

FOURIER TRANSFORM INFRARED SPECTROSCOPIC ANALYSIS OF A PLANT (*CALOTROPIS GIGANTEA* Linn) FROM AN INDUSTRIAL VILLAGE, CUDDALORE Dt, TAMILNADU, INDIA

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Abstract. FT-IR spectroscopy is used to reveal some qualitative aspects regarding the organic compounds in a plant *Calotropis gigantea* Linn collected from an industrial area. Several indicator bands that are pertained to functional groups represent chemical components or metabolic products. The application of infrared (IR) spectroscopy in plant analysis is still limited compared to its applications in other areas. In this article FT-IR spectrum is able to predict the main chemical constituents in plant materials and also to compare the quantitative differences among the similar samples.

Key words: *Calotropis gigantea*, FT-IR, Industrial pollution.

INTRODUCTION

Environmental degradation is becoming the most challenging threat to human beings as a result of population growth and related pollution throughout the world. The SIPCOT (State Industries Promotion Corporation of Tamil Nadu Limited) industries are playing an important role in the economic development of India. But, the effluents released by them produce a high degree of pollution in the soil, air and aquatic systems. SIPCOT has set up of a 200 hectare estate, 8 km away from Cuddalore town, South India and it consists of big and small units manufacturing pesticides, pharmaceuticals, chemicals, plastics, dyes and textiles. The area of SIPCOT in the Cuddalore District has been declared a 'global toxic hotspot' by environmentalists after finding that the air in the area contained extremely high levels of nearly 22 toxic chemicals, including eight causing cancer.

The plant *Calotropis gigantea* Linn belongs to the botanical family Asclepiadaceae. The plant is commonly found in rural areas on the roadside and is

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used for both medicinal and organic manure. Even though our study area is abundant with many species of plants, special interest is shown in this plant since this occupies most of vacant area around the industrial complex. Naturally, the plant *Calotropis gigantea* Linn is exposed to the air, soil and water pollutants of the SIPCOT and thought to be fit for assessing the intensity of pollution by spectroscopic methods.

MATERIALS AND METHODS

Leaf parts of the *Calotropis gigantea* were collected from SIPCOT area particularly in Kudikadu village Cuddalore District, Tamilnadu, India. The leaf samples were collected in both winter and summer seasons at five different locations [Atahangarai street (S1), Mettu street (S2), Uppannar river (S3), Middle street (S4) and Kudikadu pond (S5)] and one sample was collected from an unpolluted area, far from SIPCOT industries, which is used as a control sample (S6). The investigations were carried both in summer and winter seasons. The control sample was collected only in winter season.

The samples were oven dried at 60°C and ground into fine powder through agate mortar. Two milligrams of the sample were mixed with 200 mg KBr (FT-IR grade) and pressed into a pellet. The pellet was immediately put into the sample holder and FT-IR spectra were recorded in the range 4000–450 cm^{-1} for all samples and the results are recorded in Table 1. All investigations were carried with a Bruker 55 model FT-IR spectrometer.

RESULTS AND DISCUSSIONS

The IR spectrum of plant samples collected from all locations are shown in Figures 1 and 2. The absorption bands and their tentative assignments are given in Table 1 for the both seasons and for the control sample. The FT-IR spectrum exhibits the characteristic finger print band features. The very strong absorption bands at 3434, 3420 and 3434 cm^{-1} are representative for C-H, O-H and N-H stretching vibrations, characteristic of the presence of amino acids [7]. In all locations, it is noticed that the bands at 2918, 2921 and 2928 cm^{-1} are due to the stretching vibration of $-\text{CH}_3$ and $-\text{CH}_2$ groups [1] indicative of the chlorophyll groups. The 1632, 1640 and 1629 cm^{-1} bands are due to stretching vibration of carbonyl group characteristic of the secondary amides and other compounds containing C=O group [6]. The strong bands at 1434 cm^{-1} and 1411 cm^{-1} represent the bending vibrations of CH indicative of the lignins. The 1232 and 1216 cm^{-1} bands in all samples predict the presence of ester carbonyl [9]. The C-O-C groups exhibit strong bands at 1095 cm^{-1} and very strong bands at 1101 cm^{-1} respectively.

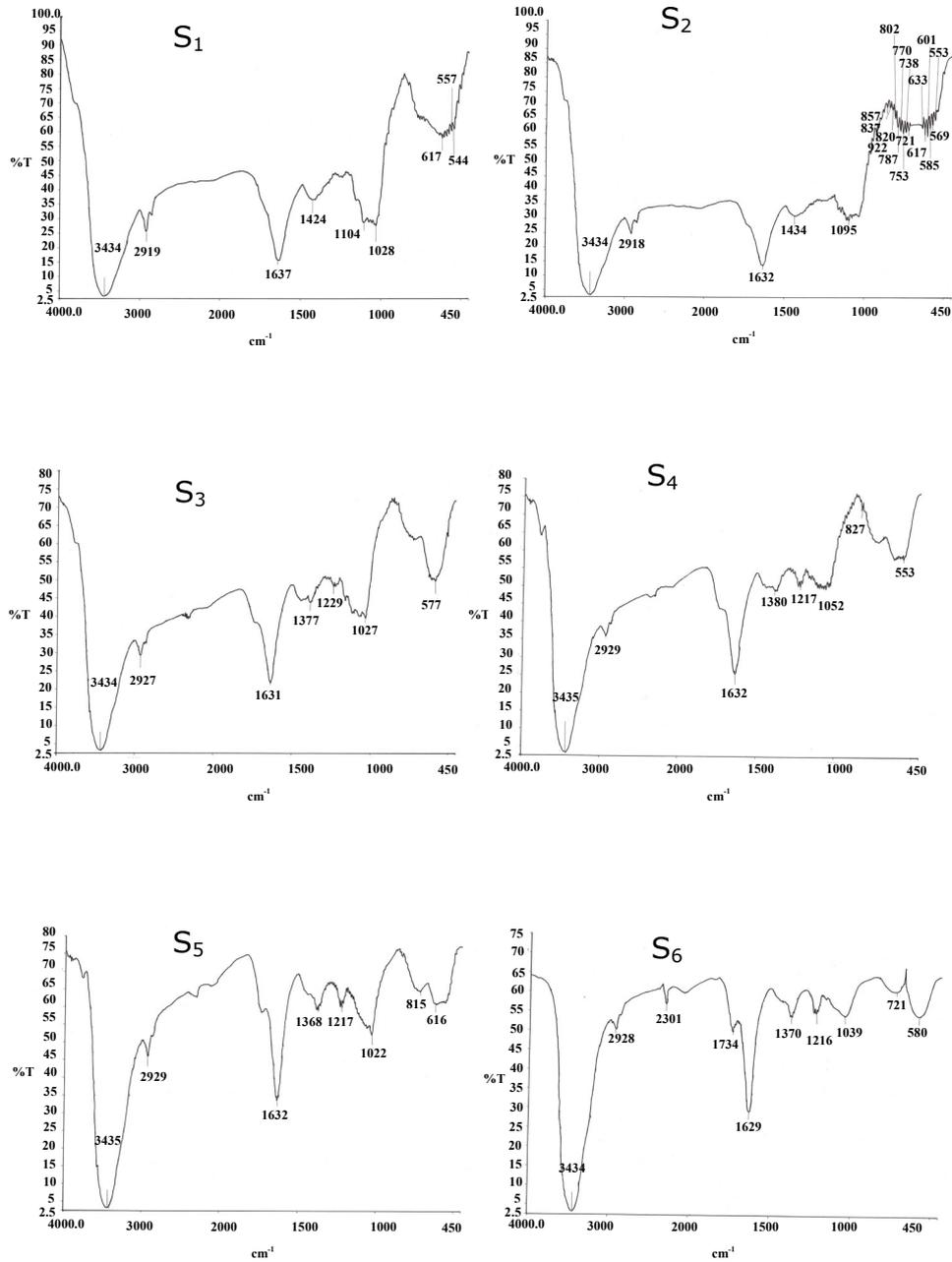


Fig. 1. FT-IR Spectra of plant (*Calotropis gigantea* Linn) samples in winter (S₁ – S₅) and control sample (S₆).

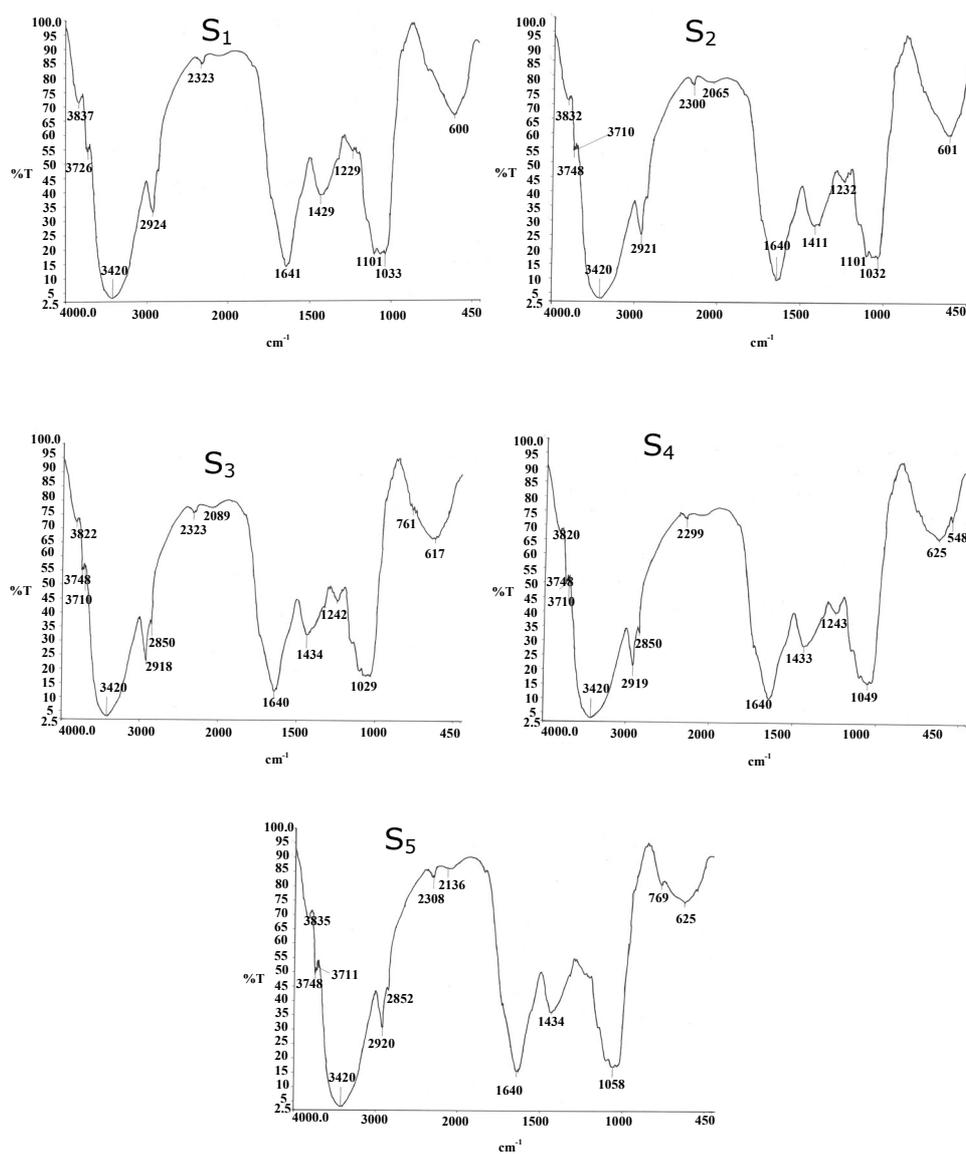


Fig. 2. FT-IR spectra of plant (*Calotropis gigantea* Linn) samples in summer (S₁ – S₅).

The absorption bands at 1100 – 1000 cm^{-1} in the fingerprint region indicate several modes such as C-H deformation or C-O or C-C stretching, pertaining to carbohydrates. Carbohydrates in the leaves were the major constituents of these absorption bands [5]. The very strong peak at 1032 cm^{-1} and 1039 cm^{-1} in the spectrum also indicates the starch content in the sample. The stronger the relative intensity of the band, the higher the chemical constituents. The secondary peaks at 770–922 cm^{-1} are assigned as characteristic absorption of the carbohydrate [8]. The absorbance bands at 837–721 cm^{-1} represent C-H in plane and out of plane bending for the benzene ring and bands at 553–633 cm^{-1} represent C-O-O and P-O-C bending of aromatic compounds (phosphates). The infrared spectrum is able to identify not only the major components in organic materials, but also to find some differences among them. These differences may be due to the industrial environment.

From the spectrum, one can notice that the bands 3835, 3728 and 3710 cm^{-1} are present in the samples only in summer season and they are absent in winter season. In the control sample the bands are also absent and hence comparison is not made and mention is left out. The bands 2921 cm^{-1} indicating the chlorophyll groups are strongly present in both winter and summer seasons except for one sample. The secondary amides 1640 cm^{-1} are present in the samples in all locations and the absorption is very strong in both seasons. It is also strong in the control sample. Likewise the lignins are present in the sample from strong absorption to weak absorption whereas it has medium absorption in the control sample. The presence of carbohydrate and starch (1100–1000 cm^{-1}) in the samples is varying from very strong to medium absorption in both seasons, but they have medium absorption in the control sample. The intensive broad absorption band appears in the characteristic carbohydrate region with a maximum at 1058 and 1033 cm^{-1} [4] in summer. The phosphate groups are present in winter and summer with a medium to weak absorption band whereas in the control sample it possesses medium absorption through 544–633 cm^{-1} .

Mueen Ahmed *et al.* (2005) showed that the leaves and latex of *Calotropis gigantea* species were found to have cardiac glycosides. The cardiac glycosides were identified as Calotropogenin and Calotropin whose structures are given below [6].

From the above discussion it results that the bands 3434 cm^{-1} VS (O-H), 2919 cm^{-1} S (CH_3CH_2), 1637 cm^{-1} VS (C=O), 1424 cm^{-1} S (C-H), 1104 cm^{-1} S (C-O, C-C) and 1028 cm^{-1} S (C-O) confirm the presence of Calotropogenin and Calotropin. Also, it is found that the plant contains all organic compounds: amino acids, chlorophyll, amides, lignins, carbohydrates and starch pertaining to a healthy plant.

Table 1
Assignment of IR absorption bands in the spectra of plant samples (*Calotropis gigantea* Linn)

Athangarai Street S ₁		Meftu Street S ₂		Uppannar River S ₃		Middle Street S ₄		Kudikadu Pond S ₅		Control Sample S ₆	Tentative assignment
Winter cm ⁻¹	Summer cm ⁻¹	Winter cm ⁻¹	Summer cm ⁻¹	Winter cm ⁻¹	Summer cm ⁻¹	Winter cm ⁻¹	Summer cm ⁻¹	Winter cm ⁻¹	Summer cm ⁻¹	Sample cm ⁻¹	
3434 V.S	3420 V.S	3434 V.S	3420 V.S	3434 V.S	3420 V.S	3435 V.S	3420 V.S	3435 V.S	3420 V.S	3434 V.S	O-H and N-H Stretching (amino acids)
2919 S	2924 S	2918 S	2921 S	2927 S	2918 S	2929 S	2919 S	2929 M	2920 S	2928 M	Aliphatic - CH ₃ and CH ₂ Stretching (chlorophyll)
										1734 M	C=O stretching vibration
1637 V.S	1641 V.S	1632 V.S	1640 V.S	1631 S	1640 V.S	1632 S	1640 V.S	1632 S	1640 V.S	1629 S	C=O Carbonyl Stretching (Secondary amides)
1424 S	1429 S	1434 S	1411 S	1377 M	1434 M	1380 M	1433 S	1368 W	1434 S	1370 M	C-H deformations of -CH ₂ or -CH ₃ groups (lignin) in aliphatics
	1229 M		1232 M	1229 M	1242 M	1217 M	1243 M	1217 W		1216 M	Ester carbonyl group, phenol
1104 S	1101 V.S	1095 S	1101 V.S								CH deformation, C-O, C-C stretching (carbohydrates)
1028 S	1033 V.S		1032 V.S	1027 M	1029 V.S	1052 M	1049 V.S	1022 M	1058 V.S	1039 M	C-O Stretching of polysaccharides, Si-O asymmetric stretch (Starch and silicate impurities)
617 M		922, 853, 837, 820, 802, 787, 770, 753, 738, 721, 633, 617, 601, 585,			761 W	827 W			769V.W		CH out of plane bending (carbohydrate)
557W	600 W	569, 553W	601 W	577 M	617 W	553W	625 W	616W	625 W	580 M	C-O-O, P-O-C bonding (aromatics) phosphate

V.S. – Very Strong; S – Strong, M – Medium, W – Weak and V.W – Very Weak

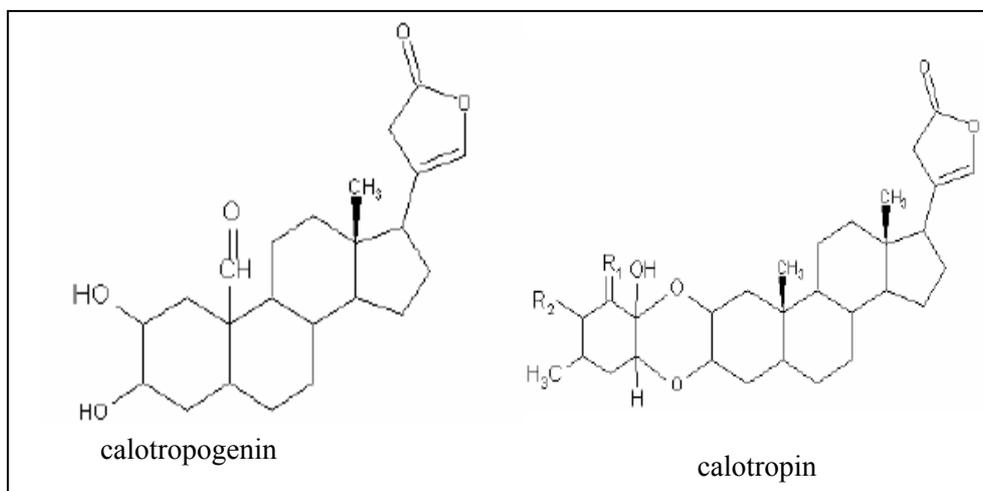


Fig. 3. The molecular structure of calotropogenin and calotropin.

CONCLUSIONS

From this analysis, we may conclude that only some minor changes have occurred in chemical constituents of plant *Calotropis gigantea* Linn. Even though the plant is exposed to the pollution of industries all the time, only minor changes in its constituents are noticed which suggests that this plant has a protective mechanism. Brooks, in 1972 [2], also suggested that plants have some kind of an 'exclusion mechanism' and this aspect, if studied deeply, will prove one of the measures for pollution control.

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