

Determination of Iron Content of Three Common *Acacias* of Sudan

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Abstract

The amount iron content of the extracts and samples of *Acacia* species was determined. Since the iron hinders the process of retanning leather, iron content is determined by wet digestion method and atomic absorption spectrophotometry. The iron contents of bark extract of *Acacia nilotica*, *Acacia senegal* and *Acacia seyal* were 0.0044%, 0.0040% and 0.0029% respectively. In contrast, the iron content of bark extract of the three species of *Acacia* had lower percentage compared to that of *Mimosa (Acacia mearnsii)* (0.0047%), which was imported from Kenya. The iron content presented in leaves, barks, mature and immature fruits of *Acacia* species were determined by the same analytical methods. Bark and mature fruits of *Acacia nilotica* had the highest and equal percentage (0.1450%). The percentage of iron content of leaves and bark of *Acacia seyal* had equal percentage (0.0750%), while the bark of *Acacia senegal* had much lower percentage (0.0375%).

Keywords

Acacia Species, Sudan, Iron Content, AAS

1. Introduction

The excess of Fe ions which was not absorbed appeared as spots of rust which was undesirable in the leather industry. The rusting of iron is the formation of hydrated oxide in the presence of oxygen and water. The rust formed on atmospheric exposure is usually more adherent than the produced by immersion. The alkali and ferrous salt, where they meet they will interact to give precipitate of yellow brown-rust consisting of hydrated ferric oxide $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$, provided that plenty of oxygen was present. All these facts have been established by direct observation. The alkali and ferrous salt can be detected by simple test, the precipitation and settlement of the rust are obvious to the eye.

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The main body of the rust is precipitated well, its composition and appearance depends on the oxygen supply. If oxygen is plentiful, Fe^{2+} , OH^- and O_2 may interact to give hydrated ferric oxide as the first solid phase; but it is generally assumed that ferrous hydroxide or basic ferrous salt is first precipitated and then becomes oxidized. Such oxidize has been studied. With deficiency of oxygen, green ferrous-ferric compounds may appear, these appear to be not simply hydroxides, but to contain Cl^- or SO_4^{2-} . In some geometric situations, black magnetite is formed. The atmospheric corrosion set up in industrial or urban atmospheres containing sulphur dioxide (arising from the combustion of coal or oil containing sulphur) presents some different features. It would seem that sulphur oxide is needed to start rapid atmospheric rusting, but serves only as the source of ferrous sulphate, when ferrous sulphate has been formed, sulphur dioxide is no longer needed [1]. There is confusion in the literature regarding the composition of the material produced by the oxidation of ferrous hydroxide. The nature of the product is important, not only from the academic point of view, but also in connection with the theory of the mechanism of the inhibition of the corrosion of iron by alkaline solutions. The following investigation was carried out in order to clarify the position.

It is well known that ferrous hydroxide is a white solid, which becomes green in the presence of a trace of air, if oxidation continues, the green material becomes known and may darken. Deiss and Schikorr (1928) examined the reaction and concluded that the green product was a basic ferrous ferrite, $\text{Fe}(\text{OH})\cdot\text{O}\cdot\text{Fe}(\text{OH})_2$. On the other hand, Girard and Chaudron (1935) regarded the green material as hydrated magnetite [2]. Green-blue hydroxide compounds occur under reducing and weakly alkaline conditions as intermediate phases in the formation of Fe oxides (goethite, lepidocrocite and magnetite). Because these green compounds were first discovered in conjunction with corrosion of steel in earth surface environments, there were called green rusts [3]. Metallic materials in practical use are normally exposed to corrosion in the atmospheric and aqueous environments. Corrosion is one of the problems we have often encountered in our industrialized society; hence it has been studied comprehensively since the industrial revolution in the late eighteenth century [4]. Green rust are very reactive iron(II)-iron(III) hydroxy-compounds were $\text{Fe}(\text{OH})_2$ -like sheets alternate with interlayers composed of anions and water molecules. Various types of anions can lead to the formation of a green rust, e.g. CO_3^{2-} , Cl^- or SO_4^{2-} [5]. The oxidation of either pyrogallol- or catechol-tanned leather is accelerated greatly by iron. Vegetable-tanned leather was equally damaged by either ferrous sulphate or sulphuric acid solutions having pH values approximately 3.5 [6]. Micro-XRF maps show that Cr and Fe are distributed together in regions where their concentrations are diffuse, and at local spots where their concentrations are high. Iron oxides, which can reduce Cr(VI) to Cr(III), are present at some of these hot spots where Cr and Fe are highly concentrated [7].

In this work, we initiated this study in order to determine the content of iron in *Acacia* species that grow in Sudan, and to determine the amount of iron present and the distribution of this metal in different parts of the plants involved. Three common species, *Acacia nilotica*, *Acacia seyal*, and *Acacia senegal*, were selected for study. The amount of iron was determined by atomic absorption spectrometer (Perkin-Elmer, model 2380 AAS).

2. Materials and Methods

2.1. Study Area and Sampling

The samples *Acacia nilotica* and *Acacia seyal* were brought from Sunt Forest at Khartoum State, whereas the *Acacia senegal* samples were brought from Debeybat Forest at South Kordofan State in Sudan. *Mimosa (Acacia mearnsii)* extract were imported from Kenya by Khartoum Tannery. The samples used for the determination of iron content were mature and immature fruits, bark and leaves of *Acacia nilotica*. For *Acacia seyal* sample, the part analyzed were leaves and bark, while for *Acacia senegal* only bark was analyzed.

2.2. Materials and Chemicals

Materials and chemical used for the analysis in this work were of high grade.

2.3. Extraction of Bark Samples

The dried bark samples of the three *Acacia* species were ground in a mill. 40 g of each sample were extracted with deionized water, another with 80% methanol, and a third with 70% acetone (200 ml) by boiling for 10 minutes. The samples were filtered (Whatman 1 paper, 18.5 cm disc) and the residual material rinsed with additional water (2×50 ml). Extracts were transferred to a tarred, round-bottomed flask and concentrated under va-

cuum to a thick extract and dried at 60°C.

2.4. Preparation of Standard Solution

Stock standard solution containing 1000 mg per liter of iron was prepared by weighing 7.0217 g of ammonium ferrous sulphate. The weight of the metal salt was dissolved in a minimum of nitric acid, this was then transferred quantitatively to 1000 ml volumetric flask and brought to volume with deionized water.

2.5. Preparation of Standard Curve

Series of standard solutions were prepared by suitable dilution of the stock solution in concentration that were expected in the sample solution. The instrumental setting was optimized for element to be measured (Table 1).

A calibration curve for the element was obtained by plotting the absorbance against the concentration of the standard solution. The curve was used to determine the concentration of the specific element in the sample solution. Figure 1 show the absorbance-concentration relationship and calibration curve for the element under investigation.

2.6. Preparation of Plant Samples for Analysis

Dried sample of aqueous, methanolic and acetone extracts, and powdered plant part of *Acacia* species and *Mimosa* (*Acacia mearnsii*) were used for the analysis.

5 grams of dried powdered plant parts and extracts were weighed accurately in a small beaker and covered with a glass watch. 37.5 ml of nitric acid (conc.) were added and the mixture was allowed to stand at room temperature until initial reaction subsided, then heated on a sand bath until the production of brown NO₂ fumes ceased. The solution was then cooled and 7.5 ml of perchloric acid (60%) were added and heating continued until almost half of the volume was evaporated. 10 ml of sulphuric and nitric acids mixture (1:1) were added and heated until a clear colourless or pale yellow solution was obtained, then the solution was cooled and filtered into a 100 ml volumetric flask, and completed to volume with deionized water. A blank solution was also prepared in the same way. The absorbance of the analyte in the sample solutions (Table 2) and the amount of the iron content was determined (Tables 3-6).

Table 1. Atomic Absorption Spectrophotometer (AAS) settings for the determination of Iron (Fe).

Element	Wavelength of spectral line (nm)	Slit setting (nm)	Light source	Flame type
Fe	248.3	0.2	H.C.L.	A-Ac.

H.C.L. = Hollow-cathode Lamp, A-Ac. = Air-Acetylene.

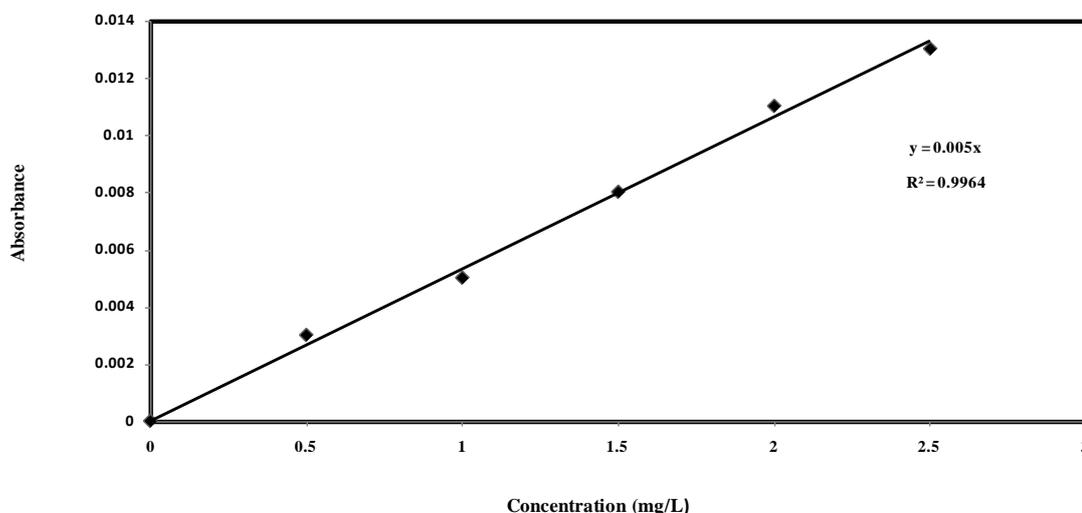


Figure 1. Absorbance of solutions of Iron (Fe) as a function of concentrations.

Table 2. Absorbance of solutions of *Acacia species* bark extracts and mimosa (*Acacia mearnsii*) as determined by AAS (at 248.3 nm).

Species	Solvent of Extraction	Absorbance
<i>Acacia nilotica</i>	Water	0.009
	80% Methanol	0.011
	70% Acetone	0.012
<i>Acacia seyal</i>	Water	0.008
	80% Methanol	0.008
	70% Acetone	0.008
<i>Acacia senegal</i>	Water	0.010
	80% Methanol	0.008
	70% Acetone	0.011
Mimosa (<i>Acacia mearnsii</i>)	Water	0.013

Table 3. Iron content of *Acacia species* bark extracts and samples as determined by AAS (at 248.3 nm).

Species	Fe concentration ^a of Extracts (mg/L)			% Fe in Extracts		
	H ₂ O	80% Methanol	70% Acetone	H ₂ O	80% Methanol	70% Acetone
<i>A. nilotica</i>	0.00165	0.0020	0.00219	0.0033	0.0040	0.0044
<i>A. seyal</i>	0.00146	0.00146	0.00146	0.0029	0.0029	0.0029
<i>A. senegal</i>	0.00183	0.00145	0.00370	0.0037	0.0029	0.0040
Species	% Fe Bark Samples					
	H ₂ O	80% Methanol		70% Acetone		
<i>A. nilotica</i>	0.00051	0.00102		0.00115		
<i>A. seyal</i>	0.00056	0.00075		0.00080		
<i>A. senegal</i>	0.00031	0.00032		0.00048		

^aAll concentrations are relative to standard solution of iron.

Table 4. Iron content of mimosa (*Acacia mearnsii*) as determined by AAS (at 248.3 nm).

Species	% Fe
Mimosa (<i>Acacia mearnsii</i>)	0.00475

Table 5. Absorbances of solution of *Acacia species* bark, leaves, mature and immature fruits as determined by AAS (at 248.3 nm).

Species	Plant Part	Absorbance
<i>Acacia nilotica</i>	Leaves	0.003
<i>Acacia seyal</i>	Leaves	0.002
<i>Acacia nilotica</i>	Bark	0.004
<i>Acacia seyal</i>	Bark	0.002
<i>Acacia senegal</i>	Bark	0.001
<i>Acacia nilotica</i>	Mature fruits	0.004
<i>Acacia nilotica</i>	Immature fruits	0.003

Table 6. Iron content of *Acacia species* bark, leaves, mature and immature fruits as determined by AAS (at 248.3 nm).

Species	Plant part	% Fe in plant part
<i>Acacia nilotica</i>	Leaves	0.1100
<i>Acacia seyal</i>	Leaves	0.0750
<i>Acacia nilotica</i>	Bark	0.1450
<i>Acacia seyal</i>	Bark	0.0750
<i>Acacia senegal</i>	Bark	0.0375
<i>Acacia nilotica</i>	Mature fruits	0.1450
<i>Acacia nilotica</i>	Immature fruits	0.1100

3. Results and Discussion

The solubility and isolation of organic compounds by solvent extraction have traditionally been made with the determinant in uncharged form, but this method is sufficient when the compound is highly hydrophilic. However, organic compounds that can appear in ionized form, can be extracted as ion-pairs. In this study, the amount of iron content of the sample and the extracts of *Acacia species* was determined. Iron content was determined by wet digestion method and using atomic absorption spectrophotometer, because wet digestion method was more reproducible than the dry ashed method. Also comparison of the amount of iron content present in the plant part materials of *Acacia species* was made with the extract of different solvents of the same species, and finally comparison was also made with the iron content present in the Mimosa (*Acacia meurnsii*) extract.

The iron content present in leaves, bark, mature and immature fruits of *Acacia nilotica* was determined. Bark and mature fruits of *Acacia nilotica* had the highest and equal percentage of iron content (0.1450%), while leaves and immature fruits of the same species had intermediate values and equal percentage (0.1100%). The percentage of iron content of leaves and bark of *Acacia seyal* had equal percentage (0.0750%), while the bark of *Acacia senegal* has much lower percentage (0.0375%), (Table 6). All results concerned the determination of iron content in this study have been expressed in terms of iron concentration (Figure 1), suggest that this technique may underestimate the quantity of iron content present.

Iron content present in *Acacia species* was affected by different solvent extraction. Iron content in the extracts was determined by the same analytical methods. The iron content of bark extracts of *Acacia nilotica* and *Acacia senegal* had highest percentage (0.0044% and 0.0040% respectively) and that of *Acacia seyal* has much lower percentage (0.0029%) (Table 3). In contrast, the iron content of bark extract of the three species of *Acacia* had lower percentage compared to that of Mimosa (*Acacia meurnsii*) (0.00475%) (Table 4). The effect of solvents on the extraction of iron from the sample of *Acacia species* can be explained by two reasons. One of the important reason is that the hydrogen bonding properties between aqueous acetone, for example, and tannins are stronger than present between iron and aqueous acetone, since iron and tannins are co-occurring in the same sample, and not on the structure of tannins (or could be extracted completely in this case). The other reason is that tannins have anionic properties, while the iron has cationic properties, since the extraction occurred as ion-pairs *i.e.* anionic plus cationic. We can conclude that extraction by aqueous acetone produce higher percentage of tannins and lower percentage of iron content, and this makes it useful for the extraction processes, when compared with Mimosa (*Acacia meurnsii*) tannins.

4. Conclusions

We can conclude that among the three *Acacia species* studied, *Acacia nilotica* is the richest in tannins content, and within the *Acacia nilotica* parts, mature and immature fruits were the highest in iron content, while the barks of the three *Acacia species* was the least. Also we can conclude that the extraction by aqueous acetone produce lower percentage of iron content, and this makes it useful for the extraction processes, when compared with Mimosa (*Acacia meurnsii*) tannins.

Recommendations that could be drawn from this study are that additional studies will be necessary to estimate variation iron content within and among population of each species.

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