6th Green and Sustainable Chemistry Conference ONLINE LIVE AND ON-DEMAND 16-18 NOV 2021

6th Green and Sustainable Chemistry Conference

Development of sustainable herbal antimicrobial finish for organic cotton fabrics using *Millettia pinnata* L. and *Pedalium murex*

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Introduction

The recent global pandemic has raised awareness of hygiene and increased the need to control the spread of infection through textiles. The textile industry professionals and academics have focussed on developing various antimicrobial and antiviral compounds for textiles. The use of plant-based antimicrobial compound is environmentally safe when compared with synthetic chemicals. In this study, we report the extraction of nano-emulsion using a combination of herbal oil - *milletia pinnata* L., curry leaf, coconut oil (**nano-emulsion 1**) and the other combination using *pedalium murex*, curry leaf, and coconut oil mixture (**nano-emulsion 2**). Health benefits of *milletia pinnata – Karanja* (Sharma et al., 2020) and *pedalium murex- Gokhru* (Patel et al., 2011) is well documented.

Objectives

To determine the antimicrobial efficacy and performance of GOTS (Global organic test standards) certified organic cotton fabrics (20 and 60 gsm) finished with nano-emulsions produced using *milletia pinnata* L., curry leaf, coconut oil and *pedalium murex*, curry leaf, and coconut oil mixture.

Methodology

The oils were extracted using the **solvent extraction method**, which offered a good yield of 92%. The different oil ratios [1:1 and 1:2] have been extracted and analysed for their effectiveness. **Thermal stability** and **pH** was determined to identify the best possible add-on for the chosen fabric structure. In addition, **Whiteness Index** was also assessed. 100% organic cotton woven fabrics were treated with herbal nano-emulsion using padding method – a continuous process and evaluated for its **antibacterial efficacy** [AATCC 100] before and after 10 washes with gram-positive [MRSA – *Methicillin-Resistant Staphylococcus aureus* and *Staphylococcus epidermidis*] and gram-negative bacteria – [*Escherichia coli*, *Klebsiella* pneumoniae]. **Anti-fungal efficacy** AATCC: 30 III, tensile strength ASTM D 5035 and vertical wicking (AATCC 197) were also assessed.

Results and discussions

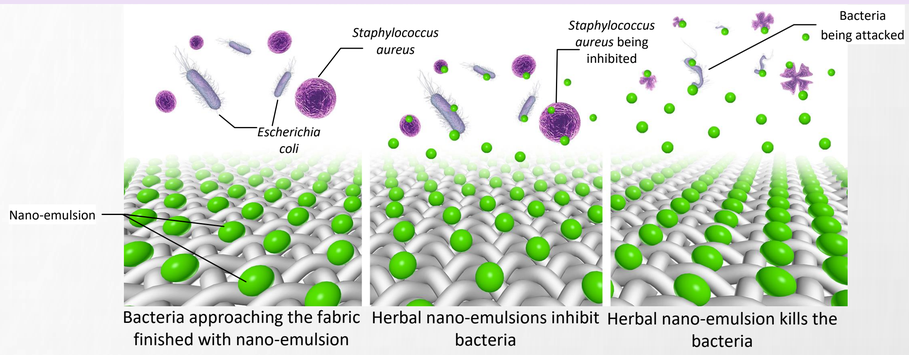
The pH for nano-emulsion 1 was 6.07±0.41 and for nano-emulsion 2 was 6.13 ± 0.3 and nano-emulsions were stable in the range 56-58ºC. The percentage add-on for nano-emulsion 1 for 20 gsm fabric was higher for 1:2 ratio than 1:1 herbal ratio. In addition the percentage add-on was higher for 20 gsm fabric than 60 gsm fabric demonstrating mechanical adsorption of nano-emulsion in the voids of the fabric structure.

Antibacterial assessments: Table 1 shows the percentage reduction of various Gram-positive and Gram-negative bacteria. Both the fabrics – 20 and 60 gsm and for both the herbal ratios the percentage reduction was in the range 99.6 ~99.89%, there was marginal decrease in the reduction of microorganism after 10 washes.

Anti-fungal assessments: No zone of inhibition was observed with minor traces of fungi for nano-emulsion 2, on a 60 gsm fabric; whilst for nano-emulsion 1, there was a zone of inhibition 4.3 mm showing higher resistance to growth of fungi.

Tensile strength: Finished cotton fabric- 20 gsm with nano-emulsion 1 (1:1 ratio) has marginal drop in the tensile strength in warp direction, however a marginal increase in strength was observed in weft direction. In the case of 60 gsm for nano-emulsion 1, there were decrease in strength in warp and weft directions. This trend was observed for nano-emulsion 2.

Vertical wicking: In the case of nano-emulsion 1, 60 gsm fabrics had higher wicking in warp direction (130 mm) than weft direction (121 mm) and the vertical wicking was lower for 20 gsm fabrics in both the directions. Wicking was marginally higher for nano-emulsion 2 than nano-emulsion 1.



Overview of various stages of the project

Table 1 Reduction of micro-organisms (AATCC 100) – Continuous method

Herbal ratio	Test Culture	Reduction of Microorganisms [R] (%) Continuous process (Padding)			
		Nano-emulsion 1 (Karanja)		Nano-emulsion 2 (Gokhru)	
		20 gsm	60 gsm	20 gsm	60 gsm
1:1	*S. aureus*	99.78	99.74	99.72	99.70
	E. coli	99.70	99.67	99.71	99.68
	S.epidermis	99.85	99.77	99.84	99.71
	K.pneumoniae	99.71	99.66	99.73	99.69
1:2	*S. aureus*	99.80	99.89	99.77	99.85
	E. coli	99.74	99.85	99.72	99.81
	S.epidermis	99.82	99.89	99.84	99.83
	K. pneumoniae	99.76	99.85	99.74	99.78
1:1 After 10 washes	*S. aureus*	99.30	99.29	99.31	99.37
	E. coli	98.96	99.05	99.05	99.16
	S.epidermis	99.06	99.47	99.17	99.17
	K.pneumoniae	98.92	98.62	99.07	98.78
1:2 After 10 washes	*S. aureus*	99.13	99.76	99.17	99.69
	E. coli	98.96	99.73	98.90	99.44
	S.epidermis	99.21	99.82	99.34	99.74
	K.pneumoniae	99.08	99.74	98.87	99.24

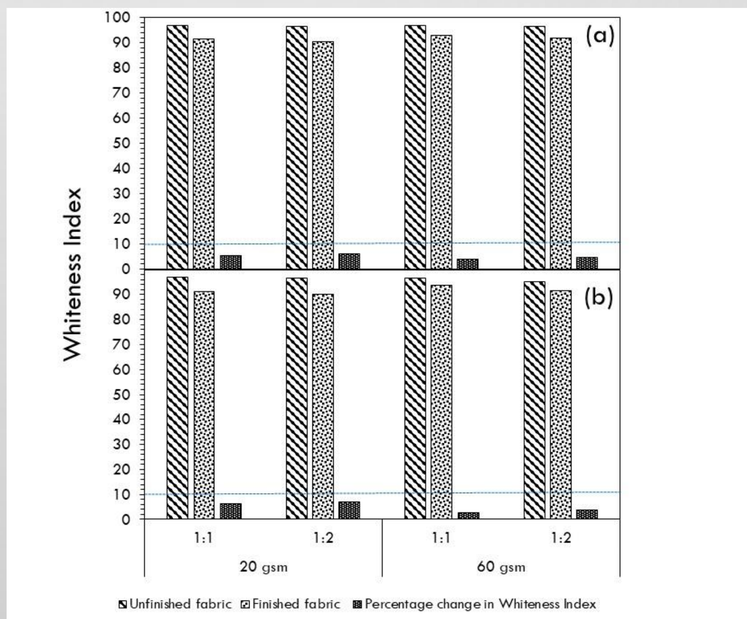


Figure 2 Whiteness Index (a) Nano-emulsion 1 (Karanja); Nano-emulsion 2 (Gokhru) for 20 and 60 gsm organic cotton fabric (dotted blue line indicates 10% index that is noticeable)

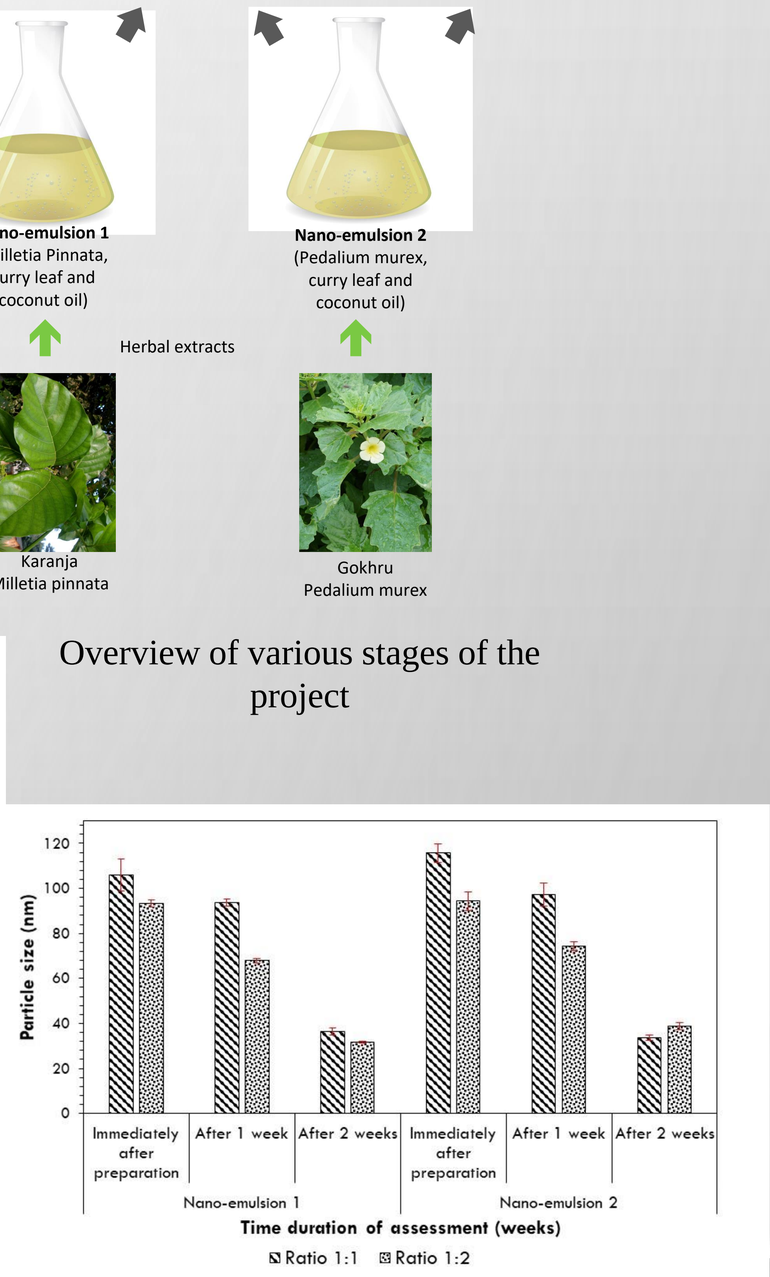


Figure 1 Particle size - Nano-emulsion 1 (Karanja); Nano-emulsion 2 (Gokhru)

Conclusions

Our findings indicates the potential for finishing organic cotton fabrics with innovative nano-emulsions developed from this research which is sustainable and environmentally friendly safe to use.

References

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Acknowledgements: The authors would like to acknowledge the kind contribution from the following technical/support colleagues: all staff of the Department of Fibres and Textile Processing Technology, ICT, Mumbai.; Dr Mrinal Choudhary (Director), WRA (Wool Research organisation), and Dr Madhura Nerurkar, Calantha Biotech, Mumbai India; and Mr V. Dhanapal, India, for providing support toward development 3D images.