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A Characterization of Plaster Of Paris as an Alternative Water-Based Ink Medium for Silk Screen Printing

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Abstract-- *This study investigates the potential of Plaster of Paris (POP) as an alternative medium for producing water-based screen printing ink. The project is based on the concept of aesthetic experimental to explore different types of print characteristics for instance, consistency, workability, colour densities, and impression qualities. Evaluation measures including medium particle size using Field Emission Scanning Electron Microscopy (FE-SEM) testing, microstructural and chemical composition analysis using Scanning Electron Microscope-Energy Dispersive Spectrometer (SEM-EDS), and toxicity analysis using Inductively Coupled Plasma Optimal Emission Spectrometer (ICPOES). The results showed that the formulated medium has a unique property and provided opportunities in creating different types of luminosity and opacity effects. It also created unique print characteristics which capable to derive a huge aesthetic potential within the context of ideas development, concept and creativity specifically for fine artists and designers.*

Keywords: *Plaster of Paris, Screen Printing, Aesthetic Characterization, Alternative Ink Medium, Water-based.*

I. INTRODUCTION

The method of silk screen printing utilizes stencil techniques, in which the ink is simply pushed through the stencil surface via a squeegee device. Prints are based essentially on designs and means, which are ideal for unique and creating eye-catching effects which become "visual language" (Stankiewicz 2004, p. 90) [1]. Screen printing is extremely versatile and can be personalized for printing on different textiles, plastic, paper, wood, metal surfaces or materials. Adam and Robertson (2003, p. 7) noted that "... assessed for its flexibility and speed regarding the variety of surfaces that can be applied to an infinite range of colours "[2], making screen printing so popular for commercial and esthetical works. Artists and designers are able to explore and experiment with various surfaces and incorporate different mediums, in particular water-based pigments, to create new ways of labelling or distortion of images that significantly affect changes in surface features (Kasikovic et al. 2013) [3]. According to Adam and Robertson (2003), various groups can now pursue several approaches to creating images and printing on a fine arts

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screen no longer needs those effects to be defined or established [2], but it is open-ended and free to "overlap and displacement of the area of distinction" (Bhabha, 2007, p. 2) [4] or uniqueness.

A new visual aesthetic was created by the rooting approach to artists and designers' continued explorations and experiments in the context of contemporary printing art development (Sedon et al., 2015). Karim and Mohamed (2011) noted that artists are more open to the use of various mediums to manufacture artworks with new methods and other mediums that permit special characteristics and attributes of new print [6]. The screen printing versatility which is adapted to any technological changes produces novel speeches and expressions that can expand the area of visual arts in aesthetic and critical contexts. Hartt (1976) points out that the change in art and style in the technical and technological approach is seen as an evolutionary representation [7].

In order to extend creativity towards ideas and the adoption of approaches to printing under various possibilities and conditions that question and alter established media perception, artists and designers are constantly exploring and referring to other visual aesthetic developments (Adam & Robertson 2003, p. 8) [2]. In the meantime, Carroll (1999) notes that the structure shifts because it takes a form of representation [8]. In this sense, an aesthetic value shift and growth has led to the search for a unique new medium where printmakers are creating workplaces that cover a wider field of studio practice than the usual case with printing (Kirker, 2009, p. 12) [9].

In developing the printing sector, ongoing testing is particularly important in the context of the development of industrial technology. Merrill (1993, p. 8) claims that "print is a theoretical language of evolving ideas... where original and reproductive functions are complemental possibilities and not categories that are opposite" [10]. In the mean time, Eames (2004) in Hamilton (2018) clarified that diverse brand markings from the silk screen discipline provided the artist the most complex visual content through the creation of a technical understanding when employing them in practice [11]. In other words, all types of exploration are to identify new screen printing possibilities, procedures and techniques as an "attempt on moving beyond conventional borders to lift criteria for print making" (Mohamed Saat, 2009, p.47 in Shair and Mohamed Saat. 2009) [12].

II. PROJECT OUTLINE

In the test method, plaster Paris (POP) was examined, tested and established into a suitable medium for the use of the "jigsaw puzzle" technique as a screen printing medium. The work covers the medium technical dimension-size, texture and aesthetic consistency, condition and strength (durability / flexibility) of the material, and the suitability of the printing process. Electron Microscopy (FE-SEM) experiments have been performed to measure the particle size— the physical characteristics. Composition tests were performed using the Scanning Electron Microscope Energy Dispersive Spectrometer (SEM-EDS) to determine the component of the medium through microstructural and chemical composition analysis. The toxicity measurement tool was also conducted with the Inductively coupled Plasma Optimal Emission Spectrometer (ICP-OES) according to the Agency for Toxic Substances & Diseases (ATSDR) Minimum Threat Substance Rate List.

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III. THE EXPERIMENTATIONS

Preparing the Plaster of Paris

The POP was initially designed to achieve a smooth consistency of the POP solution by combining a POP powder with water, with the optimal POP powder ratio of 1:2. Then pour the solution into a mold and dry it up until it is hardened and dried. The next steps are crush and squash the hardened POP solution for a finely powdered and mixing process to get a very fine powder using a ball milling machine (YLK, YKM 12L).

Field Emission Scanning Electron Microscopy (FE-SEM) Analysis

In this study, surface morphology analysis of the POP treated using SEM (HITACHI, SU8020) is analyzed after treatment with different procedures like temperature, grinding time and grinder rpm. The sputter coater type Quorum Q150PS was used to coat all specimens of POP for 30 seconds with platinum to avoid the complexities of charging. In order to get clearer pictures during study, this process is important. A tungsten filament at the top of the column, with the larger voltages, created a primary electron or electron bomb. The primary electron beam is transmitted via the electromagnetic field and condenser lenses, concentrating on the sample. Both secondary and back-stretched devices are observed through a detector when the main electron beam reaches the sample. A detector converts it into a scanning coil and sends it into image types to track the display.

Three POP (A1, A2 and A3) samples were rendered per minute from different innovative conditions (rpm). The time was 30 minutes for each grinding cycle.

The results demonstrate that A1 had an average porosity density of 8-258 μm when the rpm was adjusted to 300 rpm (Fig. 1, A1). The A2 texture (Fig. 1, A2) which was more successful as a result of smooth and dense surface fabric average 179-238 μm in porosity. In the meantime, A3 showed the best results when the rpm was calculated at 500 rpm with an average porosity size of 119 to 198 microns (Fig 1, A 3). Table 1 summarizes the analysis.

Figure 1 displays the SEM image of POP surface morphology after treatment with different grinder methods, with a voltage of 5.0 kV and a magnification of 5,000x.

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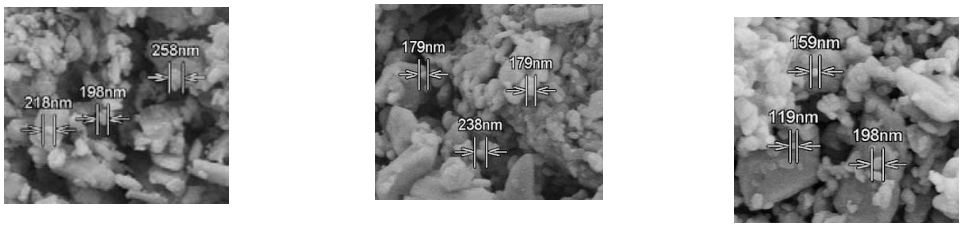

A1 **A2** **A3**

Figure 1: FESEM surface morphology

Table1: Processing Method and Particle Sizes

Sample	Method of processing	Particle sizes (μm)
A1	300rpm	198 - 258
A2	400rpm	179 - 238
A3	500rpm	119 - 198

*duration = 30 minutes

Scanning Electron Microscope-Energy Dispersive Spectrometer (SEM-EDS) Analysis

The analysis of the composition has been carried out using the scanning electron micro-energy dispersive spectrometer (SEM-EDS) in microstructural and chemical composition analysis to determine the component of the medium. The following are the results:

Table 2: Composition Analysis

Element	Weight %	Atomic %
C K	6.67	11.64
O K	52.79	69.20
Na K	0.11	0.10
Al K	0.54	0.42
Si K	0.39	0.29
S K	12.39	8.10
Ca K	15.90	8.32
Sc K	0.52	0.24

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Ti K	0.60	0.26
V K	0.34	0.14
Ge L	0.63	0.18
Rb L	0.40	0.10
Y L	0.74	0.17
Pd L	0.15	0.03
Pt M	0.70	0.08
Pb M	7.15	0.72
Total	100	

Inductively Coupled Plasma Optimal Emission Spectrometer (ICP-OES) Analysis

Inductively coupling plasma optimum emissions spectrometer (ICP-OES) was also tested for toxicity analysis and compared with the Minimal (ASTDR, 2019) [13]. The analysis showed that all of the medium samples contain insufficient heavy metals, which are healthy in the medium and can be applied in particular to humans for general purposes. The findings have been summarized in Table 3.

Table 3: ICP-OES Analysis

No.	Metals	POP Paste	Min risk levels (µg/g)
1.	Cr (chromium)	1.51	5.00
2.	Co (cobalt)	0.14	10.00
3.	Ni (nickel)	2.10	0.20
4.	As (arsenic)	0.12	5.00
5.	Se (selenium)	0.91	0.50
6.	Hg (mercury)	None	2.00
7.	Pb (leads/plumbum)	1.36	2.00

Consistency

Consistency and reproductive capability are the most important aspect of any screen printing process. 20 versions of black and white images with a POP were printed and worked perfectly during the print process without any sign of drying. The drying time of the medium is approximately 15 minutes similar to any commercial medium. It has shown that the POP-based paste is capable of reproduction and mass production during all the preparation, printed process and testing conditions of the processed POP.

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Figure 2: POP paste (white) and coloured acrylic mixture

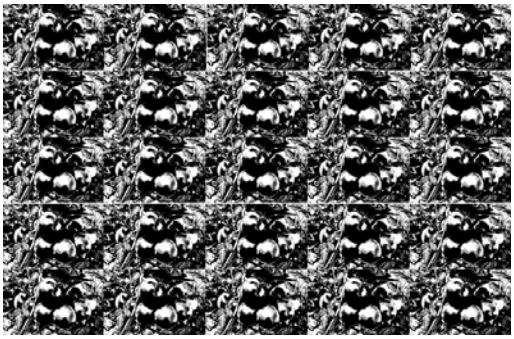

Figure 3: Edition Series Example

Mediums and Materials Experiments – Print Characteristics

Experiments with a different quality of surfaces were performed using and mixing a different color combination, such as plastic, paper, plywood, perspex, fabric and canvas. Colour responds esthetically different depending on the color blend and on the printing layers, materials and surface characteristics, which yield variations of texture, color density and printing properties. For example, the colour-mix on poster is opaquer, which gives a richer and thicker perception of colours. While on the screen mesh, the colours of food or water create a sort of delicate effect. The combination of water colours produces more clear consistency but the contrast can be seen in the blend of poster colours. The medium also works on smooth surfaces, such as plastic and perspex, that perfectly function like any other commercial media.

Food colouring on cloth

Acrylic on canvas

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Water colour on prespex Water colour on canvas

Fabric dye on plywood Acrylic on paper

Poster colour on plastic Poster colour on paper

Figure 4: Mediums, materials Experiments

IV. RESULTS AND DISCUSSION

The printable aspect, which is the image's principal representation, is dependent on impression quality. The flower pictures display composition using acrylic colour printed on a canvas using posterized techniques. Through changing the mixed ratio between the medium (past) and colour to 70%: 30%, it can provide a good colour contrast and can generate simple impressions of shape and space or objectively present.

Figure 5: Composition 1

The application of silk screen printing is very broad for various products, such as crafts, decoration and so on, in the sense of commercial production. Prints are developed for the purpose of exploring medium-scale applications (paste) suitable for a variety of applications, on paper, plastics and textile, for stationery products, cards and decorative lamps. Experiments have shown that it is suitable for commercial uses, particularly for decorative and stationary items, which can be printed on hard and soft surfaces (Fig. 6).

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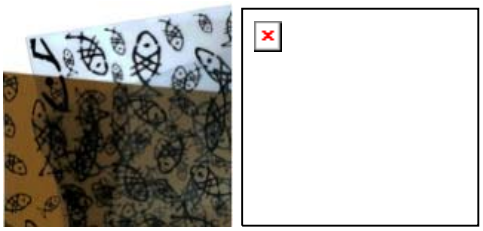

Figure 6: Stationary, craft and decoration applications

In Fig. 7, The work includes the use of poster, water colour and food blends, in 9 overlapping sheets of printed canvas. The use of various colours and textual characters provides the impression of graphical surfaces, whilst the bright colours both at the base and at the top of the work change strongly the perception of views and create an illusion of rhythmic equilibrium that causes variations in the visual quality.

The density of the transparent textual structure by the combination of different color pigments creates an interesting effect through the comparison of light and dark values, producing differences between tactual impressions. The colourful texts harmoniously align with the coloured framework, which encourages active visual experience between positive and negative spaces with the arrangement of codes in the context and variety of images positioned in a grid. With its difference in printing properties, the medium (paste) is certainly perfectly functional and ideal for screen printing.

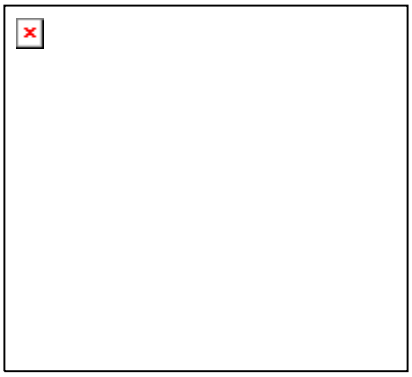

Figure 7: Abstract artwork application

V. CONCLUSIONS

This research has investigated and substantially developed the alternative water-based medium (paste) for screen printing from plaster in Paris that could be combined with other water-based colours (powder/liquid/pigment). The medium responds aesthetically differently, depending on colour mix, textures, materials and surface characters that offer the opportunity for a number of print characteristics (density and print quality). The projection of alternative ink medium contributes in enhancing the printmaking in the context of Fine

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Art and Graphic disciplines through its great potential in generating and evolving concepts within the framework of implementation, layout and creativities for artists, designers, decorators and printers for aesthetic construction or commercial purposes.

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