Effect of Temperature on Physical Properties of CNSL based Termiticides

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***Abstract*— *Cashew nut shell liquid based termiticides using neemseed oil, karanjseed oil and bhilawan shell liquid, were developed and the effect of 30, 60, 90 and 120 ^{0}C temperatures on viscosity, refractive index, specific gravity and colour was studied. It was observed that viscosity and refractive index of termiticides decreased with heating temperature from 30 to 120 ^{0}C, specific gravity found decreased with increase in temperature from 30, 60 and 90^{0}C. Colour of Neemseed oil became bright yellow and of Cashew nut shell liquid, Karanjseed oil and Bhilawan shell liquid became darker when heated at temperature from 30 to 120 ^{0}C. CNSL based termiticides were oil based therefore the properties of oils were reflected in the termiticide formulations with respect to the temperature.*

Keywords*— *Cashew nut shell, Termiticides , neemseed oil, karanjseed oil, bhilawan shell liquid.

I. INTRODUCTION

Use of chemicals for termite control is in huge quantity world over which adds in the problems of biotic and abiotic factors in the environment. Plant oils in the nature having termiticidal properties can be safer, cheaper and easily available alternative to the hazardous chemical termiticides in the market. Various plants like Cashew nut (*Anacardium occidental*), Neem (*Azadirachta indica*), Karanj (*Pongamia pinnata*) and Bhilawa or Markingnut (*Semecarpus anacardium Linn*.) have been found to have termiticidal properties. These trees are abundantly available in coastal and semi-arid regions of India and the world. Therefore, cashew nut shell liquid(CNSL), neemseed oil(NSO), karanjseed oil(KSO) and bhilawan shell liquid(BSL) were used to develop CNSL based termiticides to reduce the use of hazardous chemicals in agriculture as pesticides in general and for termite control in special. Sixteen formulations of CNSL (100, 80, 70, 60, 50%), NSO (10, 15, 20, 25, 100%), KSO (10, 15, 20, 25, 100%) and BSL (10, 15, 20, 25, 100%) were made to develop CNSL based termiticide. The influence of atmospheric temperature on physicochemical properties of oils used in the study 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. Hence effect of temperature on viscosity, refractive index, specific gravity and colour of CNSL based termiticides was studied. This study was conducted in the laboratories of Dept. of Agricultural Process Engineering., Dept. of Electrical and Other Energy Sources; and Dept. of Soil Science and Agricultural Chemistry, Dr. BSKKV, Dapoli, Dept. of Petrochemical Engineering in Dr. Babasaheb Ambedkar Technical University, Lonere, Dist. Raigad and Insta Pollutech Lab, Pune.

II. MATERIALS AND METHODS

Cashew Nut Shell Liquid was procured from Shri. Uma Industries, Plot. No. D-48, Addl. MIDC Kudal, At. Po. Nerur-Waghchaudi, Dsit. Sindhudurga- 416520. Neemseed oil was procured from Biocrop Agro Industries, 594/4, Shiroli MIDC, Kolhapur- 416122. Karanjseed oil was procured from Vijaya Agro Industries, Plot No. 136, A- Section Sangamner Co-Op. Industrial Estate, Ta. Sangamner, Dist. Ahmednagar- 02425-222415. Bhilawan Shell Liquid was procured from Shri. Hanmant Einathrao Kausalle, At. Po. Chincholi, Ta. Kandhar, Dist. Nanded. These were the tree born oils obtained directly from the source of production and were used in the study.

Cashew nut shell liquid based termiticides were developed by using NSO, KSO and BSL at different levels, mixed in CNSL as shown in Table 1. Two oils each time among NSO, KSO and BSL were mixed in CNSL to make up of the total of formulation 100%. The levels of first four formulations TO_1, TO_2, TO_3 and TO_4 were 100% of CNSL, NSO, KSO and BSL, respectively. In the next twelve formulations from TO_5 to TO_{16}, the levels of CNSL were 100, 80, 70, 60, 50%; and of NSO, KSO and BSL were 10,15,20 and 25 % each.

Effect of temperature on viscosity, refractive index, specific gravity and colour of CNSL based termiticides was studied by following standard procedures and methods as shown in Table 2.

TABLE 1
CNSL BASED OIL FORMULATED TERMITICIDES

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
17	TO_{17}(Control)	0	0	0	0

(TO- Treatment of oil formulation, CNSL- Cashew nut shell liquid, NSO- Neemseed oil, KSO- Karanjseed oil, BSL- Bhilawan shell liquid)

TABLE 2
METHODS USED FOR DETERMINATION OF PROPERTIES OF CNSL BASED TERMITICIDES

Sr. No.	Property	Method
1	Viscosity	ISO 2555:1989
2	Refractive Index	AOAC, 2000
3	Specific Gravity	AOAC, 2000
4	Colour	I.S. 548(Part 1) - 1964

2.1 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 CNSL based termiticides (T_1 - TO_{16}) was determined at temperatures 30, 60, 90 and 120 ^{0}C by using Brookfield Viscometer as per the 'ISO 2555:1989' in the laboratory of the Department of Agricultural Process Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering & Technology, MPKV, Rahuri and results are given in the Table 3.

2.2 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 589.3nm, the mean of D lines of sodium) passes from air into the oil or fat. Effect of temperature on refractive index of CNSL based termiticides TO_1 to $TO_{16}$was studied at temperatures 30, 60, 90 and 120 ^{0}C as per the 'AOAC 2000' in the National Agricultural Innovative Programme Laboratory, CAET, Dr. BSKKV, Dapoli by using Refractometer and results are given in the Table 4.

TABLE 3
EFFECT OF TEMPERATURE ON VISCOSITY OF CNSL BASED TERMITICIDES

Sr. No.	Treatment	Formulation CNSL:NSO:KSO:BSL	Viscosity (cP)				Response to temperature (%)
			Temperature (^{0}C)				
			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- Neemseed oil, KSO- Karanjseed oil, BSL- Bhilawan shell liquid)

TABLE 4
EFFECT OF TEMPERATURE ON REFRACTIVE INDEX OF CNSL BASED 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- Neemseed oil, KSO- Karanjseed oil, BSL- Bhilawan shell liquid)

2.3 Specific Gravity

Specific gravity is the ratio of weight of termiticide at 30 ^{0}C to the weight of water at 30 ^{0}C. Specific gravity of CNSL based termiticides TO_1 to $TO_{16}$was determined at different temperatures 30, 60 and 90 ^{0}C, as per the 'AOAC, 2000 in the laboratory of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. BSKKV, Dapoli by the formula given below

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

Where,

A = weight in gm of specific gravity bottle with termiticide 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

Results of specific gravity are shown in the Table 5.

TABLE 5
EFFECT OF TEMPERATURE ON SPECIFIC GRAVITY OF CNSL BASED 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- Neemseed oil, KSO- Karanjseed oil, BSL- Bhilawan shell liquid)

2.4 Colour

The colour (L*, a* and b* values) of CNSL based termiticides TO_1 to TO_{16} 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 CNSL based termiticides was determined at temperatures 30, 60, 90 and 120 ^{0}C, by Colour Flex Meter in the laboratory of the Department of Agricultural Process Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering & Technology, MPKV, Rahuri as per the 'I.S. 548(part 1)-1964' and results are given in the Table 6.

TABLE 6
EFFECT OF TEMPERATURE ON COLOUR OF CNSL BASED TERMITICIDES

Treatment	Formulation CNSL:NSO: KSO:BSL	Colour difference values at 30^0C			Colour difference values at 60^0C			Colour difference values at 90^0C			Colour difference values at 120^0C		
		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- Neemseed oil, KSO- Karanjseed oil, BSL- Bhilawan shell liquid)

III. RESULTS AND DISCUSSION

3.1 Viscosity

Table 3 shows that viscosity of CNSL based termiticides TO_1, TO_2, TO_3 and TO_4 was 562, 89, 32 and 1070 cP, at 30 ^{0}C, respectively and found decreased to 395, 5, 4 and 422cP, respectively with increase in temperature from 30 to 120^{0}C. The viscosity of TO_4 (BSL 100%) was found the highest and that of TO_3 (KSO 100%) the lowest among the formulations TO_1 to TO_4 (pure oils). Viscosity of TO_2 (NSO 100%) was found decreased by 94.38% with increase in the temperature from 30 to 120^{0}C. Asogwa et al. (2007), Djibril et al. (2015), Bobade and Khyade (2012), and Lad et al. (2016) have also observed the similar results of viscosity of CNSL. NSO, KSO and BSL, respectively.

The viscosity of oils was reflected in formulations of 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 formulation 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 all termiticides. All the oils melt at higher temperatures therefore the viscosity of termiticides was found decreased with increasing temperature from 30 to 120 ^{0}C.

3.2 Refractive Index

Table 4 shows that among the formulations TO_1 to TO_4 (pure oils) refractive index of termiticide TO_4 (BSL) was the highest i.e. 1.526,1.510, 1.504 and 1.489 and that of TO_3 (KSO)the lowest i.e.1.423, 1.411, 1.406 and 1.391 at the temperatures 30, 60, 90 and 120 ^{0}C, respectively. Mukhopadyaya et al. (2010), Djibril et al. (2015), 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 values of oils were reflected in all the termiticides from TO_5 toTO_{16}. Among termiticides from TO_5 toTO_{16}, refractive index of termiticide TO_6 was the highest, i.e. 1.510, 1.504, 1.499 and 1.469 and that of TO_{14} the lowest 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 termiticides were found the highest at 30 ^{0}C and then decreased with increase in the temperature from 30 to 120 ^{0}C.

3.3 Specific Gravity

Table 5 shows that among the formulations TO_1 to TO_4 (pure oils), the specific gravity of TO_4(BSL) was the highest i.e. 0.987, 0.985 and 0.983 and that of TO_3 (KSO) the lowest i.e. 0.933, 0.932 and 0.932 at the temperatures 30, 60 and 90 ^{0}C, respectively. Asogwa et al. (2007), Djibril et al. (2015), Bobade and Khyade (2012), and Chopra and Chopra (1956) have also observed the similar results of specific gravity of CNSL. NSO, KSO and BSL, respectively.

Among termiticides from TO_5 to TO_{16}, the specific gravity values of the TO_{15} were found the highest i.e. 0.970, 0.950, and 0.930 and that of TO_{14} the lowest i.e.0.940, 0.920 and 0.910. The specific gravity of all the formulations from TO_1 to TO_{16} was found decreased with increase in the temperature from 30 to 90 ^{0}C. With increase in temperature the molecules of oils intermiticides melted due to which its specific gravity was decreased.

3.4 Colour

Table 6 shows that the DL*(+ whiteness and –blackness) values of all the termiticides (TO_5 to TO_{16}) were negative showing colour darkness (blackness). The TO_3 (KSO) was having the least darkness values (-63.15) among all the oil formulated termiticides and it was seconded by TO_2 (NSO) (-71.26) at 30 ^{0}C. DL* value was decreased in TO_3 (KSO) initially when heated from 30 to 90 ^{0}C and then found increased at 120 ^{0}C. Darkness value 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. This value of CNSL was observed decreased, of NSO increased and of BSL slightly increased while 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 degree Celsius, 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), Djibril et al. (2015), Bobade and Khyade (2012), and Chopra and Chopra (1956) have also observed the similar results of colour values of CNSL, NSO, KSO and BSL, respectively.

IV. SUMMARY AND CONCLUSIONS

Four oils: Cashew nut shell liquid (50, 60, 70, 80, 100), Neemseed oil (10, 15, 20, 25, 100), Karanjseed oil (10, 15, 20, 25, 100) and Bhilawan shell liquid (10, 15, 20, 25, 100) were used to make CNSL based termiticide. Effect of temperature on viscosity, refractive index, specific gravity and colour of termiticide formulations was studied and conclusions were drawn as below:

- Viscosity refractive index and specific gravity of CNSL based termiticide was found decreased with increase in temperature from 30 to 120 ^{0}C.
- Colour of CNSL based termiticide became darker when heated from 30 to 120 ^{0}C.
- CNSL based termiticides were oil based therefore the properties of oils were reflected in the termiticide formulations with respect to the temperature.

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