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Eco-Friendly Preparation, Characterization and Application of Nano Tech Pigmented Inkjet Inks and Comparison of Particle Size Effect and Printing Processes

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Abstract

By acknowledging the importance of Nano tech inkjet inks, the "top down" method of nanotechnology was followed for manufacturing the Nano tech inkjet inks of pigment Yellow 14 powder 100 % dried and pigment Blue 15.1 (100 % dried powder) and then characterized for their particle size, zeta potential, purity, viscosity, surface tension, foam, pH, engineering stability, shear thinning, by using different spectroscopic, microscopic and particle size analyzing techniques. Both of the inks were applied on 100 % singed, desized, scoured, bleached and pretreated cotton weight 134.4g/m^2 through Monna Lisa Evo TRE printer EPSON (Model No EVO TRE 16). The printed samples were dried and cured 150 °C for 5 minutes. The samples were evaluated for their color fastness to light, rubbing, washing, laundering, and K/S value, by using relevant AATCC and ISO's methods. Same powders were emulsified and applied on same cotton through traditional rotary screen printing method, dried, cured at 150 °C for 5 minutes and evaluated for their fastness properties for comparative study. It was concluded that by promoting the use of green chemistry and nanotechnology, the resulted benefits include better print, increased light fastness and color gamut, reduced chemical, energy and water consumption along with environmental friendly effectiveness.

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Keywords: Nano-tech inkjet inks; Yttrium stabilized Zirconium beads; Monna Lisa Evo TRE printer; Laser diffraction particle size analyzer; Spectrophotometer; Dispersant; Surfactant; Glycol; Bead Mill; Crock Meter; Light Box; Viscometer; Pigments.

1. Introduction

- The digital textile printing is green and eco-friendly method of textile printing that is exact need of the time, as traditional method of textile printing was not cost effective, short runs were not possible to print by this method Alan Shlomo Magdassi [1]. The synthesis of pigment based Nano-tech inkjet inks for digital textile printing technique was a new art, which was revolutionary step in the developmental path of textile printing Industry, manufacturing of inkjet inks and their use in digital textile printing has reduced water, energy, color and chemical consumption S. Daplyn and L. Lin [2].
- The art of textile printing was probably as old as man was or civilization itself, its development and progress has been continued with the passage of time, digital inkjet ink printing is top trend of the time which must be adopted by the industry for their future survival Dawson and Hawk yard [3]. Recent developments in inkjet ink printing technique presents not only possibility for short production runs, but also for rapid market response on demand of short production runs, and unique design applications, as well as a new possibility for design diversity. Dehghani and his colleagues [4].
- With commencement of International Textile Machinery Association (ITMA) in 2003, several commercial textile production inkjet printers were launched into the market place, digital textile printing gained popularity as preferred production technique. Today it attracts a niche factor to the digital textile printing, H-Ujiie and ClarkD [5]. The lower energy, water, materials and low labor cost make digital textile printing competitive for short runs, lower energy and water usage play important role in making this printing method eco-friendly Bowles M. [6].
- The digital textile printing technique interlinked the design software and the printer, the printing environment, the fabric pre-treatment the post-treatment and the operator. This printing method is green and eco- friendly. As digital world and technology were touching the new horizons, digital Nano-tech inkjet pigment ink textile printing represents the future direction of technology development in the textile printing industry, in digital world customer demands the design diversity, well in time order delivery and quality product that possible by this new technique Y. Ding [7].
- This new technology is becoming popular tool in textile and clothing. It is in fact, transitioning the old traditional textile rotary screen printing technique even in developing countries like Pakistan. The opportunities and applications of cost effective digital printer are large, so many hardware and chemistry related investors are investing hopefully in this sector. By the combined efforts of inkjet ink manufacturer, printer manufacturer and designer this field of digital inkjet ink printing is getting more and more popularity worldwide B. Glover [8].
- The digitally printed fabric output was 300 % till 2005. This was almost 1 % of the global market printed fabrics. The growth of digital textile printing increased 20 % per year till 2008. Its growth and progress in the current year in developing countries like Pakistan has increased to about 40 %. Particularly water base pigmented inkjet inks are getting popularity due to their environmental friendly nature and weather

stability of the pigments as colorants. The application of pigment based Nano-tech inkjet ink digital textile printing has achieved the importance due to following reasons,

1- Simple and high speed processing
2- Compatibility with almost all substrates
3- Low energy, water, chemical and labor cost
4- Lowest possible waste production
5- Possibility for short runs and good quality prints
6- Cheap and high technical development (Fu and his colleagues [9]

2. Materials and Methods

2.1 Materials

Pigment Blue 15.1, Pigment Yellow 14, Co solvent (de-ionized water and Ethyl Glycol Egypt), surfactant (Scaural CA Daico Chemical industry Egypt), biocide (SPX Thor), buffer Dytek © HMI by Inveta), chelating agent (EDTA China), defoamer (No foam SE Sybron-Tenatex Egypt), Emulsifier OMT (N-Methyl-N-Oleoyltaurate Parchem fine and specialty chemicals) dispersing agent (Acrylic Copolymer Clariant), Anionic Surfactant (SDS) and Yttrium stabilized Zirconium beads (China).

2.2 Method

The pigment based inkjet ink concentrate was prepared by charging 100 g oven dried powder of pigment yellow 14 in 1liter stain less steel vessel. Dispersing agent N-Methyl-N-Oleoyltaurate (OMT) 60 g was added Santilli [12]. After that 400 g de ionized water and 120 g of di ethylene glycol was added while agitating slowly through frequency inverter. The agitation speed was slowly increased till 600 rounds per minute (rpm) within 15 minutes and continued for other 1.5 hrs. for making it smooth liquid (premix). Then the stirring was resumed via bead mill containing 105g yttrium stabilized zirconium beads (1 mm). The bead mill was equipped with laser diffraction particle size analyzer, for measurement of particle size distribution as a function of time tracks during the milling. The material was stirred in the bead mill continuously at 4000 rpm for about 2.5 hrs. The efficiency of size reduction was proportional to the efficiency of energy conversion Momin [13]. The temperature was controlled by continuously supplying chilled water (5-15℃) via the jacket of the bead mill. After 2.5 hrs. stirring the speed was slowed down through frequency inverter L. Lin, [2]. Then sample was taken and checked for its particle size distribution with digital particle size analyzer off line for cross verification with the particle size shown by laser diffraction particle size analyzer. It was observed that only 90 % particles were in the range of particle size distribution between 0.2-0.5 microns which was almost same as shown by laser diffraction particle size analyzer. At this stage the remaining 120 g of de ionized water, 30 g of di ethylene glycol and 10 g OMT were added. High speed agitation was resumed in the bead mill for 3.5 hrs. The temperature of the ink material circulating in the bead mill @ 4000 rounds per minute (rpm) was controlled by supplying the chilled water to the sand mill through its jacket system. After 3.5 hrs. the agitation was slowed down via frequency inverter till 100 rpm. The sample was taken and analyzed for its particle size distribution

using digital particle size analyzer, at this stage only 86 % particles attained the particle size distribution > 100 Nano meter(nm) while laser diffraction particle size analyzer shown particle of 86 % particles > 93 Nano meter (nm). Agitation was started again while putting remaining 60 g de ionized water to adjust the mixture to 10 weight % of the pigment Fukai J [14]. The contents of the ink were run in the bead mill with continuous supply of chilled water for temperature control for 4 hrs. Then the rounds per minutes (rpm) of the bead mill were reduced slowly through frequency inverter till 200 rounds per minute (rpm) and run the ink at this speed for 3 hrs. Then sample was taken and analyzed for particle size, it was observed that 99.6 % particles have attained the particle size distribution < 50 Nano meter (nm), almost same particle size distribution was noted on laser diffraction particle size analyzer. The milling and stabilization process was continued until the energy transfer between the grinding beads and the pigment particles reached its limiting value. It was experienced that the energy transfer took placed till the primary particles reached their limiting value of size reduction. At this point, the particles reduced to a limited size which is <50 Nano meter. It was clearly observed that initially there was rapid decrease in particle size, because of the breakup of loosely agglomerated large particles. As the milling progresses, rate of particle size reduction decreases with time frame because at this later stage of milling breakup of large agglomerates was done and primary particles were in particle size reduction process which was slowed down due limiting energy transfer and difficulty in reduction of primary particle size. J Provost [16]. The required fine particle size distribution was attained after around 10 hrs. of high speed milling. At this stage of process 100 g defoamer was added and agitation was stopped, almost 45 minutes were given for foam settlement, after complete foam finishing milling media was separated through Nano-tech sieving. The ink was collected in 1liter gloss bottle with air tight stopper and named sample A. The same procedure **was adopted to prepare the sample B. Only Variant was pigment Blue 15.1 (100 %) dried 100 g** imported from Kevin India and OMT was used 1% more than sample A. High speed stirring at 4000 rounds per minute (rpm) was 18.5 hrs. instead of 16 hrs. as for sample A. This variation was attributed to different structural elucidation of both the pigments (crystal size and shape) U. Hees [5]. The samples A and B of emulsion were prepared from both of the above mentioned pigments by traditional milling method for comparative study. Lab. Scale ball mill of stainless steel was used for particle size reduction of the pigments till 0.2 to 0.5 microns. Ceramic balls of 12.5 mm diameter were used as grinding media. Turbo Mixture was used to make the premix. The ball mill was run with material along with 35% ceramic balls to the total weight of the emulsion. The size reduction was completed after 72 hrs. running of the ball mill at 42 rpm speed. Particle size of the emulsion was checked by particle size analyzer. Defoamer and biocide were used for emulsion stability. Here again the pigment yellow 14 took less time and low quantity of dispersing agent than the pigment blue 15.1, as explained by AI. [15].

3. Results and Discussion

3.1 Properties of the printing inkjet inks

The inks prepared were not ready for use in digital printer Monna Lisa Evo Tre because these were still kinetically unstable. Their flocculation could cause nozzle clogging of the printer and negatively affect the hue and weather fastness properties of the printed fabrics. So, the inks before use were needed to be characterized to fulfill the required parameters like purity, particle size, viscosity, surface tension, pH, shelf life (engineering stability), in order to make them applicable to digital printing via PIJ Technique. [Provost [17]. The Graph of

particle size reduction as a function of time was shown in figure1 A and 1 B.

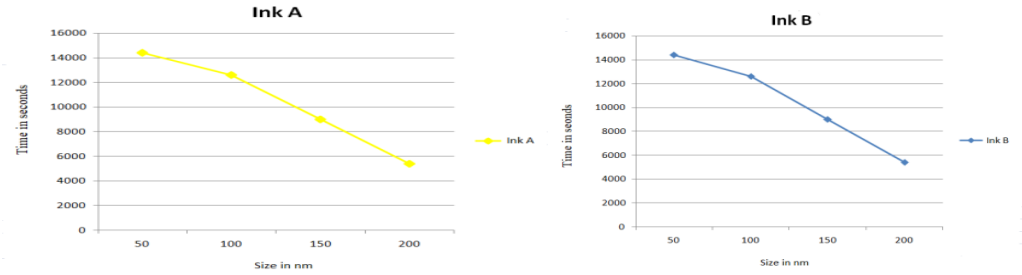


Figure 1 A & 1B: Characterization of Nano-tech inkjet ink samples A and B

3.2 Particle size

The particle size distribution of the inkjet ink samples A and B was measured by using the digital particle size analyzer and laser diffraction particle size analyzer was used on line for time scale particle size analysis. A diluted inkjet ink sample A was introduced in to the measurement chamber of the particle size analyzer and operated the instrument for correct particle size distribution. Three concordant readings of sample A were taken and then took the mean of these three readings. It was observed that 99.9 % of all the particles were in the range of particle size < 50 Nano meter (nm) for sample A. The chamber of particle size analyzer was calibrated and dried. The sample B was introduced in to the measurement chamber of particle size analyzer and the instrument was operated, three concordant readings were taken for sample B. Mean of these three readings was actual particle size of 99.9 % particles which was again < 50 Nano meter (nm). The volume percentage of the inkjet ink change in to fine particle size distribution <50 Nano meter (nm) with respect to cumulative volume (%) was shown in graph in Figure 2A and 2 B. The Digital particle size analyzer was used to measure particle size of the emulsion samples A and B. It was found that both the samples gained particle size distribution of 99 % particles in the range of 0.2-0.5 microns' particle size distribution in accordance with value studied during literature survey Y. Ding [7]

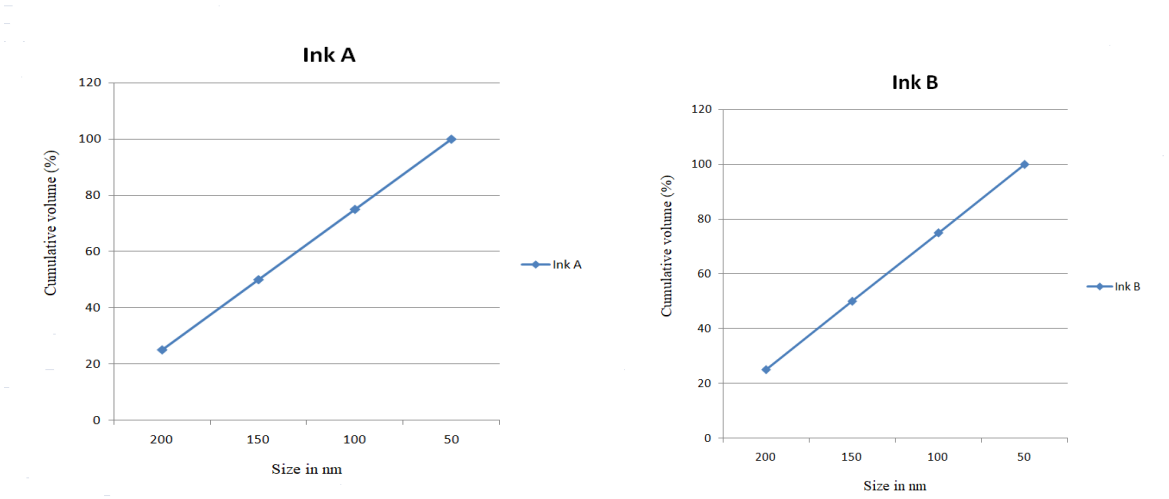


Figure 2 A and B: Change in cumulative volume (%) as function of particle size reduction of inks A and B.

3.3 Purity

The total trace metal contents of the ink samples A and B and both of emulsion samples were analyzed by inductively coupled plasma atomic emission spectroscopy. The samples were prepared for analysis by digesting them in a mixture of sulfuric acid and nitric acid. The digested material was dried ash in a muffle furnace. The dried residue was dissolved in hydrochloric acid and nitric acid. The resultant solutions were used to measure the trace metal contents present in them and matched with pure standards for quality assessment. Toxic heavy metals [Hg, As, Cd, Pb, Cr iv] were found less than the permitted limits of Okeo-Tex ® standard 100. Table No 1 showed detected limits which were below the permitted limits as per literature survey Y. Ding [7] given in Table 1&2.

Table 1. Ink A: Metals contents detected in ink A

Heavy metals in sample A	Body Contact	Skin Contact	Non skin contact	Decomposed metal
Cd	0.09(PL 0.1)	0.089(PL0.1)	0.098(PL0.1)	0.99(PL0.1)
Cu	16(PL 25.0)	14.9(PL50.0)	17(PL50.0)	20(PL50.0)
Pb	13(PL90.0)	11.9(PL90.0)	14(PL90.0)	21(PL90.0)
ZN	Not detected	Not detected	Not detected	Not detected
Fe	Not detected	Not detected	Not detected	Not detected

Table 2. Ink B: Metal contents detected in ink B

Heavy Metal in sample B	Body Contact	Skin Contact	Non skin contact	Decomposed metal
Cd	0.092(PL 0.1)	0.091(PL0.1)	0.099(PL0.1)	0.1(PL0.1)
CU	16.3(PL25.0)	15.1(PL50.0)	17.2(PL50.0)	20.4(PL50.0)
Pb	13.1(PL90.0)	12.1(PL90.0)	14.3(PL90.0)	21.2(PL90.0)
ZN	Not detected	Not detected	Not detected	Not detected
Fe	Not detected	Not detected	Not detected	Not detected

3.4 Ink Viscosity

Polymeric additives play an important role in increasing the reliability and quality by controlling the drop formation and break-up process. The successful polymeric additive was chosen, characterized by using size exclusion chromatography (SEC) to understand its structural and functional relationship, compatibility with ink and substrate. Polymeric additive 0.16 % was used and viscosity of both the samples was adjusted @ 10-12 Centre poise/second (cps) at 25 °C. The viscosity values were measured under the conditions that were suitable for their use at print head. The modern printers were operated mostly at shear rates as high as10^5 to 10^6 S^{-1}. These shear rates were not attainable with specified rotational rheometers because of structural mechanical limitations of the technology. The microfluidic rheometery, a relative new technique was adopted to measure the

high shear viscosity. Viscosity of both emulsion samples was adjusted @53 mille Poise per second (map's). It was checked and verified with by using "Digital Rotary Viscometer Model SNB-1(OLD Technique). This viscosity ranges of @ 53 m p a-s at 25 ° C was within applicable limit of rotary screen printing Hakim [10]. The viscosity of inkjet ink samples was measured by using "m-VROCI Microfluidic Rheometer at an ultra-high shear rate of 30,000 S^{-1} temperatures 20 to 40 °C. The impact of temperature on shear viscosity of the ink samples was studied at operating temperature range of the printer (Figure 3A and B). And effect of shear rate on viscosity is shown in (Figure 3A and B).

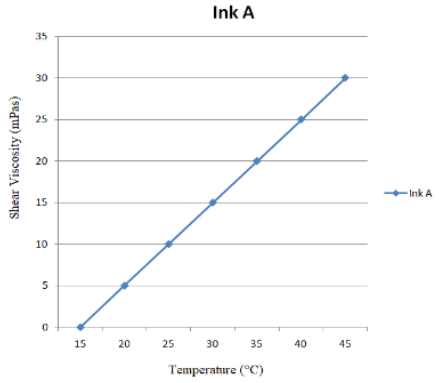


Figure 3.A: Effect of temperature on shear viscosity**.**

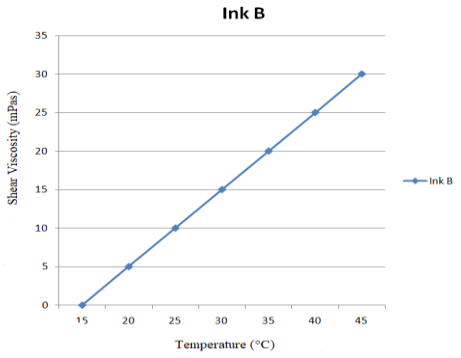


Figure 3.B: Effect of temperature on shear viscosity

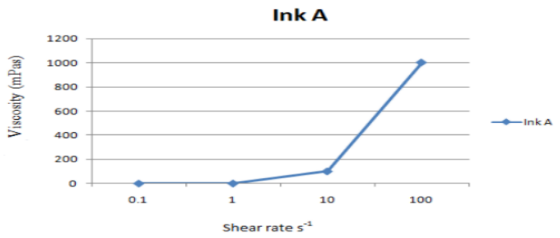


Figure 4.A: Effect of shear rate on viscosity.

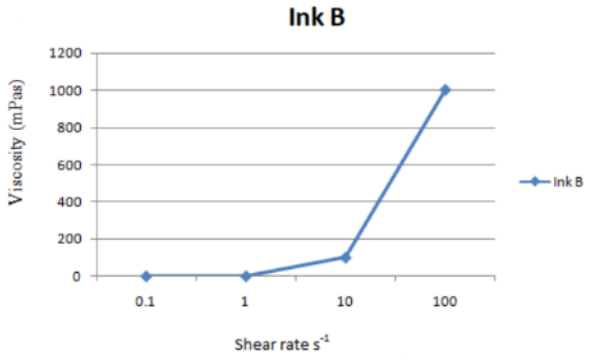


Figure 4.B: Effect of shear rate on viscosity

The results trend indicated that the viscosity of both inkjet ink samples was decreased with increasing temperature and shear rate as per literature survey Magdassi [1].

3.5 Surface Tension

Surface tension was one of the most important characteristics of the inkjet inks being used in digital textile printing. It was suggested that the surface tension of the inkjet ink was basic factor that determined the drop formation and spreading of the ink on the fabric during printing Kang HR [20]. Surface tension of the inkjet samples A and B was adjusted by using non- ionic surfactant @ 25-60 dynes/cm. It was checked and standardized with Stalagmometer. Proper choice of solvent was another important factor for controlling the surface tension within the permitted limits J Provost [16]. Due to specified surface tension range (25-60 dynes/cm) inkjet ink samples A and B wetted the capillary channels, flowed via the nozzle and formed the droplets correctly to ensure the proper jetting behavior of the inkjet ink samples A and B which was necessary for proper running of printer and good quality printed fabrics.

3.6 Foaming and Defoamer

A very common problem in the inkjet ink performance was the presence of foam on the ink surface mainly due to high speed stirring during manufacturing process and use of surfactant to control the surface tension within permitted limits. This problem was solved by using 0.01 % defoamer which was stable enough during ink storage period. The presence of foam could disturb the proper drop formation which directly impact printing quality, so foam removal was very necessary step in inkjet inks characterization.

3.7 PH Control

PH control was an important factor especially in these water based inkjet inks. Variation of pH must affect the dissolving of various inkjet ink components and could destabilize the dispersed pigment particles. Zeta potential of the pigment based inkjet ink samples was maintained to required limits, that indicated that inks were very stable. Buffer solution of pH 7 was used in ink samples A and B to make inks inert or less vulnerable to the effect of pH change. The concentration of the electrolytes was controlled (using de ionized water& sequestering

agent) within the permitted limits during manufacturing of the inkjet inks.

3.8 Ink Storage and Stability

`All the parameters of pigment based Nano tech inkjet inks including, pH, surface tension, particle size, viscosity etc., should remain constant over prolong period of time ("shelf life"). The shelf life for good quality inkjet inks at room temperature is almost two years. Inks instability was mainly due the interactions between the ink components and with the walls of containers. When particles approach each other, interaction due to van der Waals forces takes place causing the particles to aggregate and eventually reached minimum potential energy as shown in figure. 5. To prevent aggregation mechanism to overcome attraction was adopted. Anionic surfactant SDS was used to adsorb on the surface of pigment particles, it imparted negative charges to the particle surface. When particle approached each other electrical repulsion took place keeping particle away from each other as shown in figure. 5. So, inkjet inks prepared were very stable and have good storage and stability. S. Daplyn [2].

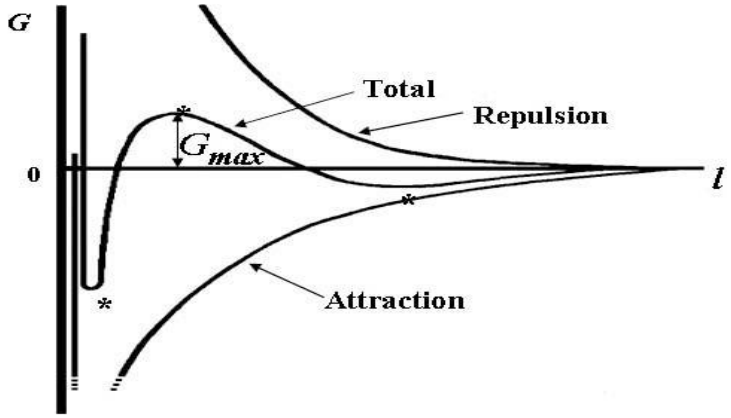


Figure 5: Showing of storage stability mechanism

4. Properties of Printed Fabrics

4.1 Color Fastness to Rubbing

Two standard methods were used to check the rubbing fastness of the printed fabric as given below.

1-ISO-105-X12

2-AATCC-08

According to ISO-105-X12 the wet pick up of the rubbing cloth was 100 %. While in AATCC-08 the wet pickup of the rubbing cloth was 65 %. Digital Crock Meter (KTS) 500x500 was used to perform dry and wet rubbing fastness test by using the method AATCC-08 both for dry and wet rubbing fastness. In wet rubbing the rubbing cloth was 65 % wet and in the dry rubbing the rubbing cloth was 100 % dried according to AATCC-8 method. The test was performed both for dry and wet rubbing turn by turn for digital textile printed fabric sample and traditionally printed fabric samples. It was concluded that digitally printed fabric exhibited the good

dry and wet rubbing fastness as compared to traditionally printed fabric. Results were shown as under. Matching was done while matching with gray scale, the grading of the results was shown in table 3 below American Association of Textile Chemists and Colorists [21].

Rubbing fastness traditional printing

Rubbing fastness traditional printing

Figure 6

Table 3: Rubbing fastness properties

Fastness Properties	Pigment Blue 15.1Conventional	Pigment Blue 15.1 Nano	Pigment yellow 14Conventional	Pigment yellow 14 Nano
Rubbing Dry	4-5	5	4-5	5
Rubbing wet	3-4	4-5	3-4	4-5

4.2 Color Fastness to Washing

ISO 105 C06 test method was adopted to check the washing fastness of both the fabric samples traditionally and digitally printed. Specimens were cut in 4x10 cm in size (ISO) both for traditionally and digitally printed fabric samples. Multi fiber swatch was attached with each specimen. All the colors were covered during the specimen cutting. Awash liquor was prepared using Grade 3 water, required amount of Sando pan DTC (Clariant) and steel balls were used in HT machine. The HT machine was run for 30 minutes at room temperature. The specimens were then removed, rinsed and dried in still air at temperature not exceeding 60 °C. Once samples were dried and conditioned, assessment was carried out. It was concluded that washing fastness of digitally printed fabric was better than traditionally printed fabric. Rating was given in table 4 while matching with gray

scale AATCC [21].

Figure 7: Washing Fastness of Traditionally Printed Fabric.

Figure 8: Rating of the digitally printed fabric

Table 4: Washing fastness properties

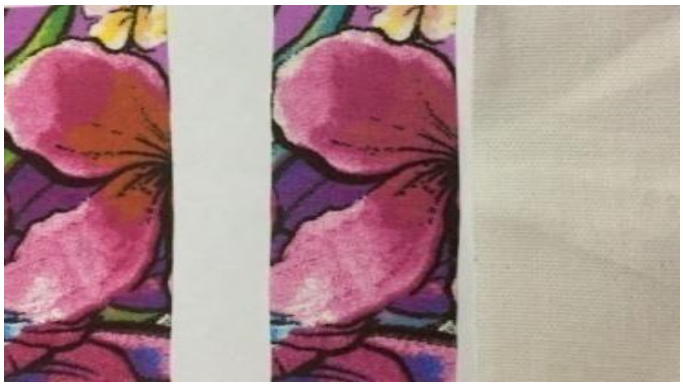
Pigment Blue 15.1 conventional	Pigment Blue 15.1 Nano	Fastness properties	Pigment Yellow 14 Conventional	Pigment Yellow 14 Nano
4	5	Washing	4	5

4.3 Color Fastness TO Dry Cleaning

ISO 105 –DO1 method was used to test the dry cleaning fastness of both digitally and traditionally printed fabric samples. Specimens of 40 mmx40 mm were cut very carefully, they were placed with white cotton fabric along with non- corrodible steel discs (30mm±2mm diameter x3mm±0.5mm, smooth and free from rough edges, of mass 20 g±2), these were put in the bag with inside dimensions of 100 mmx100 mm bag was closed very carefully. This bag was put in the steel glass of the wash wheel, added 10 ml/l perchloroethylene and 0.6 ml/L water based detergent. All the material was agitated in the wash wheel for 30 minutes at 30°C. The specimens were removed from the bag, placed them in between the absorbent paper and squeezed to remove surplus solvent. Samples were air dried at room temperature not exceeding 60°C. The specimens were assessed for their change in shade with the help of gray scale AATCC [21]. It was concluded that digitally printed samples have better dry cleaning fastness then traditionally printed samples as shown below in table 5.

Before After

Figure 9: Dry Cleaning results of Digital Printing



Before After

Figure 10: Dry Cleaning results of traditional printing

Table 5: Dry fastness Properties results

Pigment Blue 15.1 Conventional	Fastness Properties	Pigment Blue 15.1 Nano	Pigment Yellow 14 conventional	Pigment yellow 14 Nano	
4	Dry cleaning	5	4	5	

4.4 Color Fastness to light

1.1. Method: ISO105/BO2

ISO 105/BO2 test method was used which is widely accepted by most of the customers. Xenon Arc Lamp was used as artificial light source as it was representative of the natural day light. The graph given below represents comparison of sun light with artificial produced by xenon arc lamp.

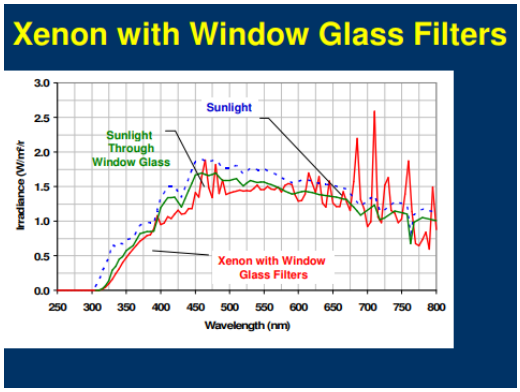


Figure 11: Presentation showing the comparison of sun light and artificial light by arc lamp

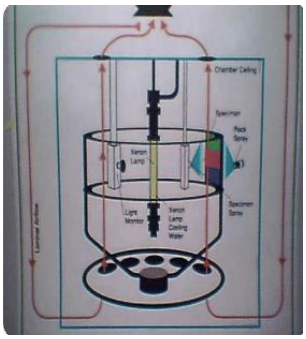


Figure 12: Arrangement of water cooled xenon arc lamp

The specimens were cut carefully and exposed in moderate effective humidity. L F of humidity test control was 5. Maximum black standard temperature was kept 45°C. Irradiance was done at 300-400 nm (1.1w/m^2/nm for

water cooled machine). Specimens were exposed until a contrast (change in color) corresponding to grey scale grade 4 and later to grey scale 3 is visible on test sample, but at most until the blue wool reference 7 show a contrast corresponding to grey scale grade 4 AATCC [21]. Specimens are assessed with blue wool reference and results are given below in table 6.

Figure 13: Blue Wool Standards-ISO 105 BO2 Water cooled light fastness testing machine Results of light fastness of traditional printing

Figure 14: Results of light fastness of traditional printing

Figure 15: Results of light fastness digital printing

Table 6: light fastness properties

Fastness Properties	Pigment Blue 15.1Conventional	Pigment Blue 15.1 Nano	Pigment Yellow 14 Conventional	Pigment Yellow 14 Nano
Light Fastness	5-6	7-8	5-6	7-8

5. Conclusions

Ink-jet inks were prepared, characterized and applied on pretreated cotton fabrics via digital printer "Monna Lisa Evo Tre" and lab. Scale rotary screen printing machine. The samples digitally and traditionally printed were cured in an oven at 160°C for 4 minutes and then evaluated both types of the samples for their fastness properties, like rubbing, washing, dry cleaning, light by using ISO, S and AATCC standard methods. We compared these fastness properties of digitally and traditionally printed fabrics samples. It was concluded that all fastness properties of digitally printed fabrics were better than the traditionally printed fabrics. The colorants used have same color index numbers but their weather fastness properties were better in Nano particle size rather than their particle size in microns. We also compared the digital inkjet ink printing method and traditional rotary screen printing method and concluded that digital Textile printing method is better printing method for quality printing, it is time saving, cost saving, energy, water, material saving, suited for short runs, eco-friendly, low waste producing and socio-economic method of textile printing as compared with traditional rotary screen printing method. The digitally printed samples shown better fastness properties as compared to traditionally printed samples. So, the digital textile printing method is eco- friendly with negligible wastage, with good socieo-economic effects as compared to traditional rotary screen printing method.

6. Recommendations

The aim of this study was to gain an increased knowledge of the pigments as colorants, impact of their particle size in microns as well as in Nano meter. We evaluated that the pigments were suitable colorants for almost all textile substrates (cotton, Polyester and blends) unlike the other colorants. They Show better color gamut and reproducibility in Nano particle size rather than in microns. Secondly we evaluated that inkjet ink manufacturing method is based on new mechanical technology (Bead Mill), easy to handle and time saving while emulsion manufacturing process is old difficult. time consuming and have more chances of contamination. Thirdly we reached to the decision that digital textile printing based on pigmented inkjet inks is better in all respect than traditional rotary screen printing method. Although developed this work still holds room for further improvements. More in-depth studies on the water based pigmented inkjet inks manufacturing, their characterization and application on different fabric substrates would lead to more accurate printing efficiency in textile industry. Further work could aid in the creation of design diversity and good quality prints. Here needed good coordination between printer manufacturer, inkjet ink manufacturer (Chemist) and pretreatment doing person (Textile Engineer) during research work on the topic and other related topics. Further research in this field would be helpful to make our environment eco-friendly, to meet the water, energy, space requirements of coming generations.

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