

OPTIMIZATION AND EVALUATION OF ANTIBACTERIAL EFFICACY OF PAPAYA SEED EXTRACT ON NON WOVEN FABRICS

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Abstract

The extraction of herbal plants for medicinal purpose was used from traditional days to treat most of the infectious diseases. The medicinal plants have phytochemicals and these active compounds have inherent properties such as antibacterial, antifungal, antioxidant and anti allergic. In the present study the *Carica papaya* seed was extracted using ethanol and treated on 100per cent bamboo, viscose and polypropylene non woven fabrics. The antibacterial activity was assessed by AATCC standard test method. The study proves that the bamboo and viscose fabric treated at lower concentration of 0.5g/10ml of water showed zone formation of six and seven mm for both *S.aureus* and *E.coli* bacteria.

Keywords: Antibacterial activity, *Carica papaya* seed and ethanolic extract

Introduction

Medicinal herbs have healing properties over thousands of years and

considered to be the most promising source of curative for healthcare systems (Wardah Shahid et al., 2013). With increase in the knowledge of the transferable diseases, there is a growing need for antimicrobial textiles in many application areas like medical textiles, healthcare materials, hygiene application and hospitals (Shahidi et al., 2007). To protect humans from microbial infections the functional finish like antimicrobial finish has become necessary (Ian, 2002 and Mucha, 2002). Thus the present study was focussed on the assessment of antibacterial activity of *Carica papaya* seed.

Materials and Methods

Collection and Preparation of Raw

Material

Carica papaya seeds were collected from fruit shops in and around the premises of Avinashilingam University area, Coimbatore. The seeds were washed thoroughly in tap water for 2-3 times and then in sterile distilled water. After washing they were allowed to air dry in shade for two

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weeks and then powdered using electrical mixer. The powder was stored in sterile sealed jar for further use.

Selection of Fabric Material

Bamboo is a vegetable fiber come with its own blessings. They are biodegradable and cheaper, pose no health hazards and provide a long-awaited solution to environmental pollution by finding new uses for waste materials. Viscose consists of cellulose like cotton. Cellulose is obtained from wood and is used for the production of rayon and cellulose acetate fibres. Considering the constantly growing environmental awareness, the possible decomposition of nonwovens gains more and more importance which also promotes the use of viscose for its unique properties such as skin tolerance, physiological safety, decomposable, good moisture absorbency and simple finished. Polypropylene plays a role as absorbable dressing's material. Traditionally it is used in wound dressings in fibre or fabric form, coupled with absorbent material.

For these reasons, regenerated fibers, which are alternatives to conventional ones, have gained importance in the manufacture as medical textiles. Thus the fabric samples namely non woven 100 per cent bamboo, viscose and polypropylene fabrics were selected and purchased from South Indian

Textile Research Association (SITRA), Coimbatore.

Extraction of Papaya Seed

The seed powder was extracted with ethanol by hot continuous method using soxhlet extractor. Thirty grams of seed powder was weighed and extracted with 300ml of ethanol for six hours. The same procedure was followed for 4-5 times to get required volume of extract. The collected extract was distilled to separate ethanol from the extract and then kept in room temperature for one day to get crude concentrated extract of papaya seeds (5).

Optimization Process

The crude extract of papaya seed was optimized by treating the fabric (100% bamboo, viscose and polypropylene non woven) samples at different concentrations of 0.5, 1.0, 1.5 and 2.0 g/10ml for time intervals of 1, 3 and 5 hours at 40°C and 50°C using 8per cent citric acid as cross linking agent by dip and dry method. After completion of time the fabric samples were taken out, dried and cured at 170°C for three minutes. The treated fabric samples were assessed for its antibacterial efficiency by agar diffusion method. The details of the treatments with various concentrations given to the viscose and polypropylene fabric are shown in Table 1.

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Table 1. Nomenclature of the Samples

Samples	Nomenclature
1.	Bamboo, Viscose and Polypropylene fabrics treated with 0.5 g/10ml conc. at 40°C for 1 hr
2.	Bamboo, Viscose and Polypropylene fabrics treated with 0.5 g/10ml conc. at 40°C for 3 hrs
3.	Bamboo, Viscose and Polypropylene fabrics treated with 0.5 g/10ml conc. at 40°C for 5 hrs
4.	Bamboo, Viscose and Polypropylene fabrics treated with 0.5 g/10ml conc. at 50°C for 1 hr
5.	Bamboo, Viscose and Polypropylene fabrics treated with 0.5 g/10ml conc. at 50°C for 3 hrs
6.	Bamboo, Viscose and Polypropylene fabrics treated with 0.5 g/10ml conc. at 50°C for 5 hrs
7.	Bamboo, Viscose and Polypropylene fabrics treated with 1.0 g/10ml conc. at 40°C for 1 hr
8.	Bamboo, Viscose and Polypropylene fabrics treated with 1.0 g/10ml conc. at 40°C for 3 hrs
9.	Bamboo, Viscose and Polypropylene fabrics treated with 1.0 g/10ml conc. at 40°C for 5 hrs
10.	Bamboo, Viscose and Polypropylene fabrics treated with 1.0 g/10ml conc. at 50°C for 1 hr
11.	Bamboo, Viscose and Polypropylene fabrics treated with 1.0 g/10ml conc. at 50°C for 3 hrs
12.	Bamboo, Viscose and Polypropylene fabrics treated with 1.0 g/10ml conc. at 50°C for 5 hrs
13.	Bamboo, Viscose and Polypropylene fabrics treated with 1.5 g/10ml conc. at 40°C for 3 hrs
14.	Bamboo, Viscose and Polypropylene fabrics treated with 1.5 g/10ml conc. at 40°C for 5 hrs
15.	Bamboo, Viscose and Polypropylene fabrics treated with 1.5 g/10ml conc. at 50°C for 1 hr
16.	Bamboo, Viscose and Polypropylene fabrics treated with 1.5 g/10ml conc. at 50°C for 3 hrs
17.	Bamboo, Viscose and Polypropylene fabrics treated with 1.5 g/10ml conc. at 50°C for 5 hrs
18.	Bamboo, Viscose and Polypropylene fabrics treated with 2.0 g/10ml conc. at 40°C for 1 hr
19.	Bamboo, Viscose and Polypropylene fabrics treated with 2.0 g/10ml conc. at 40°C for 3 hrs
20.	Bamboo, Viscose and Polypropylene fabrics treated with 2.0 g/10ml conc. at 40°C for 5 hrs
21.	Bamboo, Viscose and Polypropylene fabrics treated with 2.0 g/10ml conc. at 50°C for 1 hr
22.	Bamboo, Viscose and Polypropylene fabrics treated with 2.0 g/10ml conc. at 50°C for 3 hrs
23.	Bamboo, Viscose and Polypropylene fabrics treated with 2.0 g/10ml conc. at 50°C for 5 hrs

Antibacterial Assessment of Treated Fabrics

The bamboo, viscose and polypropylene fabrics treated for optimization was tested for antibacterial activity using *Staphylococcus aureus* and *Escherichia coli* as test organisms by agar diffusion method. Required volume of the nutrient agar was prepared in conical flask and pre-heated in the direct flame for few minutes. Then the nutrient agar was sterilized in autoclave at 121°C for 30 minutes. After sterilization the nutrient agar was poured in petri plates and allowed to solidify. The organisms were inoculated and the fabric samples were placed on the inoculated plates and incubated at 37°C for overnight (6).

Physical Property Assessment of Treated Fabric

The bamboo, viscose and polypropylene fabrics treated for optimization was tested for its physical properties namely tensile strength, elongation, thickness, stiffness, weight and absorbency.

Results and Discussion

Antibacterial Assessment of Treated Fabrics

The zone of inhibition of *Staphylococcus aureus* and *Escherichia coli* formed on 100 per cent bamboo, viscose and polypropylene fabric are depicted in Plate I, Plate II, Table 1 and Figure I.

From Table 2 and Plate I and II it is clear that the bamboo, viscose and polypropylene fabric treated at 0.5g/10ml concentration showed maximum zone formation of 7mm and 6 mm for both *S. aureus* and *E.coli* bacteria kept at 50°C for 3 and 5 hrs respectively. At 2.0g/10ml concentration the bamboo fabric showed 6mm and 5mm for *S.aureus* when compared to viscose fabric in which the fabric was treated at 40°C and 50°C for one hour. For both *S.aureus* and *E.coli* the polypropylene fabric showed the evidence of absence of zone formation underneath the fabric and thus confirms that the polypropylene fabric has antibacterial activity. This result was compared with the studies undertaken by Augustine Ocloo *et al.* (2012) and Doughari *et al.*, (2010), in which the methanol and acetone extract of papaya root and seed showed increased zone formation for both species.

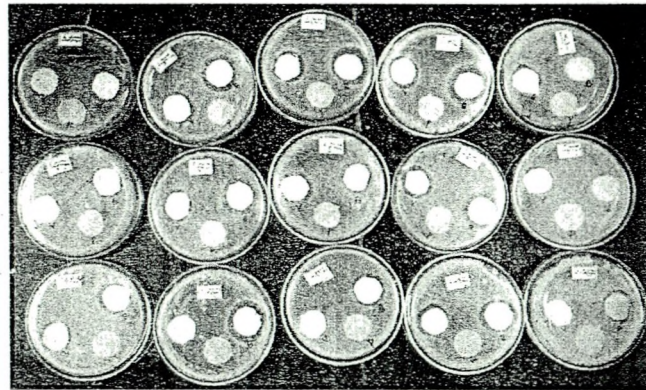
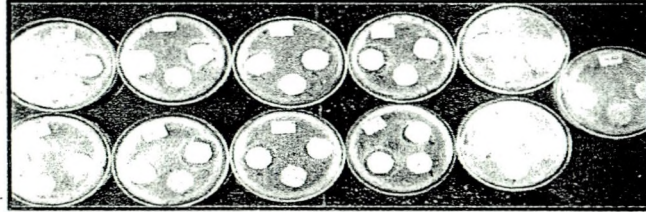


Plate I – Zone of Inhibition of *Staphylococcus Aureus* Formed on 100 Per cent Bamboo, Viscose and Polypropylene Fabrics



Plate II – Zone of Inhibition of *Escherichia coli* Formed on 100 Per cent Bamboo, Viscose and Polypropylene Fabrics

Table 2. Zone of Inhibition of Staphylococcus Aureus Formed on 100 Per cent Bamboo, Viscose and Polypropylene Fabrics

Samples	Zone of inhibition (mm)		
	Bamboo	Viscose	Polypropylene
1.	5	2	0
2.	5	4	0
3.	7	4	1
4.	7	4	1
5.	1	3	0
6.	4	5	0
7.	4	3	1
8.	5	4	0
9.	6	4	0
10.	3	2	0
11.	4	4	1
12.	6	1	0
13.	4	0	0
14.	5	4	0
15.	4	1	0
16.	3	2	0
17.	6	1	0
18.	6	3	1
19.	4	6	1
20.	5	3	1
21.	3	3	1
22.	5	2	1
23.	3	5	0
24.	4	3	1

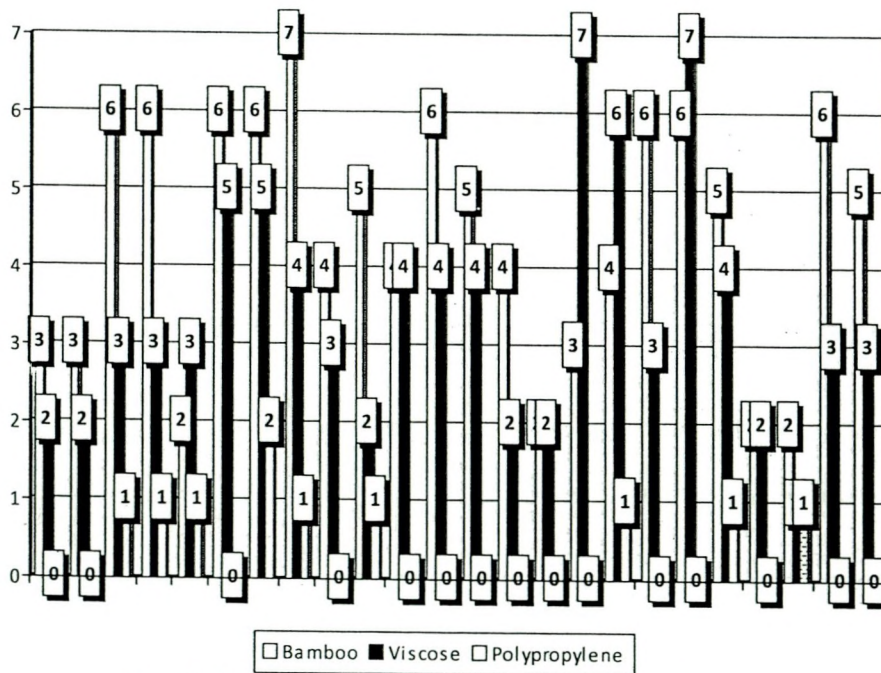


Figure II – Zone of Inhibition of Escherichia coli Formed on 100% Bamboo, Viscose and Polypropylene Fabrics

Physical Property Assessment of Bamboo Fabrics

The results of the physical property of bamboo fabrics is showed in Table IV.

Table 3. Evaluation of Physical Parameters of Papaya Seed Extract Finished 100% Bamboo Fabric

Test parameters	Tensile strength (lbs)	Elongation (inch)	Thickness (mm)	Stiffness (inch)	Fabric weight (gm)	Absorbency		
						Capillary rise (cm)	Wicking (sec)	Sinking test (sec)
Control fabric	40	4.0	0.67	3	1.471	8.2	0.01	0.04
0.5 g/10ml conc. at 40°C for 1 hr	52	4.1	0.65	2.8	2.532	7.9	0.01	0.04
0.5 g/10ml conc. at 40°C for 3 hrs	47	4.3	0.60	3.4	2.154	8.5	0.01	0.06
0.5 g/10ml conc. at 40°C for 5 hrs	47	3.9	0.54	3.2	2.365	8.2	0.01	0.04
0.5 g/10ml conc. at 50°C for 1 hr	48	4.4	0.62	2.9	2.177	8.0	0.01	0.04
0.5 g/10ml conc. at 50°C for 3 hrs	43	4.1	0.58	3.4	2.216	8.3	0.02	0.04
0.5 g/10ml conc. at 50°C for 5 hrs	43	3.9	0.51	3	1.993	8.4	0.02	0.05
1.0 g/10ml conc. at 40°C for 1 hr	59	4.0	0.68	3.3	2.329	8.1	0.01	0.04
1.0 g/10ml conc. at 40°C for 3 hrs	54	4.0	0.70	3.2	2.460	8.00	0.01	0.04
1.0 g/10ml conc. at 40°C for 5 hrs	45	4.2	0.65	3.5	2.488	8.4	0.01	0.04
1.0 g/10ml conc. at 50°C for 1 hr	49	3.8	0.55	3.6	2.183	8.3	0.02	0.05
1.0 g/10ml conc. at 50°C for 3 hrs	49	3.7	0.56	3.8	2.224	8.9	0.02	0.04
1.0 g/10ml conc. at 50°C for 5 hrs	52	4.0	0.59	4	2.268	8.7	0.02	0.05

Test parameters	Tensile strength (lbs)	Elongation (inch)	Thickness (mm)	Stiffness (inch)	Fabric weight (gm)	Absorbency		
						Capillary rise (cm)	Wicking (sec)	Sinking test (sec)
1.5 g/10ml conc. at 40°C for 1 hr	46	3.9	0.70	2.8	2.456	8.5	0.02	0.05
1.5 g/10ml conc. at 40°C for 3 hrs	48	4.3	0.69	3.1	2.762	8.8	0.03	0.05
1.5 g/10ml conc. at 40°C for 5 hrs	52	4.4	0.72	3.3	2.837	8.3	0.003	0.04
1.5 g/10ml conc. at 50°C for 1 hr	54	4.4	0.66	3.0	2.503	8.4	0.02	0.05
1.5 g/10ml conc. at 50°C for 3 hrs	49	5.1	0.68	2.9	2.618	8.3	0.03	0.05
1.5 g/10ml conc. at 50°C for 5 hrs	47	4.7	0.71	3.0	2.861	8.8	0.02	0.05
2.0 g/10ml conc. at 40°C for 1 hr	49	4.9	0.72	3.4	2.620	8.5	0.03	0.05
2.0 g/10ml conc. at 40°C for 3 hrs	47	5.2	0.67	3.3	2.569	8.3	0.02	0.04
2.0 g/10ml conc. at 40°C for 5 hrs	50	5.4	0.64	3.5	2.772	8.2	0.02	0.03
2.0 g/10ml conc. at 50°C for 1 hr	53	5.7	0.66	3.0	2.836	8.2	0.03	0.04
2.0 g/10ml conc. at 50°C for 3 hrs	52	5.6	0.72	2.6	2.878	8.8	0.02	0.04
2.0 g/10ml conc. at 50°C for 5 hrs	57	5.9	0.65	2.9	2.656	8.6	0.03	0.05

From the Table 3 it is evident that the tensile strength of the control fabric was 40 lbs and the treated fabric ranges between 43 to 59 lbs. The elongation of the control fabric showed four inches and the treated

fabric showed 5.9 inches as highest in 2% concentration at 50°C for 5 hours. The thickness of the treated fabric ranged within 0.51mm to 0.72mm and the stiffness ranged from 2.6 inches to 4.0 inches. The fabric

weight showed a gradual increase after treatment with the herbal substance as ranged from 1.993 g to 2.878 g. Through absorbency evaluation, the capillary rise test gives the movement of water from 7.9cm to 8.9 cm whereas the wicking test gives 0.01-0.03 seconds. The treated fabric took 0.03-0.06 seconds to sink completely into

the water. The table clearly proves a minimum difference between all the results for the physical properties of bamboo finished fabrics.

Physical Property Assessment of Viscose Fabrics

The results of the physical property of Viscose fabrics is showed in Table 4.

Table 4. Evaluation of Physical Parameters of Papaya Seed Extract Finished 100% Viscose Fabric

Test parameters	Tensile strength (lbs)	Elongation (inch)	Thickness (mm)	Stiffness (inch)	Fabric weight (gm)	Absorbency		
						Capillary rise (cm)	Wicking (sec)	Sinking test (sec)
Control fabric	32	3.5	0.44	2	1.273	10	0.01	0.07
0.5 g/10ml conc. at 40°C for 1 hr	34	3.8	0.46	2	1.294	8	0.02	0.10
0.5 g/10ml conc. at 40°C for 3 hrs	34	3.9	0.45	3	1.299	8	0.02	0.10
0.5 g/10ml conc. at 40°C for 5 hrs	33	3.8	0.47	3	1.283	9	0.03	0.15
0.5 g/10ml conc. at 50°C for 1 hr	35	4.0	0.47	2	1.297	7	0.04	0.20
0.5 g/10ml conc. at 50°C for 3 hrs	35	3.9	0.46	3	1.301	8	0.03	0.25
0.5 g/10ml conc. at 50°C for 5 hrs	34	3.6	0.47	2	1.296	6	0.04	0.20
1.0 g/10ml conc. at 40°C for 1 hr	33	3.7	0.49	2	1.315	8	0.04	0.20
1.0 g/10ml conc. at 40°C for 3 hrs	32	3.6	0.48	3	1.345	7	0.05	0.15
1.0 g/10ml conc. at 40°C for 5 hrs	35	3.9	0.48	2	1.367	6	0.05	0.20
1.0 g/10ml conc. at 50°C for 1 hr	34	4.0	0.47	3	1.338	5	0.04	0.20

Test parameters	Tensile strength (lbs)	Elongation (inch)	Thickness (mm)	Stiffness (inch)	Fabric weight (gm)	Absorbency		
						Capillary rise (cm)	Wicking (sec)	Sinking test (sec)
1.0 g/10ml conc. at 50°C for 3 hrs	33	3.8	0.49	3	1.329	7	0.04	0.20
1.0 g/10ml conc. at 50°C for 5 hrs	34	3.7	0.49	2	1.375	6	0.05	0.25
1.5 g/10ml conc. at 40°C for 1 hr	35	3.9	0.51	3	1.483	7	0.05	0.20
1.5 g/10ml conc. at 40°C for 3 hrs	36	4.0	0.49	3	1.492	8	0.06	0.20
1.5g/10ml conc. at 40°C for 5 hrs	34	3.7	0.52	4	1.476	5	0.04	0.30
1.5 g/10ml conc. at 50°C for 1 hr	32	3.8	0.53	3	1.498	7	0.06	0.25
1.5 g/10ml conc. at 50°C for 3 hrs	32	3.7	0.49	4	1.483	8	0.05	0.25
1.5 g/10ml conc. at 50°C for 5 hrs	34	4.0	0.51	3	1.479	7	0.06	0.25
2.0 g/10ml conc. at 40°C for 1 hr	33	3.9	0.54	4	1.576	8	0.06	0.20
2.0 g/10ml conc. at 40°C for 3 hrs	34	3.8	0.52	5	1.589	7	0.05	0.30
2.0 g/10ml conc. at 40°C for 5 hrs	36	3.7	0.53	4	1.538	6	0.05	0.30
2.0 g/10ml conc. at 50°C for 1 hr	33	3.8	0.55	4	1.593	6	0.06	0.25
2.0 g/10ml conc. at 50°C for 3 hrs	34	3.9	0.54	5	1.562	6	0.05	0.25
2.0 g/10ml conc. at 50°C for 5 hrs	33	3.9	0.55	5	1.579	7	0.05	0.20

From the Table 4 it is evident that the tensile strength of the control fabric was 32 lbs and the treated viscose fabric ranges between 32 and 36 lbs. The elongation of the small control fabric showed 3.5 inches and the treated fabric showed 3.6 inches to 4.0 inches. The thickness of the treated fabric ranged within 0.45mm to 0.55mm and the stiffness ranged from 2.0 inches to 5.0 inches. The fabric weight showed a gradual increase after treatment with the herbal substance as ranged from 1.283g to 1.593g. Through absorbency evaluation, the

capillary rise test gives the movement of water from 5.0cm to 9.0 cm whereas the wicking test gives 0.03-0.06 seconds. The treated fabric took 0.10-0.30 seconds to sink completely into the water. The table clearly indicates a very small difference between all the results for the physical properties of viscose finished fabrics.

Physical Property Assessment of Polypropylene Fabrics

The results of the physical property of polypropylene fabrics is showed in Table 5.

Table 5. Evaluation of Physical Parameters of Papaya Seed Extract Finished 100% Polypropylene Fabric

Test parameters	Tensile strength (lbs)	Elongation (inch)	Thickness (mm)	Stiffness (inch)	Fabric weight (gm)	Absorbency		
						Capillary rise (cm)	Wicking (sec)	Sinking test (sec)
Control fabric	34	3.5	0.46	3.0	1.299	7	0.03	0.15
0.5 g/10ml conc. at 40°C for 1 hr	36	3.7	0.49	3.5	1.315	9	0.05	0.15
0.5 g/10ml conc. at 40°C for 3 hrs	36	3.7	0.48	3.0	1.323	9	0.05	0.10
0.5 g/10ml conc. at 40°C for 5 hrs	40	3.9	0.48	3.4	1.326	7.5	0.06	0.15
0.5 g/10ml conc. at 50°C for 1 hr	38	4.0	0.49	3.8	1.373	8.6	0.07	0.15
0.5 g/10ml conc. at 50°C for 3 hrs	38	3.8	0.49	3.9	1.450	9.4	0.05	0.10
0.5 g/10ml conc. at 50°C for 5 hrs	40	3.7	0.50	4.2	1.483	9.0	0.08	0.20
1.0 g/10ml conc. at 40°C for 1 hr	39	3.7	0.52	4.4	1.521	7.2	0.07	0.15
1.0 g/10ml conc. at 40°C for 3 hrs	37	4.0	0.55	4.2	1.493	6.9	0.08	0.10

Test parameters	Tensile strength (lbs)	Elongation (inch)	Thickness (mm)	Stiffness (inch)	Fabric weight (gm)	Absorbency		
						Capillary rise (cm)	Wicking (sec)	Sinking test (sec)
1.0 g/10ml conc. at 40°C for 5 hrs	39	4.2	0.53	3.9	1.566	8.3	0.08	0.10
1.0 g/10ml conc. at 50°C for 1 hr	40	4.0	0.54	4.2	1.723	7.4	1.0	0.15
1.0 g/10ml conc. at 50°C for 3 hrs	41	3.9	0.53	4.4	1.794	8.5	0.07	0.25
1.0 g/10ml conc. at 50°C for 5 hrs	38	4.2	0.55	4.6	1.839	8.5	0.07	0.25
1.5 g/10ml conc. at 40°C for 1 hr	38	4.4	0.58	4.4	1.845	9.4	0.05	0.15
1.5 g/10ml conc. at 40°C for 3 hrs	41	4.3	0.58	3.9	1.798	10.1	1.0	0.30
1.5 g/10ml conc. at 40°C for 5 hrs	42	4.2	0.56	4.5	1.854	9.2	0.07	0.25
1.5 g/10ml conc. at 50°C for 1 hr	44	4.6	0.57	4.6	1.934	9.0	0.08	0.20
1.5 g/10ml conc. at 50°C for 3 hrs	40	4.5	0.60	4.6	1.893	8.8	0.07	0.25
1.5 g/10ml conc. at 50°C for 5 hrs	42	4.2	0.57	4.2	1.954	8.3	0.07	0.20
2.0 g/10ml conc. at 40°C for 1 hr	44	4.3	0.54	4.3	1.929	7.9	0.09	0.15
2.0 g/10ml conc. at 40°C for 3 hrs	43	4.6	0.60	4.6	1.967	7.7	0.08	0.20
2.0 g/10ml conc. at 40°C for 5 hrs	41	4.3	0.61	4.4	1.992	9.8	0.07	0.25
2.0 g/10ml conc. at 50°C for 1 hr	41	4.6	0.60	4.5	1.829	9.6	0.07	0.30
2.0 g/10ml conc. at 50°C for 3 hrs	44	4.4	0.61	4.6	1.872	8.8	0.09	0.30
2.0 g/10ml conc. at 50°C for 5 hrs	45	4.3	0.62	4.6	1.937	9.2	0.07	0.25

From the Table 5 it is evident that the tensile strength of the control fabric was 34 lbs and the treated viscose fabric ranges between 36 and 44 lbs. The elongation of the control fabric showed 3.5 inches and the treated fabric showed 3.7 inches to 4.6 inches. The thickness of the treated fabric ranged within 0.49mm to 0.62mm and the stiffness ranged from 3.0 inches to 4.6 inches. The fabric weight showed a gradual increase after treatment with the herbal substance as ranged from 1.315g to 1.992g. Through absorbency evaluation, the capillary rise test gives the movement of water from 6.9 cm to 10.1 cm whereas the wicking test gives 0.05-1.0 seconds. The treated fabric took 0.10-0.30 seconds to sink completely into the water. As per the table the physical properties of viscose finished fabrics shows only small difference.

Conclusion

From the study it could be concluded that plant based antimicrobial agents have greater potential against microbes with lesser side effects when compared to commercial antimicrobial agents. In this study the ethanolic extract of *Carica papaya* seed showed antibacterial activity for both gram positive and gram negative bacteria treated on textile fabrics. Since the plant extract treated on the fabric did not affect the physical properties of the fabric it can be recommended for the usage of medical textile products.

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A ULTRASONIC DYEING-A BOON TO TEXTILE EFFLUENT

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Abstract

Undoubtedly the whole world is facing irreparable damage to the mankind and the environment due to the adverse impacts of various wastes including hazardous wastes produced by several chemical and explosive industries. The growth of world population has been closely accompanied by the rapid increase in all form of pollution, especially air and water pollution. At every stage of textile production large amounts of energy, clean water and chemicals are used. Consequently generate an equally large quantity of effluent. About 50 per cent of the industries are at Tirupur, Erode and Karur districts of Tamilnadu. The water sources in the districts were becoming toxic day by day due to the continuous dumping of untreated effluents. There is growing awareness and readiness to adapt new perspectives on industrial upgrade by promoting new technologies which are both energy saving and waste reducing. Ultrasonic energy can clean or homogenize materials, accelerate both physical and chemical reactions; these qualities can be utilized for improvement of textile processing methods. The dyeing of 100 percent cotton fabric was carried out with natural dye and reactive dye of similar color

by conventional and ultrasonic technique. The dye bath of both techniques were reutilized by dyeing using fresh cotton fabrics. The study showed that the use of ultrasonic energy improves the color strength (k/s), physical properties, mechanical properties and the effluent parameters can considerably be reduced also enhances without any adverse effect on color fastness of the dyed fabric.

Keywords: Natural dye, Reactive dye, Conventional dyeing, ultrasonic dyeing, reusing dye bath, effluent

Introduction

One of the greatest problems that the world is facing today is that of environmental pollution, increasing with every passing year and causing grave and irreparable damage to the earth. Global warming, depletion of the ozone layer, disposal of toxic and nuclear wastes in the vulnerable areas of the planet, the loss of forests and arable soil at an alarming rate are a few of the numerous global environmental changes that will adversely affect the survival of the present and future generations. Pollution is the addition of any substance or form of energy to the environment at a rate faster than the

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environment can accommodate it by dispersion, breakdown, recycling or storage in some harmless form. The rapid industrial development often means excessive pollution and destruction of valuable natural resources.

Air pollution and water pollution are the two most problems of pollution because they cause the biggest damage to the environment. These two forms of pollution not only hurt the environment but are also doing tremendous damage to the health. One of the most common pollution is through water pollution caused by dumping of industrial waste into water ways or improper containment of waste. Since water is an elixir of life, it is highly essential for all living being. Water resources are fast deteriorating due to the presence of human activities. Water pollution does not only greatly damage the aquatic ecosystems but even the terrestrial organisms and ecosystems are also severely damaged and threatened. (Baskaran et al., 2012) a growing awareness of factory pollution and its consequences has led to tighter restrictions on pollution all over the world. The textile industries and dyeing units occupies a unique place in the industrial map of India. These dyeing effluents contain various organic dyestuffs, chrome dye and various types of chemicals. The complex aromatic framework of dye and presence of heavy metals induce toxicity in particular and they may be mutagenic, teratogenic or carcinogenic, due to dumping of untreated effluents. As a sequel to an order of the Madras High Court on 28th January 2011,

all common effluent treatment plants (CETPs) and 754 bleaching and dyeing units in Tirupur were closed down (The Hindu, 2011). It is not that there is no need of industry but need cleaner industry that is more environmentally friendly. Therefore, there is an urgent need to promote new technologies in textile dyeing, injecting new thoughts to the industry, as stated by Bhullar et al (2012). To put an end to speculations, the ultrasound a non-traditional technique is claimed to be the most promising since it is capable of addressing many problems and common issues. Ultrasound waves are vibration with frequency between 20 KHz and 500 MHz that is above threshold of human hearing; infer Burkinshaw and Jeong (2012). Green revolution is the best solution to arrest pollution, reuse the past, recycle the present, save the earth and go green.

1. Experimental Procedure

1.1 Materials

In this work, pretreated 100 percent plain cotton woven fabric was used. Two dyes namely natural dye from rose petals and reactive dye of similar color were chosen. Natural dyes require chemicals in the form of metal salts to produce an affinity between the cotton and dyes mordants. Alum (Aluminium Potassium Sulphate) is the most commonly used mordant. The use of alum is recommended as its eco friendly nature. Considering the above facts, alum is selected as a mordant for the study (Hummel, 2010).

1.2 Pretreatment

Pretreatment is necessary for obtaining good desizing effects, lowest possible impurities, high degree of whiteness, high color yield, high or even hydrophilicity or rewettability, avers (Anandjiwala, 2011). Therefore, the selected 100 percent cotton fabric was pretreated by desizing, scouring and bleaching.

1.2.1 Desizing

Enzymatic desizing is used to degrade and remove the starch and other impurities present in the grey fabric in an eco friendly method (Bhullar et al, 2012). The grey fabric is passed through hot water to approximately 100 percent pickup and then padded with desizing mixture containing 0.5-2 percent malt extract and non-ionic wetting agent at 60-70°C. Wetting agent helps the enzyme to penetrate the size film. The optimum conditions required are malt diastase conc. 3-20, time (One hour), pH - 4-5.5, temperature 50-60°C.

1.2.2 Scouring

Bioscouring is selected to obtain a sufficient hydrophilic fabric. Descour new, a unique blend of several enzymes especially pectinase and lipase supplied by rossari biotech. The bioscour liquor was prepared by dissolving descour enzyme (0.5%) and zywer NIS, a non ionic wetting agent (1%) in soft water, with the material liquor ratio as 1:15 and pH adjusted to 9.

The desized fabric was immersed in it, maintaining the temperature as 55°C for 30 minutes. The temperature was raised to 90°C and left for 10 minutes to deactivate the enzyme. The sample was then rinsed thoroughly in soft water and dried, as suggested by Chinnammal and Amasamani (2012).

1.2.3 Bleaching

Bleaching is the process of removing natural coloring matters present in the cotton fabric. For this purpose, hydrogen peroxide bleaching powder was used. Hydrogen peroxide is the best and most commonly used bleaching agent, expounds Gebert [2011]. Under this treatment, solution was prepared for three percent of hydrogen peroxide. The desized and scoured fabric was dropped into it and later it was taken to the boiling temperature for the time period of one hour. Then the fabric is washed thoroughly, thrice with soft water and finally dried in air, as inferred by Maulik and Roy (2011).

1.3 Dyeing

The actual parameters are selected after optimization. These parameters were used for dyeing both natural and reactive dyes using conventional and ultrasonic technique. The details of the selected proportions of dyeing parameters for dyeing cotton material are given in Table 1.

Table 1. Dyeing Parameters

Dyeing Variable	Selected Properties
Dyeing temperature	60°C
Dyeing time	15 minute
Shade	5 percent
Mordanting technique	Simultaneous technique

1.3.1 Natural and Reactive Dyeing Using Conventional Technique

The selected pretreated cotton fabric was dyed with natural coloring matter extracted from rose petal and reactive dye of similar color for 15 minutes using conventional technique at 60°C with a liquor ratio of 1:40. For the sake of comparison the same conditions of dyeing were carried out using ultrasonic technique. Finally the dyed samples were rinsed with cold water and air dried.

1.3.2 Natural and Reactive Dyeing Using Ultrasonic Technique

In the alternative dyeing technique which was also studied in this work is the use of ultrasonic energy and was carried out with the sonicator bath at 20 KHz. In this dyeing process, the cotton fabric was weighed and the liquor ratio taken as 1:40. The dyeing process started at 40°C for both natural and reactive dyes and the cotton fabric was added and then the temperature was gradually increased to 60°C, maintained for 15 minutes to allow a good penetration of the dyes and even dyeing. After dyeing, the samples were rinsed with cold water and left to dry under laboratory conditions.

1.4 Redyeing

Instead of discharging the dye bath at the end of dye cycle, the dye bath water is analyzed spectrophotometrically and reconstituted to the concentration required for a subsequent dyeing. During redyeing, it is possible to dye the fresh fabric as the supernatant solution is absolutely clear and does not lead to any residual dyeing tint during fresh dyeing. So, the dye bath is reused for dyeing natural and reactive dye using conventional and ultrasonic techniques.

1.5 Evaluation

1.5.1 Objective Evaluation

The textile testing plays a crucial part in production processes, as a result of physical, mechanical and comfort properties on fabrics for undergoing evaluation. The sample pieces, from the relative portion of the original and the dyed samples were tested by using the sample pieces, from the relative portion of the material for their fabric weight, fabric thickness, tensile strength and elongation, abrasion, crease recovery, stiffness and absorbency test.

1.5.2 Color Fastness Tests [sunlight, washing, crocking, pressing, perspiration]

Color fastness tests of dyed samples were performed for both conventional and ultrasonic dyeing. Sunlight test were performed by following AATCC 16, washing fastness were performed by following EN ISO 105-A03, rubbing fastness were performed on crock meter by following AATCC 8, pressing test were

performed by following AATCC 133 and perspiration fastness were carried on by using perspirometer and following AATCC 15.

2.5.3 Color Strength (k/s values)

The k/s values were assessed for conventional and ultrasonic dyed fabric which determines the color strength of the fabric by using spectrophotometer under 600 nm. The relative color strength (k/s values) were assessed using equation:

$$K/s = (1-R) 2/2R$$

where R=Reflectance of the dyed fabric, k=absorption coefficient and s=scattering coefficient.

1.5.4. Effluent Analysis

The effluent waste water contains BOD, COD, TDS, TSS, hardness, alkalinity, turbidity, pH, calcium, phosphate and sulphate. These are the parameters to be considered which can cause rapid depletion if it is directly discharged into the

surface of water sources. So these parameters are analyzed and compared between both conventional and ultrasonic dye effluents.

Results and Discussion

Objective Analysis

Tensile strength of the original, conventional and ultrasonic dyed samples is delineated in Figure – 1. This determines that all the dyed samples of ultrasonic show an increase in fabric tensile strength when compared with conventional and original. The Figure – 2, reveals the fabric elongation of the original, conventional and ultrasonic dyed samples and it also shows a lesser deposit of dye over the fabric. Similarly, all the other analysis such as fabric weight count, thickness, fabric stiffness, crease recovery shows satisfactory results when compared with conventional and original results. Thus it could be concluded that dyeing and redyeing improves the properties of fabric irrespective of the dye and method of dyeing.

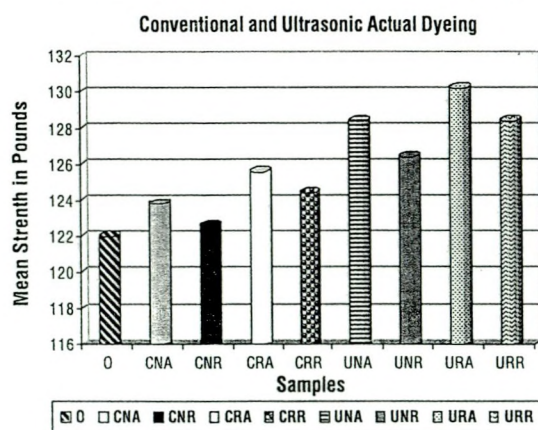


Figure 1. Tensile Strength

Effect of Absorbency

All the dyed samples symbolize lesser values than the original. Lesser the value greater the absorbency performance. The dyed samples highlight an increase in absorbency. Figure – III and IV, reveal the maximum absorbency performance was observed among the conventional and

original samples which confers the lowest value. This procedure is followed in drop test and sinking test. Whereas in capillary test, higher the value greater the absorbency performance ultrasonic samples emphasize the maximum absorbency performance among the other samples which exhibits the highest values as epitomized in Figure – V.

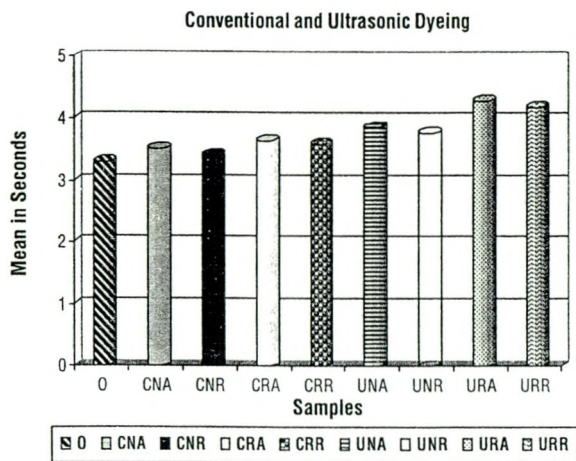


Figure 2. Fabric Elongation

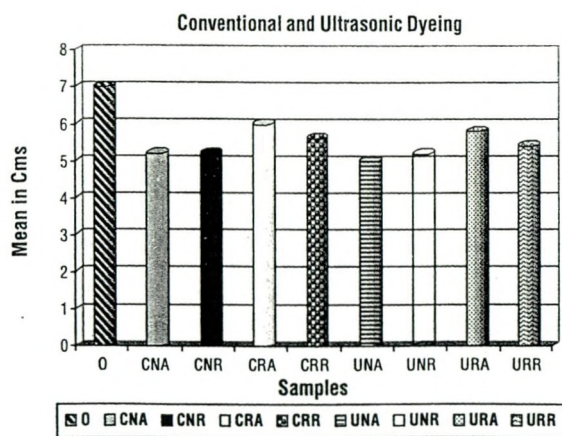


Figure 3. Drop Test

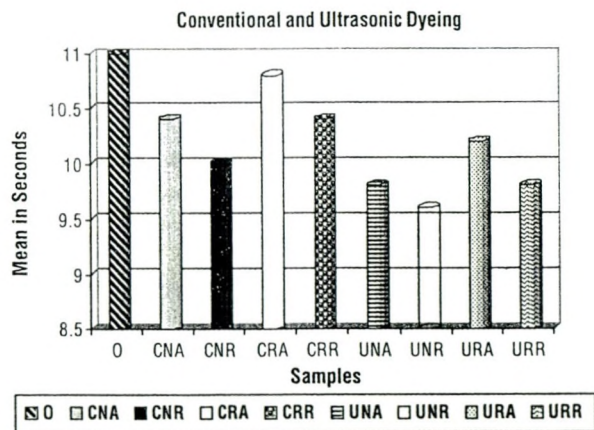


Figure 4. Sinking Test

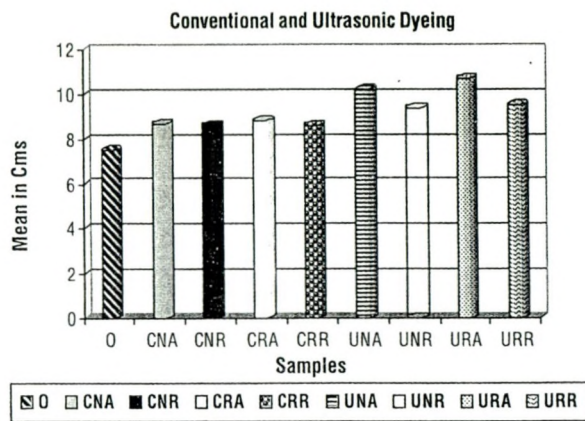


Figure 5. Capillary Test

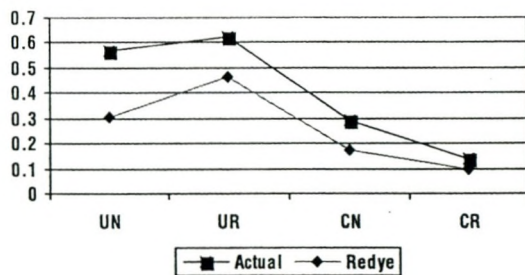


Figure 6. Colour Strength

Colour Strength

The Figure 6 bestows that the ultrasonic power proved effectiveness in the dye uptake of cotton fabric, the enhanced k/s values were more than conventional dyeing.

Colour Fastness

Fastness properties of natural and reactive dyed fabrics using ultrasonic and

conventional techniques are illustrated in Table II. The results indicate well to excellent fastness properties of the dyed samples but when comparing ultrasonic and conventional dyed samples, ultrasonic samples highlight the excellent fastness properties.

Table 2. Colorfastness for the Dyed Samples

Samples	Colorfastness							
	Sun light	Washing	Crocking		Pressing		Prespiration	
			Dry	Wet	Dry	Wet	Dry	Wet
CNA	3-4	3-4	3-4	3-4	4-5	3-4	3-4	4-5
CNR	3-4	3-4	4	3-4	4	3-4	3-4	4
CRA	4-5	4	4-5	4	4-5	4-5	4	4
CRR	3-4	3-4	4	3-4	4	4	4	3-4
UNA	4-5	4-5	5	4-5	5	4-5	4-5	5
UNR	4	4	4-5	4	4	4	4	4
URA	5	5	5	4-5	5	4-5	5	5
URR	4	4	4	4	4	4	4	4

O-Original Samples; CNA-Conventional Natural dyed sample; CNR-Conventional Reactive dyed sample; CRA-Conventional reused natural dyed sample; CRR-Conventional reused reactive dyed sample; UNA-Ultra sonicated natural dyed sample; UNR - Ultra sonicated Reactive dyed sample; URA-Ultra sonicated reused natural dyed sample; URR-Ultra sonicated reused Reactive dyed sample

Effluent Analysis

The physico-chemical characteristics of the treated effluent was determined to bestow an appreciable decrease in pollution load. The parameters such as BOD, COD, TDS, TSS, pH, hardness, alkalinity, calcium, phosphate and sulphate of the dyed and redyed effluent has been reduced according

to the norms of pollution board. Hence it could be concluded that natural dyes are less pollutant when compared to reactive dyes. Similarly ultrasonic dyeing proves to be ecofriendly. The results of the effluent treatment are in par with the results of the study, "Ultrasound for low temperature dyeing of wool with acid dye", (Ferrero, 2012).

Conclusion

These experimental results confirm the observations of ultrasonic dyeing that the enhancing effect is attributed to de-aggregation of the dye molecules, which leads to better dye diffusion and possible assistance for dye fiber bond fixation. This technique in addition to its advantage of

saving the processing time offers better environment impact as it helps much in improving dye uptake. The Indian textile industry will need to cover a lot of ground on crucial environment issues that will impact both competitiveness and bottom line in a regime driven by environmental and sustainability concerns.

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