TECHNOLOGICAL ADAPTATION IN TRADITIONAL FABRIC DISCHARGE PRINTING IN GHANA

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ABSTRACT

Fabric discharge printing involves the process of colour removal over a previously dyed fabric to produce a white or a lighter coloured design fabric. Though its effect is one of the most adaptable print techniques used for fabric decoration, its dependency on exports thickeners, how the discharging agent is used, from the mixing to its production to finishing, posed a major problem that resulted in weak and shorter life span of fabric used. The discharging powder was mixed with only water and applied on dischargeable cotton fabric, using the drawing or pouring method to produce a selectively discharged pattern that created an undesirable bleeding print effect. However, in this project, a locally produced discharge paste consisting of the discharging powder and a stable prepared local starch as a thickener was used instead, to create a precise, definite design-edge print effect on the dischargeable fabric via the hand screen printing method. The methodologies used was the action, the experimental and the descriptive methods under the qualitative research approach. The effect achieved, was as a result of adhering to the right print paste preparation and consistency, and the temperature of the prepared starch applied in the mixture. The end result proved successful under pH 7.5 at 60°C of discharge print paste consistency, used within 60 min of printing time. The conclusion drawn was that the new methodology adapted was able to resolve the earlier problems of discharge printing that enhanced the work of the discharge printers. The methodology used has now become an integral part of the traditional printing practices, in the local printing industry for the past ten years.

Keywords: Discharge, definite design, print, dischargeable cotton fabric, locally prepared print paste, Hand-Screen printing, starch.

INTRODUCTION

In textiles, discharge styles are used to introduce designs to reactive print dyed fabrics. The patterns are imparted to the reactive dyed fabric by means of a chemical destruction process to the original dyed fabric. The discharging agents used can be an oxidizing or reducing agents, acids, alkalis and of varied salts. However, this versatile and most important methods of discharging are based formaldehyde sulphoxylates (NaHSO2.CH2O.2H2O) and thiourea dioxide (Karthikeyan, 2011). In the discharge style, the fabric is first dyed with reactive dye (Vinyl sulphone fibre reactive) that can be destroyed by selected discharging agents (sodium sulfoxylate formaldehyde). The discharge paste which is actually an oxidizing and reducing agent destroys the colour by oxidation and reduction to reduce and eliminate the chromophore colour via printing, resulting in a white discharge on the printed fabric after

processing (Miles, 1994). Here, the dye linkage to the fibre is broken and the by-products of discharge removed during washing. Dillman, (1980), also indicates that Vinyl sulphone dyes, are readily colour dischargeable that offers its link, to be easily destroyed by an alkaline print paste which results in a white discharge. He further opines that where no colour is added to the discharge print paste, its result, is a white discharge. However, where a vat dye is added to the discharge print paste, the discharge agent simultaneously reduces the vat dye and enables it to colour the cotton fibre. The introduction of sodium sulfoxylate formaldehyde, by BASF (English: Baden Aniline and Soda Factory), in 1905 made a decisive contribution towards simplifying dyestuff discharges. Since then, this product has played the predominant role in the discharge of reactive dyes on cotton fabrics (Miles, 1994).

Discharge styles have been important since the earliest days of textile printing (Miles, 1994). He accounts many processes, developed with considerable ingenuity that provided a wide range of effects without the advantages of modern dyes. These styles, he continued, will always be significant because of the different and aesthetically superior effects often obtained. The technical and commercial reasons for its conception and continuation is clearly stated by Miles, (1994) to determine the usefulness of the process compared with other printing techniques.

He reiterate that the depth, levelness and penetration of the discharged printed materials with large areas of ground colour, would be difficult, if not impossible, to obtain by a direct printing process. He states further that delicate colours and intricate patterns can be reproduced on grounds of any depth, with sharp clarity without any unequal blotch spread of print paste in different directions. In addition, coloured motifs fitted into a blotch print either leaves unprinted white margins or forms a third colour where fall-on occurs. He admits that in some cases such effects are acceptable, but they can be eliminated by using the discharge technique. He further argues that its aesthetically superior results give the product a higher value and enable profit margins to be maintained or even improved; and such manifestations can often be seen with long-lasting designs used for scarves, ties, cravats and dressing gowns. The importance of an adequate knowledge of the properties of the print paste ingredients, coupled with effective application technique can produce a satisfactory discharge on whatever type of fabric is to be printed. However, the choice of discharging agent is determined largely by the type of fabric to be printed. The constituents of a basic discharge printing paste consist of a discharging agent, a thickener and water. As mentioned earlier, the most widely used reducing agents are the formaldehyde sulphoxylates. They are stability during printing and prior to its finishing processes. The use of sodium formaldehyde sulphoxylate sold as Formosul or Rongalite C established in 1905. Other products are the insoluble zinc formaldehyde sulphoxylate, water-soluble zinc formaldehyde sulphoxylate and the water-insoluble calcium formaldehyde sulphoxylate. The actual amount of reducing agent required for optimum discharge depends on the dyes to be discharged, the depth of the ground and the fabric being printed.

Apart from being wasteful, uneconomic and overuse, too much of the reducing agent, will result in haloing or flushing of white discharge blurred edges and a loss of fine detail. While the use of insufficient reducing agent will, also give an incomplete discharge (Miles, 1994). The correct choice of thickener with good stability to the reducing agent is also of great importance in discharge printing. Thickeners that have been used according to Miles, include nonionic locust bean gum, crystal gums and starch ethers. As discharge style aims at sharp and intricate patterns, it is essential to minimize the flushing and bleeding by using the low-viscosity thickeners and a high solids content. To attain the correct balance between

penetration of the fabric and control of flushing and haloing, factors such as the viscosity of the discharge print paste, the amount of print paste applied (controlled by factors such as mesh size, squeegee setting, and reinforcement of the screen) and finishing processes is paramount. Ground shades for discharge must be produced with dyes that are dischargeable.
Using cooked cassava starch in Africa as a locally manufactured adhesive or food is not new in the traditional home setting. According to Balagopalan, (2002), it is also used for sizing cotton fabrics and warp yarns to give sheen to colour. Though cassava starch has excellent flexibility, it has poor stability when cooked excessively and turns to break down to form a very clear film with prolonged boiling. The art of using cooked starch as a resist medium, especially in Yoruba of western Nigeria is not new narrates (Adetoro, 1972). According to Adetoro such technique referred to as Adire Eleko, is either formed by free-hand painting of cooked cassava starch, Lafun, on the cloth or by stenciling the starch on the material. The stencils as a vehicle, transfer the cooked starch onto the fabric, via a perforated corrugated zinc tin sheet. To Picton and Mack (1989), the boiling starch, (mixed with a little copper sulphate, extend the level of preservation) was applied to a bunch of chicken feathers in addition to a thin midrib of a palm leaf.

Kadolph's, (2007) innovativeness, suggest the use of the screen printing method to produce the Adire in Nigeria with cooked starch paste via the squeegee. Asmah et al, (2015), reiterates that the dry and fermented cassava powder called konkonte in the Akan language is used alongside other forms of constituents like wheat, lime juice and caustic soda in different proportions to obtain a viscous paste used as a resist medium for the designing of fabrics. Other known tree gums used in West Africa are resins like gum Arabic and gum tragacanth, (Mayes, 2009).

The cassava powdered starch is also available, affordable and user-friendly to the ordinary Ghanaian for either household or industrial purposes, its physical properties such as powdery, white or tiny granules, are odourless and tasteless (Defloor, et al, 1998). The cassava starch, with an intricate carbohydrate formula of (C6H10O5) x, according to Abolhasani, et al, (2009), is virtually insoluble in cold water, but becomes swollen, dextrin, sticky or gelatinised when cooked in hot water and forms an adhesive pasty jelly on cooling. The cassava powdered starch was preferred to than any other thickening agents due to its favourable reaction to discharging agent- sodium formaldehyde sulphoxylate, resulting in a high level thickener yield, satisfactory to the dischargeable fabric. Due to its solubilisation, the chosen thickener has the ability to coagulate in the presence of sodium compounds, (Satin, 2000).

Hitherto, the discharged fabrics produced by the local fabric designers in the early years of 1995, applied a mixture of a discharging agent and water directly onto the dischargeable fabric (Fig., 1& 2), hand drawn, using either a bristle brush or a syringe. The end result exhibited 'bleeding' or loss of clarity of print or of smudgy effect. This undesirable splashes and drops of watery sodium compound inevitably caused the traditional fashion industry in Ghana to show signs of weariness of using this approach for discharge printing. And therefore yearned for a method that will minimize the flushing, bleeding and half-shadow print effect to an improved sharpness, precision, and uniformity of motif outlines. In the light of this empirical assertion, researchers aimed at reversing this negative trend. The research question posed was; what can be done innovatively to attain a print paste capable of improving upon the accuracy and sharpness of prints without entertaining haloing print-effect of a dischargeable fabric? In response to this rationale, preliminary experiments and research

were conducted to ascertain the appropriate tools, materials, design and methodology needed for the study.

Fig., 1: Fabric gathered lengthways and discharge liquid applied to desired areas by pouring

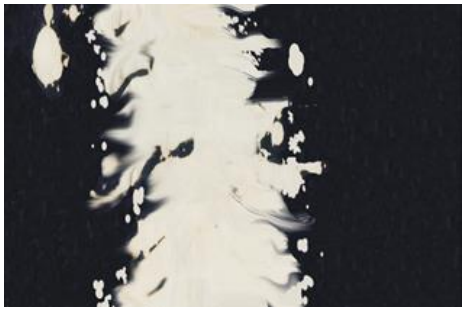

Fig., 2: The end result of the discharge application

At the end of a series of preliminary experiment, the locally available and eco-friendly thickener capable of gelling with alkali and the dischargeable fabric without bleeding, the cassava starch was realized. The actual amounts used was carefully determined under local conditions as too little would give a poor discharge effect, but too much could result in flushing and haloing. The need for accuracy resulted in the use of the customized design screen to help vividly communicate the cultural value and desires of the fashion industry.

This preliminary understanding informed the study that the use of insufficient discharging agent, gives an incomplete discharge, while too much results in flushing or haloing at the end of the discharging process. The flushing of a white discharge result in blurred edges and a loss of fine detail, usually seen as a white halo around the printed areas. This was as a result of the instability of the soluble reducing agent which migrate uncontrollably within the fabric (Fig., 1 & 2). That is not to say that haloing and flushing must be avoided at all costs, though some styles actually depend upon the various effects which can be achieved in this manner – the so-called 'bleeder styles' (Miles, 1994).

MATERIALS AND METHODS

Materials used for the study included sheda cotton plain weave fabric (140 gm/m2) normally used for the production of discharged fabrics and fashionable fabric articles due to their absorption rate, availability, comparative strength and suitability for fashionable dresses (Asmah et al, 2013). It can be washed with moderately strong detergents and requires no special care during washing and drying. Below are the geometric properties of a plain dischargeable woven cotton sheda fabric, used as the substrate for the discharge printing (Table 1).

Table 1. Geometric parameters of 100% sheda cotton fabric

Fabric	Ends/cm	Picks/cm	Gm/m^2	Warp Count (Ne)	Weft Count (Ne)
100% cotton	34	33	140	40	40

The study employed a series of action base studio experiments of qualitative research, and depended on studio activities which required the use of essential materials such as lacquer, a

mild detergent for the soaping process and washing of the discharged fabric and Photoshop software to produce the screen designs. The qualitative research gave a holistic picture of what goes on in the local discharge printing industry (Frankel, et al, 1996). The purposive sampling technique was used in selecting the materials for the study. They are plastic bucket, plastic palette bowls, cups and spoons, rubber gloves, measuring tape, tacking pins, lace material, small plastic palette bowls for the measuring chemical, sodium formaldehyde sulphoxylate and aprons. Tools and equipment employed in the project included, a pair of scissors, cutting tool, coating trough, squeegee, pens and pencils, silk mesh, cello-tape, a ruler, masking tape, working table, pressing iron, working shed, camera, computer, water reservoir for washing and Wooden frames. The methodology implemented to facilitate the study on discharge printing production procedures, the characteristics of discharge printing fabrics and its possibilities to relate to other print techniques precisely screen printing. The action base studio experiment assisted the researchers to use the analysis established in the methodology to create three unique types of discharged prints to resolve the existing issue. The activities of the experiments conducted and its results were recorded carefully, and critical observations made. Both primary and secondary data were utilized in the study. The specific quantities of the main ingredients for the final cooked cassava starch preparation are provided in Table 2.

Table 2: Ingredients for cassava starch preparation.

Chemicals and Starch	Quantity
Cassava starch (cooked)	225 grams
Boiled water (70°C)	480 ml

Due to the chemical content within the discharged paste, initial experiments conducted on the developed photographic screen proved futile and unable to establish its efficacy to accommodate the discharged print paste during the printing process. This was exceptionally important as noticed, that the chemicals corroded the photographic film on the screen. To avert this initial hitch, the next screen developed was reinforced with lacquer on the inner part of the screen. This proved highly successful upon printing (Asmah et al, 2015). To commence with the project, two designed screens were made to produce the two discharged printed fabrics.

Experiment I

The following quantities of chemicals and methodologies were adopted for the discharge paste preparation; having stretched out and secured the dischargeable fabric on the printing table, the uncooked starch was mixed carefully with a little amount of cold water (enough to dissolve), in a plastic bowl while a quantity of boiled water remained on fire in a coated cooking pan (Fig., 3). The mixture of the uncooked starch was gradually poured into the boiling water on fire and stirred continuously until the starch was half cooked and assumes a white visual appearance (Fig., 3). It was then dished from the pot into a plastic bowl and allowed to cool before use - this stage was considered crucial, if a good dischargeable print paste was to be achieved. For 3 meters of dischargeable cotton fabric, 6 tablespoonfuls of cooked starch to 2 teaspoonful of discharging agent (7.5 grams of sodium formaldehyde sulphoxylate) was measured into a small plastic bowl (Fig.4). Lastly, the mixture was then stirred gradually to dissolve into a smooth viscous consistency before use (Fig., 5). For the first experiment, the sheda cotton sample was printed with the prepared discharge printing paste via a flat lacquered silk hand screen printing technique according to the recipe outlined for 3 meters of fabric (white to colourless discharged printing) (Fig., 6)

Table 3. Printing Recipe

Chemicals and Starch	Quantity
Sodium formaldehyde sulphoxylate	7.5 grams or 2 teaspoons
Cassava starch (cooked)	84 grams or 6 tablespoons
Boiled water (70°C)	237 ml

The effectiveness of the discharged print paste, its application onto the sheda fabric was done within 40 minutes of its preparation (Fig., 3).

Fig., 3: Preparation of the starch

Fig., 4: Preparation of the discharge agent mixed with water

Fig., 5: Mixing of the starch and the dissolved discharge agent

Fig., 6: Applying the prepared discharge printing paste

Fig., 7: Effect of aeration as printing was in progress

Fig., 8A, B & C: Resultant products of some completed discharge prints

The number of times the squeegee was drawn across the screen and the pressure exerted on the squeegee determined the thickness of the discharged paste penetration into the fabric and assume a different colour as the air blows over (Fig., 7). The printed design fabric was then removed from the working table and further dried in an airy and shady place. It is worth noting, that the discharging process took place both on the working table as well as in an airy and shady place. For effective discharging, (Fig., 8A, B & C) the printed fabric hung on the drying line to allow the applied areas to filter through the fabric, ensuring enough contact with the fibres of the fabric for the rest of the drying period. The discharged fabric was finally rinsed with tap water with the aid of a cake of foam and then washed to remove the excess chemicals. Fixation after washing was achieved by the soaping process. The material was treated with hot soap solution or a mild detergent solution for 10 minutes, rinsed thoroughly in cold water and finally dried in a cool airy place away from the direct sunlight. Ironing was done while the fabric was leather dry with a pressing iron at a temperature of 1000 1400C for 5 minutes (Asmah, 2004: Asmah, et al, 2015).

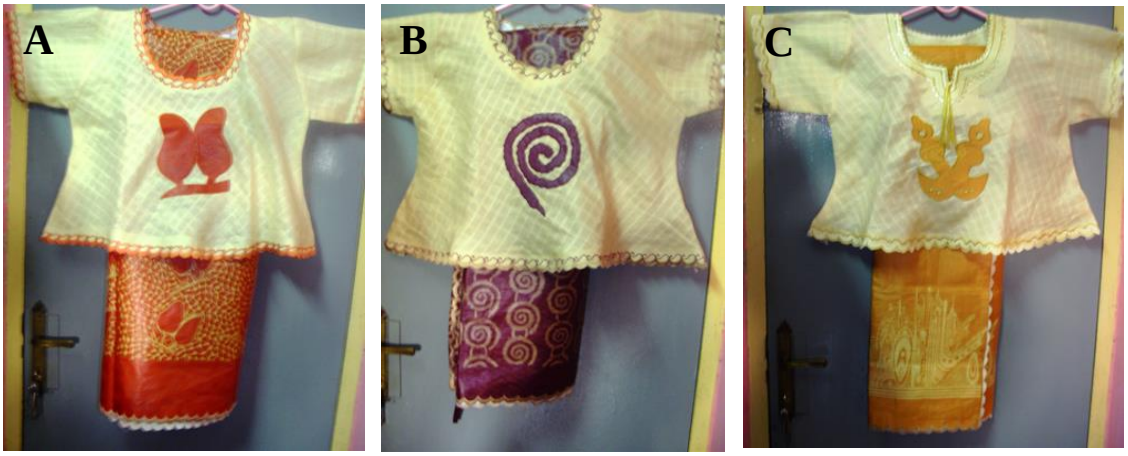

Fig., 9A, B & C: Discharge print fabrics integrated with plain fabrics turned into fashionable attires

Fig., 10A: Discharge print fabric turned into a fashionable attire

Fig., 11B & C: Discharge printed fabrics integrated with fashionable embroidered attires

Experiment II

Materials, tools and equipment peculiar to the discharge printing using the block print, was as follows: designed wooden block, and the bristle brush for applying the paste onto the

designed block substrate. Others common to all the projects have been enumerated in experiment I. In this experiment, the mixing of the discharge solution, the preparation of the discharge paste was the same as in experiment I. The printing device for the application of the discharge paste however, was the wooden block instead of the hand screen.

Fig., 12: Discharge effect produced by block stamping with discharge liquid

Experiment III

Materials, tools and equipment exclusive to the discharge printing using the lace fabric, was as follows: designed lace, fabric, and the squeegee for spreading the paste over the lace fabric, through to the dischargeable fabric substrate. Others, common to all the projects have been enumerated in experiment I.

The same processes were followed as stated in experiment one, but the exception in the discharge paste application was the use of lace fabric over the face of the dischargeable fabric. All the experiments conducted used the locally prepared discharge print paste successfully to produce excellent results in the production of a fashionable attire.

Fig., 13: Discharge effect produced only at the edge of the fabric with lace material

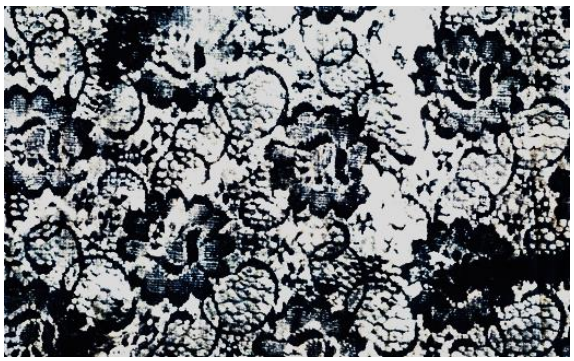

Fig., 14: Discharge effect produced all over the dischargeable fabric with lace material

RESULTS AND DISCUSSIONS

The discharge printing via the screen printing technique using a mixture of locally prepared, cooked cassava starch as a thickener and sodium formaldehyde sulphoxylate, as the discharging agent proved successful. The choice of the cassava starch preparation as a binder was due to its stability at low pH levels when integrated with the sodium compounds to facilitate satisfactory adhesion and film elasticity Abolhasani et al, 2009: Black et al, 1991). In preparing the discharge printing paste, it became imperative that the quantity of discharging agent added to the cassava starch, be in measured portions to attain its required stability. These proportions helped avoid the destruction of the developed screen and the fabric, and contributed to the good resultant effect achieved after printing. The one-level

printing application was exclusively considered as an intermediary technique for the production of fashion apparel since its resultant effect could easily be predicted, depending on the type of dyed ground used.

The comparative resultant effects of the three experiments showed tremendous improvement with the screen, as it created a precise, definite design-edge print effect on the dischargeable fabric better than the second and third experiments prepared under the same conditions. The screen frame constructed in wood and the screen coated with lacquer, strengthen the photosensitive film of the screen to avoid the chemical content of the print paste from corroding the screen materials used for the various productions (Asmah et al, 2015). In principle, the composition of the discharged print paste systematically handled, with regards to the recipe used, the printing technique, the substrate and the application utilized, produced a good resultant effect. The success of the printing process was as a result of the discharging agent and the ability of the locally prepared starch to hold the dissolved discharging agent in a stable state throughout the printing process. Under such stable chemical state, the print paste diffused uniformly into the fibres of the fabric, to register a discharging effect on the dischargeable fabric. The consistency of the thickener aided the prints to register its discharging effect in the required areas per the screen design applied on the printing table (Miles, 1994: Asmah, 2004). The relevance of such stable consistency increased the precision of the discharge paste due to its acquired property maintained throughout the printing process.

Design elements adopted by the lead author were based both on the general design concepts and the behaviours of the print paste and the method of application of the print paste on the dischargeable fabric. The understanding is that the resultant products achieved, attained a strong and longer fabric life span and affirmed its success to resolve the earlier problem of discharge printing that was characterized by an undesirable bleeding print effect. The designs produced demonstrated the preferred desires of costumers and satisfied both the visual illustration of cultural subjects as well as plant life, man-made objects and aesthetic principles of design that interprets the philosophy of local Ghanaian consumers in the traditional setting (Fosu, 1993: Asmah, 2014). The design was achieved with a technological, cultural, artistic approach, however, the design, and execution focused more on the aesthetic value (artistic approach) that was achieved with artistic design principles and existing material base application – lace fabric (Veryzer, 1993). The main motif used, was the outcome of an idea development out of a goat jaw bone coupled with forms of lines around an Adinkra modified star symbol in the background border design. Two separate screens were used to compose the design fabric with a strip of border design serving as the boundary and the main motif as the isolated design distributed over the majority of the fabric substrate space to maintain an aesthetic and a balanced design fabric. The traditional interpretation connotes the dependency of every creature on earth, to respond to the directions of the celestial bodies. The arrangements of the design elements reflected the contemporary design concept and imitated the use of rectilinear and square grid lines, mostly found in traditional Adinkra cloths composition (Glover, 1971: Asmah et al, 2015).

The printing processes involved the use of three ingredients – the cooked cassava starch as the thickener, water as the facilitator and sodium formaldehyde sulphoxylate, as the discharging agent. This mixture used, formed the discharge print paste that was applied to the dischargeable fabrics in patterns. The prints executed using the flat-bed screen printing technique - mainly used for custom work (Asmah, et al 2015). The steps in the printing process included preparation of the discharge print paste, alignment of fabric on the printing

table, printing of the sheda fabric, rinsing of printed fabric, fixation and drying of the fabric. With such clear methodology, the operation was easily repeated. In discharge printing, the introduction of the design on the dischargeable fabric is produced by the chemical destruction of the original dye in the printed areas. The discharging agent used was adsorbed onto the fibre of the fabric as the discharging agent reduced within the fibre with accelerated elements such as the dischargeable agent, the substrate and preparation of the substrate and water. The implication of such processing, coupled with variables such as time, temperature, and the dischargeable agent ratio appropriately applied to the dischargeable fabric, realized a good printing results. To ensure thorough penetration, the cooked cassava paste and the chemical was mixed uniformly and evenly while on the printing table and on the drying lines. This ensured that most of the discharge paste utilized was liquefied into the printed areas of the fabric.

Such printing condition helped fix the discharging agent into the fibre after which the substrate was rinsed and washed to remove the chemical residue. This was done to ensure level print shade, even after drying, as the discharged fabric goes through a series of rinsing and washing to remove un-bonded or unreacted paste before aeration over the drying lines. The mechanical finishing operation, in addition to other initial preparations carried out also improved upon the appearance and usefulness of the fabric after the printed fabric was given an ironing treatment to complete the fixation process. The implications are that the discharge print was achievable and its improvement and sustenance will be enhanced if schools and colleges are engaged in such printing process. Other entrepreneurs and fashion houses can also benefit immensely from this product if they can take advantage of this study to engage printers to customize their products. The study will inspire creativity, especially among educationist and textile instructors to sustain design education in textiles, entrepreneurship in fabric decoration, and innovations in the traditional textile industry in Ghana.

CONCLUSION

Technology involve the making, modification, usage and knowledge of tools, techniques, craft, methods of organization, to solve identified problem, improve established solution to a problem, and achieve a definite goal or perform the specific function (Asmah, et al, 2015). This project therefore combined technology, culture and aesthetics which results in the application of appropriate technology to develop the discharge prints. The designed project focused mainly on the aesthetic value, culture and technology aimed at a well-designed discharge printed fabric. The result of the research, shows that the application of the discharged print paste attained a precise, definite design-edge print effect on the dischargeable fabric via the hand screen printing method. This proved successful under pH 7.5 at 60°C of discharge print paste consistency, used within 60 min of printing time. The conclusion drawn was that the new methodology adapted was able to resolve the earlier problems of discharge printing that enhanced the work of the discharge printers. The methodology used has now become an integral part of the traditional printing practices, in the local printing industry for the past ten years. In addition to the resultant print achieved, an innovative discharge print paste prepared for a dischargeable fabric via a customized design screen, designed wood block and lace material has proved viable to communicate the desires of many discharge fabric printers and consumers in Ghana.

Trends keep on changing and consumers' quest for new decorative print concepts increases; Ghanaian fashion designers and discharge printers now have the privilege of adapting this innovative concept of discharge print to meet the diverse need of the consumer. The effect of

the discharge prints definitely has had tremendous impact on the preservation of the discharge print fabrics and has broadened the scope of discharge print designs in the local fashion industry for the past 10 years of its introduction. The outcome has reinvigorated the dynamism of the Ghanaian traditional fashion industry and commands a broad spectrum of generational appeal and this has increased the options available to both producers and buyers of printed fabrics. The practice has enhanced the business opportunity for discharge printers and fashion producers in Ghana. The methodology adopted for the preparation of the cooked cassava starch used as a thickener finds its application with other chemicals for wood, leather and other substrates ornamentation.

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