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Research Article

FTIR Analysis of Panchavalkala and Its Green Synthesised Copper Nanoparticles

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ABSTRACT

Since herbal medications have become more and more popular worldwide, it is now essential to carefully monitor their quality in order to ensure both their effectiveness and safety. Fourier Transform Infrared spectroscopy (FTIR) is a non-destructive, reproducible, and easy-to-use technique that can be used to quickly evaluate and verify herbal medicines. The FTIR approach was used to analyze the three samples: copper sulphate, green synthesized copper nanoparticles utilizing Panchavalkala (PVK-CuNPs), and Panchavalkala, a polyherbal formulation. In order to find related chemicals, the produced spectra were analyzed using peak locations and intensities. Panchavalkala, copper sulphate, and PVK-CuNPs all have comparable functional groups, such as carboxylic acid, amine salts, nitro compounds, and halo compounds. It is well known that compounds with carboxylic groups have strong antibacterial properties. Due to the high concentration of aromatic amino acids (AAA) in human skin and perspiration, certain bacteria on the skin have the ability to convert these amino acids into trace amines, which aid in the healing of wounds. This comparative FTIR analysis describes the functional group similarities among these three chemicals. The PVK-CuNPs were successfully capped with a range of organic compounds found in Panchavalkala, according to the FTIR study. These chemicals most likely came from the bio-reducing agents utilized during synthesis. These functional groups are appropriate for biomedical applications since they help to increase biological activity.

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INTRODUCTION

Panchavalkala is a well-known Ayurvedic mixture of bark extracts from five different trees: Vata (Ficus benghalensis), Ashvattha (Ficus religiosa), Udumbara (Ficus racemosa), Plaksha (Ficus lacor), and Parisha (Thespesia populnea). It is in charge of pharmacological actions such as wound purification, antiseptic, anti-inflammatory, antioxidant, antibacterial, and antimicrobial properties. One Panchavalkala kashaya, classified in Ayurveda under the category of Kashaya Kalpana (astringent preparations), is useful in treating vraṇa (wounds) and śotha (inflammations) because to its kaṣhaya (astringent) rasa, which is present in all five remedies.[2]

Copper nanoparticles were created using the a forementioned formulation, Panchavalkala, and the green synthesis process. Since its use in ancient civilizations, copper has had a long history of antibacterial properties.[3] Copper (Cu) is a reasonably cheap metal when compared to Au and Ag. CuNPs are produced by employing a variety of plant extracts to reduce aqueous Cu ions.[4] Transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), UV-Vis spectroscopy, and other techniques are used to examine the size, shape, morphology, and stability of the resulting CuNPs.[5] In this study, FTIR of synthesized copper nanoparticles is examined.

FTIR's primary feature is its ability to identify multiple components in a single sample simultaneously using a single analysis method.[6] It measures how much infrared light a sample absorbs at different wavelengths, giving each component a unique molecular fingerprint.[7] The FTIR approach provides a fingerprint of the different chemical components found in each plant, allowing for the identification of the functional groups (such as -OH, -COOH, -NH2, etc.) contained in the complex combinations of bioactive compounds found in herbal remedies.[8]

MATERIALS AND METHODS:

The basic principle of infrared spectroscopy is the measurement of the amount of infrared light that a sample absorbs (or emits) in relation to wavelength.

With IR spectroscopy, there are numerous opportunities to clarify molecular structure. 8. The infrared spectrum of a polyatomic molecule is composed of molecular vibrations, each of which is affected by the mass, bond strength, and intra- or intermolecular interactions of the atom. Therefore, compared to the IR absorption traces of other compounds, including isomers, the infrared spectra of organic compounds have a unique fingerprint that can be read differently. When reference spectra are available, the majority of compounds can be identified by their infrared spectrum.[9]

The materials were analyzed on potassium bromide (KBr) discs to generate an infrared spectrum (FTIR Spectrum) using a Japanese Shimadzu IR Affinity-1. Upon scanning the samples, characteristic peaks were discovered. The FT-IR measurements that were highest were recorded.[10] The analysis was carried out at The KLE College of Pharmacy in Nehru Nagar, Belagavi, Karnataka, India.

Sample 1 consists of the Panchavalkala medicines, which were extracted from natural sources, sun-dried, and milled into a fine powder. Sample 2 is copper sulphate, which was utilized to create copper nanoparticles. The synthesis of copper nanoparticles was achieved by mixing a 5:5 aqueous extract of Panchavalkala with a 5 mM solution of copper sulphate. The mixture was left undisturbed for 24 hours, and the color changed

from light brown to dark brown, signifying the synthesis of copper nanoparticles. This is sample 3.

RESULTS:

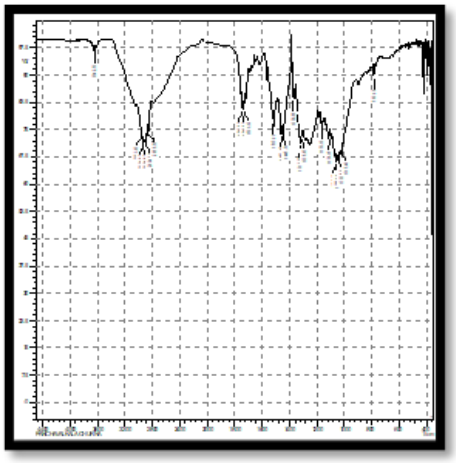

Fig 1: FTIR Spectra of sample 1

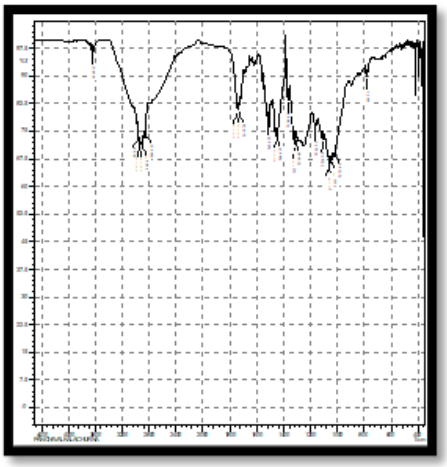

Fig 2: FTIR Spectra of sample 2

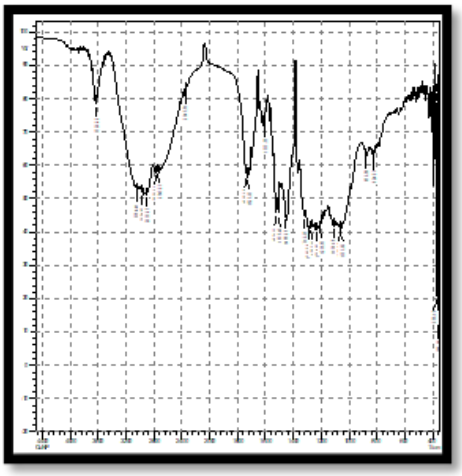

Fig 3: FTIR Spectra of sample 3

Table no 1: Functional compounds detected in sample 1

Sr. No.	Peak position	Group	Class	Peak details
1	3642.73	O-H stretching	Alcohol	Medium, sharp
2	2960.86	O-H stretching	Carboxylic acid	Strong, broad
3	2934.82	N-H stretching	Amine salt	Strong, broad
4	2894.31	O-H stretching	Carboxylic acid	Strong, broad
5	2855.73	O-H stretching	Carboxylic acid	Strong, broad
6	1473.72	C-H bending	Alkane	medium
7	1731.19	C=O Stretching	Cyclopentanone	Strong
8	1516.11	N-O stretching	Nitro compound	Strong
9	1452.46	C-H bending	Alkane	medium
10	1445.71	C-H bending	Alkane	medium
11	1368.55	S=O Stretching	Sulfonamide	Strong
12	1319.37	S=O stretching	Sulfone	Strong
13	1305.86	S=O stretching	Sulfone	Strong
14	1163.13	C-O stretching	Ester	Strong
15	1108.15	C-O stretching	Aliphatic ether	Strong
16	1062.82	C-O stretching	Primary alcohol	Strong
17	1055.11	C-O stretching	Primary alcohol	Strong
18	1033.89	S=O stretching	Sulfoxide	Strong

19	1017.49	C-F stretching	Fluoro compound	Strong
20	783.13	C-Cl stretching, C-H bending	Halo compound, 1,2,3-trisubtituted	Strong

Table no 2: Functional compounds detected in sample 2

Sr.No.	Peak position	Group	Class	Peak details
1	3215.47	O-H stretching	Carboxylic acid	Strong, broad
2	3085	O-H stretching	Carboxylic acid	Strong, broad
3	3054	O-H stretching	Carboxylic acid	Strong, broad
4	3036.09	O-H stretching	Carboxylic acid	Strong, broad
5	2941.57	N-H stretching	Amine salt	Strong, broad
6	2930.96	N-H stretching	Amine salt	Strong, broad
7	2908.78	N-H stretching	Amine salt	Strong, broad
8	2899.13	N-H stretching	Amine salt	Strong, broad
9	2891.42	N-H stretching	Amine salt	Strong, broad
10	2887.56	N-H stretching	Amine salt	Strong, broad
11	2851.88	N-H stretching	Amine salt	Strong, broad
12	2845.13	N-H stretching	Amine salt	Strong, broad
13	2838.37	N-H stretching	Amine salt	Strong, broad
14	2813.30	N-H stretching	Amine salt	Strong, broad
15	2802.69	N-H stretching	Amine salt	Strong, broad
16	2795.94	O-H Stretching	Carboxylic acid	Strong, broad
17	2787.26	O-H Stretching	Carboxylic acid	Strong, broad
18	1524.79	N-O stretching	Nitro compound	Strong
19	1160.23	C-F Stretching	Fluro compound	Strong
20	1149.62	C-O stretching	Tertiary alcohol	Strong
21	1139.01	C-O stretching	Tertiary alcohol	Strong
22	1072.47	C-O stretching	primary alcohol	Strong
23	1060.89	C-O stretching	primary alcohol	Strong
24	1044.50	CO-O-CO Stretching	Anhydride	Strong, broad
25	1029.07	C-F Stretching	Fluoro compound	Strong
26	994.35	C=C bending	Alene	Strong
27	892.12	C-H bending	1,3 disubstituted	Strong
28	845.82	C-Cl stretching	Halo compound	Strong

Table no 3: Functional compounds detected in sample 3.

Sr.No.	Peak position	Group	Class	Peak details
1	3629	O-H stretching	Alcohol	Medium and sharp
2	3054	O-H stretching	Carboxylic acid	Strong, broad
3	2964	N-H stretching	Amine salt	Strong, broad
4	2903	N-H stretching	Amine salt	Strong, broad
5	2769	O-H stretching	Carboxylic acid	Strong, broad
6	2740	O-H stretching	Carboxylic acid	Strong, broad
7	2346	O=C=O stretching	Carbon dioxide	Strong
8	1736.97	C=O stretching	Beta lactone	Strong
9	1726.36	C=O stretching	α, β-unsaturated ester	Strong
10	1606.77	C=O stretching	Beta lactone	Strong
11	1521.90	N-O stretching	Nitro compound	Strong
12	1507.43	N-O stretching	Nitro compound	Strong
13	1455.35	C-H bending	Alkane	medium
14	1319.37	S=O stretching	Sulfone	Strong

15	1283.68	C-N stretching	Aromatic amine	Strong
16	1272.11	C-N stretching	Aromatic amine	Strong
17	1234.50	C-O stretching	Alkyl aryl ether	Strong
18	1205.56	C-O stretching	vinyl ether	Strong
19	1108.15	C-O stretching	aliphatic ether	Strong
20	1065.72	S=O stretching	Sulfoxide	Strong
21	1060.89	S=O stretching	Sulfoxide	Strong
22	879.58	C-H bending	1,2,4-trisubstituted	Strong
23	824.60	C-Cl stretching	halo compound	Strong

DISCUSSION:

Carboxylic acid, amine, halo, and nitro chemicals were found to be similar molecules in all three samples. It has long been recognized that carboxylic organic acids, including as acetic, propionic, citric, and lactic acids, are intermediates of important carbon metabolic pathways and have potent antibacterial qualities. O-H stretching around 2700-3700 cm-1 indicates the presence of carboxylic acid. C=O stretching at 1600-1850 cm-1 verifies the presence of beta-lactone.[12] Strong bioactivity against human cancer cell lines, bacteria, and fungi has been observed in natural substances that include β-lactone.[13]

The existence of alcohols and carboxylic acids, which are commonly found in plant metabolites, was suggested by a broad peak at 3054 cm^{-1} and sharper peaks at 3629, 2769, and 2740 cm^{-1} that correlated to O–H stretching vibrations. The involvement of amine salts in capping was confirmed by strong N–H stretching peaks at 2964 and 2903 cm^{-1}. The presence of β-lactone and ester groups was indicated by carbonyl (C=O) peaks in 1736, 1726, and 1606 cm^{-1}. Furthermore, nitro groups (1521, 1507 cm^{-1}), sulfone (1319 cm^{-1}), and sulfoxide (1065, 1060 cm^{-1}) were found, indicating a complex organic matrix around the nanoparticles. C–Cl and substituted aromatic structures were suggested by peaks below 900 cm^{-1}, which further supported the stabilizers' organic composition.

The existence of halo compounds is indicated by a strong peak in the fingerprint area, which is typical for C–Cl bond stretching and is located between 700 and 800 cm-1. A study on the antibacterial activity of halogenated phenols examined the antimicrobial capabilities of many halogenated phenolic compounds against Staphylococcus aureus in contrast to vancomycin (VAN) and gentamicin (GEN). 2,4,6-Triiodophenol was found to have notable anti-Staphylococcus aureus properties, including anti-Candida albicans polymicrobial biofilms.[14]

CONCLUSION:

According to the FTIR study, The $CuSO_4$ nanoparticles were successfully capped with a range of organic molecules, most likely from the bio-reducing agents utilized during synthesis. These functional groups make nanoparticles acceptable for biomedical and environmental applications by enhancing their stability and potentially increasing biological activity.

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