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Antibacterial and wound healing efficacy of *Chromolaena odorata* treated dressings

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This paper reports the characteristics of viscose fabric treated with the extracts of *Chromolaena odorata,* traditionally used for healing the wounds. *C. odorata* extracts (5%) are nano-sprayed and applied on spun lace viscose fabric using an ultrasonic atomiser and antibacterial competence is optimised for *S. aureus* and *E. coli*. The wound healing potential of the *C. odorata* treated dressing and histopathological analysis of the wound tissues have been studied *in vivo* on *Albino Wistar* rats and compared with wound without any dressings, chitosan treated dressing, chitosan and *C. odorata* treated dressing along with the commercial silver bandage. The FTIR analysis of the phytochemicals finished fabric indicates the presence of phenolic group. Cytotoxicity test reveals 22% cytotoxicity and 78% cell viability with mild toxicity. Shelf life discloses the decrease in antibacterial efficiency after third and fourth week. Curing of *C. odorata* extracts treated fabric inversely affects the antibacterial efficiency, and sterilisation reports 46.7% *E.coli* reduction after one hour. The fabricated wound dressings are found to have good wound healing efficiency as compared to commercial silver bandage. The histopathological analysis reveals complete healing of wounds after 21 post wound healing days. The study proves that the phytochemicals can be imparted on spun lace viscose fabric for antibacterial and wound healing application to a certain period of time.

Keywords: Antibacterial textiles, Bioactive wound dressings, *Chromolaena odorata,* Cytotoxicity, *In vivo* wound healing, Spun lace viscose

1 Introduction

People suffering from wound are reported to have physical pain, mental distress, anxiety, physical and unrecognised impact on their quality of life, and hence wounds are also called as 'Silent Epidemic'[1]. Wound dressings are vital to protect, reduce pain and promote wound healing process. Wound dressings has evolved over the time along with the continuing response of wound healing models, and at present dressing materials are likely to speed up healing and protect wound[2]. The characteristics of textiles such as porosity, air and moisture permeability, sufficient strength and elasticity, contribute to make an appropriate wound dressing material[3].

Polymers and fibres used to make wound healing products are numerous. Natural and reformed cellulose, collagen, chitin/chitosan, hydrogels and alginates and the textile fibres, such as viscose and cotton, have been used as dressing materials and many researches are directed to improve their performance[4]. Nonwoven fabrics are chiefly preferred for disposable medical textile products[5]. Ease of processing, larger surface area, and porosity make it one of the best fabric for the wound dressings[6,7]. The soft, elastic, and light weight characteristics of spun lace non woven provide flexibility with body movements. The most important factor to consider spun lace non woven is the absence of binder, and permitting sterilisation at high temperatures[8]. Viscose fibre is one of the most preferred wound dressing materials, because of its excellent absorbency, softness and breathability properties[9]. However, cotton and viscose dressings are mostly suitable for dry wounds but not ideal for exudating wounds, as they stick with the wound bed and cause delay in wound healing[10].

The uses of medicinal plants for curing of diseases have been in practice from ancient time. The realisation of the society to lead a sustainable life has focused towards the revival of natural and plant based products[11]. Several plants have been identified having wound healing properties[12], and they are treasure trove of natural antibacterials. The therapeutic qualities of plants are based on the phytochemicals present in them, such as phenolic compounds,

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alkaloids, flavonoids, andtannins, which have a definite physical action on the human body[13,14].

C. odorata (Chromolaena odorata), also called as floss flower or Siam weed, belongs to *Asteraceae* family, and is traditionally used to treat fresh cut and wound. The plant is reported to have antibacterial, haemostatic and wound healing efficacy[15]. Flavonoids present in the plant extracts are associated with the wound healing efficiency[16]. Since the extracts of *C. odorata* leaves are reported to have wound healing efficiency, the potential of plant extracts treated fabric for antibacterial and wound healing efficacy could be evaluated. Hence, the weedy plant *C. odorata* was chosen for the study with an objective to analyse the characteristics of *C. odorata* extracts treated viscose nonwoven fabric and to evaluate its wound healing efficiency, sterilisation capability and shelf life. The wound healing efficiency of *C. odorata* extracts treated wound dressings has also been compared with chitosan treated wound dressing, commercial silver dressing, chitosan and *C. odorata* extracts treated dressing and wound without any dressing.

2 Materials and Methods

2.1 Materials

C. odorata plants were collected from the Palakkad district, Kerala; Chitosan was prepared from the shells of *Metapenaeus dobsoni*; and spun lace viscose nonwoven fabric (78 GSM) was procured from Ginni Filaments Ltd. Gujarat, Methanol 500mL (Lobal-99.5%) and ethanol (Heyman)were used.

2.2 Methods

2.2.1 Preparation of C. odorata Extracts

Fresh leaves of *C. odorata* plants were cleaned and rinsed with distilled water, followed by drying in shade at room temperature (30° C) to remove dirt. The dried leaves were powdered and preserved for further use. Methanol extracts of *C .odorata* have maximum *in vitro* inhibition against clinical bacteria, as compared to other solvents as reported by Sukanya *et al*[17]. Hence, methanol was selected to extract bio active agents from *C. odorata*. The extraction was done at 35° C, with 500 mL methanol and 30g *C. odorata* leaf powder using a Soxhlet apparatus, and the solvent was evaporated to obtain crude plant extracts. Pilot study was done to optimise the concentration and curing temperature of *C. odorata* plant extracts and chitosan finished fabric for antibacterial activity, evaluated as per the AATCC Test Method 90-2011, towards *E. coli (Escherichia coli*) and *S. aureus(Staphylococcus aureus)*.

2.2.2 Phytochemical Analysis

Phytochemicals present in the methanolic extracts of *C. odorata* was identified as per the procedure given by Milton *et al*[18], Harini *et al*[19]. and Egwaikhide and Gimba[20]. The presence of phenolic compounds was tested by dissolving 0.5 mL *C. Odorata* extracts in 20% sulphuric acid and later few drops of aqueous sodium hydroxide solution was added to it. *C. odorata* extracts (1-2mL) was taken in separate test tubes and then ferric chloride solution (1-2 drops), 1% ammonia solution and few drops of Wagner's reagent were added to each test tube separately for testing the presence of tannins, flavonoids and alkaloids respectively. The change in colour of the *C. odorata* extracts particular to each compound was observed to confirm the presence of each phytochemicals.

2.2.3 Nano-spray Drying

Since nano particles are expected to have better performance[21], the crude extracts of *C. odorata* and chitosan were spray dried with the aid of Buchi Nano spray dryer B-90 (Fig. 1). The size of the spray dried particles offered by the instrument ranges between 200nm and 500µm. Spray drying was carried out with *C. odorata* extracts dissolved in methanol, with the instrument set at 32.5m Bar and temperature at 84° C, with 100% spray strength in the presence of carbon dioxide and nitrogen gas, as mentioned in the user guide. Nano-spray dried *C. odorata* extracts were stored in the deep freezer. Similarly, chitosan (0.025%) dissolved in 1% acetic acid was filtered and spray dried at 120° C, 100% spray and 39m Bar pressure[22].

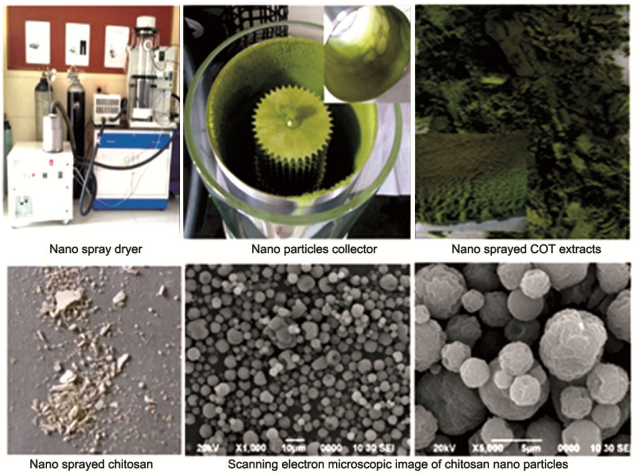

Fig. 1 — Nano-spay drying of *C. odorata* extracts and chitosan

2.2.4 Application of Plant Extracts and Chitosan on Fabric

Plant extracts and chitosan solutions were prepared individually and in combination as shown below:

- *C. odorata* extracts (5%) dissolved in ethanol
- Nano-spray dried *C. odorata* extracts (5%) dissolved in ethanol
- 2% Chitosan dissolved in acetic acid
- Combination of *C. odorata* extracts (5%) dissolved in ethanol with 2% chitosan solution.

The prepared solutions were applied on viscose nonwoven fabric using an ultrasonic atomiser (Vibra cell) set at 10 mL/min liquid dispensing speed. The code and identification of various fabric samples treated with antibacterial agents are represented in Table 1.

2.2.5 Development of Wound Dressings

Wound dressings were prepared by placing spun lace polyester fabric of dimension 5.5 × 5.5 cm as the top layer, followed by 4.5 × 4.5 cm untreated spun lace viscose fabric as an absorbent material, followed by antibacterial agents finished wound contact layer of dimension 4.5 × 4.5 cm. To thermally seal the edges of the wound dressing and to keep all layers in position, spun lace polyester fabric of 5.5 × 5.5 cm dimension with opening of dimension 3.5 × 3.5 cm at the centre was made and placed on top of the wound contact layer, (Fig. 2), so that the function of the wound contact layer is not hindered. Separate wound dressings were prepared with 5% nano-sprayed *C. odorata* extracts, 2% Chitosan and 5% *C. odorata* combined with 2% chitosan as wound contact layer for comparing the wound healing efficacy[23].

Table 1 — Sample details

Sample	Code
Untreated fabric	UTF
C. odorata extracts applied fabric	CTF
Nano-sprayed *C. odorata* extracts applied fabric	NTF
Ethylene oxide sterilised nano-sprayed *C. odorata* extracts applied fabric	ENTF
Chitosan applied fabric	CHTF
Nano chitosan applied fabric	NCHTF
Without wound dressing	WWD
Commercially available non medicated silver treated dressings	CSD
Nano sprayed *C. odorata* extracts applied wound dressings	NCD
Chitosan wound dressings	CWD
Chitosan and *C. odorata* extracts combined wound dressing	CCD

2.2.6 Characterisation of Fabric

The biocompatibility of the NTF was assessed as per ISO 10993-5. FTIR examination of NTF was done according to AATCC Test Method 94-2007 to identify the constituents adsorbed on the treated fabric. Since air permeability and absorbency were considered as one of the vital properties required by wound dressing materials, it was tested as per ASTM D 737-04 and AATCC Test method 79-2010 respectively. The water vapour permeability was tested as per ASTM E-96. Scanning electron microscopy was done to determine the size and appearance of the nano-sprayed particles on the fabric structure. The shelf life was analysed based on the antibacterial efficacy of the *C. odorata* extracted finished fabric according to AATCC Test method 90-2011 against *E. coli* and *S. aureus* with two week interval until they were not able to inhibit the microbes. The influences of ethylene oxide sterilisation on antibacterial efficiency were also evaluated as per ASTM E2149-10.

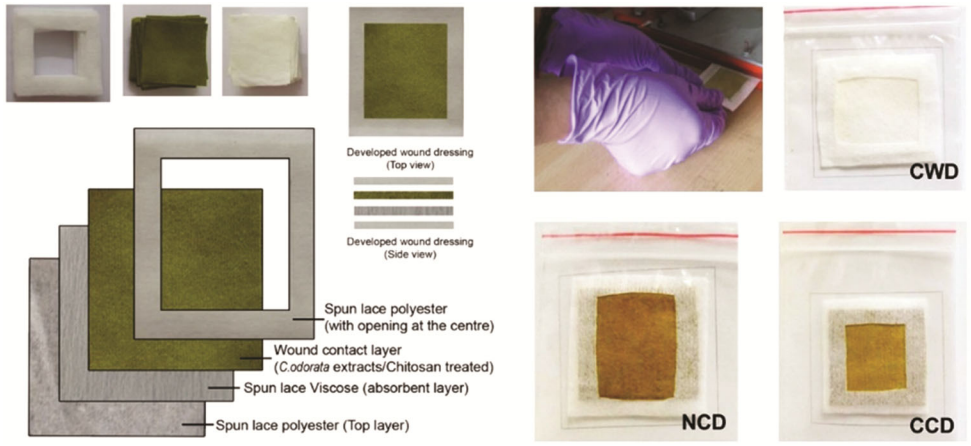

Fig. 2 — Developed wound dressings [NCD–Nano-sprayed *C. odorata* extracts applied wound dressing, CWD– Chitosan wound dressing and CCD– Chitosan and *C. odorata* extracts combined wound dressing]

2.2.7 Wound Healing Analysis

The healing potential of the developed wound dressings was evaluated *in vivo* after obtaining ethical clearance for conducting the animal experiments. Five groups of male *Albino Wistar* rats (150-200g) with six rats in each group were taken for the study. Group I (control) WWD and Group II (standard) dressed with CSD, were taken as the commercial non medicated dressings with metallic silver ion coating on the wound pad, Group III (test group) dressed with NCD, Group IV (test group) with CWD, and Group V (test group) with CCD were used. Rats were anesthetised with diethyl ether, the dorsal hair was removed and full thickness wounds of dimension 1.5 × 1.5 cm and 0.2cm depth was made on the dorsal thoracic region under sterile condition. The created wounds were dressed with the different wound dressings such as CSD, NCD, CWD, and CCD for Group II, Group III, Group IV and Group V respectively, except Group I (control). The progress in wound healing was observed and measured by tracing the wounded area on a transparent sheet as well as by taking photographs; every third day for 21st post wounding days, and the wounds dressings were changed accordingly. The days required for dead tissue remains to fall devoid of lingering raw wounds was used to compute the epithelisation duration[24–26]. Dermis and hypodermis were collected from the wounded area on the 3rd, 7th, and 21st days during wound healing for histological examination. The percentage wound closure was calculated using the following formula:

$$\text{Percentage of wound closure} = \frac{\text{Wound area on day}^0 - \text{Wound area on day}^n}{\text{Wound area on day}^0} \times 100$$

For histopathological analysis, formalin and paraffin at 10% neutral buffered solution were used to fix dermis and hypodermis. Specimens (5µm thickness) were stained using haematoxylin-eosin reagent and examined under microscope[27–29]. The morphology of re-epithelialisation, tissue inflammation, and blood vessels, the existence of oedema, neutrophils, lymphocytes, formation of granulation tissue, and the presence of fibro collagenous tissue were all noted as observations.

2.3 Statistical Analysis

Microsoft Excel 2010 software was used to analyse the data to calculate the standard deviation, arithmetic mean, CV% and one-way ANOVA at 0.05 significance levels.

3 Results and Discussion

3.1 Yield of Plant Bioactive Agents

The yield of phytochemical extracted from 30g dried leaves of *C. odorata* was (5.56g) 18.53%. The yield was calculated using the following formula[30]:

$$\frac{\text{Weight (g) of dried extract}}{\text{Dry weight (g) of plant material}} \times 100$$

3.2 Phytochemical Analysis

The phytochemical analysis of the *C. odorata* extracts reveals the presence of phenolic compounds, alkaloids, tannins, and flavonoids. The presence of tannins is confirmed by change in colour of the *C. odorata* extracts to brownish green and the change to yellow colour reveals the presence of flavonoids[18]. The formation of reddish brown precipitate confirms the presence of alkaloids and the presence of phenolic compounds is confirmed by blue colour[19]. The studies have indicated that, the antibacterial activity of tannins, alkaloids and phenolic compounds is due to disruption of the membrane, substrate deprivation, interacting with DNA or cell wall[31].

3.3 Ethylene Oxide Sterilisation and Antibacterial Efficiency

The effect of ethylene oxide sterilisation on antibacterial efficiency against *E. coli* (ATCC 35218) for NTF, ENTF and CTF and UTF (Table 2) reveals that NTF has reduced 20% initially and 99.6% after one hour, whereas the ENTF has reduced 11.8% strains initially and 46.7% after one hour. CTF has inhibited 27.7% strains initially followed by 75.09% after one hour and UTF was not capable of reducing the bacterial strains neither at initial nor after one hour. Test results reveal that *C. odorata* extracts treated fabrics show antibacterial properties, while the nano-spray technique facilitates covering of a larger surface area to volume ratio of the fabric and higher bacterial load reduction. Also, a reduction in antibacterial efficacy is observed for ETO sterilised *C. odorata* finished fabric.

3.4 Fourier-transform Infrared Spectrum (FTIR) Analysis

The FTIR spectrum of the NTF (Fig. 3) reveals the presence of typical functional groups of *C. odorata* on surface of the fabric. The peak 3650.79cm^{-1} indicates

Table 2 — Ethylene oxide sterilisation and antibacterial efficacy of *C. odorata* finished viscose fabric

Fabric	Bacterial reduction, % *(E. coli* ATCC 35218)	
	"0" contact time	1st hour
UTF	0	0
CTF	27.7	75.09
NTF	20	99.6
ENTF	11.8	46.7

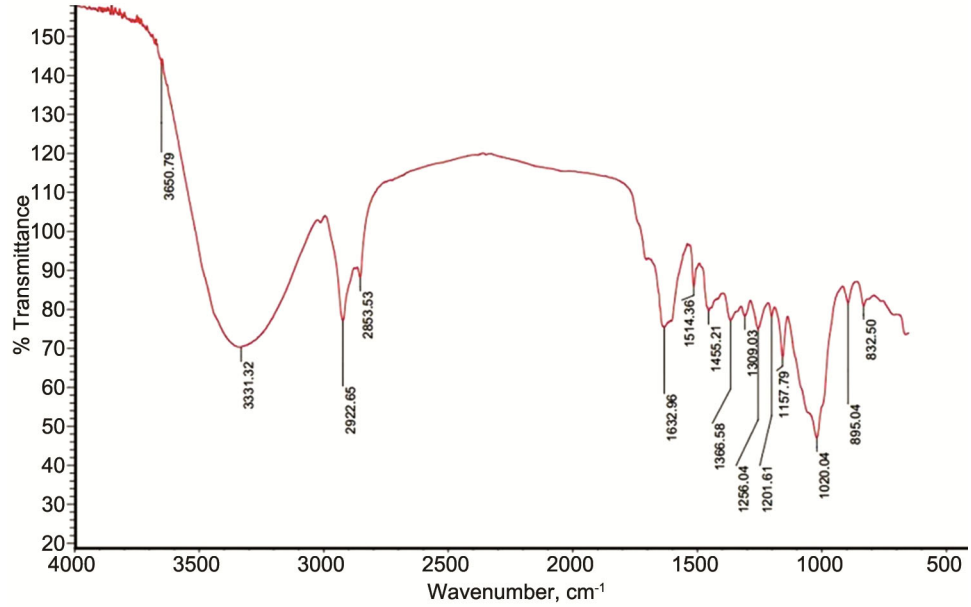

Fig. 3 — FTIR spectrum of nano-sprayed *C. odorata* extracts applied fabric (NTF)

the occurrence of stretch free vibration type alcohol with O-H, 2853.53cm^{-1} and 1514cm^{-1} peaks represent organic aromatic group and carbonyl acid with C=C and O-H stretch correspondingly. The presence of C-H stretch organic amines is confirmed with the presence of 1157.79 cm^{-1} band. The presence of functional groups like organic (alkene; =C-H bending), carbonyl (acid; C-O stretch), organic (alkene; C=C stretch), organic (alkane; C-H stretch), and carbonyl (amide; N-H stretch) are confirmed with the occurrence of infrared bands at 895.05, 1256.04, 1366.58, 1632.96, 2922.65, and 3331.32 cm^{-1}, which indicate the presence of the phenolic group on the NTF treated fabric, indicating be reason for antibacterial efficiency[17].

3.5 Test for Cytotoxicity

The results of *in vitro* cytotoxicity test of NTF reveals mild cytotoxic effect with 78% cell viability and 22% toxicity. As per ISO 10993-5, *in vitro* cytotoxicity of medical devices, slight cytotoxicity is represented if more than 20% of cells are not round, with changes in morphological structure, occasional rupture of cell membrane, and minor growth inhibition. However, if 30% cells are affected it indicates mild cytotoxic effect[32]. The 5% concentration of *C. odorata* extracts might has resulted in mild cytotoxicity of the NTF.

3.6 Shelf Life

The shelf life of the NTF was evaluated for a period of three months, based on the antibacterial efficiency towards *E. coli* and *S. aureus*. The *C. odorata* extracts treated fabrics were stored in zip lock pouches at room temperature (30°C approximately) and the antibacterial test was run fortnightly. The zone of inhibition formed is found three mm by 1st week and 2mm by 3rd week for both the strains. However, after 4th and 8th weeks the zone of inhibition observed remains 1 mm and by 10th week NTF samples has not shown any zone of inhibition, which reveals that the antibacterial competence of *C. odorata* extracts finished samples lasts for almost three months under room temperature of approximately 30° C, when stored in zip lock pouches. Further research could be done to explore the optimum storage temperature and package for an increased shelf life.

3.7 Characterisation of the Fabric

The characteristics of the fabric imparted with different treatments are depicted in Table 3. All the treatments show increased fabric weight, from 78.74g (UTF) to 88.5 (NTF) and 96.5g (CHTF). The thickness of CTF and NTF had decreased as compared to the thickness of UTF, but an increase of 0.12mm was noticed for CHTF. A reduction in drape coefficient is observed. An increased stiffness of the treated fabric is observed for CTF, NTF and CHTF respectively as compared to UTF.

A reduction in tensile strength is also observed for CTF and NTF comparing to UTF, and an increase in strength is noted for CHTF. But the elongation of

Table 3 — Characteristics of different treated and untreated viscose fabrics

Samples	GSM	Thickness mm	Drape Coefficient %	Fabric Stiffness cm	Tensile strength kg	Elongation cm	Water absorbency per second	Air permeability $cm^3/ cm^2/s$	Water Vapour permeability $g/m^2/24h$
UTF	78.74	0.48	68.68	3.13	6.08	5.74	0	179.2	1358
CTF	87.76	0.43	80.04	4.41	2.63	7.21	2	162.3	1546
NTF	88.56	0.46	72.85	4.24	4.35	7.57	1	166.8	1486
CHTF	96.40	0.60	100	6	13.79	2.26	>60	137.4	1463
F Value	5246.42	14.66	348.04	53.87	117.20	40.36	*	50.02	1.870
F Crit	3.238	3.238	3.238	3.238	3.238	3.238	*	2.866	4.066

*Statistical analysis not performed since CHTF was not absorbing water for >60s.

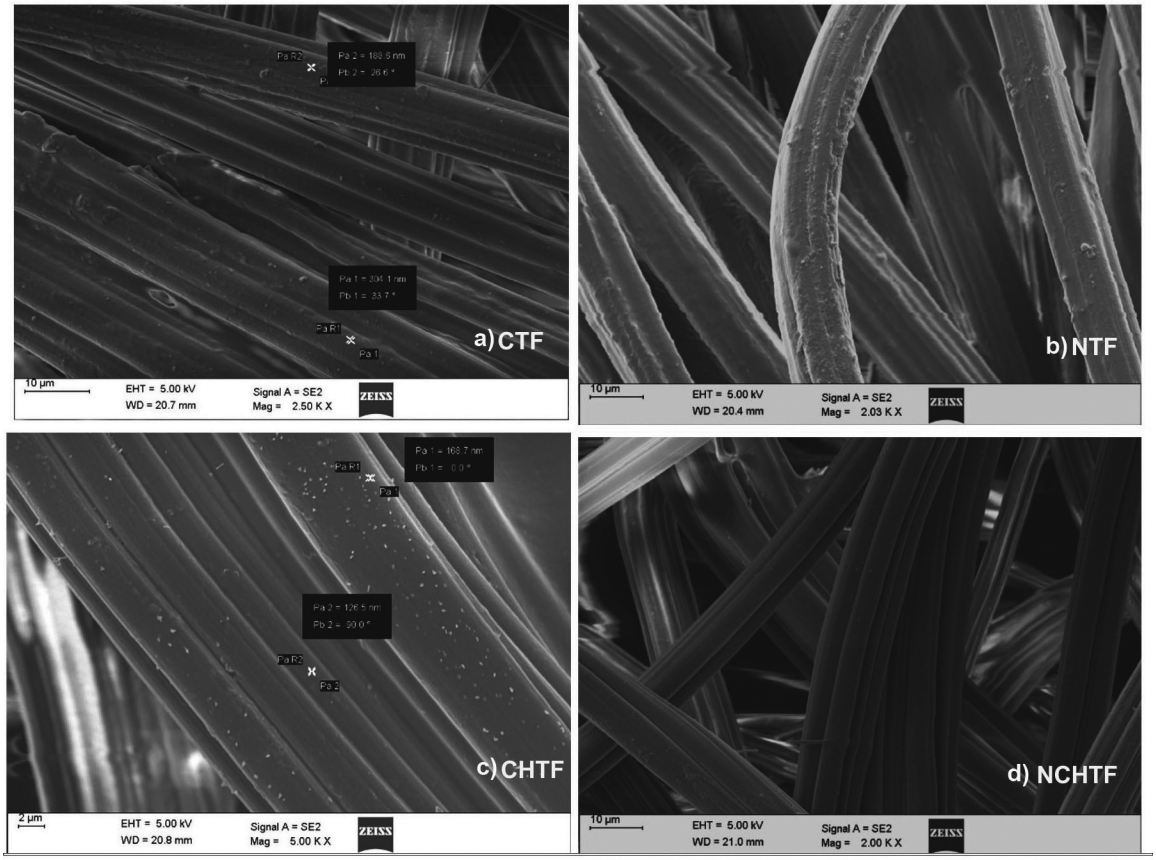

Fig. 4 — SEM images of (a) CTF-*C. odorata* extracts applied fabric (× 2.50k), (b) NTF-nano-sprayed *C. odorata* extracts applied fabric (× 2.03k), (c) CHTF-Chitosan applied fabric (× 5.00k) and (d) NCHTF-nano-Chitosan applied fabric (× 2.00k)

CTF and NTF shows increase for CTF and NTF as compared to UTF; however the elongation of CHTF is inversely affected. Scanning electron microscopic images (Fig. 4) at a magnification of × 5.00kV confirm the adherence of *C. odorata* and chitosan particles on the fabric surface, indicating a pattern of adsorption, little affecting porosity of the fabric. The particles size ranges 127-169nm (CTF), 84-94 nm (NTF), 126-126 nm (CHTF) and 59-94nm (NCHTF).

The fabric finished with 5% *C. odorata* extracts requires more time to absorb water, compared to unfinished fabric. NTF takes one second to absorb water, CTF two seconds and UTF zero second, but in case of CHTF the water dropped on the surface of CHTF remains as such for more than 60s. The air permeability of UTF is found179.2$cm^3/cm^2/s$, where as CTF and NTF show 162.3$cm^3/cm^2/s$ and 166.8$cm^3/cm^2/s$ respectively. The range of air permeability between the treated and the untreated fabrics reveals reduction in air permeability in *C. odorata* extracts finish on the fabric and this could be because of the fact that extracts partially block the

pores of the fabric structure. The treatment of the fabric with *C. odorata* extracts shows increased water vapour permeability, as compared to UTF. The CTF exhibits 1546g/m^2/24h water vapour permeability as compared to UTF (1358g/m^2/24h) and NTF (1486g/m^2/24h).

3.8 Wound Healing Analysis

The wound healing efficacy analysis of NCD in comparison with WWD, CSD, CWD and CCD (Table 4 and Fig. 5) reveals that Group IV treated with CWD and Group V treated with CCD show 46.91% and 40.28% wound healing efficiency during initial days than WWD 37.52% (Group I), NCD 25.67% (Group III) and CSD 24.12%(Group II) respectively. The wound created on Group I is neither covered nor any medication is applied, but the initial wound healing rate is found better, as compared to Group II dressed with CSD and NCD. The initial wound healing rates of CSD and NCD are almost in same phase. NCD shows mild toxicity of 22%, which could be the reason for initial delay in wound healing as compared to Group I.

Table 4 — Wound healing efficiency (%) of various wound dressings

Day	WWD	CSD	NCD	CWD	CCD	F Value	F Crit
3	37.52±4.84	24.12±3.08	25.67±3.13	46.91±3.45	40.28±4.15	39.83	2.76
6	45.94±4.14	33.99±3.38	37.26±2.26	54.85 ±5.73	49.69±5.13	24.13	2.56
9	56.16±6.12	46.56±2.09	48.24±2.68	63.65 ±5.15	59.80±4.86	16.35	2.76
12	64.85±2.98	57.03±2.75	61.55±4.10	75.16 ±4.08	70.16±4.69	19.47	2.76
15	76.60±2.99	67.46±4.61	76.49±3.89	84.73 ±4.27	76.99±2.93	15.51	2.76
18	85.86±2.43	81.48±5.38	89.87±4.93	92.74 ±2.86	88.41±1.75	7.73	2.76
21	92.18±2.15	93.76±5.93	99.18±1.17	98.31 ±2.68	96.35±2.91	4.64	2.76

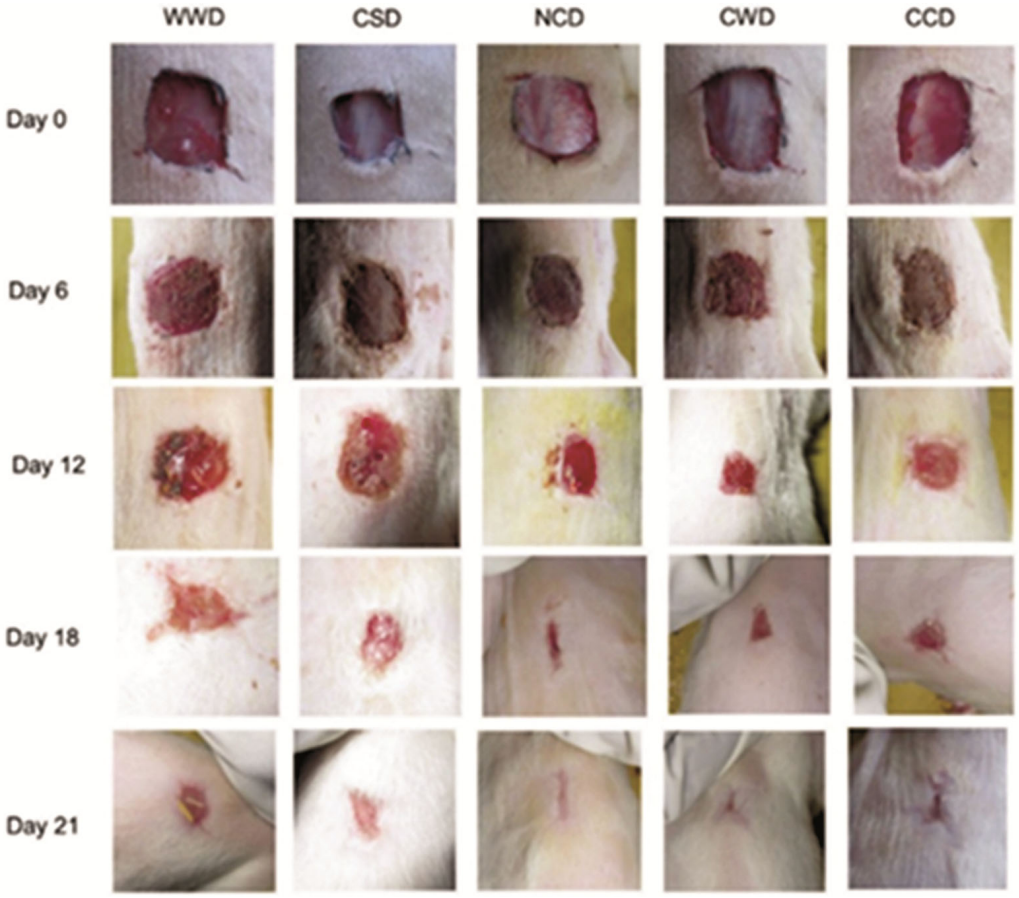

Fig. 5 — Wound healing analysis of WWD–Without wound dressing, CSD– Commercially available non medicated silver treated dressings, NCD– Nano-sprayed *C. odorata* extracts applied wound dressings , CWD– Chitosan wound dressings, CCD- Chitosan and *C. odorata* extracts combined wound dressing

Towards 15th and 18th post-operative days, NCD exhibits wound healing rate of 76.49-89.87% comparing to WWD 76.60-85.86%, CSD 67.46-81.48%, CWD 84.73-92.74% and CCD 76.99-88.41%. The phytochemical analysis of the *C. odorata* extracts reveals the presence of phenolic compounds, alkaloids, tannins and flavonoids, which are reported to have noteworthy antibacterial properties, credited to their ability to capture the reactive oxygen, which activates the platelets, macrophages, neutrophils, fibroblasts, and lymphocytes that helps for wound healing process[33]. Also, the bioactive compounds in the extracts of *C. odorata* are responsible for stimulating the haemostatic activity, prevents inflammation and provokes cell proliferation, which improves neovascularisation and migration of the cells associated with wound healing process[34], which might be the reason for higher healing rate of wounds during 18th-21st post wounding days. The F test point out that the healing efficiency of all the medicated wound dressing are significant, compared to wound without any dressings[23].

3.9 Histopathological Analysis

Wound healing process involves different stages of healing at wound site, such as infection, epithelialisation, and growth of granulation tissue[35]. The histopathological images of different test groups are represented in Fig. 6. The analysis of the tissues collected from the wound dressed with WWD disclosed necrosis and congested vessels. Presence of inflammation is visible for the tissues collected from CSD, and lymphocytes and neutrophils are shown around the fibro collagenous tissue for NCD. The mentioned observations indicate that the wound healing process is progressing stage wise. Towards post-operative 7th day, the tissues collected from the WWD dressed group indicates the development of thin walled capillaries and inflammatory infiltrates. For CSD dressed group, scattered inflammatory infiltrates and areas of necrosis are identified and the group dressed with NCD shows the presence of granulation tissue with proteinaceous material, which reflects slight infection. The presence of granulation indicates that the wound dressed with NCD has better wound healing efficiency than CSD and WWD. By the 21st day of post wounding, all the treated groups show the epithelialisation. The WWD treated wound tissues indicate the occurrence of inflammatory infiltrates, which reveals that healing process is still in progress, and CSD and NCD treated indicates the presence of

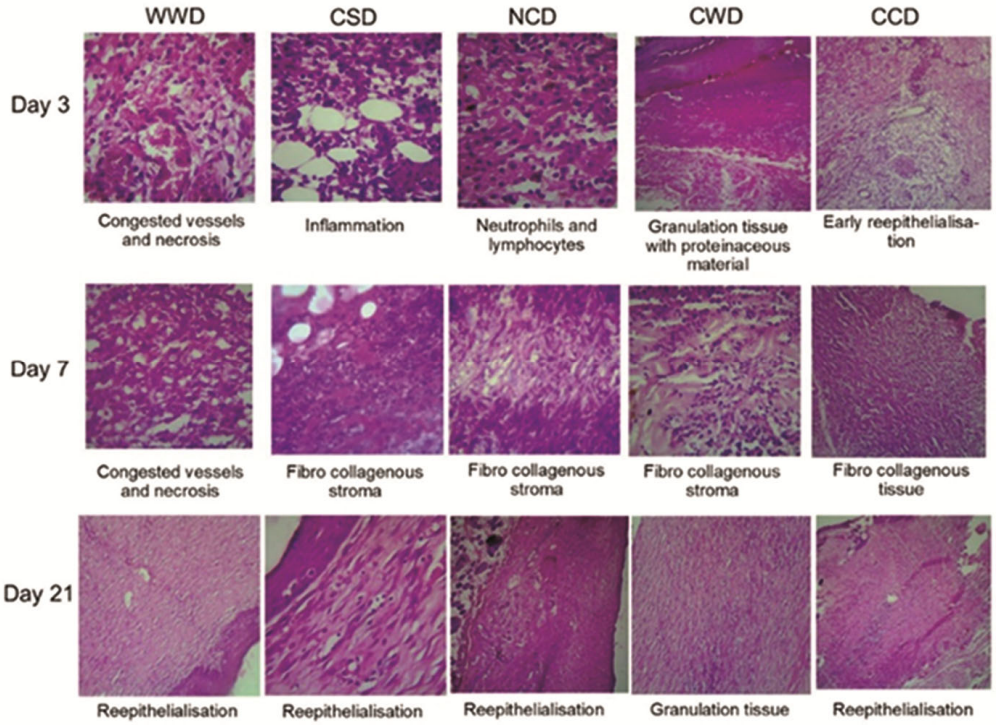

Fig. 6 — Histopathological analysis of the wound tissues: WWD–Without wound dressing, CSD– Commercially available non medicated silver treated dressings, NCD– Nano-sprayed *C. odorata* extracts applied wound dressings, CWD– Chitosan wound dressings, CCD– Chitosan and *C. odorata* extracts combined wound dressing

collagenous stroma. The tissues from the group treated with NCD exhibit good healing[23].

4 Conclusion

The test results reveal the potential of a wild, underutilised, but widely available plant, *C. odorata* extracts for medical textile application. The comparison of physical properties of the *C. odorata* extracts finished fabric over Chitosan finished and control fabric reveals that the *C. odorata* extracts (at 5%) influence the physical properties of the fabric. Even with mild cytotoxicity (22%), observed with the *C. odorata* extracts finished fabric, the wound healing efficacy of the *C. odorata* extracts and Chitosan finished wound dressing are found better than that of without wound dressing or without any medication. ETO sterilisation also shows a reduction in the antibacterial efficiency; hence, appropriate method of sterilisation needs to be explored for the *C. odorata* extracts treaded wound dressing materials. The shelf life analysis indicates a reduction in antibacterial efficiency after three weeks, when stored under room temperature (28-30^{0}C) in zip lock pouches. Hence, appropriate package and storage temperature need to be evaluated in future research. The test results affirm that the therapeutic quality of the plant bioactive agents can be imparted on viscose fabric up to a certain period.

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