Ultrasonic studies on sargassum dye using water/ethanol extraction at different temperatures

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Abstract: *Ultrasonic velocities (ν), densities (ρ) and viscosities (η) were measured in seaweed extractions using ethanol, and water at various concentrations and in the temperature range 20-40˚C. Acoustical parameters such as adiabatic compressibility (β), Intermolecular free length (L_f), Characteristic impedance (z), Absorption coefficient (α/f^2), and Viscous relaxation time (τ) were calculated to compare these seaweed extractions of using water and ethanol as solvent. There is significant difference in the acoustical and thermo dynamical parameters of the seaweed extractions of water and ethanol at temperature range 20-40˚C.*

Key Words: Ultrasonic, seaweed, natural dye, acoustical parameters.

1. INTRODUCTION

Seaweed is a loose, colloquial term encompassing macroscopic, multicellular, benthic marine algae. The term includes some members of the red, brown and green algae. Seaweeds can also be classified by use as food, medicine, fertilizer, industrial, etc. The seaweed sargassum is used in our project and extract is obtained by using water and ethanol. Sargassum species serve as sources of alginates [1]. Plants are generally brown or dark green in color [2]. Tissues are differentiated into holdfast, stipes, fronds, and fruiting bodies and in some species there are gas-filled bladders. Some species may grow to a length of several meters. Common in the beach drift of beaches near *Sargassum* beds. *Sargassum* species are the tropical equivalent to *Ascophyllum* and *Fucus* in terms of uses and applications. They are used as raw materials for alginate production [3] and are also used as a component of animal feed and a source of liquid plant foods or plant biostimulants. There may also be nutraceutical or pharmaceutical applications for fucoidan and other bioactive extracts of the genus.

Sargassum species are found throughout tropical areas of the world and are often the most obvious macrophyte in near-shore areas where sargassum beds often occur near coral reefs. The plants grow sub tidally and they attach to coral, rocks or shells in moderately exposed or sheltered rocky or pebble areas. In some cases (e.g. Sargasso Sea) there are floating populations. We made an attempt first time the extraction received from the seaweed using water and ethanol.. This extraction is used as dye for coloring the leather and achieved encouragable results.

The solution (dye) was extracted from the seaweed of using two different solvents viz. water [4] and ethanol [5] and therefore they differ in the chemical properties. Since both solutions (dyes) are extracted by using different solvents (water & ethanol) they are structurally different and hence the molecular interactions should be different. Ultrasonic is an emerging field to analyze molecular interactions hence it is used as a tool to study these dyes. Further, this method is a non-destructive and precise. Acoustical parameters like adiabatic compressibility (β), intermolecular free length (L_f), characteristic impedance (z), Absorption coefficient (α/f^2), and viscous relaxation time (τ) are computed from ultrasonic velocities, densities and viscosity values. In this project it is reported the ultrasonic velocities, densities and viscosities of these two different solutions at various concentrations in different temperatures from 20 to 40˚C and different trends are observed.

2. Experimentation:

2.1 Materials:

Ethanol used in our study is from SDFCL, 99.9% Analar and Water used were triple distilled water. Freshly prepared dyes were used in all the measurements.

2.2 Methods:

Ultrasonic velocity measurements (accuracy ±0.01%) were made using interferometer (Mittal Enterprises, New Delhi, India) vibrating at a frequency of 2 MHz The temperature was maintained constant using thermostatic water bath (Lauda) having a accuracy of ±0.01˚C. Mettler Toledo model AG245 analytical balance with an accuracy of ±0.01mg was employed for mass measurements. Viscosity and density measurements were carried out for all the solution in Oswald viscometer and gravimetric bottles respectively. The various derived acoustical parameters were calculated using Microsoft Excel and graphs plotted using Micro Cal Origin plotting software. The equations used in the computation of Acoustical and thermodynamic parameters are given elsewhere [6-8]. Dye Solutions were extracted from seaweed (sargasam) by using (i) Ethanol, (ii) Water.

(i) The seaweed was treated with 0.2 N HCl to remove dirt particles and then washed with water. The remaining solid was re-suspended in a 2% Na_2CO_3 solution. This suspension was heated for two hours at 70˚C. The resulting Na-alginate solution was added with 95% aqueous ethanol, then Centrifuged and the precipitate was separated. The filtered ethanol extraction after removing the precipitate was used for our study as a dye.

(ii) The seaweed was mixed with distilled water approximately 1:3 ratios respectively were heated for 3 hrs at 80˚C. The filtered solution taken as dye and the same was used for our present study.

3. Results and discussions

Densities and viscosities are measured for various concentrations of water extraction at 20°C-40°C in the steps of 5˚C and are presented in Tables-1.

Table-1: Density and viscosity of seaweed extracted from water

Concentration (%)	Density					Viscosity				
	20°C	25°C	30°C	35°C	40°C	20°C	25°C	30°C	35°C	40°C
100	1.00945	1.00944	1.00943	1.00940	1.00934	2.38698	2.31267	2.36254	2.32281	2.27194
75	1.00724	1.00744	1.00720	1.00695	1.00719	1.93828	1.88262	1.88296	1.87238	1.82996
50	1.00496	1.00460	1.00413	1.00328	1.00281	1.50663	1.47548	1.49873	1.48542	1.47138
25	1.00264	1.00165	1.00105	1.00094	1.00082	1.20248	1.24416	1.21243	1.22815	1.19324
12.5	1.00063	0.99952	0.99816	0.99806	0.99572	1.09037	1.07444	1.09074	1.09645	1.08347

Similarly densities and viscosities are measured for various concentrations of ethanol extraction at 20°C-40°C in the steps of 5˚C and are presented in Tables-2.

Table-2: Density and viscosity of seaweed extracted from Ethanol

Concentration (%)	Density					Viscosity				
	20°C	25°C	30°C	35°C	40°C	20°C	25°C	30°C	35°C	40°C
100	0.92496	0.92484	0.92224	0.91974	0.91724	2.36112	2.08919	1.79693	1.51265	1.26865
75	0.95522	0.95491	0.95503	0.95217	0.95101	2.94929	2.34250	2.00302	1.66791	1.42316
50	0.90930	0.90866	0.90691	0.89935	0.90122	2.66959	2.22584	1.89378	1.57417	1.33985
25	0.85308	0.85058	0.84841	0.84251	0.84432	1.99388	1.67252	1.49321	1.26142	1.10673
12.5	0.81987	0.81611	0.81368	0.80544	0.80692	1.66095	1.42894	1.27476	1.10669	0.97623

The variation of ultrasonic velocity against water extracted seaweed concentration at different temperatures is plotted in Fig -1.

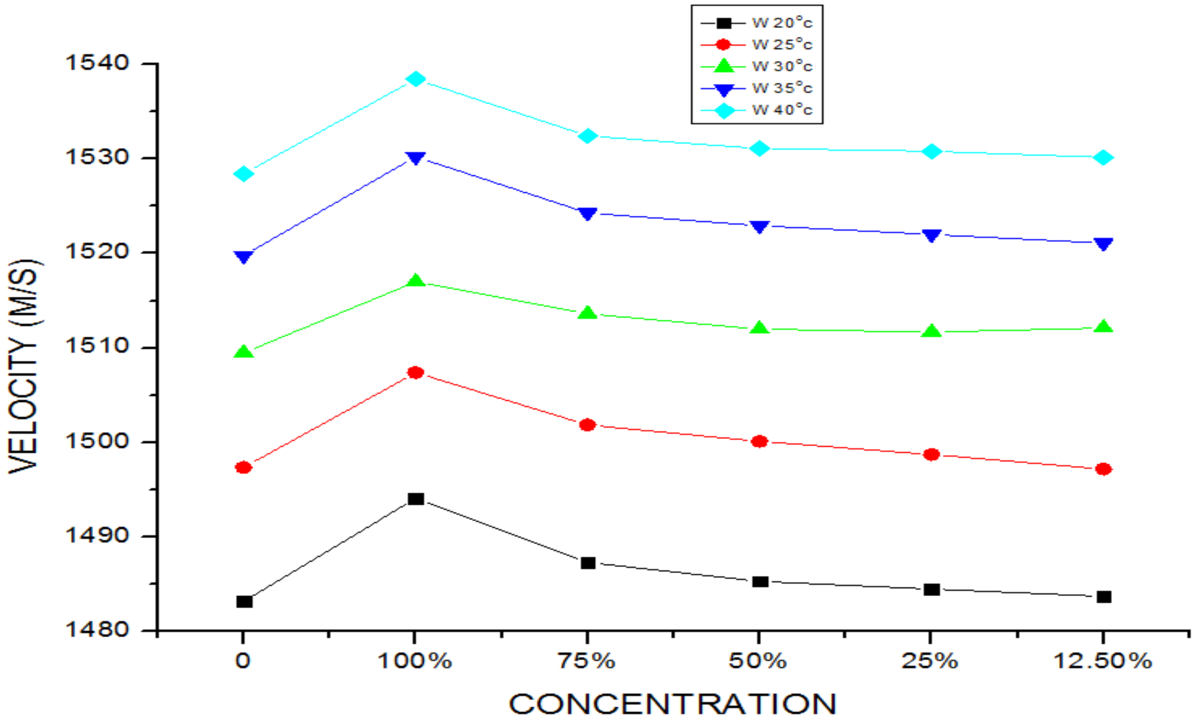

Fig -1: Ultrasonic velocity versus water extracted seaweed concentration at different temperatures

Similarly the variation of ultrasonic velocity against Ethanol extracted seaweed concentration at different temperatures is plotted in Fig -2.

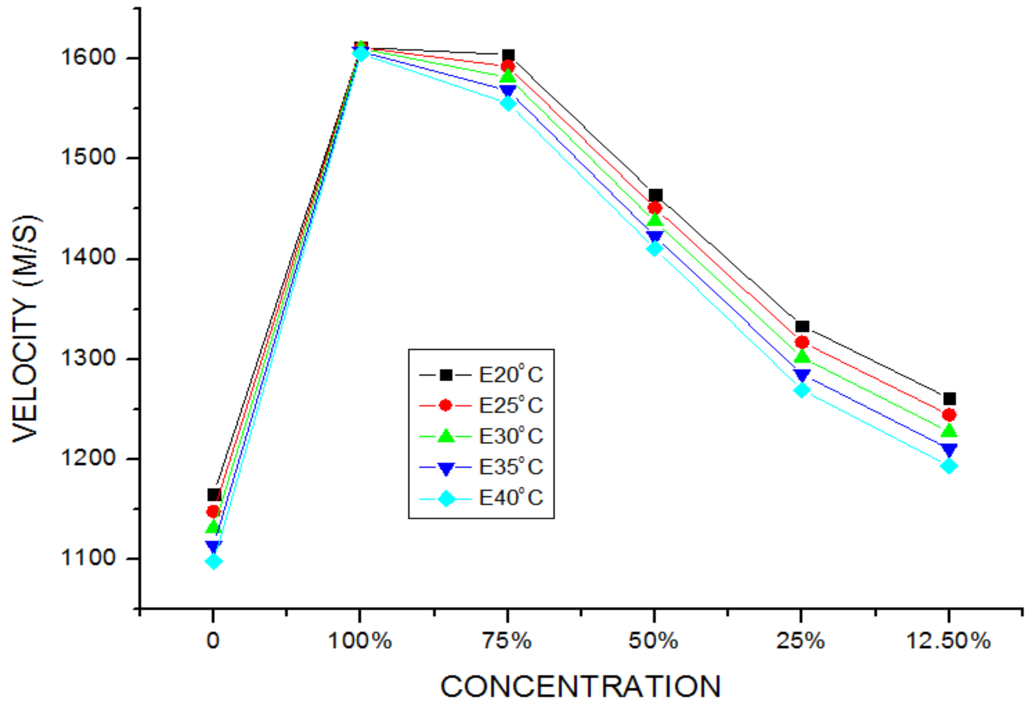

Fig -2: Ultrasonic velocity versus ethanol extracted seaweed concentration at different temperatures

It was observed from above results that both water and ethanol extracted seaweed concentration shows similar trend i.e., from 100% concentration the velocity decreases with decrease of concentration. With increased temperature for both solutions, the trend is opposite, which indicates that the ultrasound behavior in the two solutions depends on structure of extraction, concentration and temperature.

Adiabatic compressibility (β) is another parameter used in our study to analyze molecular interactions. Salvation studies can be made from the β values. In the present investigation, β values are calculated from the ultrasonic velocities and densities at different temperatures. The variation of adiabatic compressibility with water extraction concentration at different temperatures is shown in fig -3.

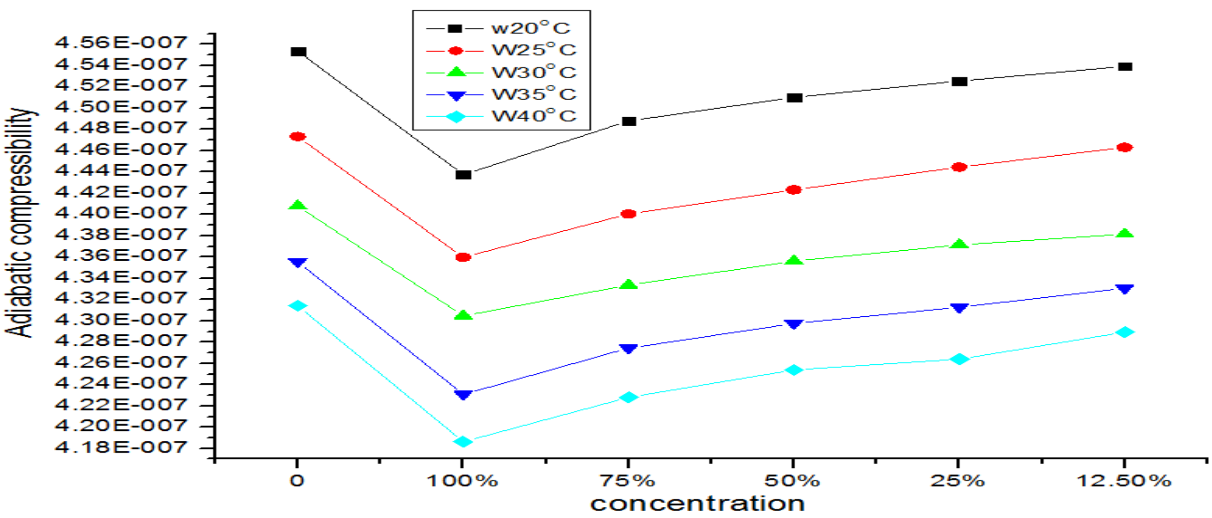

Fig -3: Adiabatic compressibility versus water extracted seaweed concentration at different temperatures

Similarly, the variation of adiabatic compressibility with ethanol extraction concentration at different temperatures is shown in fig -4.

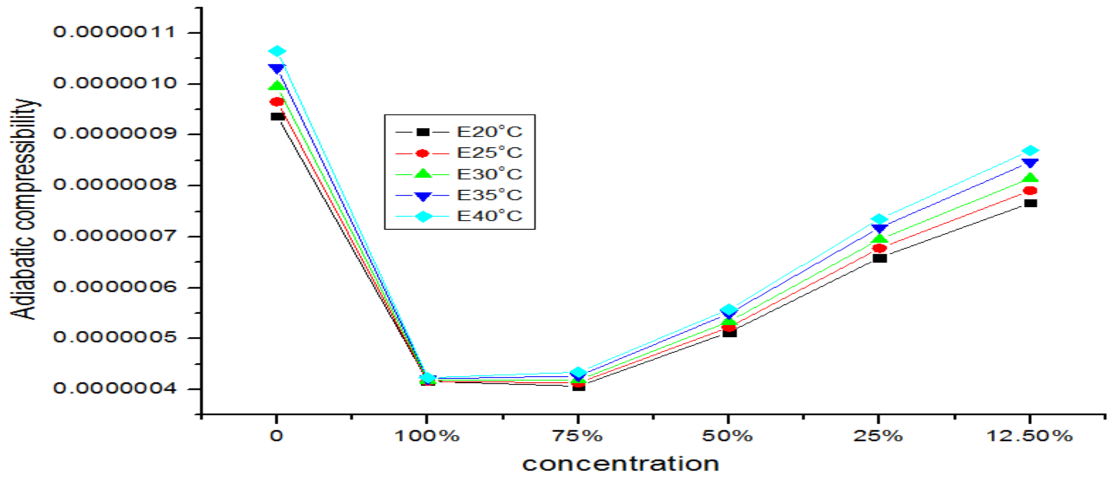

Fig -4: Adiabatic compressibility versus water extracted seaweed concentration at different temperatures

From above data, it was observed that a decrease in β values with increase in concentration in water / ethanol solutions. In the case of water the β values are decrease with increase in temperature whereas opposite trend is observed in ethanol extraction.

Intermolecular free length (Lf) in a liquid system is a measure of molecular association. In order to compare the intermolecular attraction in the two extractions, intermolecular free length values are computed from the ultrasonic velocities and densities of water and ethanol extracted solutions at different temperatures. The variations of Intermolecular free length with water extraction concentration at different temperatures are shown in Fig -5.

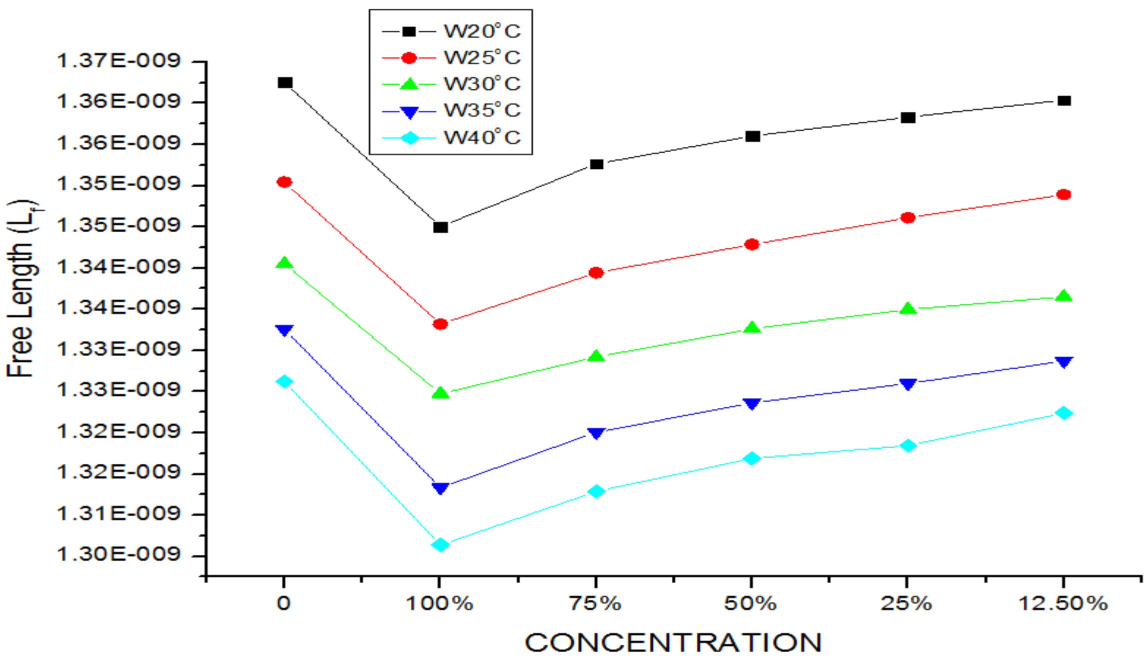

Fig -5: Intermolecular free length versus water extracted seaweed concentration at different temperatures

Similarly the variations of Intermolecular free length with water extraction concentration at different temperatures are shown in Fig -6.

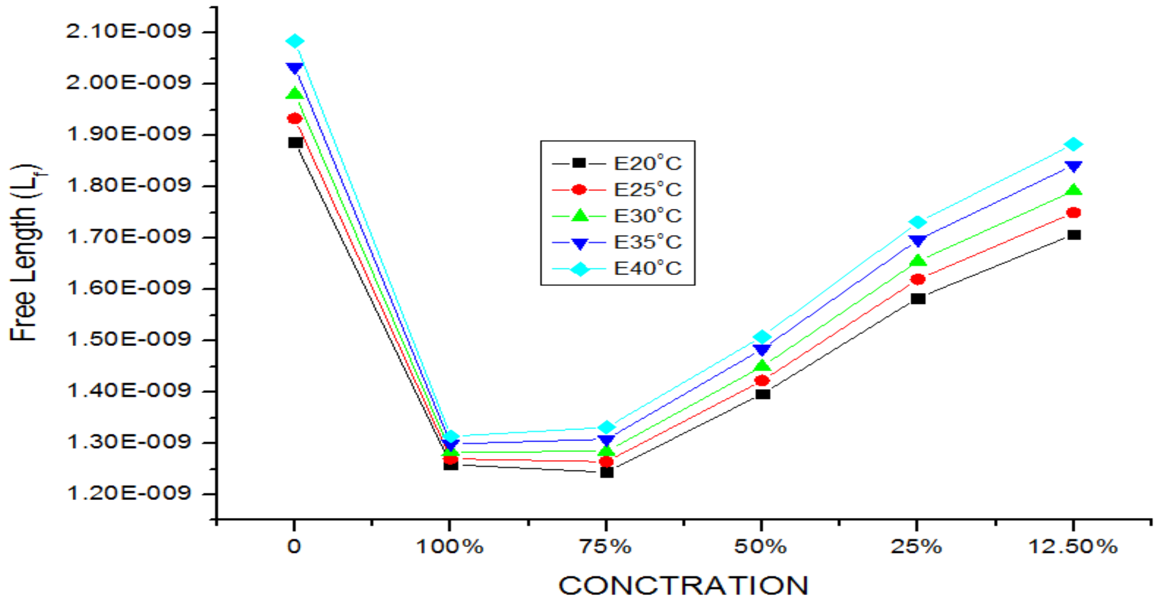

Fig -6: Intermolecular free length versus ethanol extracted seaweed concentration at different temperatures

Analysis of the data indicate that Lf values of ethanol increase with increase in temperature and opposite trend observed in water extraction, but decreases with increase in concentration at a given temperature. This may be due to thermal agitation and loosening of intermolecular attractions with rise in temperature and the association of molecules with increase in concentration.

Absorption coefficient (α/f2) is characteristic of a compound and depends on its structure. The effect of water concentration on Absorption coefficient at different temperatures is shown in Fig -7.

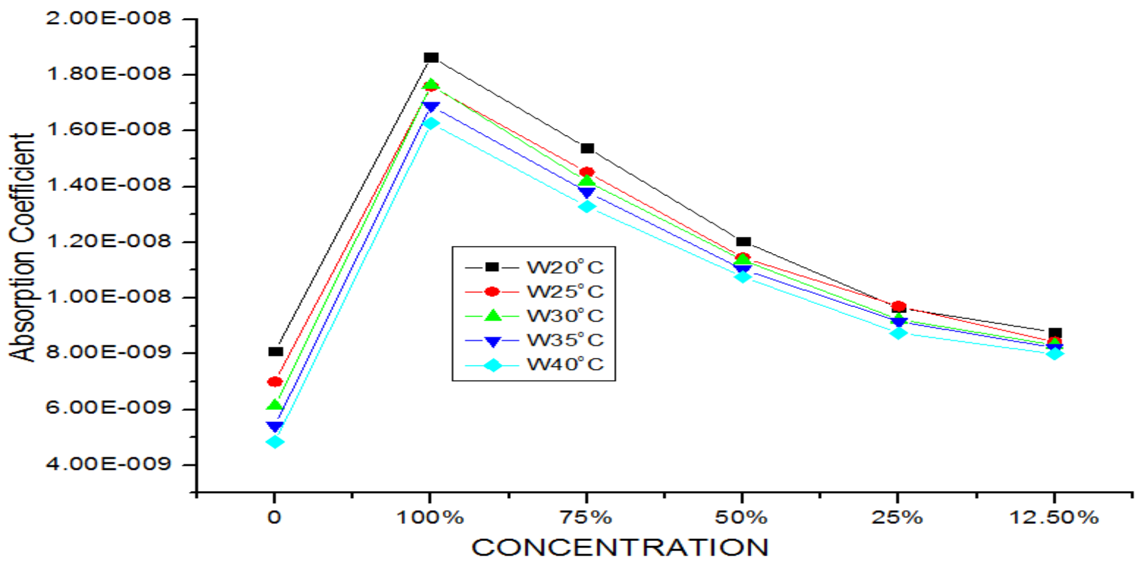

Fig -7: Absorption coefficient versus water extracted seaweed concentration at different temperatures

Similarly the effect of ethanol concentration on Absorption coefficient at different temperatures is shown in Fig -8.

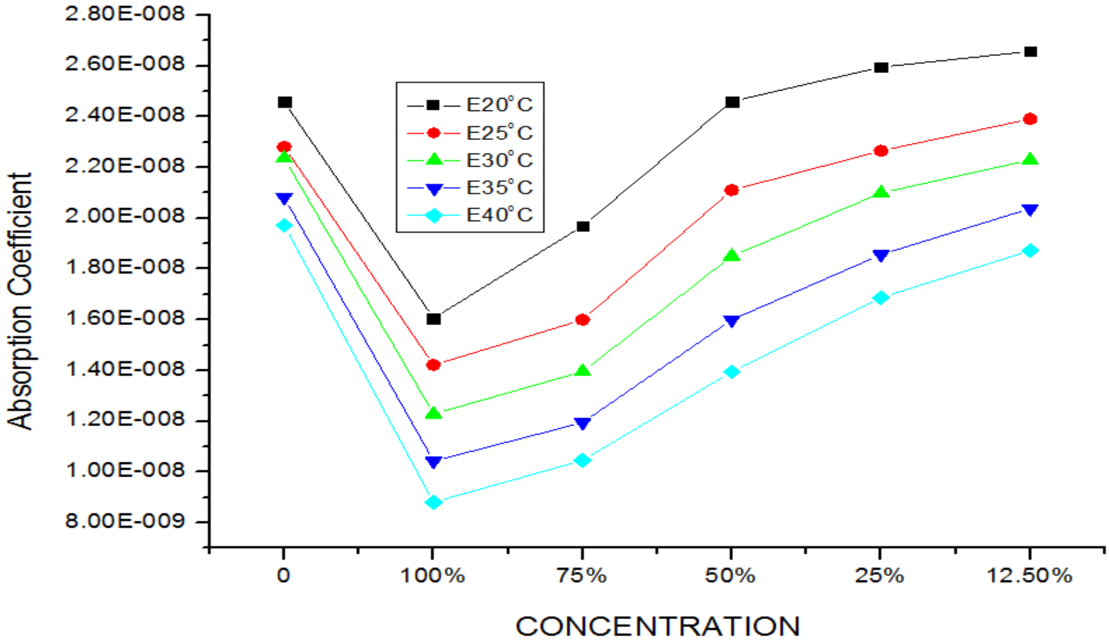

Fig -8: Absorption coefficient versus ethanol extracted seaweed concentration at different temperatures

From above two plots it was observed that there is a slight decrease in α/f2 values in the concentration range from 12.5 to 100% in ethanol at the same temperature. This observation suggests that the solute- solvent interaction is maximum for ethanol extraction at 100% concentration, whereas the interaction is less for water extraction in the same concentration range at the same temperature.

The relation between viscous relaxation time (τ) against water concentration of seaweed extraction with different temperatures is shown in Fig -9.

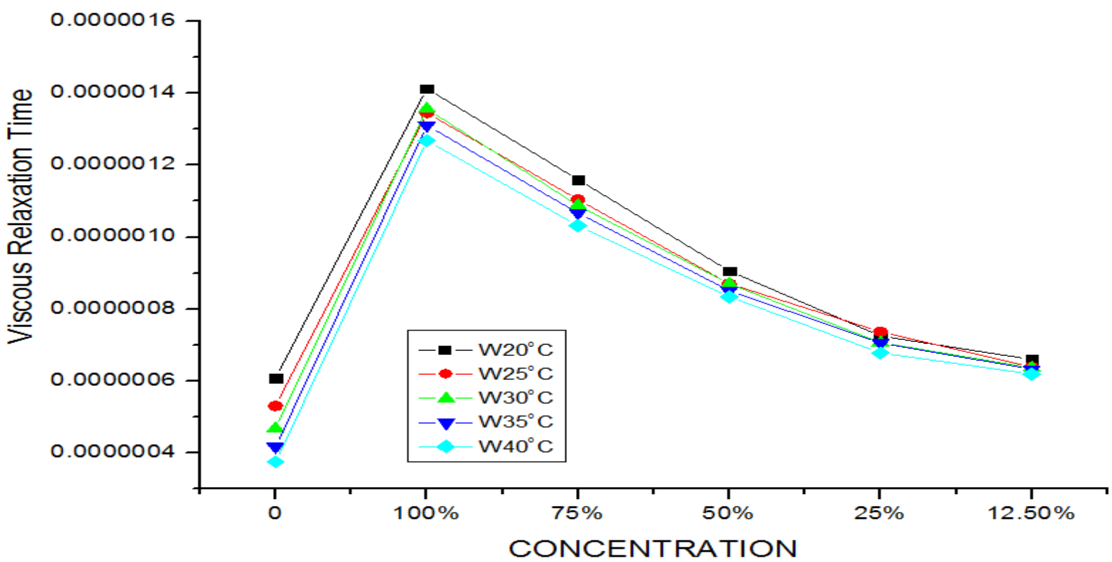

Fig -9: Viscous relaxation time versus water extracted seaweed concentration at different temperatures

From above two figures it is clear that for both seaweed extraction similar behavior is observed with increase in temperature, whereas opposite trend is observed in concentration effect for water extractions is decrease and for ethanol extraction increases with increase in concentration.

Acoustical impedance (Z) in a liquid system can be used to assess the molecular interaction between the components. The effect of Characteristic impedance on water extracted seaweed concentration at different temperatures is shown in Fig -10.

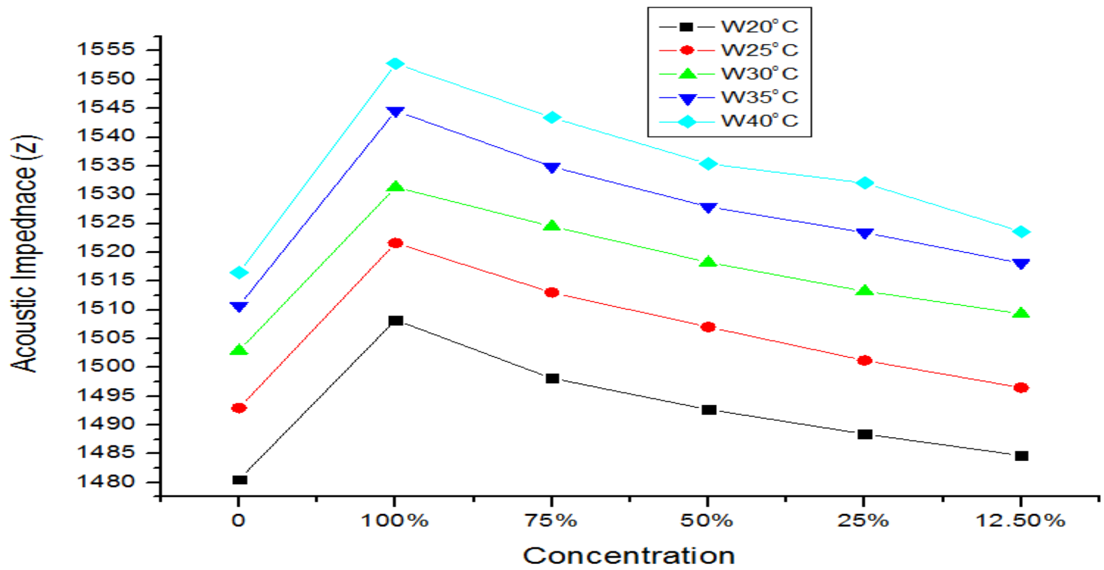

Fig -10: Acoustical impedance versus water extracted seaweed concentration at different temperatures

Similarly the effect of Acoustical impedance on ethanol extracted seaweed concentration at different temperatures is shown in Fig -11.

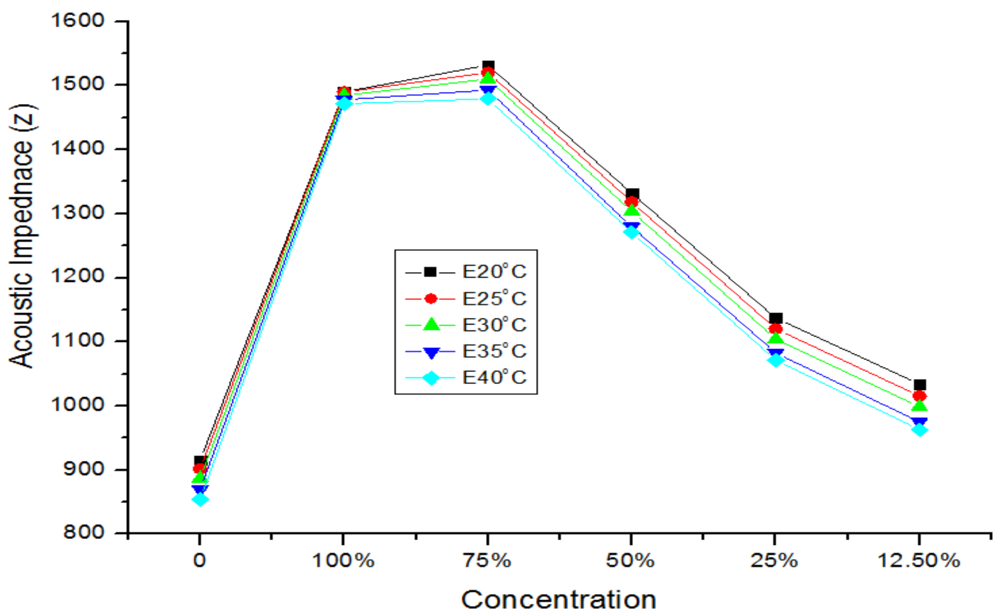

Fig -11: Acoustical impedance versus ethanol extracted seaweed concentration at different temperatures

From above data it was found that the Z values of both extractions increases with increase in concentration suggesting that the solute- solvent interaction increases with increase in the concentration.

4. CONCLUSIONS

Abundantly available eco friendly seaweed used presently as an additive agent in biscuits and chocolates was taken for our present study. After examining the seaweed extraction of using water/ethanol, it is concluded that this extraction is also good for leather industries used as a dye for coloring the leather. It was observed that using the extraction light color shade is achieved on leather which was supported by thermo dynamical parameters.

5. REFERENCES

[1] M. Ganesan, O. P. Mairh and P. V. Subbarao, *"Effect of shelf life of brown algae sargassum wightii (Fucales/Phaeophyta) and Turbinaria conoides (Fucales/Phaeophyta) on alginic acid yield",* Indian Journal of Marine Sciences, vol. 26, pp. 108-110, 2001.

[2] A. Thomas Davis, Miriam Ramirez, Alfonso Mucci and Bjørn Larsen, *"Extraction, isolation and cadmium binding of alginate from Sargassum spp." Journal of Applied Phycology, vol.* 16, pp. 275-284, 2004.

[3] Taratra Andrée Fenoradosoa, Ghina Ali, Cedric Delattre, Celine Laroche, Emmanuel Petit, Anne Wadouachi and Philippe Michaud, "*Extraction and characterization of an alginate from the brown seaweed Sargassum turbinarioides Grunow",* J Appl Phycol, vol. 22, pp. 131–137, 2010.

[4] T. Bechtold, A. Turcanu, E. Ganglberger and S. Geissler, *"Natural dyes in modern textile dye houses — how to combine experiences of two centuries to meet the demands of the future?",* Journal of Cleaner Production, vol. 11, pp. 499–509, 2003.

[5] R. Marcia Torres, P. A. Alessandra Sousa, A. T. Eduardo Silva Filho, F. Dirce Melo, P. A. Judith Feitosa, C. M. Regina de Paulab and G. S. Maria Limaa. "*Extraction and physicochemical characterization of Sargassum vulgare alginate from Brazil*", Carbohydrate Research, vol. 342, pp. 2067−2074, 2007.

[6] S. Govindarajan, Venu Kannappan, M. D. Naresh, K. Venkataboopathy and B. Lokanadam, "Ultrasonic studies on the molecular interaction of gallic acid in aqueous methanol and acetone solutions and the role of gallic acid as viscosity reducer", Molecular Liquids, vol. 107, pp. 289-316, 2003.

[7] B. Vijay Kumar Naidu, K. Chowdoji Rao and M. C. S. Subha, "*Densities, Viscosities, and excess properties for Binary Mixtures of some Glycols and polyglycols in N- Methylacetamide at 308.15K."* Journal of chemical eng data, vol. 48, pp. 625-627, 2002.

[8] T. Sankarappa, M. Prashant Kumar and Adeel Ahmad, *"Ultrasound velocity and density studies in some refined and unrefined edible oils",* Physics and chemistry of liquids, vol. 43, pp. 507-514, 2005.