A Micro-Analytical Study of Nigerian Aluminium Repousses and its Implications for Preservation

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Abstract
Metals are used extensively in the production of artefacts in some Nigerian cultures. Overtime, studies of such artefacts have centred largely on their iconography, production materials as well as production techniques. However, this study focused on the elemental composition of the metals employed in the production of aluminium repousses in Nigeria in contemporary times. To achieve this, three Ion Beam Accelerator (IBA)-based techniques of Particle-Induced X-Ray Emission (PIXE) Spectroscopy, Rutherford Backscattering Spectrometry (RBS) and Proton Induced Gamma-Ray Emission Spectroscopy (PIGE) were used simultaneously. The aim was to determine the elemental make up of the two repousses that formed the samples in the study. The result of the investigation revealed that aluminium was significant in both items, with other elements detected and measured with very low values and some others as traces. Aside providing diagnostic markers for the artefacts, the elemental study of the items is also important in determining the protocol for their preservation as well as clues in case of material defects or deterioration.

Key words: Nigerian metal arts, aluminium repousse, aluminium alloy, Ion Beam Accelerator (IBA) based techniques, artefacts preservation

Introduction

In Nigeria, the use of metals in artistic creation is prominent. Different types of metals like ferrous and non-ferrous as well as precious metals are used in the production of artefacts. Historically, Nok, Ife, Benin and Igbo Ukwu are some cultures in Nigeria recognized globally for the production of metal artefacts. Aside these cultures, some others like Osogbo, Oyo and Kano also employ metals in the fabrication of artefacts. Specifically, Osogbo is renowned for beaten aluminium panels (Probst, 2011: 78; Hackett, 1998: 66), and in Kano, decorative and functional spoons (Wolff, 1986: 40-47, 64-67).

Oftentimes, most studies on the metal artistic traditions from Nigeria tend to focus on the production methodologies as well as iconography of the metal artefacts. But the perspective in the present study is on multi-elemental analysis of 20th Century aluminium repousses produced in Nigeria. Following global trends, scientific study of artefacts has also become quite imperative. According to Gutiérrez (2009: 9), scientific study of artefacts is quite essential in the total understanding of artefacts. This is in the sense that elemental studies of materials provide information about the material composition of artefacts. This is also with an aim to provide diagnostic markers through material characterization of the artefacts studied. Specifically, artefacts' diagnostic markers according to Dran (2002:124) are more or less likened to deoxyribonucleic acid (DNA) which tends to carry 'genetic information' about specific artefacts. More importantly, it helps to determine what preservation methods to adopt. In the opinion of Vandenabeele & Moens (2002), such information is crucial to giving a better insight on an artefact as well as in the preservation of such artefacts. In effect, that data obtained from the characterisation of an artefact is to a large extent useful in safeguarding such an artefact from material defects and deterioration, as well as in the choice of chemical treatment. It is against the foregoing background that extant aluminium repousses produced in Nigeria were studied scientifically. The sampled repousses are taken to be presumptuous of contemporary aluminium repousses produced by metal artists in Nigeria.

The term repousse refers to a technique of sheet metal working as well as the outcome of the technique. In other words, repousse connotes a process and an end product. Technically, in artistic parlance, repousse as a technique is the raising-up of forms or motifs or designs by the exploitation of the plasticity of sheet metals. In this regard, a repousse is a relief form that gives a somewhat three dimensionality from a sheet metal. Thus, this technique is employed alongside chasing and both techniques overlap as well as interchange. Basically, repousses are beaten metal works. Traditionally too, the metal types used for this sheet metal working process are those with good malleability. The metals include gold, silver, copper, brass, bronze, steel and aluminium (Corwin, 2010: 2-17).

The Repousses studied

Using the purposive sampling technique, two aluminium repousses were randomly selected and studied. The repousses were produced by Luqman Alao, a visual artist based in Lagos, Nigeria. The repousses were produced in early 20th century. The aluminium sheets employed in the production of the repousses are used lithographic plates. The plates which are used for offset printing are sourced from printing presses. The plates are of two gauges. The thicker of the two sheets is 3mm thick while the other is 2.5mm thick. The lighter of the two gauges is commonly referred to as 'soft plate' by the repousee artists while the thicker type is commonly called 'strong plate'. The repousse expressed in figure 1 entitled "Oba Esigie and attendants" was produced with 2.5mm aluminium sheet. It measures 29cm by 30cm Two different sheets of the soft aluminium were and used in this repousse. One end of a sheet was glued horizontally to the other end of second sheet. This point of joint forms a slightly visible ridge on the horizontal half of the piece. This repousee was inspired by the famous Benin bronze plaques of antiquity. The brown hue stain effect of this piece was achieved by the application of printing ink.

Plate 1: Oba Esigie and attendants. Photographed by: Kingsley O, Emeriewen (2020).

The second repousse (expressed in figure 2) is titled "Oba Ozolua and retainers". It was produced from a full sheet of 3mm aluminium plate. It is in a tray form. Its dimension is 20 c.m by 25 c.m. This repousse was also inspired by the famous Benin bronze plaques of antiquity.

Plate. 2: Oba Ozolua and retainers. Photographed by: Kingsley O, Emeriewen (2020)

Experimental Procedures

Sample Collection and Preparation: For the purpose of this study, a sample measuring about 1cm square was cut out from the off-cuts of the 2.5mm and 3mm variants of the aluminium sheets (fPlates 3 & 4). This was predicated on the fact that the Ion Beam Accelerator (IBA) used for the study is a vacuum model. In other words, the accelerator does not have an external beam, thus making sampling imperative. The sample from the 2.5mm aluminium sheet was tagged SAL (Plate 3) while the sample from the 3mm aluminium sheet, HAL (Plate. 4).

Plate 3: Sample from SAL.

Plate 4: Sample from HAL

To ensure all external materials like the chemicals used in preparing the lithographic plates for printing were removed from the samples, the off-cuts from which the samples were taken were brass brushed with detergent and water and dabbed dry with a clean handkerchief.

Analysis: Three Ion beam Accelerator (IBA) based analytic techniques of proton induced X-ray emission spectroscopy (PIXE), proton induced gamma-ray emission spectroscopy (PIGE) and Rutherford backscattering spectrometry (RBS) were used simultaneously for the compositional analysis of the two items. PIXE is renowned for its multi-elemental determination, non-destructive capabilities, small sample size requirement and low detection limits up to part per billion levels (Asubiojo *et al.*, 2012). PIGE just like PIXE is used in the determination of the elemental content of samples.

The ion beam accelerator used for the microanalysis of the items is situated at the Tandem Accelerator Laboratory of the Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife. The Tandem Accelerator is centred around a NEC 5SH 1.7 MV Pelletron. The Accelerator is equipped with RF charge exchange ion source. The ion source is equipped to provide proton and helium ions. In the profiling of the items, proton beam with energy of 2.5 MeV was used to irradiate the samples. An appropriate pinhole filter that has a 20% hole at the centre was placed in front of the Si (Li) detector. The filter which is an X-ray absorber was useful in the study of thick samples as well as the simultaneous analysis of both light and heavy elements in the target samples.

To ensure the accuracy of the experimental procedure, an in house calibration of the Ion Beam Accelerator was performed using the Standard Reference Materials (SRM) and the National Institute of Standards and Technology (NIST) 1139a &1761a. The intensities of the X-rays from the samples were processed with GUPIXWIN software and matched with those on the commercial standards provided in Amptek K and L emission lookup chart standard.

Results and Discussion: A summary of the microstructure readings for the two repousse samples are expressed in tables 1 and 2.

Table 1: Elemental Composition of SAL

Elements' Symbol	Concentration (ppm)	Concentration (%)
Al	859999.8	86.3
Si	47964.9	4.8
S	48018.7	4.9
K	8090.4	0.8 *t*
Ca	15302.6	1.5
Ti	1187.3	0.1 *t*
Fe	14360.1	1.4
Cu	1026.2	0.1 *t*
Zn	1101.5	0.1 *t*

t: Trace element

Elements' Symbol	Concentration (ppm)	Concentration (%)
Al	966746.7	96.7
Si	17554.0	1.8
S	5614.9	0.6 *t*
K	2838.9	0.3 *t*
Ca	1753.4	0.2 *t*
Fe	4227.4	0.4 *t*

Table 2: Elemental Composition of HAL

t: Trace element.

A total of eight elements were detected and measured in SAL. In this item, aluminium was measured with a value of 86.3%, thus making it the major element in the sample. Other elements with very low values in SAL are silicon, sulphur, and iron with 4.8%, 4.9% and 1.4% respectively. In the case of potassium, calcium, copper and zinc, they were detected in this item as traces. For the sample tagged HAL, six elements were detected and measured. Aluminium was measured with a significant value of 96.7%, while silicon with a value of 1.8% is the only element in HAL with a low value. The other four elements in this item were detected with trace values ranging between 0.2% - 0.6%.

Given the predominance of the value of aluminium in both items, the samples can be classified as aluminium alloys with somewhat homogeneity. However, when compared with Schimtz's (2006: 9) specification of wrought and cast aluminium alloys, SAL with silicon value of 4.8% and 1.4% of iron is fairly consistent with casting alloy. On the other hand, HAL recorded a low value of silicon (1.8%) and a trace of iron makes it consistent with wrought aluminium alloy specification. While there is some homogeneity in the predominant elements in both items, same may not be said of the trace elements. Comparatively, the traces of elements detected and measured in both samples present a matrix that may be described as inhomogeneous. In SAL, the elements detected and measured in trace values are; potassium calcium, copper and zinc. For HAL, the trace elements are sulphur, potassium, calcium and iron. Worthy of note is the absence of copper and zinc in HAL which were detected and measured as traces in SAL.

The foregoing elemental analysis has implication for the preservation of the aluminium alloy repousses. In the argument of Mahindru and Mahendru (2011) aluminium and its alloys are resistant to corrosion under most environmental conditions. This is due to inert and protective character of aluminium oxide film which naturally forms on the surface of the metal. However, some other corrosive agents which actively attack aluminium and its alloys include alkalis, hydrochloric acid, lead-based paints, certain wood preservatives and chlorides (Waite, 1992: 150). Significantly too, wet lime mortar, Portland cement plaster and concrete will also cause some surface corrosion on aluminium and its alloys (Waite, 1992: 150).

In effect, the aluminium alloy repousses may be resistant to general atmospheric corrosion but are yet susceptible to some chemicals and corrosive agents. As a result, for the aluminium alloy repousses studied to remain well preserved, contact between them and the corrosive agents highlighted by Waite (1992) should be avoided.

Conclusion and Recommendations

A micro-analytic investigation of extant aluminium repousses from Nigeria using IBA provided qualitative and quantitative elemental data for the items studied. From the detected and measured elements in the items studied, aluminium was significant, thus categorising them as aluminium alloys. Some other elements detected had low values while in some others, traces. By implication, the elemental data of the items studied are diagnostic markers for the artefacts. Importantly too, such diagnostic markers have overtime proven to be invaluable in artefacts' preservation and conservation protocols. It is also recommended that some acids, wood preservatives and some cement types amongst other chemicals highlighted above should be kept away from aluminium alloy repousses in order to preserve the integrity of the repousses.

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