Chapter

Cultural Heritage Objects of Southern Benin: Plant Dyes and Exudates Used in Their Confection

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Abstract

Colors are practically ubiquitous in the artistic and craft objects of the South Benin region, affiliated to the Yoruba cultural area. Apart from the usual ochres and kaolin, the paint layers of the sculptures are little known, especially in terms of their binders but also plant dyes exploited. Colors from plants, usually used in textile dyeing or wickerwork, were among others also used in painting. The mid-term of research and analysis carried out in a multidisciplinary context provided information on the techniques formerly used by artists and craftsmen as well as on the original materials used. This information is inherent in a possible restoration of old museum objects.

Keywords: heritage objects, painting, characterization, conservation-restoration, Benin

1. Introduction

The experience of developed societies and those emerging today confirms the primacy of culture over development [1]. Cultural mastery unleashes the creative energies of development through art, mainly African art which integrates the three elements of the universe: nature, human and the divine. This art does not target the isolated individual, but the integrated person, deeply united with the group and the community. In fact, inventing sustainable development involves building a new cultural vision based on scientific research. Indeed, the dyes used in the making of heritage works represent a cultural element of the first order [2]. In all parts of the world, natural dyes have been used since time immemorial until the end of the nineteenth century, when they were dethroned by the discovery and economic development of synthetic dyes.

The organic compounds responsible for color in ancient materials were obtained from plants, insects, crustaceans and lichens [3]. In addition, the mineral substances used came from red or yellow colored earth, … Their identification in the recipes formerly used in the confection of ethnic objects is important, not only as an indicative technical element, but it also promotes the knowledge of intentions artists, mixing or preparation systems, the quality of the pigments used, their origin and their supply points [2]. Therefore, it provides important information for the application of appropriate treatment in modern conservation-restoration interventions. In addition, beyond the recognition of simple artistic technicality, it contributes to the revelation of their cultural and cult reference.

The recurring problem with ethnographic collections is linked to the lack of documentation or its imprecision, particularly for objects collected in the past [4]. The example of the objects presented in this work is indicative of these shortcomings. However, it has been clarified, according to certain inscriptions and/or characteristics of representation, that these are objects collected around 1900 and coming from the Yoruba-Nago region currently located on the territory of the Republic of Benin. These objects belong to the collections of two museums located in the city of Lyon-France; it is about the African museum and the museum of Confluences. These objects are particularly important because beyond the esthetics, they were all intended for a specific use in their locality of origin. Indeed, the Guèlèdè masks, the Ibéji statuettes, the Shango or hunter costumes …, worn during specific rituals, or other propitiatory ceremonies increase the spiritual vision of the wearer. This shows, in fact, that ethnic objects remain characterized by the genius of assembling or mixing materials, and moreover by the genius of the expression of matter and of the verb.

In recent decades, ethnic objects have gained value by circulating between galleries, auction houses and foreign museums; it is important to safeguard and enhance the objects of Beninese cultural heritage in this flourishing art market.

To this end, an ethnobotanical survey was therefore carried out upstream, with the aim of selecting as well as characterizing the coloring principles of the dye plants most used in South Benin in the making of artistic and craft objects [5, 6], followed by an analytical chemical study by Liquid Chromatography (HPLC-UV-visible), by infrared spectroscopy and *via* microchemical tests of dye materials taken from ancient ethnic objects, in order to identify their matrix origin [7]. Overall, this paper is a social and scientific contribution to the knowledge of natural dyes and materials historically used in the artistic field in Benin in order to improve and revive, ultimately, knowledge of traditional skills as well than for better conservation-restoration of heritage objects.

2. Historical overview on ethnic objects

We cannot separate the historical context of the chemical characterization of the materials formerly used by African artisans and artists in the making of cultural heritage objects, in particular with regard to the identification and the geographical origin of the objects that have been deported, sold or exchanged. Indeed, works of art from the African continent were formerly relegated to second place, calling them gross or magical. In 1898, the Great Encyclopedia affirmed that "Among the Negroes who seem, however, like all the races of central and southern Africa, very backward in matters of Art, we find idols representing men and reproducing with a grotesque fidelity the characters of the Negro race" [8]. This attitude of Eurocentric academics, which consisted in classing peoples according to their level of artistic technicality, can be explained for a reason which is twofold: the lack of written documents capable of allowing a study is the first; the second finds its foundation in slavery and colonization.

A few decades later, voices were raised against this mechanical determinism; this is the case of R. Andree cited by Laude (1988) [9]. The latter mentions in his book that in 1885 Andree wrote that: "Peoples situated at a lower degree of culture may have reached a relatively high degree in the field of art, […] it does not appear not always as the highest state in the evolution of a people". It follows a material influx from Europe on the question of Negro art which generates more curiosity. Indeed, the Europeans will be interested in the products of the civilization of the negroes which they bought in mass and accumulated them in their museums. At the same time, some missionaries (SMA: Society of African Missions) collected these objects, most of which were described as fetishes and which they deported to Europe. This is the case in Benin of the Reverend Father Francis Aupiais. Indeed, a few years after the creation of the S.M.A (1856), the priest Auguste Planque asked the missionaries living in Dahomey to send: "*a collection of things from your new homeland. We want to have in our museum weapons, tools, household utensils, all your gods. In a word, everyday objects that are outside our customs*." [10]. In addition, the works were gathered to facilitate their study, their knowledge by everyone who could have business in Africa. It was the beginning of a very obvious predilection for descriptions and observations made of Negro art. As a result, today, the vast majority of objects of African heritage are found in European and North American museums. It is rightly so, that the materials characterized and/or presented in this paper, were taken from ethnic objects coming mainly from the museum of the service of the African missions (SMA) known under the name of the African museum of Lyon and whose did not have information as to the materials mainly, the dyes used in their manufacture.

3. Methodological approach and principle of the physico-chemical analysis plan for materials taken from museum objects

The success of a heritage approach requires a preliminary or even permanent interaction with the holders of endogenous knowledge and skills. To this end, an ethnobotanical study was carried out on the materials historically used in the making of cultural heritage objects in the region of southern Benin [6]. The target of this survey was mainly aimed at artisans and artists as well as resource persons invested in local cultural awareness. This is a survey based on a semi-structured interview, followed by demonstration sessions on the use of natural materials used by the craftsman, as well as their harvesting for analytical purposes. The analysis plan used is based on a succession of physicochemical analysis techniques which consist in promoting, at each stage, the choice of the appropriate method for the rest of the analysis. This procedure made it possible to reduce the number of experiments to be carried out on the samples taken while increasing the quality of the results obtained. Indeed, very small quantities of dye material the size of a pinhead, are taken from the sampled objects. Then, using a binocular magnifier, the pigments are sorted in order to have the best homogeneous material which is analyzed using an infrared Fourier transform spectrometer (IR-TF) [7]. The interpretation of the results obtained, and their comparison to direct witnesses or to the IR-TF database, conditions the choice of the following analysis. Thus, the coloring matter undergoes either microchemical tests to complete or confirm the results derived from the IR for the inorganic compounds, or an HPLC analysis with a view to identifying the organic dyes. The schematic summary of the sample analysis plan is presented in **Figure 1**.

The IR-TF analysis consists in preparing translucent KBr pellets from the materials taken from the objects, which are subjected to the beam of a spectrometer (Nicolet AVATAR Thermo-360 FT-IR, DTGS KBr detector/OMNIC treatment version 6.0/ acquisition of 64 scans). Colored textiles are directly subjected to the infrared beam in ATR mode. IR-TF spectra were collected in the mid infrared (400–4000 cm^{-1}).

Microchemical analysis consists in highlighting the constituent ions of mineral pigments. It is carried out by the wet route in a drop of solution under a binocular magnifier. The detection of iron(II) was carried out by reaction with thiocyanate (KSCN, 160 g L^{-1}) in an acid medium according to the conventional protocol [11]. That of iron(III) was confirmed by reaction with potassium ferricyanide ($K_3[Fe(CN)_6]$, 100 g L^{-1}) in an acid medium [12]. The presence of the sulfide ions S^{2-} was visualized in an acid medium by reaction with the addition of the reagent iodine-sodium azide and that of the Al^{3+} ions by the addition of the acetic buffer and

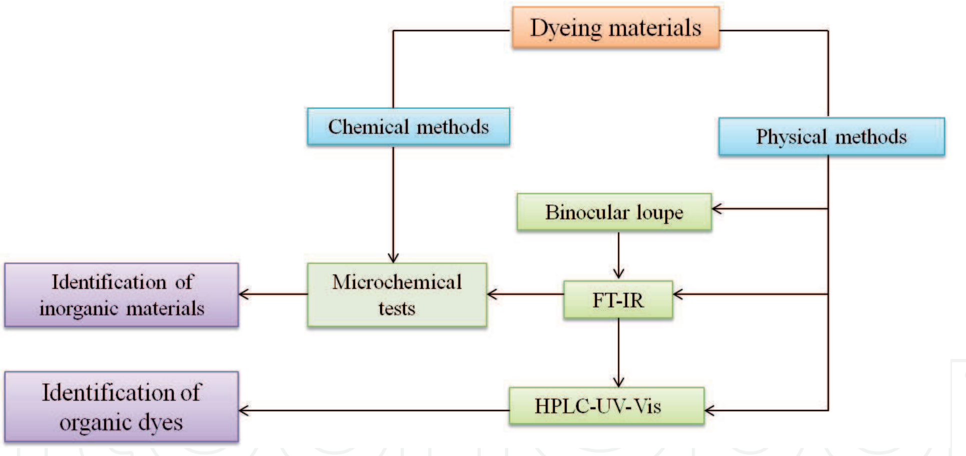


Figure 1.
Schematic principle of the physico-chemical analysis plan for materials taken from museum objects.

of aluminon III according to the protocol of Odegaard et al. [13]. The recognition of the binders was carried out by means of the experiment on the heating plate [12].

Regarding the identification of organic dyes by HPLC, the samples were prepared according to the nature of the pigment, favoring a non-denaturing decomplexation method of Bourhis et al. [14]. In fact, the dye material taken from the objects was treated with an acetic buffer solution (pH = 4.3) and then subjected to ultrasound (SOLEX 180 prototype). However, the colored textiles are extracted directly with the mixture of methanol-dimethylformamide solvent (MeOH-DMF, 1:1; v/v). The extract obtained is filtered, evaporated to dryness and then taken up in methanol before being injected into the system. The prototype used includes a Waters 600 quaternary gradient pump, equipped with an autosampler and a Waters 2996 photodiode array detector (PDA). The stationary phase used is a C18-e column (Symmetry Shield RP-18, Waters 5 µm; 4.6 × 250 mm) and the mobile phase consists of a binary mixture of solvents, acetonitrile-water acidified with TFA (0.01%) in gradient mode. The compounds were detected between 190 and 800 nm and the data were processed under control of Empower 2 software.

Overall, the references used for the characterization of materials taken from ethnic objects, consist of coloring principles purified or isolated from the most used dye plants in the region of South Benin, and about 50 commercial standards of phenolic, flavonoid structures, quinones, etc. In addition, the laboratory database contributed in particular to the IR-TF analysis of the samples.

4. Ethnobotany survey, a springboard for promoting ethnic objects

The ethnobotanical survey carried out with resource people, in particular craftsmen and artists, made it possible to draw up a list of natural materials, mainly the dye plants most used in arts and crafts, especially in basketwork, pottery, sculpture, weaving, ..., in southern Benin. Around, 26 plant species belonging to 14 botanical families (**Table 1**) provide various colors usable by these artisans.

These plants were the subject of a report published in 2014 in the journal *Ethnopharmacologia* [6]. The methods of preparing the dyes listed are decoction, grinding, kneading, pressing, crushing, pounding and maceration with the possible addition of mordant. This study revealed that almost 97% of the listed species are also valued for medical care by the respondents, since they are used to treat common ailments such as anemia, malaria, diarrhea and hemorrhoids. In addition, the local Yoruba-Nago names reported for these plants mostly refer

Family	Name (genus and species)	local appelation yoruba/nago	Products
Anacardiaceae	*Anacardium occidentale* L.	Kandju/Cajou	Yellow dye
	Mangifera indica L.	Mangoro	Yellow dye
Bixaceae	*Bixa orellana* L.	Osun elede	Red pasty material
	Cochlospermum planchonii Hook. f. ex Planch.	Gbehoutou/Ferou	Yellow dye
Cannabaceae	*Trema orientalis* (L.) Blume	Afoforo	Red brown dye
Capparaceae	*Crateva religiosa* G. Forst.	Eyigouhonron/Erun	Yellow dye
Combretaceae	*Anogeissus leiocarpus* (DC.) Guill. & Perr.	Anyi	Yellow dye / brown dye
Euphorbiaceae	*Jatropha curcas* L.	Akpôro	Brown yellow dye
Lamiaceae	*Tectona grandis* L. f.	Ikpatomu	Red dye
	Vitex doniana Sweet	Ori	Dye red brown or black
Leguminosae	*Baphia nitida* Lodd.	Irosun/owiwi	Red dye
	Indigofera tinctoria L.	Shenshe/chenche	Variable blue dye
	Parkia biglobosa (Jacq.) G. Don	Igba	Brown dye / reddish brown dye
	Philenoptera cyanescens (Schum. & Thonn.) Roberty	Elu	Variable blue dye
	Pterocarpus erinaceus Poir.	Apepe/ Osun dudu	Brown red dye
	Pterocarpus osun Craib	Igi osun	Red dye paste
	Senna occidentalis (L.) Link	Adjangoulou	Black dough / red-brown juice
Lythraceae	*Lawsonia inermis* L.	Lali	Red brown dye paste / red brown dye
Malvaceae	*Gossypium barbadense* L.	Owu	Red dye
Meliaceae	*Azadirachta indica* A. Juss.	Dogonyaro	Orange yellow dye glue
	Khaya senegalensis (Desv.) A. Juss.	Gawo	Orange red dye
Moraceae	*Ficus thonningii* Blume.	Odan	coating
Phyllanthaceae	*Bridelia ferruginea* Benth.	Igi ira	Brown dye / dark khaki / black dye bath
	Hymenocardia acida Tul.	Igi osu/ orukpa	Red brown dye
	Flueggea virosa (Roxb. ex Willd.) Royle	Iranjé	Black dye
Poaceae	*Imperata cylindrica* (L.) Raeusch.	Ekan	Yellow dye (variable)

Table 1.
Directory of dye plants used by artisans and artists in the region of southern Benin.

to dye use or the medicinal properties of the plant. This is the case of *Pterocarpus osun* whose vernacular name "osun" refers to the miracles attributed to the soft red substance prepared from this plant. Indeed, this substance is used in the form of an ointment by women right after delivery to announce not only the birth of the baby because of its color but especially for its antifungal properties. It is the same for "Orukpa", local name Yoruba, of the plant *Hymenocardia acida* which literally designates "release of red smoke which kills", because of the toxicity of its wood under the effect of heat. Regarding the indigo dye, it should be mentioned that Benin is distinguished by the low diversity of these blue plants, but also by their quality as well as that of the tank technique used. *Philenoptera cyanescens* (liana indigo) is the most used species accompanied by *Indigofera tinctoria* (indigotier). In addition, in the Yoruba culture (Nigeria and Benin), the application of certain dyes requires special provisions, in particular a good state of purification of the artist so that the dye stays on the support. Sexual intercourse the day before or before dyeing is detrimental to its tenacity. Indigo dye is associated with the worship of a deity named ***Iya Mapo*** who protects the female world and its activities, such as pottery, oil pressing or soap making. However, it should be noted that this practice is nearing extinction.

5. The objects and dyes used

5.1 Masks of Guèlèdè

They characterize the Guèlèdè and its dance. They are sculpted by artists in convents called "Ashè" from the trunks of light cylindrical trees exclusively identified; the best known being the cheese maker *Ceiba pentandra*. Most of the Guèlèdè crest masks consist of two parts: A lower part characterized by a calm face in a conventional simple and static form, with almond-shaped eyes and short scarifications on the cheeks and/or the forehead which represent identity scars held in high esteem in the Yoruba-Nago ethnic group. The upper part, on the other hand, very lively, very complex, is linked to the artist's creativity and to a specific event. It conveys articulated scenes illustrating both socio-educational messages linked to this event and religious messages, then expresses, in addition to ritual magic, a very popular "media magic" aimed at restoring the social cohesion put endangered by the harmful behavior of certain individuals or certain entities. Consequently, there is a manifest ingenuity, at the origin of the making of these crest masks, of sculpture to the application of polychromic materials, followed by their process of sacralization through dance or the power of the verb, which, moreover give them life. This is what makes this art, the best known of the Yoruba-Nago cultural artifacts and was inscribed in 2008 by UNESCO on the representative list of the intangible cultural heritage of humanity.

Indeed, when the sculpture is painted, the pictorial layer consists of a colored layer derived from mineral, vegetable or animal materials, and a binder (oil, egg, wax, latex, resin, etc.). It can be dyed; in this case, it is a colored liquid which the wood absorbs. This liquid comes from a dye solution and can have additives (alum, lime, various salts, etc.) or it is a coloring principle extracted directly from the plant and applied to wood. The example of some of the masks presented (**Table 2**) is indicative of the dyes as well as the techniques, among others, used in their manufacture.

The stratigraphic study of the structure of the samples visualized with a binocular magnifier, shows that the mask referred to as **2013.7.1**, has a very thin layer of dye stuck to the wood. It is a stain directly applied to wood. On the other hand,

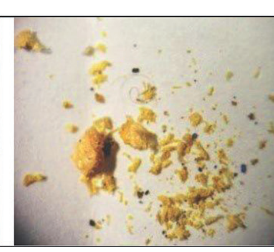
Reference	Guèlèdè mask African museum; Ref. 2013.7.1	Guèlèdè mask African museum; Ref. 401.940.023	Guèlèdè mask Confluence museum; Ref. 60004102
Masks			
Pigment structure			

Table 2.
Some masks from Beninese cultural heritage.

the structure of the samples from the masks **Ref. 401.940.023** and **Ref. 60.004.102** reveals respectively a more or less thick mass of red pigment supported by a layer of yellow crystals, and of yellow pigment surmounting a layer of blue pigment very characteristic of a blue washing powder. This observation indeed reflects a variety of techniques for dyeing ethnic objects. In addition, the identification of dyes by HPLC-UV-visible of these different layers of pigments on the basis of the uniformity of their retention time (tR) and their UV-Vis spectrum to that of the purified or isolated compounds from dye plants studied with reference, made it possible to characterize three compounds: 2-hydroxy-1,4-naphthoquinone (tR = 15.1 min) as well as two flavone aglycones; luteolin (tR = 19.7 min) and apigenin (tR = 22.5 min) at the mask **Ref. 2013.7.1** (**Figure 2**).

Indeed, the compounds identified are characteristic of the *Lawsonia inermis* (henna) species [15], in particular 2-hydroxy-1,4-naphthoquinone (lawsone) which is the specific coloring principle of this species [16]. Thus, the use of this species in the coloring of the mask **Ref. 2013.7.1** is revealed by its coloring marker; the lawsone. Therefore, even in the absence of flavones (luteolin and apigenin), which could not be detected in the red sample from the mask **Ref. 401.940.023**, the identification of the only lawsone in this object, indicates the contribution of henna in the preparation of its red pigment. In addition to lawsone, epicatechin is identified in this sample. This reveals in addition to henna, the use of a tannin plant in the preparation of this dye recipe. Indeed, epicatechin is the major dye characterized in the bark of *Khaya senegalensis* mainly used in dyeing by Beninese craftsmen not only as a bite for its richness in tannin but also for the natural red tint which they exhume by pyrolysis [6].

Furthermore, the IR-TF analysis of the yellow pigments from the lower layer of dyes of the mask **Ref. 401.940.023** and the upper layer of dyes from the mask **Ref. 60.004.102** supplied characteristic tapes in the fingerprint region (<1600 cm^{-1}). In fact, the absorption bands around 600 cm^{-1}, characteristic of iron oxide imprints of the yellow ocher type (Fe_2O_3, nH_2O) have been observed. These bands are attributed to two types of vibrations. These are the vibrations appearing respectively at 540 cm^{-1} and 470 cm^{-1} for the mask **Ref. 401.940.023** and at 630 cm^{-1} and 600 cm^{-1} for the mask **Ref. 60.004.102**. They are characteristic of a deformation beyond the plane, of the O—H group and of a valence vibration of the Fe—O bond. In addition, a band of high intensity appearing in double form between 3698 and 3621 cm^{-1} could be attributed to a valence vibration of the OH group, while the OH associated with the hydrated form of this iron oxide appears in the form of a wide strip at 3435 cm^{-1} for the mask **Ref. 401.940.023** (**Figure 3**).

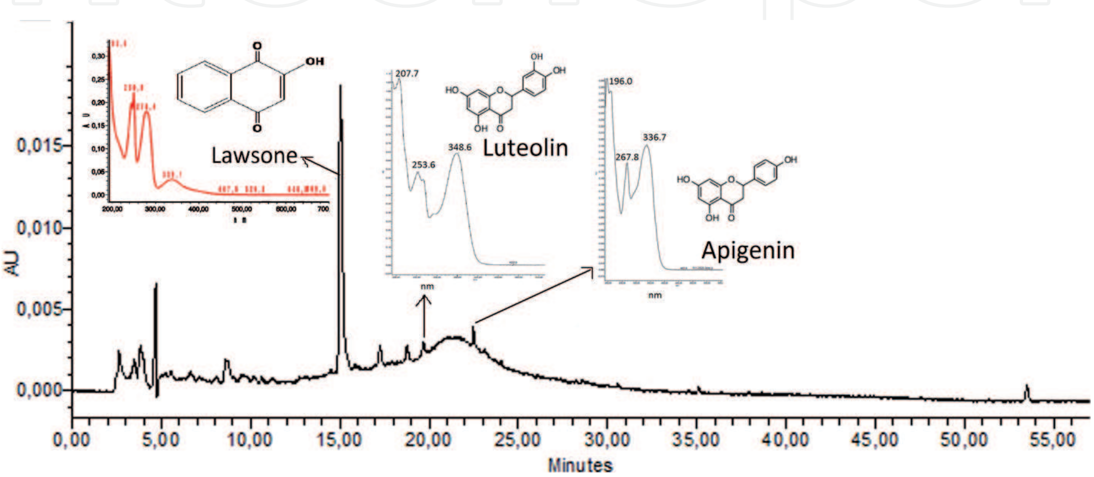


Figure 2.
Chromatogram at 350 nm and UV–visible spectra of the compounds identified in mask ***Ref. 2013.7.1***

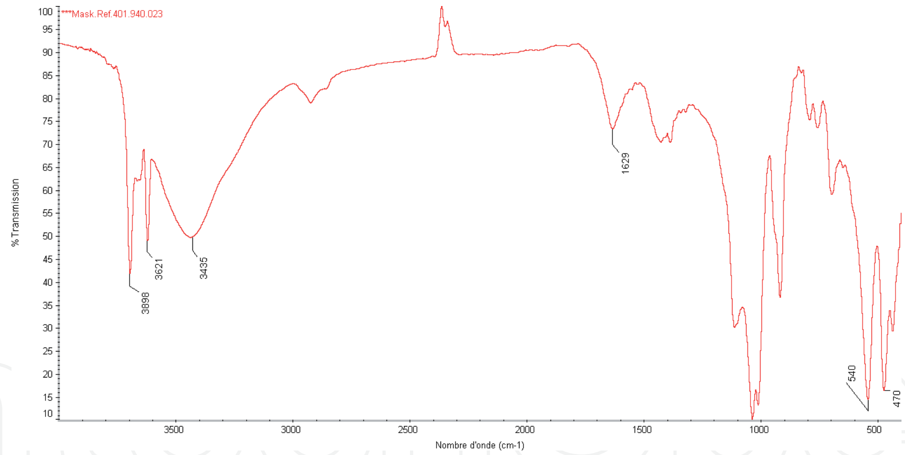


Figure 3.
*IR-TF spectrum of yellow mask pigment **Ref. 401.940.023.***

On the other hand, at the level of the mask **Ref. 60.004.102**, this last band appears in the form of a very large and intense doublet above 3400 cm^{-1}. In addition to the absorption band at 1622 cm^{-1} characteristic of an elongation vibration of the OH bond, there is another elongation vibration of stronger intensity, corresponding to the SO bond of the sulfates which appears in the form of doublet around 1115 cm^{-1}. This assumes that the yellow pigment of the mask **Ref. 60.004.102** consists of a mixture of iron oxide and hydrated sulfate ($CaSO_4$, $2H_2O$), the main constituent of gypsum. This result was confirmed by a control (yellow ocher + $CaSO_4$) available in the laboratory (**Figure 4**).

Microchemical tests revealed the presence of ferric and ferrous ions, constituents of iron oxide in the samples of masks **Ref. 401.940.023** and **Ref. 60.004.102**. It is the same for the ions S^{2-}, component of the mixture of calcium sulfate and yellow earth of the pigment **Ref. 60.004.102**, whose FT-IR spectrum has been characterized. In addition to the sulfide ions, the detection of Al^{3+} ions in the blue pigment of the mask **Ref. 60.004.102**, is associated with washing blue (Na8-10Al6Si6O24S2–4) of the lower layer of this sample.

5.2 "Ibéji" twin statuettes

The Ibéji twin statuette represents the soul of the deceased twin transferred to a wooden figurine. Indeed, in the religious tradition of the Yoruba-Nago, it is considered that the twins have one soul, united and inseparable. For this reason, if a twin dies, the life of the survivor is threatened since his soul is no longer in balance.

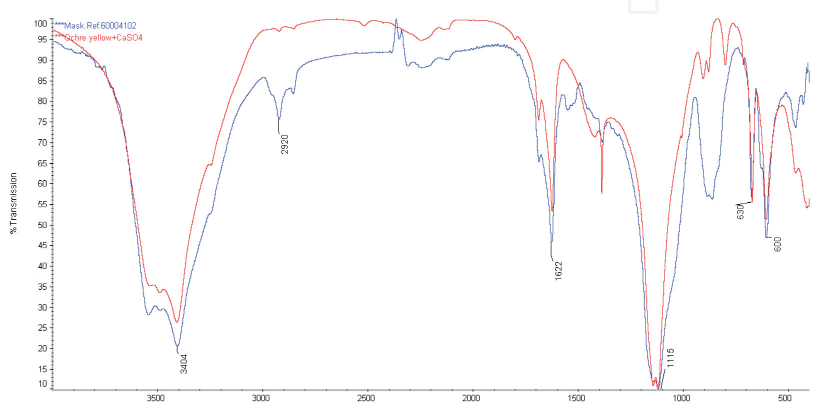


Figure 4.
*FT-IR spectra of the control (mixture of yellow ocher + $CaSO_4$) and of the yellow pigment of the mask **Ref. 60.004.102.***

The anger of the deceased twin can put his entire family at serious risk (illness, bad luck, etc.). In order to avoid these harmful risks for the family, it is necessary to find a way to reunite the souls of the twins. Thus, after consultation with the "Ifa" oracle, ritual arrangements are made and through a cult ceremony, the soul of the deceased is transferred to the wooden figurine. Therefore, this statuette becomes the guardian of the soul of the deceased and must be able to benefit from the same treatment and care as the survivor. Theoretically, it is therefore not necessary to sculpt these wooden statuettes if the two twins die, because the union of their souls is no longer compromised or compromising. But in the Yoruba belief, the dead twins are endowed with supernatural powers, more powerful than those of the ancestors, so even if the two babies die, a couple of Ibéji are sculpted, in order to bring to the twins offerings or their offer sacrifices so that they protect the mother and the whole family. The Ibéji does not represent a child, as one would expect, but an adult more often, with the face and the naked body of an adult (**Figure 5**). It is the sculptor who decides on the artistic form he will give to the statuette. The only element which links it to the request is the sex of the twin or twins who must be sculpted.

Although the statuette represents a living soul, the blue dyes frequently found on the head of Ibéji's sculptures, are traditionally translated by the divine breath that decorates the hairstyle of those who have gone into eternity. Stratigraphic analysis of the pigment taken from the head of the twin **Ref. 501.931.002** reveals a simple application of blue dye adsorbed by the wood. The study of the chemical composition of this pigment in IR-TF presented a spectral profile typical of cyan blue equivalent to Prussian blue $Fe_4[Fe(CN)_6]_3$. It is characterized by a systematic stretching vibration of the C≡N triple bond at 2095 cm^{-1} which appears in a very intense band. There are also weak absorption bands characteristic of the vibrations of elongation of Fe—N bond at 600 cm^{-1} and of Fe—C and C—Fe—C or Fe—CN bonds at 500 cm^{-1}. The characteristic bands of water, which appear at 3436 and 1634 cm^{-1} respectively corresponding to vibrations of elongation and deformation of the O—H group (**Figure 6**).

Characterization by HPLC-UV–Visible of the blue sample from twins **Ref. 501.931.002**, also made it possible to identify an organic dye, indigotin (tR = 7.33 min), a coloring principle of plants to indigo (**Figure 7**).

However, this sample does not contain indirubin. It should be mentioned that two species of indigo plants, *I. tinctoria* and *P. cyanescens*, are used in dyeing in Benin [6]. The origin of the indigo plant was determined by studying the ratio of the relative content of indigoids (indirubin/indigotin) in the plant's original matrix [5]. Indeed, the absence of indirubin (structural isomer of indigotin) and degradation

Figure 5.
Ibéji twins African museum; ***Ref. 501.931.002.***

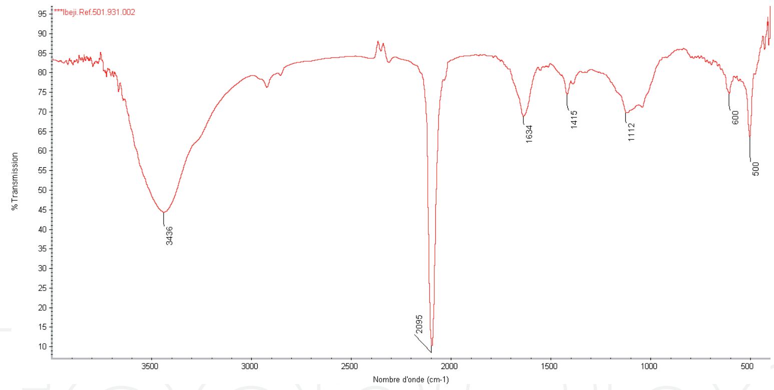


Figure 6.
IR-TF imprint of the blue pigment of Ibeji statuette ***Ref. 501.931.002.***

markers (isatin and anthranilic acid) of the two indigoids, show the high indigotin content of the species initially used in the preparation of this blue dye. A preliminary study of indigo plants indicates that *P. cyanescens* has a higher content of indigotin than *I. tinctoria*. The indigo plant associated with this sample therefore appears to be indigo liana and, this result corroborates the preliminary ethnobotanical study [6], showing that the frequency of use of *P. cyanescens* due to its richness in indigotin, is two times that of *I. tinctoria*. Indeed, the high content of indirubin in *Indigofera tinctoria* is to the detriment of the yield of indigotin sought by dyers.

In summary, it emerges from the chemical characterization of the thin layer of blue dye taken from the twin head Ref. 501.931.002, that this sample consists of either a mixture of synthetic pigment of Prussian blue and natural dye solution indigo, or a natural shade of indigo that was subsequently given a brush of cyan blue synthetic pigment. Indeed, it has been reported that, sometime after the synthesis of synthetic blue pigments, at the end of the nineteenth century, 150 salesmen criss-crossed the planet to sell these different blues; notably in Tunisia, Morocco, Gabon, Togo, Côte d'Ivoire, Benin and Nigeria [4]. The same is true of aniline blue marketed in 1897 as far as Africa, which has gradually replaced natural indigo in the textile field, while on painted wooden objects, laundry blues are frequently encountered.

5.3 Fetishes

Fetishes designate any object, which, following certain ritual acts, is invested with personal powers or impersonal forces. It can be activated by sacrificial gifts and used for a magical act intended to harm, attack or repel the supernatural attacks

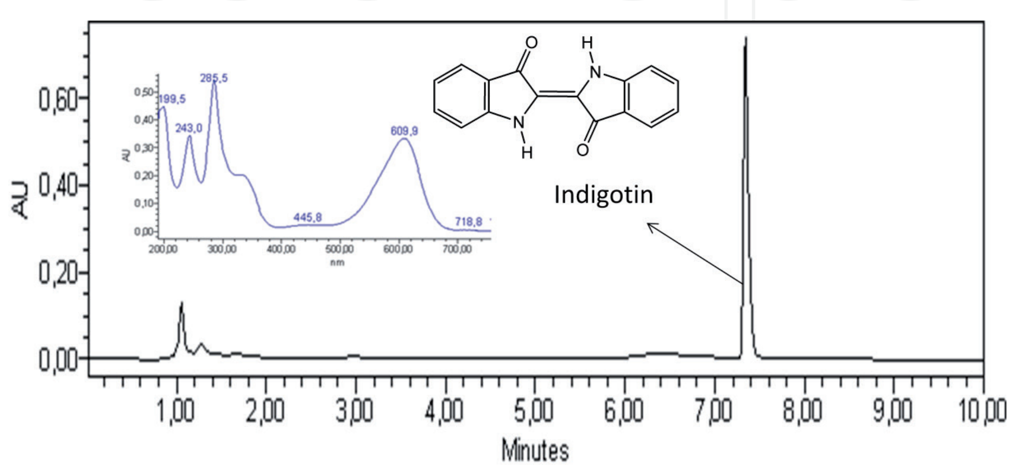


Figure 7.
Chromatogram at 285 nm of Ibéji blue dye ***Ref. 501.931.002.***

of human enemies or to have children and moreover any other wealth [17]. Most fetishes form an assembly of substances to which particular forces are attributed. They are often certain sculptures, stones, horns, claws, teeth, bones, hair, animal skins, coloring substances, etc. but also shreds of tissue, filth, menses and other such impure as effective materials. It plays a role of receptacle and functions by communication with invisible spirits. The fetish sculpture presented is an example. It is marked by white and blue hues in places, especially the blue hues on the head and the white hues of koalin on the eyes and the neck (**Figure 8**).

Kaolin, used in the tradition, translates the communication with the ancestors. It is taken from depressions which are assimilated to the refuge of the ancestors' males. Around the eyes, it keeps ghosts away. Indeed, kaolin is a clay which serves as an adsorbent and can maintain the pigments between them and on the support. It does not contain iron or other chromogenic metals, hence its whiteness. It is therefore transparent in refractive binders such as oil, it is then considered as a filler. The ancients mixed kaolin with their dyes, which, due to its physical characteristics, can therefore partially fix the color by absorption.

In addition, the application of dyes to specific places on the object, in particular the blue tint affixed to the dorsal column of this fetish, denotes coded know-how which reveals that the role of these dyes goes beyond the mere decorative function. Indeed, it should be noted from Bleton et al. [18], that these materials give life to the object and participate in its identity.

The stratigraphic analysis of pigment removal carried out on the fetish back **Ref. 60.003.627**, revealed that it consists of an upper layer of blue dye overlying a layer of red dye. The identification of the dye composition of this HPLC-UV-Visible sample revealed that it contains indigotin (tR = 25.7 min) and lawsone (2-hydroxy-1,4-naphthoquinone; tR = 15.1 min) (**Figure 9**). This last dye comes from the red lower layer of the analyzed sample and shows the use of henna (*L. inermis*) and indigo liana (*P. cyanescens*) in the preparation of the dye recipe which was used to cover the dorsal hollow of this fetish **Ref. 60.003.627**.

5.4 Cult and customary textiles

Textiles occupy a prestigious place in the Yoruba-Nago culture, not only for esthetic reasons, but also for cultural and ritual reasons. For the latter, they

Figure 8.
Fetish confluence museum; Ref. 60.003.627.

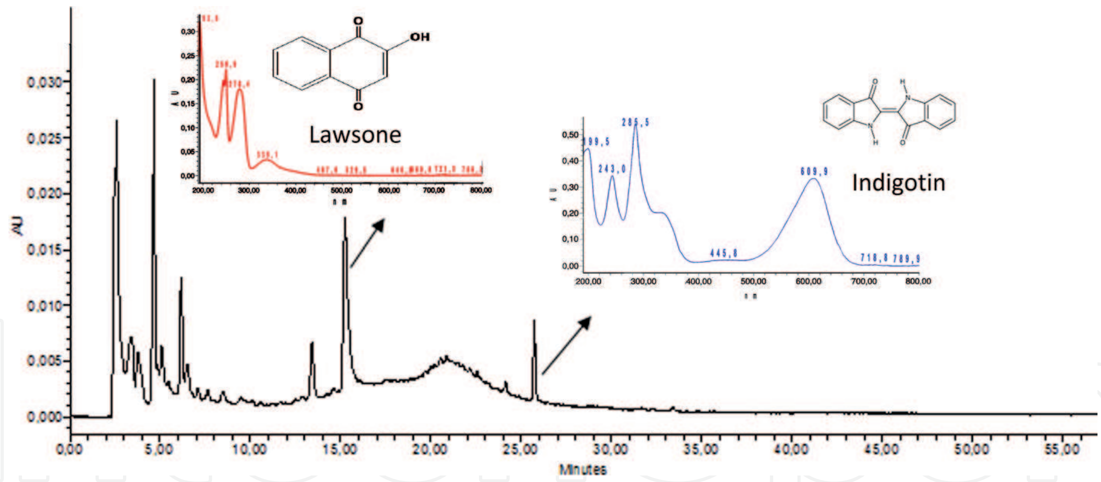


Figure 9.
Chromatogram at 350 nm of fetish dyes ***Ref. 60.003.627*** *and the UV–visible spectra of the identified compounds*

constitute the support of various materials, in particular dyes, coatings, cowries, animal bones, mirror, amulet or any other substance, the whole of which forms an armor which amplifies not only the spiritual vision of the wearer but also and above all ensures his protection against any external or spiritual attack. These textiles, qualified as "prepared", appear in the form of colorful and marvelous costumes used for the Egungun cult or the Guèlèdè cult, while the hunter costumes have a very particular appearance and appear in the form of a vest (**Figure 10**). It is the same for the ritual accouterments of Shango.

IR-TF analysis in ATR mode of a blue textile part of a hunter's jacket **Ref. 2013.0.152**, has absorption bands characteristic of natural cellulosic material with an intense band at around 1109 cm^{-1} due to CO and a wide band at 3339 cm^{-1} linked to the OH group and, a low band at 2920 cm^{-1} due to CH. This result is similar to that from the analysis of a cotton control used as a reference and moreover corroborates the major place occupied by cotton fibers in the field of weaving in black Africa (**Figure 11**).

Figure 10.
Hunter costume jacket African museum; ***Ref. 2013.0.152.***

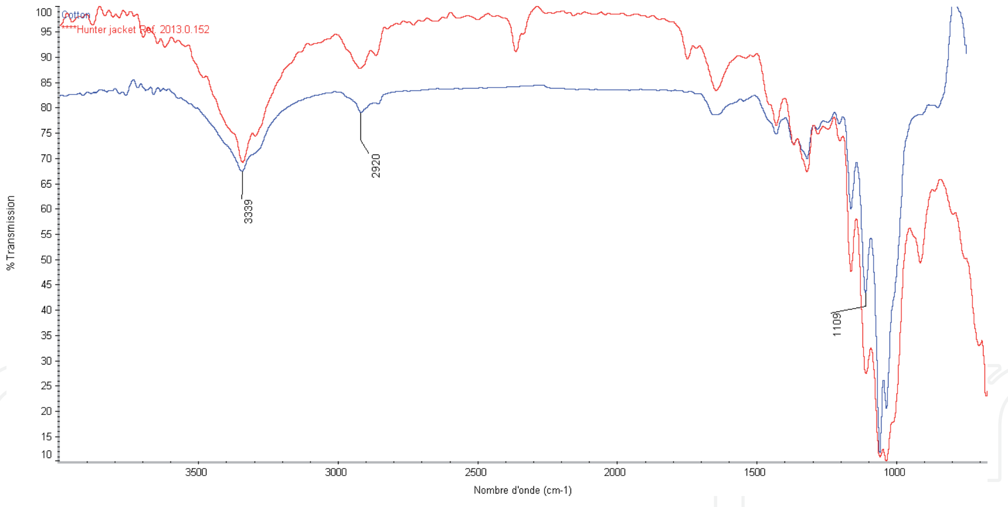


Figure 11.
*FT-IR spectra of blue textile hunter costume jacket **Ref. 2013.0.152** and cotton.*

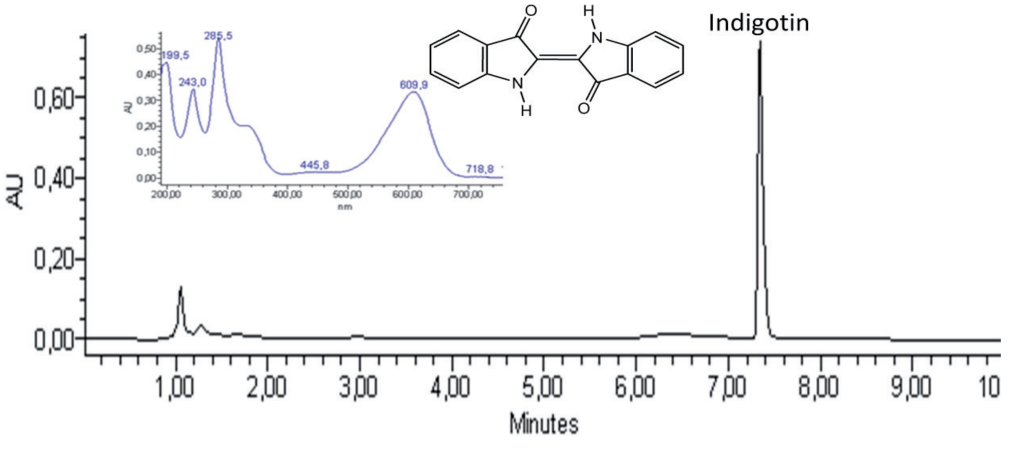


Figure 12.
*Chromatogram at 285 nm of blue textile hunter costume jacket **Ref. 2013.0.152.***

IR-TF analysis of this sample only allowed to determine the nature of the cotton support used to make this vest **Ref. 2013.0.152**. However, its analysis by HPLC-UV-Visible revealed that it mainly contains indigotin (**Figure 12**).

The identification of the only indigotin in this sample reminds us of the use of indigo liana *P. cyanescens* in the dyeing of this textile. Indeed, *P. cyanescens* is the most popular indigo plant in the Yoruba-Nago cultural area, for dyeing blue or black blue cotton, bark (formerly), raffia and other plant fibers, as well as leather, hair and woodcarvings. Yoruba women use this plant, locally called "èlu", as a source of indigo in the manufacture of "adire" fabric; decorative technique similar to batik (dyeing method by which we cover the parts of the fabric that we do not want to dye with detachable wax), which has the effect of creating pale blue patterns on a dark blue background [19]. Traditionally, woven fabrics known as "country fabric" or "Asho ibilè" and dyed with indigo liana were reserved for dignitaries for ceremonial attire, dowries, burial clothes, court fines and gifts to distinguished visitors [5].

6. Other vegetable exudates used

Apart from the natural organic dyes characterized in almost all of the heritage objects studied, field surveys have made it possible to identify other exudates of plant origin, in particular binders: oils, resins, latex, gums, etc., which are also highly valued by craftsmen and sculptors for their different technical than cult properties. Indeed, from a technical point of view, *Alstonia boonei* Wild (Apocynaceae) exudes a toxic latex used to coat the surface of sculptures because of its fungicidal and insecticidal properties, while the latex of *Hevea brasiliensis* (Euphorbiaceae) and that of *Ficus congensis* (Moraceae) are used to seal the carved objects. The same is true of the mucilaginous fruits of *Afraegle paniculata* (Schum. and Thonn.) Engl. (Rutaceae) which serve as glues used in pottery. As for the latex of the Iroko, *Chlorophora excelsa* (Moraceae), it is used specifically for its spiritual dimensions in the sculptures. The iroko is considered a sacred tree, frequently protected near homes and in cultivated fields. In Benin, it is used squarely as a fetish.

The chemical analysis of binders of vegetable origin was much less approached than that of dyes, because it was necessary for these first works to select artifacts which can be compared, having similar functions and/or having a similar analytical technology. However, a binder sample taken from the yellow strip on a Guélédé crest mask **Ref. 60.004.102**, and subjected to microchemical staining tests on a thin section and of the heating plate, made it possible to observe a behavior typical of a natural emulsion. Its IR-TF spectrum displayed a very good correlation coefficient with that of the whole egg. It is interesting at this point to recall that during ethnobotanical field surveys, it was reported that an egg binder was used by the ancients [20]. Its use strictly requires a state of purification since the day before.

7. Conclusion

Analytical techniques IR-TF and HPLC-UV-Visible and microchemical tests applied to the study of dyes and pigments extracted from samples taken from ethnic objects including masks (Guèlèdé), statues of Ibéji, fetish and textiles from museum collections, provided, among other things, information on the matrix origin of materials than on the techniques used in their making. The dyes identified on the objects presented as an example are mostly of plant origin. They reveal the results of the entire corpus of objects studied and testify to the knowledge and use of local natural resources in the making of ethnic objects. However, natural mineral pigments such as kaolin, and soils rich in iron oxides, as well as two synthetic blue pigments have been identified on certain objects. Apart from the dyes, the binders reported in the manufacture of heritage objects come largely from the plant world, nevertheless binders to the whole egg or part of the egg were also reported during field surveys and highlighted. Regarding the way of African painting, it was observed that the color can be directly applied to the wood and then be covered with a resin or a tree sap (or conversely, the resin of first applied to the wood underlay). It can also be applied in two layers of different dyes. In addition, the application of dyes to specific places on the object, in particular the shade affixed to the heads, the dorsal column, or the face, denotes coded know-how which reveals that their use goes beyond the mere decorative function.

8. Recognition

This work is the result of scientific collaboration between a North-South university institution and museum conservator-restorer. Indeed, a research program has been set up and continues to explore the field of coloring plants and organic exudates used by sculptors and craftsmen in West Africa. It brings together Louis Fagbohoun of the Higher Normal School of Natitingou of the National University of Sciences, Technologies, Engineering and Mathematics of

Benin, Cathy Vieillescazes, and Carole Mathe of Avignon University as well as Camille Romeggio independent conservator-restorer. The objective, goes beyond the conservation of the heritage material, through scientific analyzes, it is about exploring a culture very respectful and learned of its natural environment and enhancing its endogenous knowledge.

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References

[1] Kouéna ML. La place et le rôle des œuvres d'art dans le développement africain: cas du Congo-Brazzaville 11è Assemblée Générale du CODESRIA. 2005. pp. 1-12

[2] de Balbín Behrmann R, Alcolea González JJ. Les colorants de l'art paléolithique dans les grottes et en plein air. L'anthropologie. 2009;**113**:559-601

[3] Peggie DA, Hulme AN, McNab H, Quye A. Towards the identification of characteristic minor components from textiles dyed with weld (*Reseda luteola* L.) and those dyed with Mexican cochineal (*Dactylopiuscoccus* costa). Microchimica Acta. 2008;**162**(3-4):371-380

[4] Romeggio C. Sièges rituels yoruba. Questions de conservation-restauration, entre contexte africain et recontextualisations occidentales. In: Mémoire de Master en conservation-restauration d'œuvres peintes. 2007

[5] Fagbohoun L. Etude chimique de colorants naturels et matériaux résineux traditionnels du Bénin dans le domaine artisanal [Thèse de doctorat]. HAL Id: tel-01168469. 2014. Available from: https://tel.archives-ouvertes.fr/tel-01168469

[6] Fagbohoun L, Gbaguidi AF, Ayedoun MA, Mathe C, Moudachirou M, Vieillescazes C. Etudes ethnobotanique et phytochimique des plantes tinctoriales sources de colorants naturels et matériaux résineux traditionnels du Bénin dans le domaine artisanal (Ifangni/Bénin). Ethnopharmacologia. 2014;**52**:56-66

[7] Fagbohoun L, Mathe C, Gbaguidi FA, Ayedoun MA, Moudachirou M, Vieillescazes C. Chemical characterization and origin of dyes used in the manufacture of Beninese cultural heritage objects. Color Research and Application. 2019;**44**(2):234-242

[8] Feau E, Joubert H. L'art Africain. In: La Grande Encyclopédie. Paris: Editions Scala; 1996. p. 8

[9] Laude J. Les arts de l'Afrique noire. Paris: Sté Nle des Editions du Chêne; 1988. p. 381

[10] Romeggio C. Liste et fiches techniques des matériaux naturels utilisés dans l'artisanat à Porto-Novo et aux alentours. In: Rapport de stage. Ecole du Patrimoine Africain de Porto-Novo; 2006. p. 145

[11] Charlot G. Analyse qualitative rapide des cations et des anions. 4è ed. Dunod; 1980

[12] Philippon J. Microanalyse chimique des pigments et des liants par voie humide. Paris: Annale Lab., Institut Français de Restauration des Œuvres D'art; 1986. pp. 35-59

[13] Odegaard N, Carroll S, Zimmt SW. Material Characterization Tests for Objects of Art and Archaeology. 2nd ed. Archetype Publications; 2005

[14] Bourhis K, Blanc S, Mathe C, Dupin J-C, Vieillescazes C. Spectroscopic and chromatographic analysis of yellow flavonoidiclakes: Quercetin chromophore. Applied Clay Sciences. 2011;**53**:598-607

[15] Afzal M, Al-Oriquat G, Al-Hassan JM, Muhammad N. Flavone glycosides from *Lawsonia inermis*. Heterocycles. 1980;**14**:1973-1976

[16] Dixit SN, Srivastava HS, Tripathi RD. Lawsone, the antifungal antibiotic from the leaves of *Lawsonia inermis* and some aspects of its mode of action. Indian Phytopathological Society. 1980;**31**:131-133

[17] Dianteill E. Le Pouvoir des objets. Culture matérielle et religion en Afrique et en Haïti. Archives de Sciences Sociales des Religions. 2000;**110**:29-40. DOI: 10.4000/assr.20201. Available from: http://journals.openedition.org/assr/20201

[18] Bleton J, Rivallain J, Sansoulet J. Caractérisation et fonctions d'enduits placés sur les masques Ejumba de Basse Casamance, sud du Sénégal. Journal d'Agriculture Tropicale et de Botanique Appliquée. 1995;**2**:25-35

[19] Cardon D, Jansen PCM. *Philenoptera cyanescens* (Schumach. & Thonn.) Roberty [Internet]. In: Jansen PCM, Cardon D, editors. Fiche de PROTA4U. Wageningen, Pays: PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale); 2005

[20] Fagbohoun L, Vieillescazes C, Mathe C, Romeggio C. Couleurs et plantes colorantes dans l'art yoruba Enquête de terrain. CeROArt. 2019;**11**:1-22. DOI: 10.4000/ceroart.6622