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The surface and soil properties of azadirachta indica oil in sodium dodecyl sulfate

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Abstract

The objective of this investigation is to examine the surface properties of neem oil in sodium dodecyl sulfate (SDS). The density and ultrasonic velocity of neem oil in SDS solutions are measured. The surface properties viz., surface tension, surface area and surface energy are calculated using the experimental values. The results of the surface parameters proved that adhesive forces in 8mM solutions were predominant over cohesive forces. Sodium dodecyl sulfate in liquid reduces the surface tension of water. The decrease in surface tension of the solution will increase wetting ability. Increasing the wetting ability will permit the neem oil to diffuse into the soil and thereby helping to maintain the structure of soil. Soil physical properties like pH, electrical conductivity (EC), organic carbon (OC) and chemical properties like nitrogen, phosphorus, potassium, zinc, sulfur, iron and boron were analyzed. Cowpea crop was taken for study and grown using pot culture technique. Before seeding, the soil was mixed with neem oil solution to increase water movement and reduce weeds. It was examined that weeds control was minimum at 8mM SDS solution.

Keywords - *SDS, neem oil, surface tension, pH, electrical conductivity, organic carbon.*

1. Introduction

The studies of the properties of aqueous solutions are extremely essential in many areas of science and researches. Science and technology of ultrasonic is widely sought in the recent years for agriculture and medical applications (Renuka Devi, K. et al., 2015) [1]. The physical and chemical effects of ultrasonic in liquid media have been extensively used in food processing applications. The surfactant chosen for present study is an anionic surfactant viz., sodium dodecyl sulfate. Surface active agents or surfactants are detersive chemicals characterized by having two special moieties, one polar and the other nonpolar at contrary ends of a single molecule. The polar moiety is referred to as hydrophilic or lipophobic and the nonpolar as hydrophobic or lipophilic. The nonpolar end is usually a long-chain hydrocarbon, which can be linear, branched or aromatic. Surfactants are broadly categorized as anionic, cationic, non-ionic and zwitterion, according to the nature of the hydrophilic yield in aqueous solution (Singer, M.M et al., 1993) [2].

Neem oil is now valued worldwide as a vital source of phytochemicals for use in human health and pest control (Estefania, V.R. et al., 2016) [3]. It has been used in traditional medicine over centuries. It exhibits different biological activity which makes it a good target for antibacterial studies (Rodina Sadr Ghotbi, 2014) [4]. Neem oil mixed with aqueous SDS, when applied to the leaf parts of plants, provides complete protection for all species (Sharma, V. P, 1993) [5]. The behaviour of a pesticide in the environment depends on its stability, physico-chemical properties of the soil activities (Geeta Negi, 2014) [6].

Soil is a non-renewable dynamic natural useful resource which is essential to humanbeing. Movement of water, quality of water, usage of land and vegetation productivity all have relationships with soil. Soil plays an important role in maintaining lifestyles on earth. The physical properties of soil have an intensive effect on influence of soil quality that determines nutrient and moisture levels in soils (Jon E. Schoonover, 2015) [7].

Plant growth is influenced by soil properties, but in a field environment, it may not be easily distinguished from effects of other factors that also influenced plant growth (Carol Sue Gordon, 2004) [8]. Plant nutrient availability is overcome by soil pH that is a measure of the hydrogen ion activity

within the soil solution. Soil pH is characteristic of components of soil and is usually lower wherein weathering is more advanced (Miller Jarrod, O., 2017) [9]. The amount of dissolved salt in the soil is found by EC. EC & pH values help the farmer to choose the quantity of fertilizer to be added for a particular soil thereby improving the fertility of the soil. Macro and micro nutrients are necessary for plant growth. The growth of plant and productivity are decided by the availability of soil nutrients. Pesticide is a crucial tool to increase harvesting and protect the crops from pest, insects, nematode and weeds (Bourguet, D., 2016) [10].

2. Experimental section

Sodium dodecyl sulfate used in the present study was of AR grade (99% purified) purchased from Merck Specialities Private Limited, Mumbai. Neem oil was purchased from local market (Ponnamaravathi). The different molarities of neem oil in various concentrations of sodium dodecyl sulfate (6, 7 and 8mM) are prepared. The densities of the solution were measured using a 10 ml specific gravity bottle by relative measurement method. The ultrasonic velocity was found by using a single crystal variable path interferometer (Mittal Enterprises, New Delhi, model: F-81) running at 2 MHz frequency. The accuracy in the measurement of ultrasonic velocity of the solution was $\pm$ 0.1%. These values are measured at 298K, 303K and 308K temperatures. The temperature was maintained using a constant temperature water bath (Raaga Industries, Chennai). The accuracy in the measurement of temperature was ± 0.1°C.

3. Computation

The measured values were used to calculate the following parameters using the standard relations,

Surface tension $(\sigma) = U^{\frac{3}{2}}(6.3)10^{-4}\rho$ N/m

Surface area $(Y) = (36\pi N V_a)^{\frac{1}{3}}$ m^3 mol^{-1}

Surface energy $(E) = \sigma * (V_m)^{\frac{2}{3}}$ J mol^{-1}

U – Ultrasonic velocity of the solution, ρ – density of the solution, V_a– molar available volume, σ – surface tension of the solution, V_m – molar volume of the solution

4. Vegetation studies

The pot culture experiment was carried out to find the effect of neem oil in SDS solution on the growth of cowpea crop (Subhashini, V., et al., 2013) [11]. The different ratio of reddish brown soil, sand and farm yard manure was taken for the preparation of soil samples (4:1:1). The clay pots were filled with 3 kg of soil, each sown with 5 seeds of cowpea. Before seeding, the solution was mixed in the soil

5. Results and Discussion

The influence of temperature and concentration on the surface properties of neem oil in SDS was studied by using ultrasonic technique. Using the observed values of density and ultrasonic velocity of neem oil solution, surface tension, surface area and surface energy are calculated at different temperatures (298K, 303K and 308K). Their values are listed in table 1.

Surface tension also often known as interfacial tension is an important property of liquid. It is the force appearing at the surface of a liquid, tending to minimize the surface area. It affects physical properties including wettability of the liquid. The surface tension of the solutions increases with concentration of neem oil and temperature is given in table 1. The similar variation was observed by Ravichandran S and Ramanathan K. In addition, it also increases with SDS concentration and temperature. The highest value of surface tension indicates strong intermolecular forces existing between solute and solvent molecules in the solution. The intermolecular forces may be categorized into cohesive forces and adhesive forces [12, 13]. The value of surface tension in the solution is in the order: 8mM > 7mM > 6mM of SDS solution.

Surface area values decrease with increase of SDS and neem oil concentrations. It affects evaporation because if more area is exhibited to air, water molecules acquire more heat energy from the surroundings. This increase energy causes rapid movement of the water molecules that helps them to overcome the force of attraction and evaporate. This conveys that the molecules on the surface are pulled inwards and causes the liquid surfaces to contract least possible areas which should be consistent with the total mass of the liquid. It is established that minimum surface area is obtained for 8mM solution. This minimum surface area implies that the surface tension is maximum in that solution.

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Surface energy is the amount of work done per unit area [14]. It requires an amount of energy in bringing the molecules from the bulk against the inward attractive forces. If the molecules of a liquid are being attracted where enormous, the inward pull may be large. Consequently, the amount of work done will be huge. The deviation of surface energy is identical to that of surface tension. The greater surface energy indicates that the molecular association is higher.

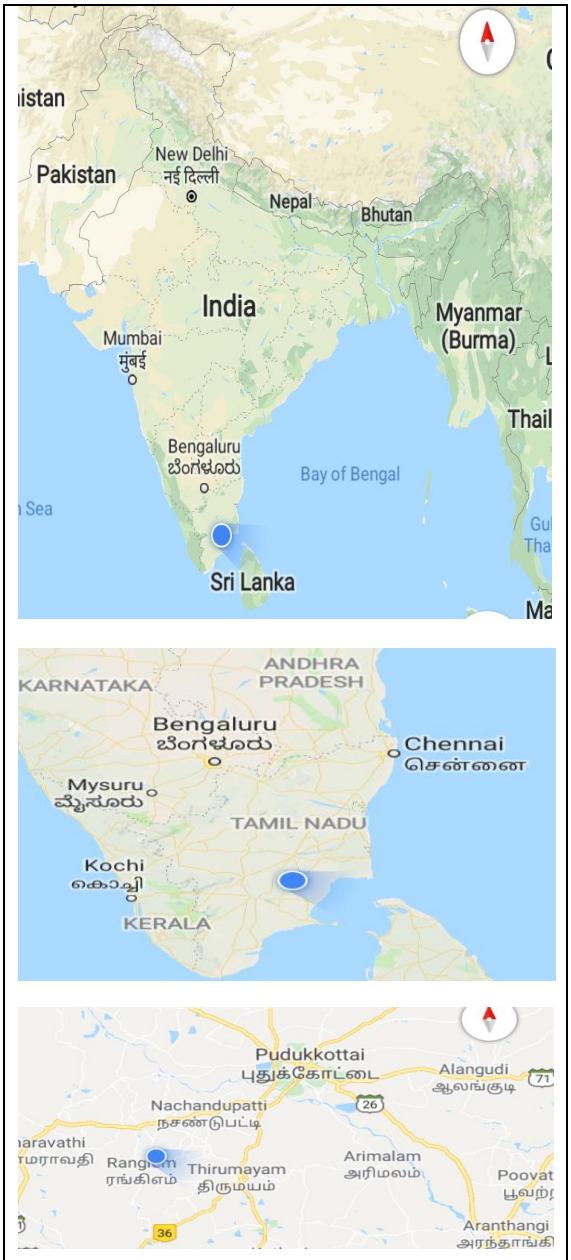

Figure 1: The location of vegetation study

Figure 2: Root growth of cowpea on control soil

Figure 3: Root growth of cowpea on treatment soil

Figure 4: Growth of cowpea

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Table-1: Values of surface tension (σ), surface area (Y) and surface energy (E) of neem oil in aqueous sodium dodecyl sulfate at different concentrations and temperatures.

Molarity (M)	σ (10^4Nm^{-1})			Y (10^{-6} m^{3}mol^{-1})			E (J mol^{-1})		
	298K	303K	308K	298K	303K	308K	298K	303K	308K
6mM SDS with neem oil									
0	3.7278	3.7479	3.7629	3.9511	3.8504	3.7458	25.7167	25.8645	26.0008
1.39	3.7642	3.7886	3.8109	3.8214	3.6938	3.5378	26.0581	26.2338	26.4223
2.78	3.7971	3.8264	3.8509	3.7029	3.5247	3.3717	26.4228	26.6459	26.8237
4.16	3.8254	3.8606	3.8908	3.6510	3.4227	3.2091	26.7076	26.9809	27.2081
5.55	3.8408	3.8877	3.9236	3.6012	3.2919	3.0277	26.9649	27.3201	27.5801
6.94	3.8600	3.9150	3.9390	3.5275	3.1469	2.9166	27.2476	27.6600	27.8583
7mM SDS with neem oil									
0	3.7692	3.7797	3.7881	3.7785	3.7065	3.6321	25.9937	26.0859	26.1733
1.39	3.8030	3.8183	3.8367	3.6536	3.5553	3.4294	26.3064	26.4271	26.5725
2.78	3.8331	3.8499	3.8702	3.5230	3.3940	3.2530	26.6663	26.8093	26.9600
4.16	3.8601	3.8798	3.9019	3.4651	3.3071	3.1567	26.9499	27.1178	27.2742
5.55	3.8816	3.9126	3.9331	3.4061	3.1638	2.9687	27.2232	27.4714	27.6428
6.94	3.8984	3.9278	3.9575	3.3225	3.0911	2.8501	27.5019	27.7304	27.9425
8mM SDS with neem oil									
0	3.7958	3.8064	3.8221	3.6624	3.5858	3.4436	26.1075	26.2000	26.3550
1.39	3.8283	3.8430	3.8637	3.5331	3.4278	3.2680	26.4724	26.5921	26.7604
2.78	3.8591	3.8751	3.8979	3.3916	3.2520	3.0703	26.8355	26.9765	27.1510
4.16	3.8838	3.9042	3.9259	3.3290	3.1564	2.9901	27.1146	27.2845	27.4401
5.55	3.9030	3.9249	3.9471	3.1918	2.9711	2.7451	27.4373	27.6296	27.8052
6.94	3.9191	3.9479	3.9688	3.1464	2.8527	2.6410	27.6796	27.9250	28.0810

The pH and electrical conductivity (EC) of neem oil solutions were analysed. The details are given in table 2. The pH values decrease with the concentration of SDS and neem oil. The pH values of the solutions are minimum for 8mM SDS solution. The addition of 6.94mM neem oil in 8mM SDS has changed the nature of the solution to neutral. pH is maximum (9.05) for 1.39mM neem oil in 6mM SDS and minimum (7.31) for 6.94mM neem oil in 8mM SDS. This fortifies that the solution of pH value 7.31 is suitable for plant growth. It is in concurrence with the result of surface area for 8mM SDS solutions. The two different neem oil concentrations with SDS (6, 7 and 8mM) solutions have low electrical conductivity that is less than 1 dS/m and they have been considered as non-saline nature.

Table-2: The pH and EC results of solution

Parameters	6mM SDS		7mM SDS		8mM SDS	
	1.39 mM neem oil	6.94 mM neem oil	1.39 mM neem oil	6.94 mM neem oil	1.39 mM neem oil	6.94 mM neem oil
pH	9.05	7.44	8.63	7.43	8.45	7.31
EC	0.20	0.18	0.21	0.20	0.24	0.22

Data presented in table 3 shows the variations of pH, EC, macro and micro nutrients of control and treatment soil. The measurement of control and treatment soil parameters (pH, electrical conductivity, nitrogen, phosphorus, potassium, zinc, sulfur, iron boron and organic carbon,) will provide valuable information to assess soil condition for plant growth. In mineral soils, pH is a general indicator of available soil nutrients for plant growth (Pavan, M, 2016) [15]. Soil pH of control soil was strongly alkaline (9.23). The addition of 6.94mM neem oil had changed the pH value to 9.32. The pH of the soil in which plants are grown can have considerable influence on the

mineral content of the food along with number of environmental conditions of the soil which will affect the quality of plant growth. The impact of nutrient availability depends on the size and charge of the nutrient molecules (Gerry, K. et al., 2012) [16]. The EC values of 8mM SDS solution and control soil were 0.22 and 0.11 dS m^{-1}. The application of the solution in the treatment soil had not affected the salinity of the soil.

Table-3: pH, EC, macro and micro nutrients of control and treatment soil

Soil texture	Sandy clay loam									
Soil type	Reddish brown									
Sample	pH	EC	Macro nutrients			Micro nutrients				
		dS m^{-1}	N	P	K	Zn	S	Fe	B	OC
			Kg ha^{-1}			ppm				%
Control	9.23	0.11	172	9.0	160	0.40	5.01	3.12	0.02	0.20
8mM SDS + 6.94 mM neem oil	9.32	0.10	184	9.0	160	0.52	5.00	3.26	0.04	0.20

Nitrogen (N) is the most limiting factor in crop production. Optimum limit of total nitrogen is in four categories such as low, medium, high and very high. The availability nitrogen status of the soil was about 172 and 184 Kg ha^{-1} and is presented in table 3. From the results, the soil N content is greater for treatment soil. In this study, it was found that the value of P remains the same for control and solution added soil. Potassium (K) is another important nutrient. It is not only important for the increase of soil fertility status but also directly involved with plant growth. It is important for early growth stimulation, increasing protein production, improves the efficiency of water and improves resistance to diseases and insects. From the results, the soil content of K is in medium level. The Zn and Fe concentration of treatment soil are increased. Sulfur, boron and organic carbon predicted that there was no change in the value.

6. Conclusion

The activity of neem oil in aqueous SDS was studied. The surface properties were evaluated by using ultrasonic measurements. From the surface parameters (surface tension 8mM>7mM>6mM, surface area 8mM<7mM<6mM and surface energy 8mM>7mM>6mM), it was found that there exists a strong interaction of neem oil in 8mM SDS. Pot culture studies were carried out to find out the availability of nutrients on soil. The results of data analysis of the nutrients, soil pH and EC showed variations between control and treatment soil. It helps to identify the soil characteristics and the amount of macro and micronutrients. This study of neem oil is usually chosen for surfactant based remediation procedures because of their lower degree of absorption in soil. The seed germination of cowpea were unaffected by 8mM SDS + 6.94 mM neem oil solution, which can be used as a soil conditioner.

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