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Evaluation of different factors on Dyeing of Polyester and Cotton Blend processing using pigment produced by *Aspergillus nidullans*

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Abstract

Pigment produced by fungi considers one of the most emerging fields of research in more safe products for textile industry with less degradable dye and eco-friendly natural pigment products. Fungi have a precious origin of pigments due to they are able to produce high variety yields of the pigments using the cheap culture medium, making the bioprocess economically viable on the industrial scale.

In this work, *Aspergillus nidulans* pigment produced was extracted by methanol and evaluated its ability to dye both of polyester and cotton. Infra red (IR) analysis for function groups for natural Dye with polyester and cotton blends to explain the main function group which responsible for dye both of cotton and polyester at the same process

So, effect of Various Parameters on Dyeing of Polyester Cotton Blend was applied in textile as One-bath dyeing of polyester/cotton blends natural pigment produced by *A. nidulans*. One-bath dyeing of polyester/cotton blends was successful. The dyeing behavior was applied on cotton, polyester fabrics and finally applied onto polyester/cotton blends. The result of fastness properties were good to poor. One-bath dyeing of polyester/cotton blends was also successful.

The aim of this work was produced natural pigment used for dying polyester/cotton blends otherwise chemical dyes which used to cotton and polyester separately. Also natural dye low cost and less toxicity for human rather than chemical dyes which cause some hypersensitivity in some cases

Keywords: Polyester/Cotton blends, *Aspergillus nidullans*, natural pigment, Textile application,

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Introduction

Side effects of synthetic dyes on human being health and harmful effects on the environment leads to development ways for obtaining pigments from microbial natural sources was considered as significant urge all worldwide. Fungal pigments production has great attention for textile industry due to its safer products, easily degradable, eco-friendly and do not cause side effects. Natural pigment produced by fungi was considered more advantageous due to it is a more efficient and less cost than synthetic chemical pigments process. Fungi also more tendency sources of natural pigments when compare with pigments produced by animals and plants as fungi do not effect by seasonal restrictions, also, natural dye produced by fungi do not need limited farming land with actual foods, and natural pigment produced by it is easily and by using cheap fungal culture medium to produce high yields (Akilandeswari and Pradeep, 2016)

Pigments produced by fungi are considered as secondary metabolites structurally heterogeneous with low molecular weight not essential for fungal growth especially fungi that produces this pigments. Large different species of fungi produce different natural pigments as secondary metabolites (Berdy 2005)

Pigments produced from fungi is considered as the most important alternative way of traditional chemical synthetic dyes and pigments which may fall in the broad classification of carotenoids, as the concern has become high for their harmful effects like hampering the environmental and human health (Khan et al. 2013). Specifically, textile industry that uses large quantity of chemical dye stuff with the effluents of different process, is polluting our soil and water sources. They are also listed as mutagenic, carcinogenic, allergic and cytotoxic agents posing threats to all life forms (Khandare & Govindwar 2015). Recent research trends which are focused on pigments for textiles reveal significant advancements. (Devi et al.,2014)

The results in this work will be useful and encourage a greater number of researches on fungal pigment production to apply innovative and sustainable solutions for human health and the environment especially in textile industry to reduce usage of synthetic dye production. Natural pigment produced by microbial origin especially fungi as sources of textile dying industry open new gate for new interdisciplinary filed between microbiology and textile industry. Further studies will be carry out in future to apply the results of this work in industrial scale

Materials and Methods

Strains and growth conditions

A. nidullans used in this study was kindly provided from Culture Collection of The Regional Center for Mycology and Biotechnology- Al-Azhar University, Cairo, Egypt

Cultivation medium

Czapek Dox agar medium with the following composition was used as cultivation medium, NaNO3, 2.0 g, K2HPO4, 1.0 g, KCl, 0.5 g, MgSO4·7H2O, 0.5 g, FeSO4·7H2O, 0.001 g, sucrose, 20 g, agar, 20 g. The pH was adjusted at 6.5 – 7.0. This medium was inoculated with 10^6 conidia/ml and incubated at 28^o C in a rotary shaker at 220 rpm. After growth for ten dayes, the mycelium was collected by vacuum filtration and the pigment present in the mycelium and culture medium was then extracted.

Pigment extraction

A. nidullans was cultured in 500 ml Czapek Dox broth flasks. The culture flask was incubated at temperature 28 ±2°C for 10 days. Then the pigment was extracted. The extraction process of pigment was done by by boiling both the mycelium and the fungal culture broth media in methanol at 98°C showing color together and then filtered.

Effect of Various Parameters on Dyeing of Polyester Cotton Blend

Fabrics:

Mill desized , kier boiled and bleached cotton ,was supplied by Misr Company for Spining And Weaving – Mehala El-Kobra .-Polyester fabric and cotton/polyester fibers blend (50:50), were supplied by Elshorbagy co.

pre mordanting

Cotton and polyester samples in aqueous solution contine (3%) ferrous ammonium sulphate solution for 30 min at 60˚C with L:R 1:50 than dried with washing

Dyeing process

the mordant samples were dyed in freshly prepared aqueous 10 g/l NaCL and 3% *A. nidulans* (fungal pigment) .The dyeing process was carried out at 80˚C temperature for 45 min then the fabric washed with distilled water and dried at ambient condition.

The dyed samples were thoroughly rinsed and washed in a bath containing 1g/l non-ionic detergent for 15 min at 90°C to remove unfixed dye as well as residual auxiliaries and additives.

Testing and Analysis

Measurement of colour strength (K/S)

The color strength of the dyed samples was evaluated by light reflectance technique using ICS-TEXICON computerized spectrophotometer; model M 520220 (produced by ICS – TEXICON Limited Co. England.

The color strength expressed as K/S value was assessed directly by the Spectrophotometer according to kubelka-Munk equation [(1)].

$$K/S = (1-R)^2 /2R - (1-R_0)^2 /2R_0$$

K/S is directly related to the color intensity of the obtained dyeing, where K is the light absorption coefficient, S is the scattering coefficient; R is the decimal fraction of the reflectance of the dyed samples, R_0 is the decimal fraction of the reflectance of the undyed samples.

Evaluation of color Fastness properties

Colour fastness to washing

It was determined according to the AATCC test 61-1975[(2)] using launderometer

Color fastness to rubbing

It was determined according to the AATCC test 8-1996[(2)] using crock meter under controlled conditions to determine dry and wet crocking fastness.

Color fastness to perspiration

Two artificial perspiration solutions were made as follow; acidic solution and alkaline solution, this test was carried out according to the AATCC test method 15-1997[(2)].

Color fastness to light

This test was evaluated according to the AATCC test method 16-1998 [T]in order to determine the degree of color resistance to photo –degradation.

Test organisms for Antimicrobial assay:

Staphylococcus aureus ATCC 29213, *Escherichia coli* ATCC 25922 and *Candida albicans* MTCC183

Antimicrobial activity of Polyester Cotton Blend by diffusion method (Garrod & Waterworth, 1971):

Overnight broth cultures of test organisms (*staphylococcus aurues, Escherichia . coli and candida albicans*) were freshly prepared, Nutrient agar plates 15 ml were prepared and then surface dried at 37 o C for 30 min. the bacterial or fungal inoculum were spread over the surface of the dried agar plates using a sterile glass spreader. The plates were dried, inverted at 37 o C approximately 30 min until the bacterial overlay had dried. 1cm × 1cm sterile pigmented

Polyester Cotton Blend and another not pigmented as control to assay their antimicrobial activity and was placed onto the agar plate and incubated at 37 o C for 24 h for bacteria and at 28 o C for 48 h, in case of fungal species. The diameter of the inhibition zone for each was recorded in mm.

Result and discussion

Dyeing process is addition of color on textile products. The principle objective of the dyeing on textile object may be maximized value addition, progress of the achievement and fulfill of the needs of customer. At present Textile dyeing industry uses massive quantity of synthetic chemical dyes to overcome the required coloration of global consumption of textiles due to cheaper prices, wider ranges of bright shades, and considerably improved fastness properties in comparison to natural dyes. Dyeing is considered as an ancient art which predates written records. Its practice could be traced back during the Bronze Age in Europe (Ado etai., 2014)

Chemical synthetic dyes used in textile industries and their wastes are considered the worst polluters for water and soil. Search for alternative sources of natural pigments was more interests due to the toxicity produced by synthetic dying agents. Plants are used for natural pigments but inadequate yield of those sources hampered the progression. Microbial pigment production especially by fungi will provide a readily available alternative source of more safe and less expensive natural pigments by fermentation process and biotechnology

But the production of synthetic dyes is dependent on petrochemical source, and some of these dyes contain carcinogenic amines. The uses application of synthetic chemical dyes leads to serious dangerous health hazards and effect bad effect on the ecosystem of nature. Moreover, many countries already imposed stringent environment standards over these dyes. In this situation, a higher demand is put towards the greener alternatives or agricultural residues. As a result, natural dyes are among the promising options for developing a greener textile dyeing process and such interest is reflected to the increased number of recent publications (Samanta & Konar 2009)

Fungi produce a huge number of pigments as secondary metabolites, which have roles in a range of cellular processes such as transcription, development and intercellular communication. In addition, many of these compounds have been found to have important applications, for instance, as antibiotics or immunosuppressant (Brakhage 2013),

Effect of Various Parameters on Dyeing of Polyester Cotton Blend

Study of mordant concentration

(Effect of Fe^{++} concentration)

The effect of Ammonium ferrous sulphate (Fe^{++}) concentration of the mordanting solution was studied since different conc. Of Fe^{++} were used (0 , 1. 3 , 5 , and 7 % (of weight of fabric) than Cotton and polyester samples were dyed with 3% *A. nidulans* fungal pigment ,10 g/l NaCL , for 45 min at 80°C and L.R.1:50 **.** the result are reported in figure (1) showed that the K S of both fabrics increased with increasing (Fe++) up to 5% but it decreased above 5% .

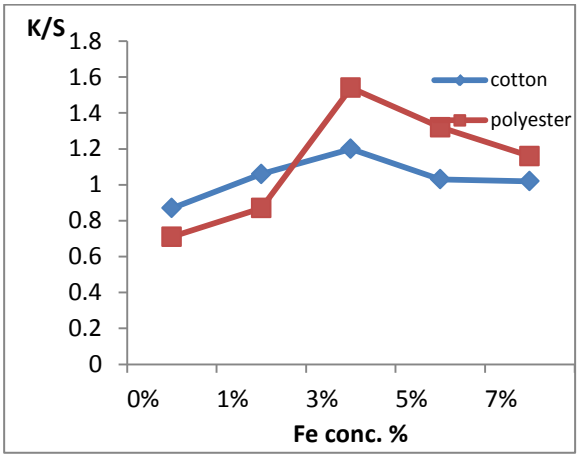

Fig. 1 : Effect of Fe concentration

Study of dyeing parameters

Effect of pH of grafting

After mordanted of cotton and polyester samples with (3%) ferrous ammonium sulphate solution for 30 min at 60˚C with L:R 1:50 than dried with washing**.**

The effect of pH level of the dyeing medium was studied since different levels of pH were used (3, 5,7,9 and 11) in presence of 3% *A. nidulans* (natural dye) , 10 g/l NaCL, for 45 min at 80°C and L.R.1:50.

the result are reported in figure (2). showed that the K/ S of both fabrics increased with increasing pH up to 7 but it decreased above 7

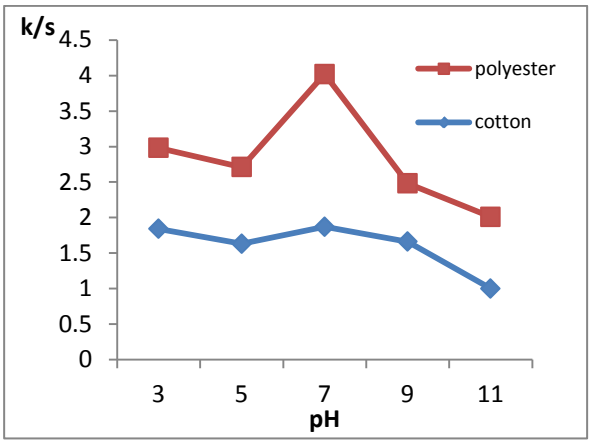

Fig. 2: Effect of different pH of grafting

Effect of dyeing temperature

In order to study the effect of dyeing temperature dyeing process was carried out at different temperatures (30, 50, 70, and 90°C) in presence of 3% *A. nidulans* , 10 g/l NaCL, , at pH 7 , the dyeing was performed for 45 min using L.R.1:50, followed by soaping and rinsing. the result are reported in figure (3) showed that the K/ S of both fabrics increased with increasing temperature up to 100°C

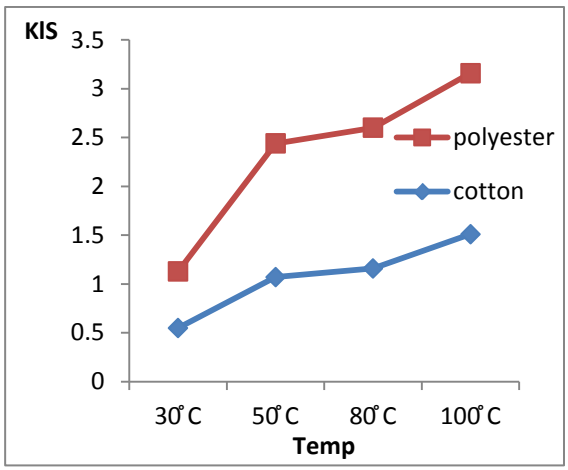

Fig. (3)Effect of different dying temperature

Effect of dyeing time

The effect of time of dyeing in the presence of of 3% *A. nidulans* , 10 g/l NaCL,, at pH 7 at 90°C using different times (30,45, 60,and 90 min) at L.R. 1:50, followed by soaping and rinsing. the result are reported in figure (4) showed that the K/ S of both fabrics increased with increasing time up to 90'

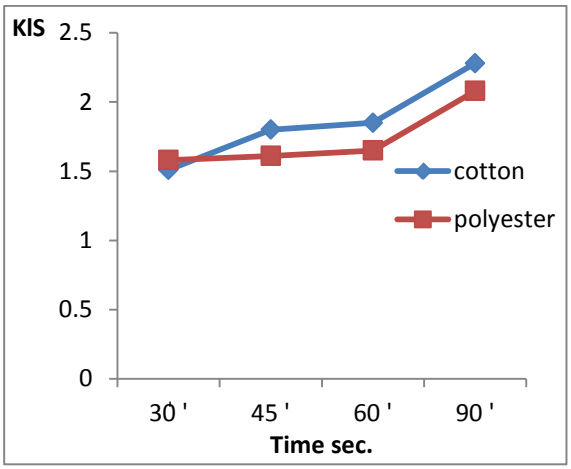

Fig.(4)Effect of different dying time

Effect of different NaCL concentration

The effect of time of dyeing in the presence of of 3% *A. nidulans* at pH 7 at 90°C for 90 min at L.R. 1:50, using different concentration of NaCL (0,10,30 and 50 g/L), followed by soaping and rinsing. the result are reported in figure (5) showed that the K/ S of both fabrics increased with increasing NaCL concentration.

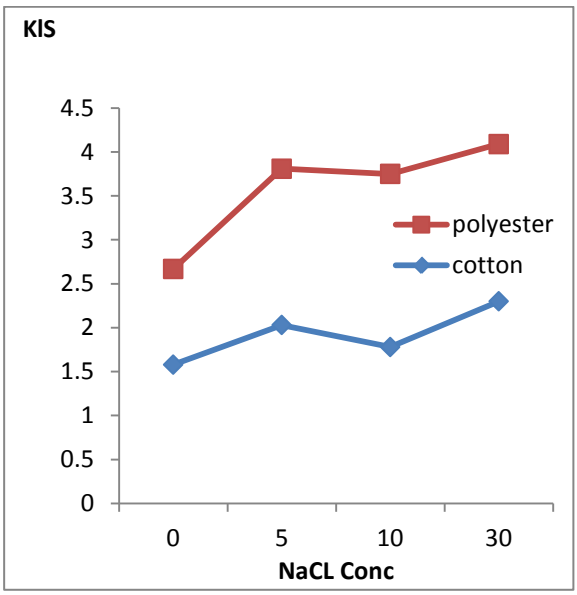

Fig.(5)Effect of NaCL concentration

Color fastness

The color fastness of the dyed polyester/cotton blend fabrics to washing, rubbing, perspiration and light were shown in table 1. The rubbing and perspiration and dry washing fastness properties of dyed polyester /cotton blended fabrics were good, wet washing and light fastness were poor.

Antimicrobial activity of Polyester Cotton Blend by diffusion method:

The antimicrobial activity of Polyester Cotton Blend was evaluated by diffusion methods and the results showed that no antimicrobial activity

K/S		Washing fastness		Rubbing fastness		perspiration fastness				Light fasteness
		dry	wet	St.	Al.	Alkaline		Acidic		
						St.	A	St.	A	
Polyester /cotton	2.03	4	3-4	4	4	4	4	4	4	3-4

Table 1: color fastness of polyester/ cotton blended fabric dyed with *A. nidulans*

IR Results of *A. nidulans* pigmrnt:

Infra red was evaluated for pigment produced by *A. nidulans* compared with dyed cotton and polyester to dtermine the the acive group which lead this pigment to dye both cooton and polyester. Also undyed cotton and polyester were evaluated by IR as control and to explain the diffrence between undyed and dyes cotton and polyester as shown in fig. (6,7,8,9 and 10). As shown in fig.6 the IR results of pigment produced by *A. nidulans* showed variety in chemical functional groups as 3254 cm^{-1} of N-H stretch refers to presence of amine group from Amino acids, at peak of 2925 cm^{-1} referes to C-H weak stretch bond of alkanes group. In addition 2860 cm^{-1} refers to aldehyde group with stretch in its bond with H-C= O: C-H. at peak of 1730 cm^{-1} indicates that presence of Ester group in this pigment. At peak of 1604 cm^{-1} for C-C stretch bond in aromatic ring. At peak of 1445 cm^{-1} CH3 of methyl group with bend medium bond of alkanes. At peaks 1259, 1071 and 1021 cm^{-1} refer to C-N with stretch bond of aliphatic amine of amino acids indicate that the presence of aliphatic amino acids which highly hydrophobic and branched side chain. At peak 932 refers to presence of OH group of carboxylic.

With compare between IR results of dyed cotton with dyed cotton peaks at fig 7 and 8 the results showed that no obvious changes between dyed and undyed cotton except in dyed cotton presence new peak at 2307 cm^{-1} refer to carbon triple bond with nitrogen C≡ N with stretch

bonds of nitrile group which means that conversion of C-N group in dye to C≡ N in aliphatic amino acid chain of pigment

Whereas, in case of polyester dyed and undyed IR results fig. 9, 10 showed that obvious changes in chemical structure of pigment due to chemical reaction between natural pigment and polyester

Polyester is a synthetic polymer made of purified terephthalic acid (PTA) or its dimethyl ester dim ethyl and monoethylene glycol. Polyester is hydrophobic in nature and quickly dry. The lack of polarity and the very crystalline structure resists the entry of water molecules into the polymer system. So, when polyester fiber colourant with natural dyes, it should be pre treated. So the hydrophobic activity of pigment produced by *A. nidulans* and non-polarity of lead to dyed the polyester with this natural pigment

Little work has been carried out on dyeing of synthetic fiber with natural dyes produced by fungi. Synthetic fabric requires pretreatment process before dyeing with natural dyes. Among pretreatment process majority of the work is carried out on mordant process. The natural dye along with mordant gives good fastness properties. There is need to carry out more research work to improve the fastness properties of natural dye on synthetic fabrics. There is need to develop data base with production of appropriate shade card for synthetic fabrics. I this work the effect of *A. nidulans* extracted pigment was effective in both of cotton and polyester dying also all factor effect on pigment efficacy in dying both of cotton and polyester was evaluated

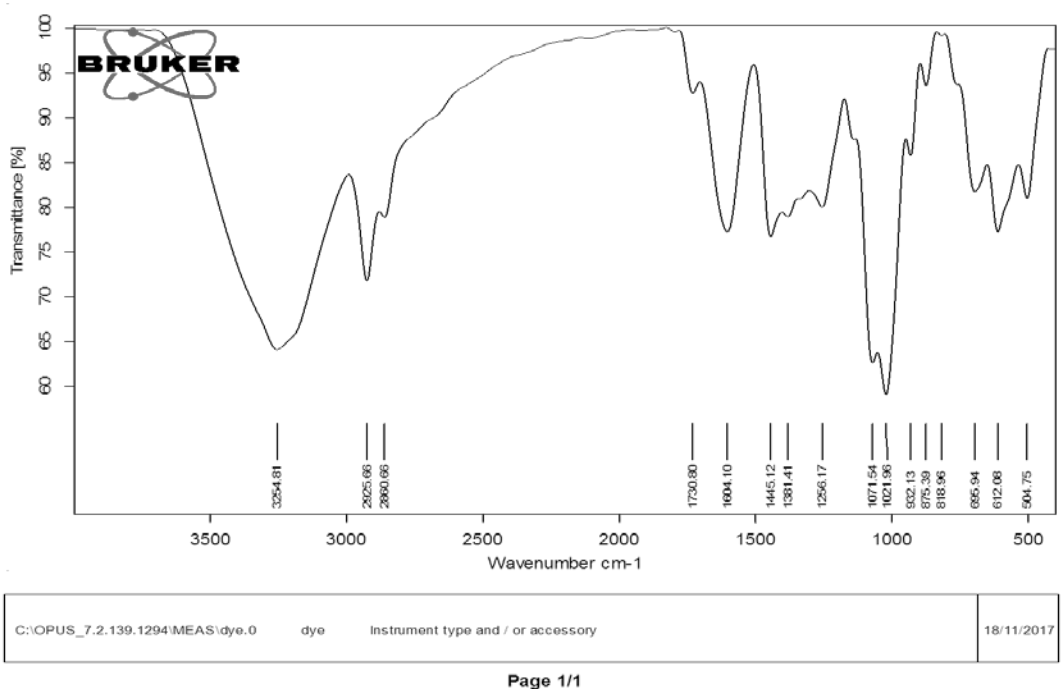

Fig. 6 showed the IR results of *A. nidulans* extracted pigment

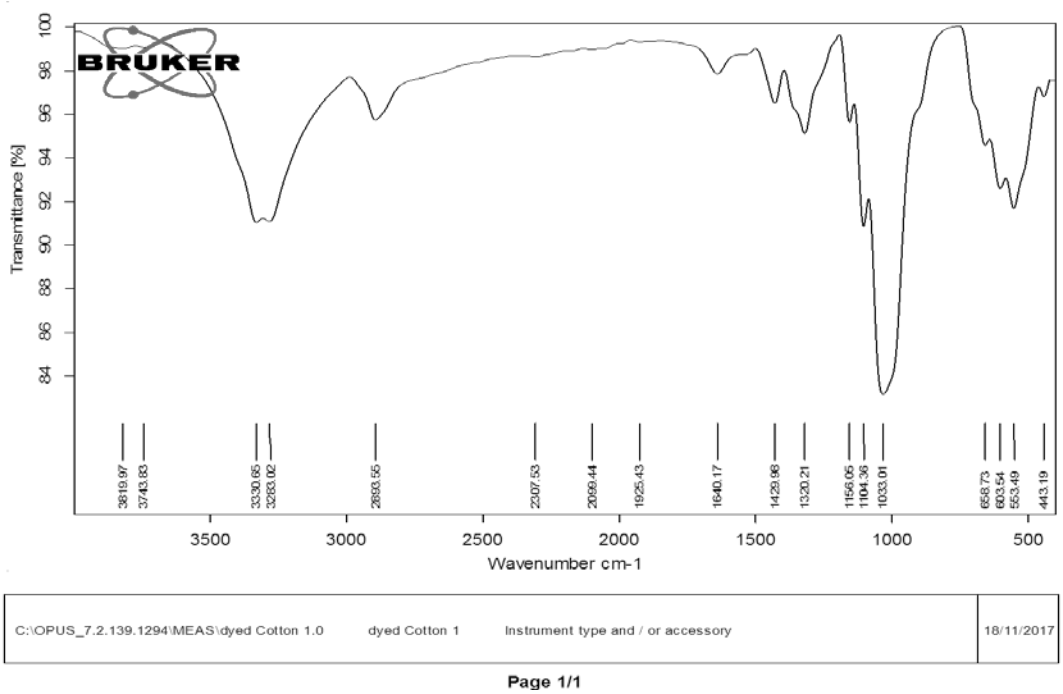

Fig. 7 showed the IR results of dyed cotton with *A. nidulans* extracted pigment

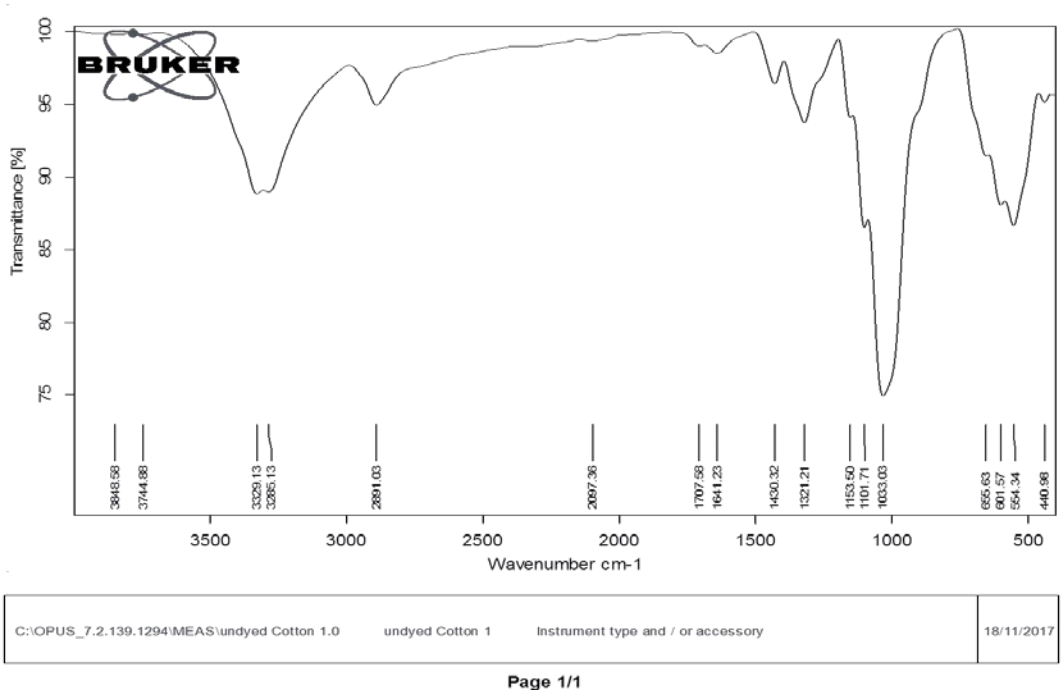

Fig. 8 showed the IR results of undyed cotton

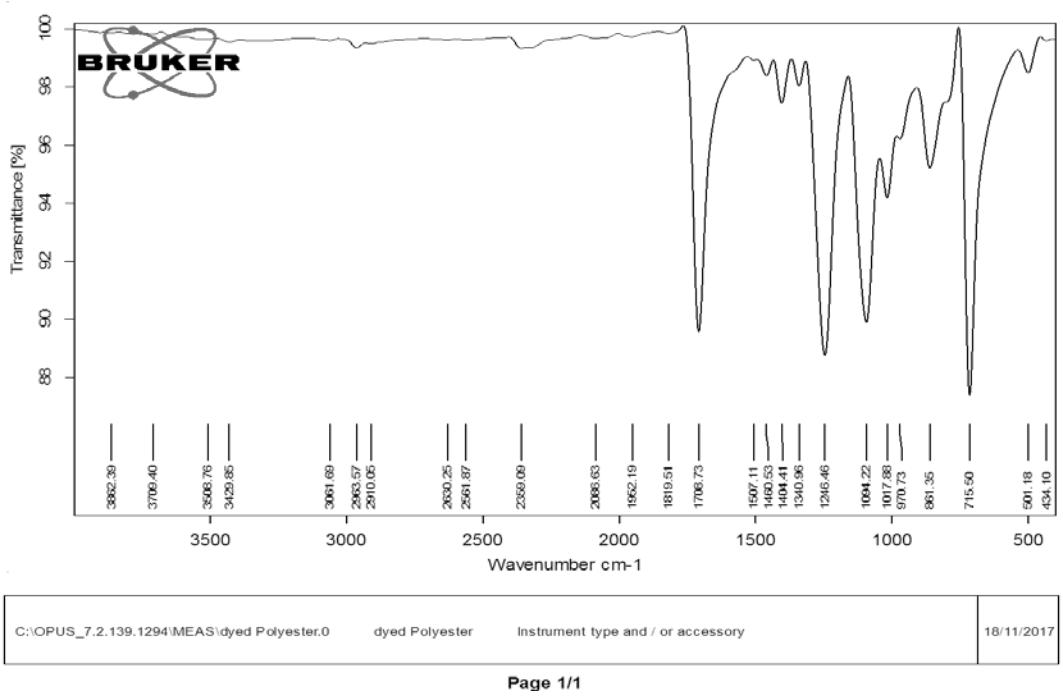

Fig. 9 Showed the IR results of dyed polyester with *A. nidulans* extracted pigment

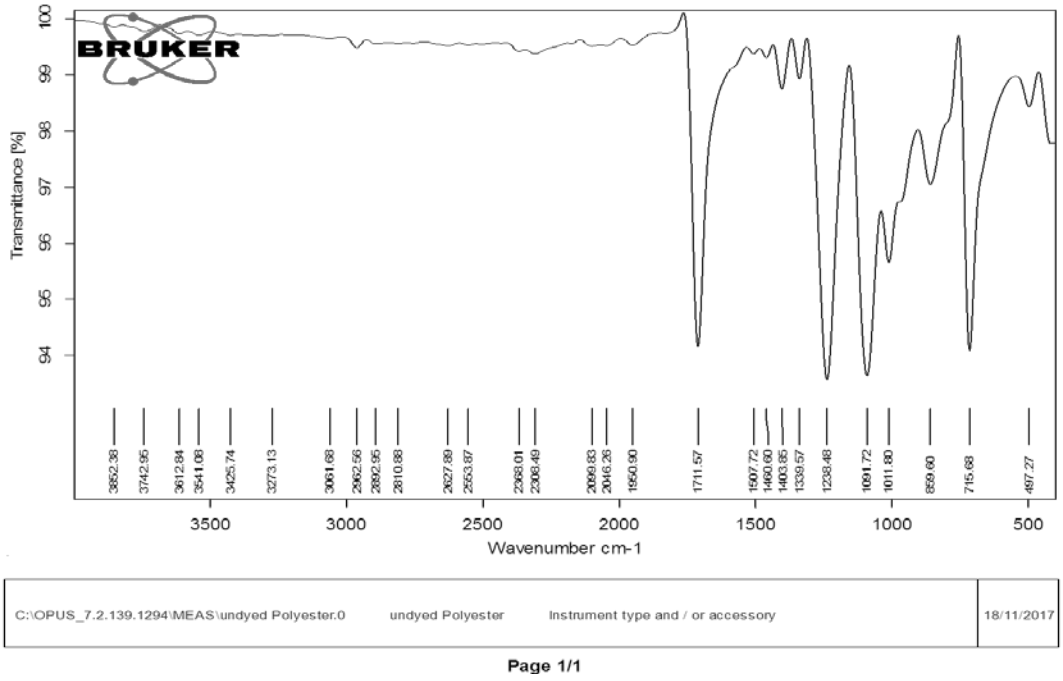

Fig. 10 Showed the IR results of undyed polyester

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