity values of the TO_{15} were found the highest i.e. 0.9657, 0.9485, and 0.9347; and that of TO_{14} the lowest i.e. 0.9428, 0.9232 and 0.9077 at the temperatures 30, 60 and 90 ^{0}C, respectively. The specific gravity of all the oil formulated termiticides was found decreased with increase in the temperature from 30 to 90 ^{0}C. With increase in temperature the molecules of oil formulated termiticides melted due to which its specific gravity was decreased.

TABLE 7
EFFECT OF TEMPERATURE ON REFRACTIVE INDEX OF OIL FORMULATED TERMITICIDES.

Sr. No.	Treatment	Formulation	Refractive Index				Response to temperature (%)
			Temperatures (°C)				
		CNSL : NO : KO : BSL	30	60	90	120	
1	TO_1	100:0:0:0	1.512	1.508	1.486	1.471	2.71
2	TO_2	0:100:0:0	1.471	1.462	1.448	1.443	1.90
3	TO_3	0:0:100:0	1.423	1.411	1.406	1.391	2.25
4	TO_4	0:0:0:100	1.526	1.510	1.504	1.489	2.42
5	TO_5	80:10:10:0	1.499	1.494	1.49	1.459	2.67
6	TO_6	80:10:0:10	1.510	1.504	1.499	1.469	2.72
7	TO_7	80:0:10:10	1.505	1.499	1.495	1.464	2.72
8	TO_8	70:15:15:0	1.491	1.486	1.481	1.453	2.55
9	TO_9	70:15:0:15	1.507	1.501	1.495	1.468	2.59
10	TO_{10}	70:0:15:15	1.500	1.494	1.489	1.46	2.67
11	TO_{11}	60:20:20:0	1.496	1.479	1.473	1.448	3.21
12	TO_{12}	60:20:0:20	1.506	1.499	1.493	1.467	2.59
13	TO_{13}	60:0:20:20	1.507	1.489	1.485	1.457	3.32
14	TO_{14}	50:25:25:0	1.479	1.472	1.465	1.814	3.04
15	TO_{15}	50:25:0:25	1.505	1.497	1.49	1.467	2.52
16	TO_{16}	50:0:25:25	1.492	1.483	1.479	1.454	2.55

(TO - Oil formulation treatment, CNSL- Cashew nut shell liquid, NSO - Neem seed oil, KSO- Karanj seed oil, BSL- Bhilawan shell liquid)

3.10 Colour

Table 9 shows that the DL*(+ whiteness and –blackness) values of all the oils (TO_1 to TO_4) and oil formulated termiticides (TO_5 to TO_{16}) were negative showing colour darkness (blackness). The oil KSO (TO_3) was having the least darkness values (-63.15) among all the oil formulated termiticides and it was seconded by NSO (TO_2) (-71.26) at 30 ^{0}C. DL* value was decreased in KSO (TO_3) initially when heated from 30 to 90 ^{0}Cand then found increased at 120 ^{0}C. Darkness values of TO_1, TO_2 and TO_4 were increased with increase in temperature from 30 to 120 ^{0}C. The Da*(+ redness and – greenness) value of CNSL, NSO and BSL and all oil formulations was less green whereas that of KSO it was 11.65 i.e. reddish. The Da*(+ redness and – greenness) value of CNSL was observed decreased, of NSO increased and of BSL slightly increased where as that of KSO it was increased with increase in temperature from 30 to 120 ^{0}C.

The Db* (+yellowness and – blueness) value of CNSL, NSO and BSL and all oil formulated termiticides was bluish whereas that of KSO it was (11.06) yellowish. With increase in temperature from 30 to 120 ^{0}C, the yellowness of KSO was increased (from 11.06 to 19.68), blueness of NSO slightly increased and that of CNSL and BSL blueness was increased. The reflection of colour values of oils is clearly observed in all the oil formulated termiticides with slight differences at the temperatures from 30 to 120 ^{0}C. Asogwa et al. (2007[e]), Djibril et al. (2015[l]), Bobade and Khyade (2012[l]), and Chopra and Chopra (1956[g]) have also observed the similar results of colour values of CNSL, NSO, KSO and BSL, respectively.

TABLE 8
EFFECT OF TEMPERATURE ON SPECIFIC GRAVITY OF OIL FORMULATED TERMITICIDES.

Sr. No.	Treatment	Formulation	Specific Gravity			Response to temperature (%)
			Temperature (°C)			
		CNSL : NO : KO : BSL	30	60	90	
1	TO_1	100:0:0:0	0.948	0.942	0.939	0.94
2	TO_2	0:100:0:0	0.938	0.937	0.933	0.50
3	TO_3	0:0:100:0	0.933	0.932	0.932	0.03
4	TO_4	0:0:0:100	0.987	0.985	0.983	0.40
5	TO_5	80:10:10:0	0.950	0.940	0.930	1.54
6	TO_6	80:10:0:10	0.960	0.950	0.930	3.43
7	TO_7	80:0:10:10	0.950	0.930	0.910	3.51
8	TO_8	70:15:15:0	0.950	0.940	0.920	2.91
9	TO_9	70:15:0:15	0.960	0.940	0.940	2.45
10	TO_{10}	70:0:15:15	0.950	0.940	0.92	3.78
11	TO_{11}	60:20:20:0	0.950	0.930	0.91	3.51
12	TO_{12}	60:20:0:20	0.950	0.940	0.920	3.40
13	TO_{13}	60:0:20:20	0.950	0.940	0.910	4.88
14	TO_{14}	50:25:25:0	0.940	0.920	0.910	3.72
15	TO_{15}	50:25:0:25	0.970	0.950	0.930	3.21
16	TO_{16}	50:0:25:25	0.960	0.950	0.930	3.95

(TO - Oil formulation treatment, CNSL- Cashew nut shell liquid, NSO- Neem seed oil, KSO- Karanj seed oil, BSL- Bhilawan shell liquid)

TABLE 9
EFFECT OF TEMPERATURE ON COLOUR OF OILS AND OIL FORMULATED CNSL BASED TERMITICIDES.

Treatment	Formulation CNSL:NSO: KSO:BSL	Colour difference values at 30 ^{0}C			Colour difference values at 60 ^{0}C			Colour difference values at 90 ^{0}C			Colour difference values at 120 ^{0}C		
		DL*	Da*	Db*	DL*	Da*	Db*	DL*	Da*	Db*	DL*	Da*	Db*
TO_1	100:0:0:0	-72.49	0.85	-2.26	-72.40	0.72	-2.15	-72.59	0.52	-2.18	-73.14	0.91	-2.59
TO_2	0:100:0:0	-71.26	1.48	0.08	-71.34	2.52	0.15	-71.50	1.74	-0.12	-72.53	5.70	1.11
TO_3	0:0:100:0	-63.15	11.65	13.06	-60.67	10.13	17.01	-58.74	9.44	19.68	-68.61	10.75	13.47
TO_4	0:0:0:100	-72.36	0.44	-2.35	-72.79	0.46	-2.31	-72.53	0.49	-2.35	-73.09	0.59	-2.57
TO_5	80:10:10:0	-73.36	1.13	-1.94	-72.93	1.19	-2.06	-73.52	1.48	-2.04	-73.25	1.58	-2.01
TO_6	80:10:0:10	-73.39	0.84	-1.76	-73.38	0.69	-1.34	-73.35	0.68	-1.75	-73.40	1.43	-2.46
TO_7	80:0:10:10	-72.94	1.47	-2.10	-72.95	1.27	-2.26	-72.73	1.91	-2.50	-72.46	1.81	-2.70
TO_8	70:15:15:0	-72.29	0.48	-2.55	-72.42	0.45	-2.88	-72.43	0.29	-2.93	-72.60	0.86	-3.16
TO_9	70:15:0:15	-71.99	0.80	-3.33	-72.19	0.81	-3.11	-72.17	0.59	-2.80	-72.29	0.61	-2.88
TO_{10}	70:0:15:15	-72.14	0.86	-2.88	-72.03	0.61	-2.94	-72.26	0.58	-3.10	-72.19	0.35	-2.99
TO_{11}	60:20:20:0	-71.46	0.50	-2.73	-71.72	0.70	-2.79	-71.83	0.54	-2.80	-71.65	0.66	-2.50
TO_{12}	60:20:0:20	-72.02	0.66	-3.04	-72.62	0.56	-2.98	-72.19	-0.10	-2.70	-72.36	0.76	-2.97
TO_{13}	60:0:20:20	-72.15	1.13	-3.37	-72.35	0.77	-3.33	-72.34	1.09	-2.85	-72.39	0.63	-2.60
TO_{14}	50:25:25:0	-72.06	0.33	-2.56	-72.22	0.28	-2.94	-72.31	1.06	-3.13	-72.13	0.60	-2.83
TO_{15}	50:25:0:25	-72.48	0.90	-2.91	-72.27	0.27	-2.50	-72.70	0.46	-2.94	-72.76	0.40	-2.71
TO_{16}	50:0:25:25	-72.13	0.96	-3.11	-72.42	1.17	-3.07	-72.69	0.67	-3.42	-72.65	0.63	-3.10
+DL* = Whiteness, –DL*= Blackness, +Da*= Redness, -Da*= Greenness, +Db* = Yellowness, -Db*= Blueness													

(TO - Oil formulation treatment, CNSL- Cashew nut shell liquid, NSO- Neem seed oil, KSO- Karanj seed oil, BSL- Bhilawan shell liquid)

From the results it is observed that properties of CNSL, NSO, KSO and BSL were found reflected in all the CNSL based termiticides with respect to the proportions of oils in the formulations.

IV. SUMMARY AND CONCLUSION

To search the alternatives to the chemical termiticides, CNSL based termiticides were developed by using NSO, KSO and BSL in different proportions. Physicochemical properties of sixteen formulations were determined. Effect of temperature on some properties as well as effect of proportions of oils on physicochemical properties of sixteen formulations of termiticide was studied. From the results obtained it is concluded that physicochemical properties of CNSL, NSO, KSO and BSL can be reflected in the CNSL based termiticides developed.

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