

Structural Characterization and Physical Properties of *Hydnora africana*

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Abstract: The physical properties of several parts of *Hydnora triceps* (Cover, root and seeds) were investigated. The structure of four parts of *Hydnora* was investigated using X-ray fluorescence (XRF) and X-ray diffraction (XRD). The XRD indicated that structures of all types are amorphous. The XRF results for the cover and seeds indicated that, both are contained Potassium (K), Iron (Fe), Copper (Cu), Zinc (Zn), Lead (Pb), Barium (Br), Strontium (Sr), Yttrium (Y). Optical properties of *Hydnora* were carried out using Fourier Transformation infrared spectroscopy (FTIR) and Ultra violet spectroscopy (UV). The FTIR spectra showed a broad and strong absorption band in the range 1100-2920 cm⁻¹, and these absorptions were assigned to the different stretching vibrations. The absorption for *Hydnora* cover, root, seed 1 and seed 2 was found to be 1.8, 3.0, 0.83 and 0.37 a. u, while the wave length was found to be 235, 220, 200 and 195 nm, respectively. The energy band gap is calculated and found to be 5.46, 4.96, 5.50 and 5.60 eV, for cover, root, seeds 1 and seeds 2 of *Hydnora*, respectively.

Keywords: energy band gap, *Hydnora*, spectroscopy, X-ray fluorescence (XRF)

INTRODUCTION

Hydnora is a genus of holoparasitic flowering plants growing on the roots of mainly *Euphorbia* and *Acacia* species. In the entirely African in distribution, with some reports from the Arabian Peninsula. The plant of *Hydnora* consists of thick succulent root. *Hydnora* has no stems. The flower of *Hydnora* is borne on the surfaces of the roots [1,2].

The plant *Hydnora africana* belongs to family hydnoraceae [3]. The two genera that belong to the Hydnoraceae family; *Prosopanche* which is restricted to the eastern half of South America and *Hydnora africana* which is a strictly African genus. The genus name *Hydnora* is taken from the Greek word, *hydnon*, which means fungus-like and refers to the resemblance that this species has to the fungus genus *Hydnum*. The specific name *Africana* means from Africa. Its parasitic plant found in the dry and semi-arid parts of succulent Karoo, Little Karoo, Eastern Cape Karoo, and the dry Coastal thickets between the Eastern Cape and Kwazulu-Natal in South Africa [4]. It grows very close to its host plant but may not be seen in the drier parts of the year. It occurs in both winter and summer rainfall areas with the most common vegetation being the Succulent Karoo, and Eastern Cape Karoo [5-6].

The *Hydnora africana* fruit is considered as traditional Khoi food and it is very delicious with sweetish taste. It is extremely astringent and used for tanning and preserving fishing nets. In addition to that, it treats Diarrhea, dysentery, bladder and kidney complaints [7]. *Hydnora* species have been described with antimicrobial properties [8] and its infusion is used as a face wash, which helps in acne treatment. This parasitic plant is known as the father of South African botany. The root parasites *Hydnora africana* (jakkalskos) and *Sarcophytes anguinea* (wolwekos) are both called umavumbuka in Xhosa. Men and women apply a thin reddish paste, made by rubbing the dried fruiting body on a coarse stone with a little water, directly to the skin to treat and prevent acne and other skin blemishes. The effectiveness in treating these complaints can most likely be attributed to the high tannin content of the plant. The application is repeated daily until the symptoms disappear. Men and women who work outdoors also use the paste on a daily basis as an effective sunscreen [9-10].

In the Sudan and other parts of east Africa the dried root of *Hydnora* are used as anti-diarrheal medicine were are not aware of similar used in South African. The apparent center of diversity is south Africa, where at least three species are currently recognized. More than 12 *Hydnora* species have been described with antimicrobial properties [11].

Motivated by the important of this useful medical plant, our aim in this work is to investigate the structure and the properties of the *Hydnora Africana* from the physics point of view. The structure of *Hydnora Africana* was investigated using X-ray diffractometer (XRD) and X-ray fluorescence (XRF). Whereas, the optical properties were explored using Fourier transform infrared spectroscopy (FTIR) and UV-Visible spectroscopy (UV).

MATERIALS AND METHOD

Sample preparation

The samples were grained and prepared using mortar for cover, root, seeds 1, and seeds 2, separately. The name seeds 1 and seeds 2 to differentiate between the two types of seeds. In order to investigate samples on the FTIR device, the powder samples were mixed with a little amount from potassium bromide (KBr).

In order to prepare samples for UV vis test, small amount of powder samples of *Hydnora africana* (cover, seeds 1, seeds 2, root) were dissolved in distilled water separately.

Equipment's and measurements

The powder XRD analysis was carried out to confirm the purity of the synthesized materials using Shimadzu 6000 X-ray diffractometer with Cu-K α radiation of a wavelength of $\lambda = 1.5406 \text{ \AA}$ source.

The XRF was performed using Cd-109 XRF spectrometer system, whereas the FTIR results were obtained using the instrument Satellite FTIR serial no. 20010102.

The measurements of absorption of the samples were carried out using UV min 1240 spectrometer Shimadzu.

RESULTS AND DISCUSSION

X-Ray Diffraction Result

The structure of *Hydnora* samples is confirmed by XRD patterns. Figure 1 displays the typical XRD spectra for the triceps. All samples are showed one peak and the XRD indicated that structures of are amorphous, with slight different in intensity of *Hydnora* triceps.

XRF Analysis

XRF is one of useful technique that used to analysis materials and allows the researchers to examine the present of elements in the sample. An X-ray source is used to irradiate the specimen and to cause the elements in the specimen to emit (or fluoresce) their characteristic X-rays.

Table 1 and 2 showed the elements existed in cover and seeds of *Hydnora* triceps. The elements are found to be the same but differ in concentration of certain element in cover and seeds. The XRF results for the cover and seeds indicated that, both are contained Potassium (K), Iron (Fe), Copper (Cu), Zinc (Zn), Lead (Pb), Barium (Br), Strontium (Sr), Yttrium (Y). The Potassium (K) is found to show highest concentration among the elements in both cases cover and seeds as well. Some elements are found to have higher concentration in cover than that of seeds and vice versa. Table 3 shows the comparison between the concentrations of elements.

FTIR Analysis

Infrared spectroscopy is a technique based on the vibrations of the atoms of a molecule. Because each different material is a unique combination of atoms, no two compounds produce the exact same infrared spectrum. Therefore, infrared spectroscopy can result in a positive identification (qualitative analysis) of every different kind of material. In addition, the size of the peaks in the spectrum is a direct indication of the amount of material present [12].

In case of the cover of *Hydnora* absorption peak is appeared at 1659 cm^{-1} and is assigned to the bond of C-C type, another peak with absorption at 1413 cm^{-1} is assigned as functional group of carboxylic acids and a molecular motion with O-H bend. The absorption peak appeared at 3118 cm^{-1} may be belonged to functional group carboxylic acids and molecular motion O-H stretch.

The root of *Hydnora* is showed absorption peak at 1650 cm^{-1} and the bond is C-C type and these bonds appearance is strong. The second peak is appeared at wave number 1408 cm^{-1} and could be assigned to the carboxylic acids functional group and O-H molecular motion bend. The absorption peaks at 2852 and 2920 cm^{-1} could be assigned to the functional group of carboxylic acids as well.

The seeds 1 and 2 samples showed similar absorption and functional group with slight different in the position of certain peak. Figure 2 shows the FTIR spectrum of *Hydnora Africana* (seeds 1). The absorption peak appeared at 1628 cm^{-1} is of functional group alkenes and molecular motion C=C stretch (conjugated), while the peak at 1408 cm^{-1} is the functional group carboxylic acids and molecular motion O-H bend. The absorption peak appeared at 2854 and 2920 cm^{-1} is of functional group carboxylic acids where the molecular motion O-H stretch.

UV-Visible Analysis

The absorption as a function of wavelength for the samples (Cover, root, seeds1 and seeds2) are shown in figure 3. The absorption for *Hydnora* cover, root, seed 1 and seed 2 was found to be 1.8, 3.0, 0.83 and 0.37 a. u, while the wave length was found to be 235, 220, 200 and 195 nm, respectively (see table 3). The absorption of root is found to be the highest among the samples. The optical band gap energy of the materials is obtained using the following equation [13]

$$(\alpha hv) = A(hv - E_g)^m \quad (1)$$

In Eq. (1) E_g , the optical band gap whereas m represents the nature of the transition band gap, constant A is an energy-independent constant, (hv) is energy of photon. Assuming direct band gap transition for the samples, m was assigned a value of 1/2. To evaluate a precise value for the optical band gap, we plotted $(\alpha hv)^2$ versus energy (hv) for *Hydnora Africana* (cover) as shown in figure 4. The optical band gap was determined by extrapolating the linear portion of the plot to $(\alpha hv)^2 = 0$ and is found to be 5.46 eV.

Table 1: the elements and concentration of *Hydnora triceps* for cover sample

EL	E[KEV]	INT[C/S]	S	T	CONC[FRAC]	ERROR
K	3.312	1.034	3.12E+04	0.0409	3.92E-03	5.65E-04
Fe	6.400	1.816	2.72E+05	0.2338	1.37E-04	1.94E-05
Cu	8.041	0.992	6.55E+06	0.3889	1.87E-06	2.69E-07
Zn	8.631	0.248	4.51E+05	0.4423	5.98E-06	1.00E-06
Pb	10.540	0.287	4.39E+05	0.5864	5.37E-06	8.64E-07
Br	11.907	0.931	9.48E+05	0.6614	7.17E-06	1.04E-06
Sr	14.142	0.423	9.92E+05	0.7450	2.77E-06	4.33E-07
Y	14.933	0.156	1.37E+06	0.7663	7.21E-07	1.57E-07

Table 2: the elements and concentration of *Hydnora triceps* for seeds sample

EL	E[KEV]	INT[C/S]	S	T	CONC[FRAC]	ERROR
K	3.312	1.614	3.12E+04	0.0409	6.13E-03	8.72E-04
Fe	6.400	3.056	2.72E+05	0.2275	2.35E-04	3.31E-05
Cu	8.041	1.121	6.55E+06	0.3797	2.15E-06	3.08E-07
Zn	8.631	0.409	4.51E+05	0.4328	1.00E-05	1.55E-06
Pb	10.540	0.230	4.39E+05	0.5772	4.36E-06	7.256E-07
Br	11.907	2.106	9.48E+05	0.6531	1.64E-05	2.32E-06
Sr	14.142	0.555	9.92E+05	0.7380	3.65E-06	5.59E-07
Y	14.933	0.248	1.37E+06	0.7597	1.16E-06	2.19E-07

Table 3: the wave length, absorption and energy band gap of *Hydnora triceps*

Type of <i>Hydnora triceps</i>	Wavelength (nm)	Absorption (a.u)	E_g (eV)
Cover	235	1.80	5.46
Root	220	3.00	4.96
Seeds 1	200	0.83	5.50
Seeds 2	195	0.37	5.60

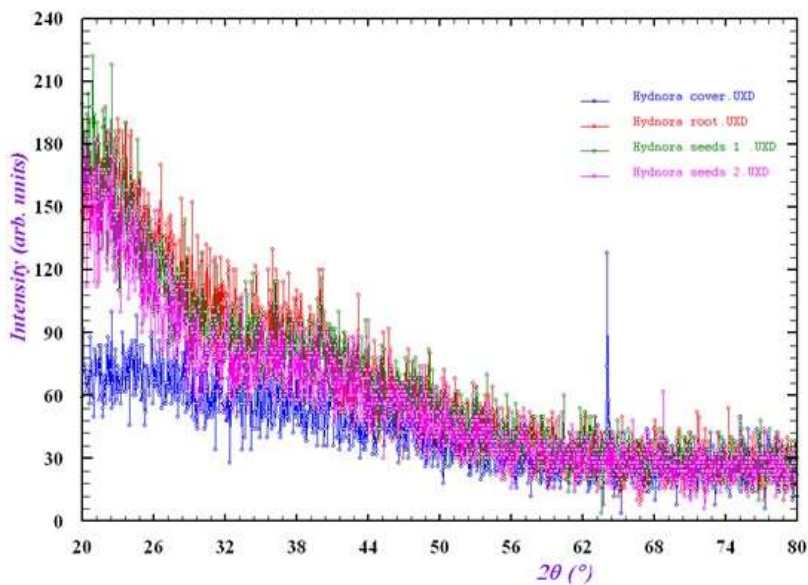


Fig-1: XRD patterns of Hydnora triceps

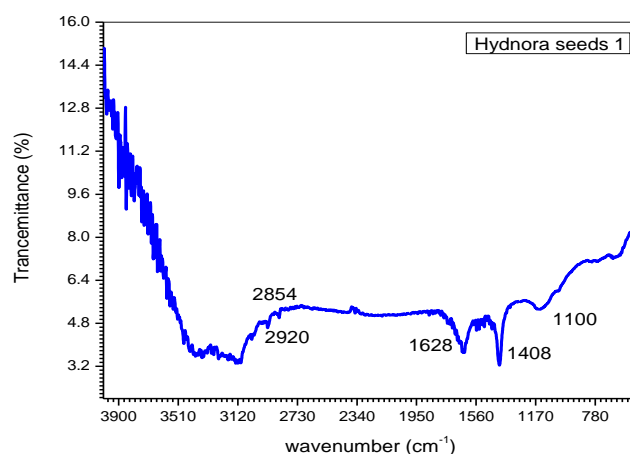


Fig-2: The FTIR spectrum of Hydnora Africana (seeds 1)

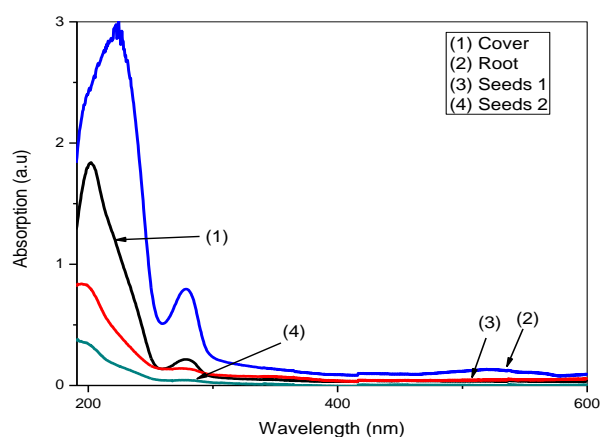


Fig-3: Absorption as a function of wavelength for samples of Hydnora (Cover, root, seed 1 and seed 2)

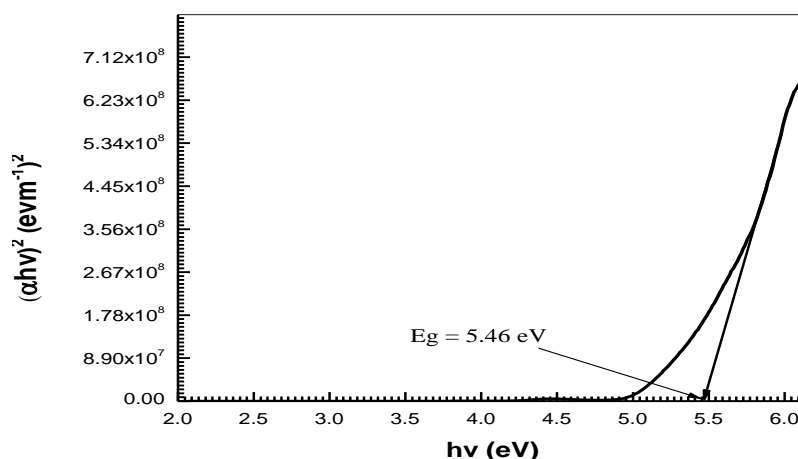


Fig-4: Plot of $(ahv)^2$ versus $h\nu$ for Hydnora African (Cover)

CONCLUSIONS

The physical properties of several parts of Hydnora triceps (Cover, root and seeds) were investigated. X-ray fluorescence (XRF) indicated that both cover and seeds are contained Potassium (K), Iron (Fe), Copper (Cu), Zinc (Zn), Lead (Pb), Barium (Br), Strontium (Sr), Yttrium (Y). The X-ray Diffraction (XRD) confirmed that structures of all parts of Hydnora Africana are amorphous. Fourier Transformation infrared spectroscopy (FTIR) spectra showed a broad and strong absorption band in the range $1100\text{-}2920\text{ cm}^{-1}$, and these absorptions were assigned to the different stretching vibrations. The energy band gap was calculated and found to be 5.46, 4.96, 5.50 and 5.60 eV, for cover, root, seeds 1 and seeds 2 of Hydnora, respectively.

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