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UV-VISIBLE SPECTRAL ANALYSIS OF BORIC ACID IN DIFFERENT SOLVENTS: A CASE STUDY

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ABSTRACT: Boric acid is one of the widely used inorganic compound in pharmaceutical industry. We find its utilization as an antiseptic, in eye wash preparations, as an insecticidal, as a buffering agent etc. In this present work, a comparative study of the UV-Vis spectras of the boric acid solution in different solvents have been done. A variety of solvents like water, ethanol, methanol, glacial acetic acid, hexane, Tetrahydrofuran and 0.2M HCl solution have been employed for spectral analysis. When water was taken as a solvent, aqueous boric acid solution gave negative absorbance in complete range of UV-Vis analysis i.e. 1100nm to 190 nm. In contrary to this, when methanolic solution of boric acid was taken, positive absorbance in the complete range of spectrum was noticed. Purely on the basis of spectras obtained for boric acid solution in different solvents, best solvent out of those have been regarded as the most suitable solvent for carrying out the UV-Vis analysis for boric acid.

INTRODUCTION: Boric acid is a weak inorganic acid used extensively in the pharmaceutical and chemical industries and common laboratory works and research work. It is known to be used widely as an antiseptic, in eye wash preparation, as an insecticidal [1], as a buffering agent etc. As it is a weak acid, it acts differently in different solvents. Say for example, Boric acid when dissolved in water acts as a Lewis acid and accepts a OH^- ion from a water molecule and generates a H+ ion (equation No. 1, Cotton and Wilkinson, 1972). This equilibrium is possible only when the concentration of boric acid in solution less than or equal to 0.025M. [2, 3, 4, 5, 8]

$B(OH)_3 + H2O \rightarrow B(OH)_4^- + H^+$ (pK= 9.0) [equation No 1]

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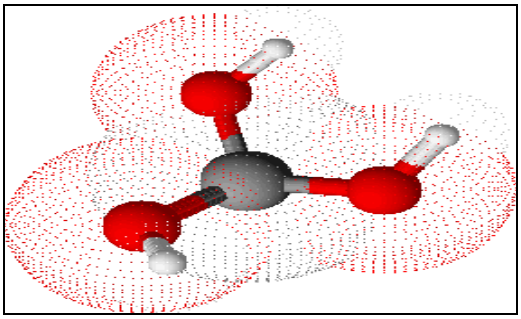
At Higher concentrations, i.e. more than 0.025M, polyborates are found to be formed which are either ring structures or chains in structure.(eq. 2)

$3B(OH)_3 \rightleftharpoons B_3O_3(OH)^{4-} + H^+ + 2H_2O$ (pK = 6.84) [equation No 2]

While in case of alcohol, boric acid forms alkyl borates $B(OR)_3$ with alcohol [6]. e.g. formation of ethyl borate when boric acid is dissolved in ethanol. (equation No 3)

$B(OH)_3 + 3\ C_2H_5OH \rightleftharpoons (C_2H_5O)_3B + 3\ H_2O$ [equation No. 3]



BALL AND STICK MODEL WITH DOTS STRUCTURE OF BORIC ACID
(PREPARED USING CHEMSKETCH SOFTWARE, A PRODUCT OF ACD LABS)

MATERIAL AND METHODS:

Chemicals Required:

Boric Acid (USP grade) was purchased from Bio Laboratories, New Delhi. Hydrochloric acid, Glacial Acetic acid and Methanol was purchased from Rankem, India. Ethanol (Marketed as Emsure®) was purchased from Merck, Germany. Tetra-hydro-furan (THF) was purchased from Central Drug House (CDH), New Delhi. Hexane was purchased from Spectrochem, Mumbai and Double distilled water was prepared in-house using double water distillation unit model: WDU-2000.

Instruments Required:

Shimadzu UV-VIS spectrophotometer (model: UV - 1601), Analytical Balance.

Method of preparation of Aqueous Solutions:

Accurately weighed Boric acid powder viz. 20 mg, 25 mg, 30 mg, 35 mg, 40 mg and 50 mg was dissolved in double distilled water so as to obtain a 1ml of boric acid solution of varied concentrations. From each concentrations, 100µl of resulting boric acid solution was taken and is diluted up to 3 ml with double distilled water. This resulting solution was used for obtaining the UV - Vis spectra of boric acid in aqueous solution.

Method of preparation of Alcoholic solutions (Methanolic and Ethanolic boric acid Solutions) of boric acid:

Both Methanol and ethanol was used as solvents for carrying out the UV-Vis spectral analysis of Boric acid. 20 mg of boric acid was accurately weighed and alcoholic solutions up to 1 ml was prepared using ethanol and methanol respectively. In both the solvents, a clear solution was observed and boric acid was found to be completely soluble in the given concentration i.e. 20 mg/ml. 200 µl of this solution was taken and diluted to 3 ml using ethanol and methanol respectively. These resulting solutions were used for carrying out the UV Vis Spectra of boric acid in alcoholic solutions.

Method of preparation of solution of Boric acid in 0.2M Hydrochloric acid solution:

Boric acid solution was prepared by using 0.2 M HCl solution. For this 20mg of Boric acid was accurately weighed and dissolved in 0.2M HCl solution so as to get a solution up to 1ml. This solution was further diluted by taking 200µl of the solution and diluting it up to 3ml using 0.2M HCl solution. The resulting solution was used for carrying out the UV- Vis analysis of boric acid solution prepared using 0.2M HCl solution.

Method of preparation of solution of Boric acid in Glacial acetic acid

Boric acid solution was prepared by using Glacial acetic acid as solvent. For this 20mg of Boric acid was accurately weighed and dissolved in Glacial acetic acid so as to get a solution up to 1ml. As all the amount of added boric acid was not completely dissolved in Glacial acetic acid, the solution was shaken vigorously for 5 min so that maximum solubility is attained. The solution was kept undisturbed for 30 min so that the excess un-dissolved boric acid will sediment. The supernatant (saturated with boric acid) was separated from the un-dissolved boric acid. This supernatant was further diluted by taking 200µl of the supernatant and diluting it up to 3ml using Glacial acetic acid. The resulting solution was used for carrying out the UV- Vis analysis of boric acid solution prepared using Glacial acetic acid.

Method of preparation of solution of Boric acid in THF:

Boric acid solution was prepared by using Tetra-hydro-furan as solvent. For this 20mg of Boric acid was dissolved in THF so as to get a solution up to 1ml. As all the amount of added boric acid was not completely dissolved in THF, the solution was shaken vigorously for 5 min so that maximum solubility is attained. The solution was kept undisturbed for 30 min so that the excess un-dissolved boric acid will sediment. The supernatant (saturated with boric acid) was separated from the un-dissolved boric acid. This supernatant was further diluted by taking 200µl of this supernatant and diluting it up to 3ml using THF. The resulting solution was used for carrying out the UV- Vis analysis of boric acid solution prepared using THF.

Method of preparation of solution of Boric acid in Hexane:

Boric acid solution was prepared by using Hexane as solvent. For this 20mg of Boric acid was dissolved in hexane so as to get a solution up to 1ml. As all the amount of added boric acid was not

completely dissolved in hexane, the solution was shaken vigorously for 5 min so that maximum solubility is attained. The solution was kept undisturbed for 30 min so that the excess un-dissolved boric acid will sediment. The supernatant (saturated with boric acid) was separated from the un-dissolved boric acid. This supernatant was further diluted by taking 200µl of the supernatant and diluting it up to 3ml using hexane. The resulting solution was used for carrying out the UV- Vis analysis of boric acid solution prepared using hexane.

Solubility profile of boric acid in some solvents: [7]

Solubility profile of boric acid in some of the solvents, as given in the literature are as follows. **(Table 1)**.

TABLE 1: SOLUBILITY PROFILE OF BORIC ACID IN DIFFERENT SOLVENTS

Solvent System	Temperature ◦C (◦F)	Boric acid% by weight in saturated solution
Water	35 (95)	7.12
Methanol	25 (77)	22.66
Ethanol	25 (77)	11.96
Glacial acetic acid	30 (86)	6.30

RESULTS AND DISCUSSION:

Different types of commonly used solvents were used for studying the effect of solvent on the UV-Vis profile of boric acid. Common solvents like water, methanol, ethanol, GAA, Hexane, THF and 0.2M HCl solution were used for the current work.

Observed Solubility of boric acid in different solvents

The observed solubility of boric acid in different solvents on the basis of the solution formed with and without the precipitation of excess boric acid is as given in **Table 2**.

TABLE 2: OBSERVED SOLUBILITY OF BORIC ACID IN DIFFERENT SOLVENTS.

Solvent	Observed solubility
Water	taken amount was completely soluble
0.2M HCl solution	taken amount was completely soluble
Ethanol	taken amount was completely soluble
Methanol	taken amount was completely soluble
Glacial acetic acid	taken amount was partially soluble
THF	taken amount was very slightly soluble
Hexane	taken amount was very slightly soluble

UV-Vis spectrum of Boric acid solution in water

In case of water, different concentrations of aqueous boric acid solution was prepared which were subjected for UV-Vis analysis **(Fig. 1)**. It was observed that aqueous boric acid solution gave negative absorbance in its UV-Vis spectrum. except for the concentration of 0.67mg/ml, all other aqueous solutions having concentration viz. 0.83 mg/ml, 1 mg/ml, 1.167 mg/ml, 1.33 mg/ml, 1.67 mg/ml showed a negative absorbance **(Fig. 1)**. This is most likely to be due to the formation of polyborates at higher concentrations in water [2, 3, 4, 5] and thus gave a negative absorbance at higher concentrations.

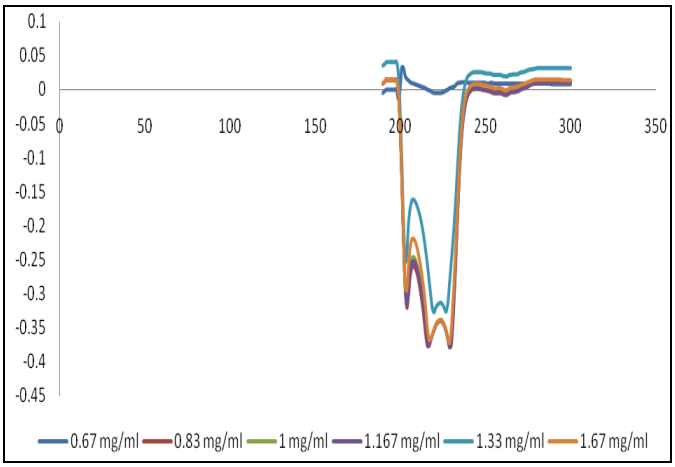


FIG 1: UV-VIS SPECTRA OF AQUEOUS BORIC ACID SOLUTION AT DIFFERENT CONCENTRATIONS

UV-Vis spectrum of Boric acid solution in Ethanol:

Boric acid when dissolved in ethanol at a concentration of 1.33 mg/ml gave the following UV-Vis spectra **(Fig 2)**. Unlike aqueous boric acid solution, ethanolic boric acid solution gives positive absorbance in its UV-Vis spectra. This can be accounted by the fact that when boric acid is dissolved in ethanol, triethyl borate is formed [6] in equivalent amount as that of boric acid and may thus gives a positive absorbance. The chemical reaction taking place between boric acid and ethanol can be given as follows (equation No: 4)

$B(OH)_3 + 3 C_2H_5OH \rightleftharpoons (C_2H_5O)_3B + 3 H_2O$ (equation No. 4)

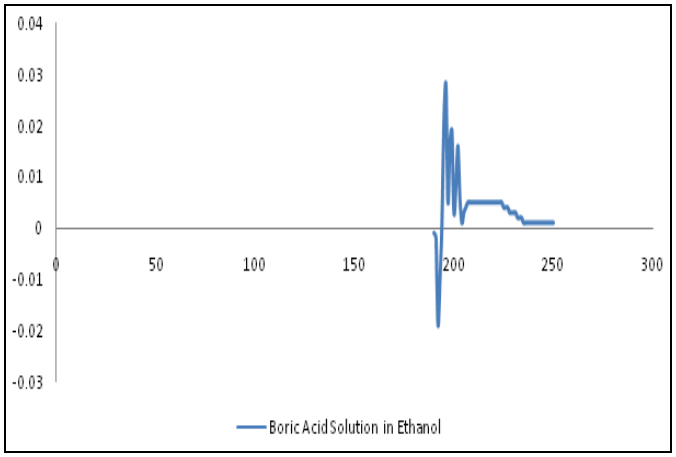


FIG 2: UV-VIS SPECTRA OF ETHANOLIC BORIC ACID SOLUTION

UV-Vis spectrum of Boric acid solution in 0.2M HCl solution:

Boric acid solution in 0.2M HCl solution gave the following UV-Vis spectra **(Fig 3)**. In this spectra, a small hump (for positive absorbance) followed by a small dip towards negative absorbance can be observed.

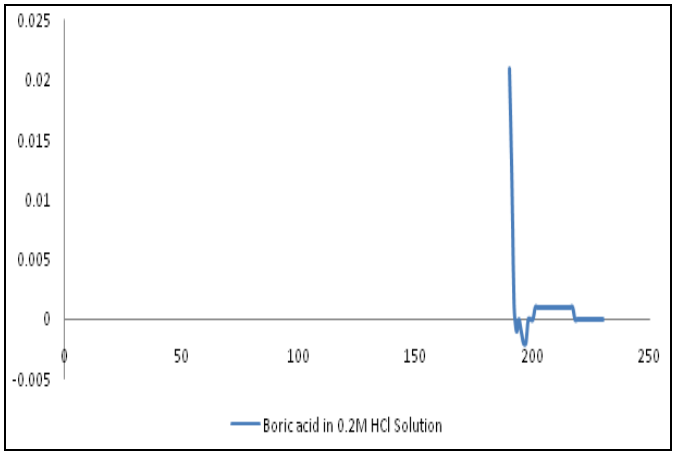


FIG 3: UV-VIS SPECTRA OF BORIC ACID SOLUTION IN 0.2M HCL SOLUTION.

UV-Vis spectrum of Boric acid solution in Glacial acetic acid:

Boric acid solution when made in Glacial acetic acid, no complete dissolution of added amount of boric acid was observed hence, saturated solution of boric acid in glacial acetic acid was used. This saturated solution was further diluted as per the concentrations mentioned above. In the spectra of Boric acid in Glacial acetic acid, a wave like pattern can be observed **(Fig 4)** giving a positive as well as negative absorbance.

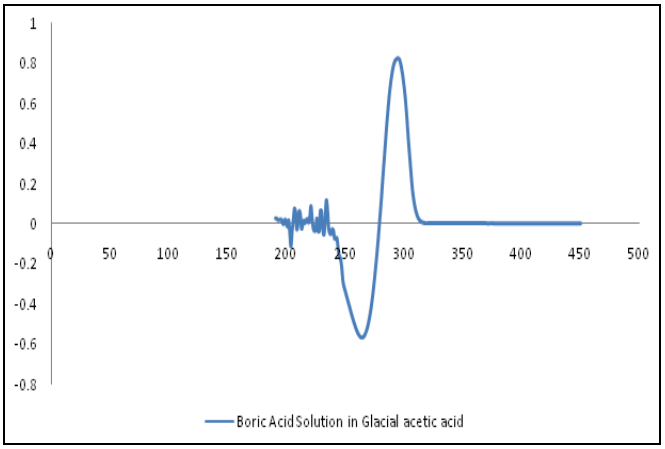


FIG 4: UV-VIS SPECTRA OF BORIC ACID SOLUTION IN GLACIAL ACETIC ACID

UV-Vis spectrum of Boric acid solution in hexane

When Boric acid was added to hexane, no complete dissolution of added amount of boric acid was observed hence, saturated solution of hexane with boric acid was used. This saturated solution was further diluted as per the concentrations mentioned above. In the spectra of Boric acid in hexane, a positive absorbance in the spectra **(Fig. 5)** was observed. Though the solubility of boric acid in hexane is very low as compared to the other solvents used, better results were obtained when compared with water. When water was used as a solvent, the spectrum showed negative absorbance throughout the range of scan.

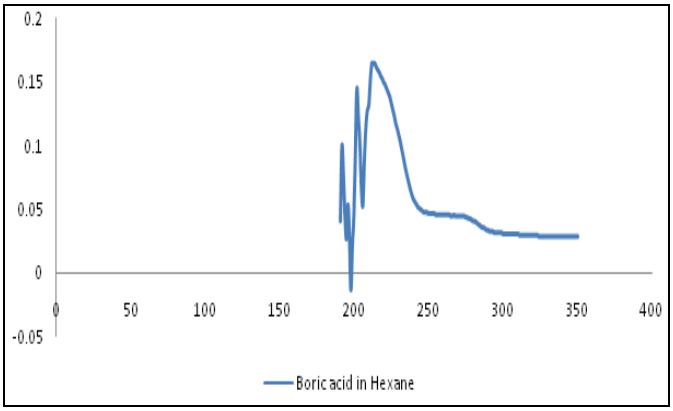


FIG 5: UV-VIS SPECTRA OF BORIC ACID SATURATED IN HEXANE

UV-Vis spectrum of Boric acid solution in Methanol: UV-Vis spectra of Boric acid when methanol was used as a solvent gave the following

spectra **(Fig 6)**. As we can see a clear spectra without any crowding of signals in the spectrum. This was assumed to be the best solvent for the analysis of boric acid from the list of solvents which were used in the current work.

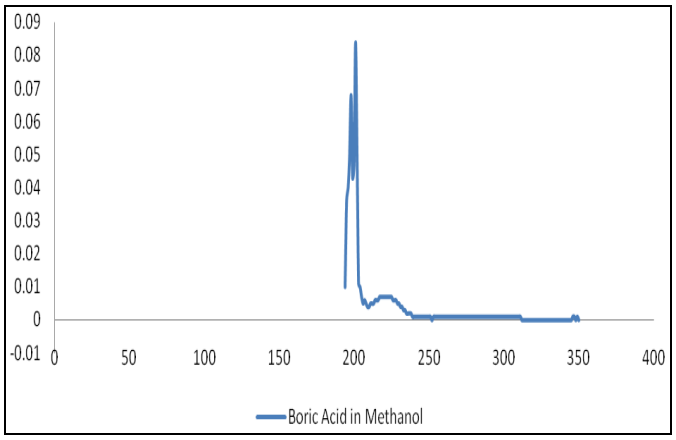


FIG 6: UV-VIS SPECTRA OF BORIC ACID SOLUTION IN METHANOL.

UV-Vis spectrum of Boric acid solution in THF

Boric acid when added to THF, no complete solubility was attained of added amount of boric acid and hence saturated solution of THF with boric acid was used. This saturated solution was further diluted as per the concentrations mentioned above. In the spectra of Boric acid in THF, a positive absorbance in the spectra along with multiple peaks was observed. **(Fig 7)**

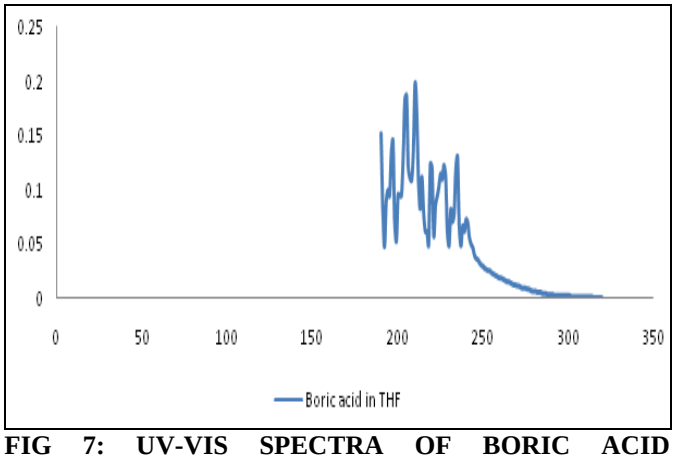


FIG 7: UV-VIS SPECTRA OF BORIC ACID SATURATED IN THF

CONCLUSION: Different solutions have been prepared for boric acid using both polar and non polar solvents. Difference in the UV Vis spectra of the boric acid solution in different solvents was also observed. In case of water, where the aqueous boric acid solution gave negative absorbance, in case of methanol, a clean spectrum without any negative absorbance can be seen. In case of saturated THF with boric acid, multiple peaks can be pointed out. All other solvents i.e. GAA, HCl solution, hexane and ethanol, UV-Vis spectra showed both positive as well as negative absorbance. So, we can say that out of different solvents used for studying the spectra of Boric acid, methanol showed to be the best solvent for carrying out the UV-Vis spectra of boric acid in our list of solvents.

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