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Formulation of Eco-friendly Inks for Ink-jet printing of Polyester and Cotton Blended fabric

Hafeezullah Memon [1], Nazakat Ali Khoso [1], Samiullah Memon [2], Ningning Wang [1], Chengyan Zhu [1,*]

[1] Key Laboratory of Advanced Textile Materials & Manufacturing Technology, Ministry of Education, Zhejiang Sci-Tech University, Hangzhou 310018, PR China

[2] Synthetic Fiber Development and Application Centre, Karachi, Pakistan

[*] Corresponding author: Chengyan Zhu; E-mail: cyzhu@zstu.edu.cn

Keywords: Ink-jet printing, ink formulation, shelf life, blended fabrics, eco-friendly.

Abstract. The aim of this research is to discover such a strategy so that Ink-jet Printing of polyester and cotton blended fabric. This research focuses to develop inks by the combination of Reactive and disperse dyes and by using eco-friendly co-solvents. This paper covers a brief introduction of Ink jet printing technologies and types of inks. A summarized study of the evaluation amid ink jet printing as well as rotary screen printing is also given. In addition to, requirements and composition of water-based ink-jet inks focusing on methodology is given. Furthermore, shelf lives of inks, image sharpness, surface tension, color fastness to rubbing, analysis of head with some personal experiences are also discussed.

Introduction

The present worldwide manufacturing of printed textile fabrics is over 34000 million square meters annually and is conquered by rotary screen printing [1]. It is predictable that approximately 11-13% of textile goods are printed worldwide annually with the growth rate of 2% yearly [2]. The international market for digitally printed textiles is projected to reach $6000 million within the coming five years [1]. 90% of the textile printing is done using three dye classes namely pigments (48%), reactive dyes (24%) and disperse dyes (18%). Printing with reactive and disperse dyes engages costly after processing steps such as steaming for their fixation. In 1937, pigment based printing was first launched in the textile market [3]. Today the average speed of a conventional textile printing machine is 30m/minute. Kurt Salmon Associates reported that the textile industry loses $45000 million per year due to long manufacturing time cycles leading to high costs of supplies, swarming and stock-outs in 1997 [4]. The wastewaters producing from this operation are often strong and may hold some toxic compounds, yet the amount of polluted waste may be very low generated in the result of ink-jet printing [5]. This inkjet printing represents the advantages over traditional rotary printing, with the difference of manufacturing capacity only; Ink Jet Printing is almost fruitful [6]. This emphasizes entrepreneurs to spend on this newer technology. During few decades this technology has been broadened too much. The advancement can be deduced from the Figure 1 given below.

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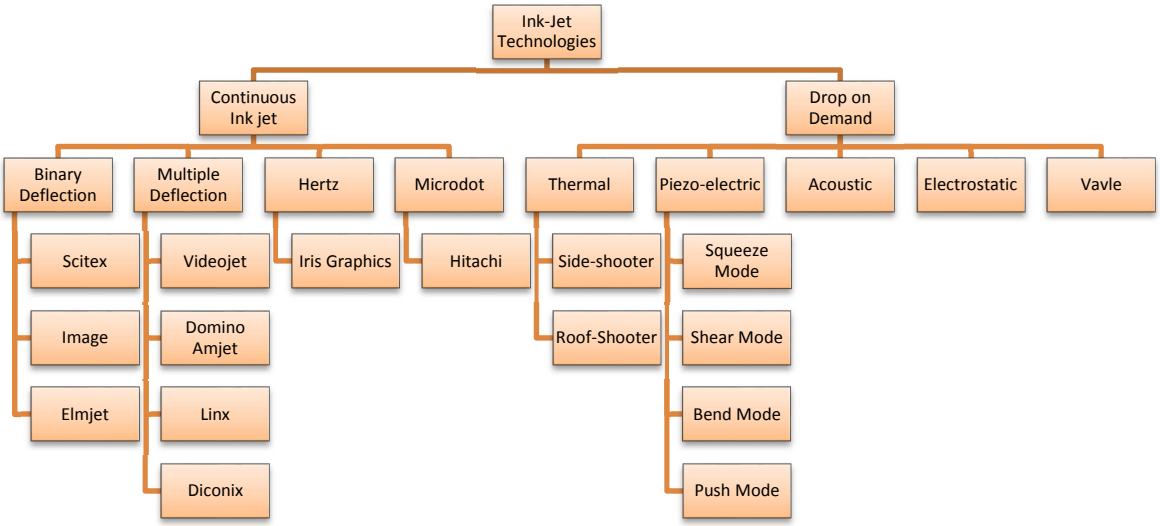

Fig. 1 Ink jet printing technologies [7]

Not only printing methodologies have been broadened too much but also Ink formulations have been broadened too. The advancement in the area of Ink Formulation can be deduced from the Figure 2 given below.

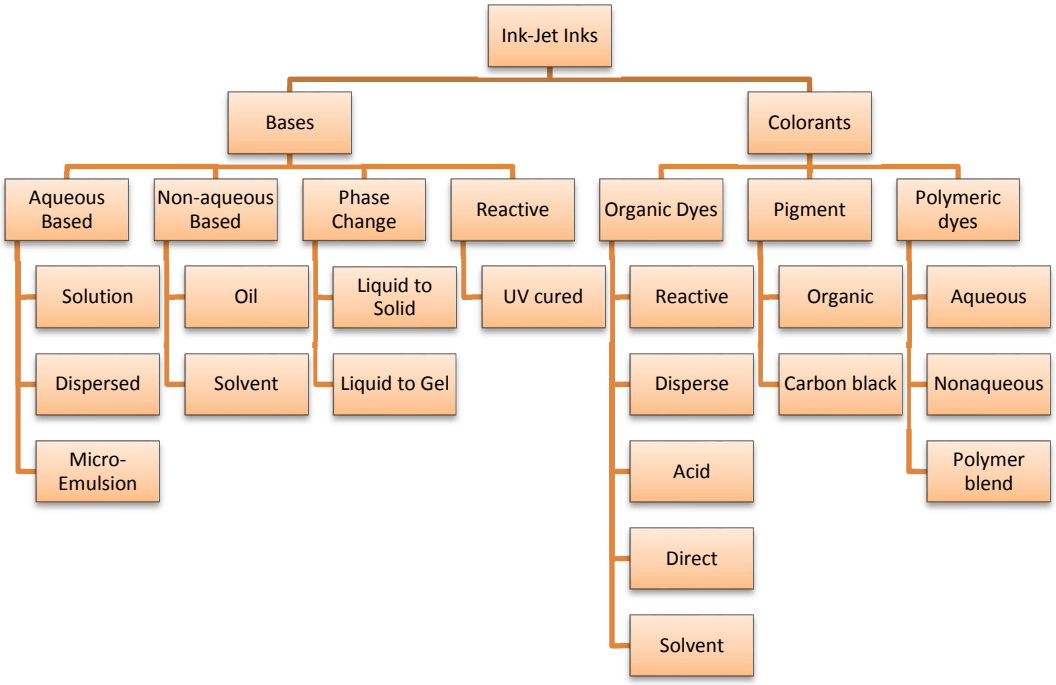

Fig. 2 Classification of Inkjet Inks

This latest inkjet printing was first introduced to meet the orders of shorter lengths and quicker manufacturing response, sooner it attracted the larger area of textile ink-jet printing [8]. Water is a cheap and easily available natural resource. Textile ink jet printing is the study of textiles in addition to electronics, thus special care is needed while developing the inks. Here in Table 1, some ink requirements are mentioned for different ink jet printing systems.

Table 1 Analytical requirements of the inks used for ink-jet printing [9]

Ink Property	CIJ Binary	CIJ Multi-deflection	DOD Piezo	Valve-jet	Office Piezo	Office TIJ
Resistance to flow (viscosity) [cps]	~ 1.5	1-10	5-30	100	~ 1.5	1-3
Surface Tension [dynes/cm]	> 35	25-40	>32	>24	>35	>35
Max Particle Size [microns]	1	3	1	5	1	0.2
Conductivity [microsiemens]	Yes >500	Yes >1000	No	No	No	No

Textile is the second basic need of the mankind. Today people like to buy innovative things. Everyone is rushing about something unique. This project is desire of today's fashion designers, printing masters, and textile engineers because trends of coloration technology are being changed from Dyeing to Printing, and in the area of printing the next era is of Digital ink-jet Printing means the era of being changed from Printing pastes to printing Inks, and due to Ecological consideration these inks should be eco-friendly. Keeping the globe save is not only motto of environmental scientists, environmental advocates, environmental engineers, environmentalists but it is the responsibility of every one, who lives on this globe. This research is too important and timely because ink-jet printing is going to be used for special purposes other than textiles too, nowadays, such as it shall be used in making e-textiles, PCB on textile specimen etc.

Although many of Ink making companies might be doing research on this area, yet none of them have claimed yet to offer such inks. The inks produced from organic solvents are mostly volatile. On drying of the textile specimen, the volatile solvents evaporate and thus it can be inhaled by surrounding persons. Water based inks are seemed to be eco-friendly then others, yet needed a co-solvent, that is commonly an organic liquid [4]. Even some of the inks need three chemical bases; water, co-solvent mostly a petrochemical and oil. Pigments and dyes are added into these solvents to give color to the ink.

Dyes are soluble in the solvents thus it blends with water based solution, causing staining textile specimen at molecular level, and offers light reflection more evenly and appears more vivid. Contrary, pigments are insoluble, so light reflected from the prints formulated using pigments do not come into view to be lively owing to the dispersion of the revealed light. However, the color fastness to light of pigment based printed fabric is much better than dye based printed fabric because dye has relatively smaller molecular sized compare to pigments and thus they are easily damaged by UV light than that of pigment based prints. Some companies are offering now the inks in combination of dyes and pigments, referred as hybrid inks. Such as Epson claimed that its inks may last up to 200 years. The dyes and pigments should also be eco-friendly, as the textile specimen has contact with skin. A similar approach has recently been published but it was only for cotton fabrics, rather than blends [10]. A nano silver coating has also been made by using ink jet printing technology [11]. Though the extensive literature review it can be said that there is not any publish data regarding exactly this approach. This research focuses of making hybrid of Disperse dyes and Reactive Dyes. In addition to, different additives are used to get different properties and functions. Such as buffering agents to maintains the pH of the inks, resins are introduced to impart resilience, and humectants are used to avoid the evaporation of inks. Many other components are added to different types of inks that may include surfactants, fungicides and biocides. Having large number of varieties of solvents and co-solvents; with choice of different ratios of dyes and pigments, by adding various Additives make unique compositions. Each of these compositions suggests seeing its impact on the environment.

Experimental

Materials. The woven polyester and cotton blended fabric was arranged from Popular fabrics (Pvt) Ltd. Pakistan having 120g/m^2. The fabric had a construction of 30x30/68x56. Reactive Black and Black Disperse dyes suitable for dyeing at neutral pH were obtained from DyStar Pakistan and used without further purification. Isopropyl alcohol was purchased from Merck KGaA, Germany. Deionized distilled water was obtained from the Wet Processing lab.

Methodology. Epson and Hewlett-Packard Printer were used to print on polyester cotton blended fabric. The fabric was pasted with glue stick on A4 paper. The printer was being connected to computer to get prints. Inks were formulated using 2% reactive dye and 2% disperse dye with different concentrations of isopropyl alcohol.

Testing. The shelf lives of inks were assessed visually against the passage of time. Only the colorfastness to rubbing (ISO 105 X12) was done to assess the fastness properties of printed fabric. The local made crock meter was used for assessing the color fastness to rubbing. Image sharpness was analyzed visually. Surface tension was analyzed by DIY instrument, designed in wet processing lab of Textile department.

Results and Discussion

Shelf Life of Inks. The shelf lives of the inks were assessed by visual assessment in the beaker. Although the shelf lives of inks become better by increasing co solvent, yet they are not enough for their commercial applications. The shelf life inks with respect to the concentration of cosolvent are presented in Figure 3.

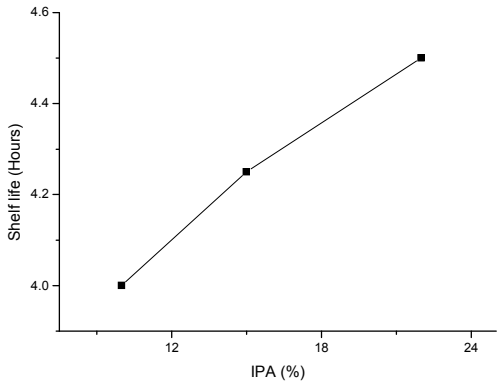

Fig. 3 Shelf Life of Inks

Image sharpness. Image sharpness was analyzed by visual assessment, the Arial fonts between 8, 12, 14, 18 and 22 were printed by using only one ink i.e. IPA-22. Although for fonts above than Arial 14, the image sharpness was right yet for smaller fonts the sharpness were not accurate.

Surface Tension. The measurement of surface tension by capillary rise or fall was taken into account while measuring surface tension of inks, during our project of ink formulation for ink jet printing on lab scale.

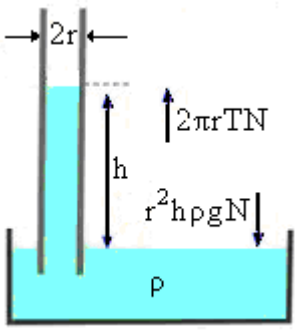

Fig. 4 DIY measurement of surface tension

Consider the figure, the liquid has risen a height h inside a capillary tube of radius r, the upward force is thus $2\pi rTN$ and is balanced by a downward force of $r^2h\rho gN$, where ρ is the density of liquid, thus, it may be equated to get the required equation.

$$2\pi rTN= r^2h\rho gN. \quad (1)$$

$$T= ½\ rh\rho g. \quad (2)$$

Where, 'g' is gravity constant, 'r' is the radius of the tube, 'h' is the height and '*p' i*s density of liquid.

The surface tensions of all inks were analyzed by using a lab made approach. The surface tension of all inks were slightly higher than as recommended in the range to used for ink-jet printing. This is because not any surfactant was used in the ink formulation.

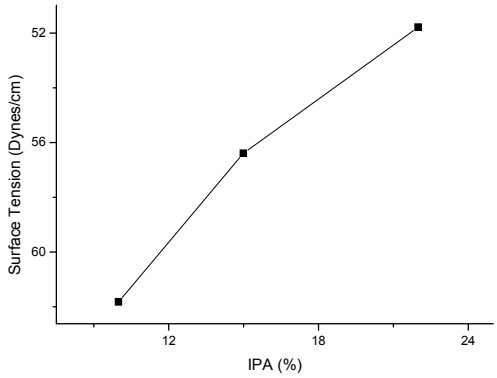

Fig. 5 Surface Tension of Inks

Color fastness to rubbing. The color fastness to rubbing of the printed fabric by inkjet printer on polyester cotton fabrics was evaluated by assessing the amount of color transferred from the printed fabric in both dry and wet conditions to the standard rubbing cloth. The tests were carried out according to ISO-105-X12 method on crockmeter (Local Made). After the completion of test the standard rubbed strip of cotton was evaluated by using standard gray scale for staining. The results of all the samples of polyester cotton fabric are listed in Table 2. The ratings clearly represent that the rubbing fastness properties obtained by this printing method are enough to be accepted.

Table 2 Color fastness to rubbing of inks

Salt	Dry	Wet
IPA – 10%	4/5	4
IPA – 15%	4/5	4
IPA – 22%	4/5	4/5

Analysis of Head. The head of Epson printer was blocked and chocked sooner after some samples, later the inks filtered by muslin cloth was used in HP Printer for this research. This might be due fine quality of printing head installed in the Epson printer than HP Printer. As the shelf lives of formulated Inks were not enough good to be fruitful to store inks in the printer so the inks were supposed to be washed off properly from head. Even though the inks were filtered by muslin cloth yet the second printing head was also chocked after several samples. This suggests that all physical and chemical parameters are essential to be considered into account to maintain printer's head safe and image sharpness.

Conclusion

In conclusion, it is expected that the inks can be formulated to print both polyester and cotton at one time simultaneously. Ink jet printing is need of textile designers because of large number of color choices; textile entrepreneurs because installing a design studio is less expensive than installing a wet processing industry, textile marketers because short orders can also be handled out. The benefit of this research are too wide; it shall be beneficial for entrepreneurs to start this new business, society by getting job opportunities, environment by being safer from toxic chemicals and designers to bring their ideas forward without being restricted to number of color choice. Furthermore, this research will fill the gap between market supply and demand. Because, large lot production is not preferred due to rapid market change nowadays.

Piezo-jet is the most important among others technologies of ink jet printing and it governs the ink jet printing sector of textile [12]. In conventional printing we use liquor ammonia to maintain pH first basic to get the reactive dye fixed into the cotton portion of textile specimen and then it evaporates and make the pH acidic to allow disperse dye into Polyester fiber portion. Such strategy seems not to be suitable for Ink-jet printing because basic pH results corrosion in the head of printer. Thus in this research we shall have to work on any suitable alternative. The research in this area is highly recommended to find the solution of textile designers, entrepreneurs and textile scientists.

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